File: PJ-3183 Doc: IC19/720

ITEM 11 ALLANS CREEK FLOOD STUDY (2019)

At the 28 October 2019 meeting, Council considered a report on the draft Allans Creek Flood Study 2019 and resolved that "The item be deferred for a 6 week period to allow for a review of the methodology and further consultation with key stakeholders". This report documents the review of the methodology and the consultation that occurred following Council's resolution.

RECOMMENDATION

1 That the Allans Creek Flood Study (2019) be adopted

2 That the Floodplain Risk Management Study and Plan for Allans Creek commence as a priority

3 Persons who made submissions be thanked and advised of Council's decision

REPORT AUTHORISATIONS

Report of: Mike Dowd, Manager Infrastructure Strategy + Planning
Authorised by: Andrew Carfield, Director Infrastructure + Works - Connectivity Assets + Liveable City

ATTACHMENTS

1 Copy of report to Council's meeting on 28 October 2019
2 Peer Review Report - Allans Creek catchment hydrologic modelling

BACKGROUND

At its meeting on 28 October 2019, Council considered a report on the draft Allans Creek Flood Study 2019 (refer attachment 1) as well as a presentation by Dr John Mathieson, on behalf of the Northview Estate Flooding Residents Action Group (NEFRAG) and resolved that "The item be deferred for a 6 week period to allow for a review of the methodology and further consultation with key stakeholders".

In order to implement Council's resolution, Council engaged GHD to undertake an independent peer review of the Advisian WBNM model as well as NEFRAG's WBNM model. The following information was provided to the peer reviewer:

- Advisian's WBNM model,
- Advisian's draft flood study report,
- NEFRAG's WBNM model, read first disclosure statement and copy of emails from NEFRAG explaining how their model has been set up.

The role of the reviewer was to review the methodology applied to both models and objectively and independently draw his own conclusions without Council staff, NEFRAG, or any other involved parties giving their own opinions about the models under review.

The NEFRAG's submission on the draft Allans Creek Flood study report from Advisian was also provided to the reviewer and its review and implication on the peer review are documented in Addendum 1 of the report provided by GHD.

In addition, Council staff consulted with NEFRAG and Dr John Mathieson via emails. Extensive information was exchanged by both parties.

Provided in attachment 2 is the peer review report. It highlights that the Advisian's hydrologic model is considered fit for purpose and more reliable than the NEFRAG's model.

PROPOSAL

The Allans Creek Flood Study (2019) be adopted. After adoption, undertake the following actions:

- Update the flood planning levels - Planning + Environment
- Update the relevant Section 10.7 of the planning certificate - Planning + Environment
- Provide flood level information advice in accordance with new study results - Infrastructure + Works

- Progress to engage a consultant to undertake the Floodplain Risk Management Study and Plan for Allans Creek which will take into consideration the new AR&R 2019 guidelines.

CONSULTATION AND COMMUNICATION

A copy of the peer review report was provided to the Central Floodplain Risk Management Committee for their information. The committee had previously, by majority, recommended to that the Allans Creek Flood study 2019, be adopted by Council.

PLANNING AND POLICY IMPACT

This report contributes to the delivery of Our Wollongong 2028 goal "We Value and Protect our Environment". It specifically delivers on the following:

Community Strategic Plan	Delivery Program 2018-2021	Operational Plan 2019-20
Strategy	3 Year Action	Operational Plan Actions
1.1.3 The potential impacts of natural disasters, such as those related to flood and landslips are managed and risks are reduced to protect life, property and the environment	1.1.3.2 Establish effective urban stormwater and floodplain management programs	Develop and implement Floodplain Risk Management Plans

FINANCIAL IMPLICATIONS

The cost of the peer review is $9,188.00 (exc. GST). Staff time and cost to act on Council resolution has been evaluated at 33 hours and a value of approximately $3,000.

Council has received notification on 4 November 2019 that its grant application for the Allans Creek Floodplain Risk Management Study and Plan (FRMSP) was successful. Should the flood study be adopted by council, it will be possible to progress the FRMSP straight away.

CONCLUSION

Flood studies are highly technical documents. They are undertaken and reviewed by flood engineers with skills and expertise in hydrology and hydraulics. Flood modelling in Wollongong LGA due to the steepness of the terrain and presence of structures that affect flood behaviour and create flow diversions requires extensive experience not only in hydrology and hydraulics but also in modelling. For that reason, council ensures that it engages flood consultants with relevant expertise and knowledge through a thorough competitive procurement process and that technical review of the work undertaken by consultants is performed by flood experts in Council and State Government (NSW DPIE). This ensures that the studies are technically sound and reflect best practices of the time at which they are prepared.

However, the results of a flood study are never static in time and are always best estimates. There are a number of assumptions that inform flood studies, and as new flood events occur, new terrain or survey information, new rainfall statistical data or blockage data, new flood modelling guidelines become available flood studies are reviewed and flood levels estimates change.

The highly technical nature of the document and on-going changes to flood levels pose a challenge when it comes to public understanding. We have aimed to provide an executive summary of our flood studies to facilitate their comprehension and explain in broad terms how and why flood levels have changed.

The draft Allans Creek Flood Study (2019) is technically sound and is recommended for adoption by Council.

File: PJ-3183 Doc: IC19/633

ITEM 8 ALLANS CREEK FLOOD STUDY (2019)

The Allans Creek Flood Study (2019) went on public exhibition from 29 July 2019 through to 26 August 2019 and is now finalised. It is recommended Council adopt the Allans Creek Flood Study (2019) which will inform land use planning and planning certificates.

This catchment encompasses various suburbs including Mount Keira, Figtree, Mount Kembla, Kembla Heights, Cordeaux Heights, Unanderra and Port Kembla. It incorporates five main tributaries, namely, Byarong Creek, American Creek, Charcoal Creel, Allans Creek and the Unanderra Industrial Area Drains. The study improves the accuracy and reliability of flood levels and flood behaviour in the Allans Creek Catchment.

The reports and flood models for the Allans Creek Flood Study (2019) will be placed on the NSW Flood data portal so that they can be publicly accessed. This will lead to a greater understanding of flood behaviour and risk and wiser decision making.

RECOMMENDATION

1 That the Allans Creek Flood study (2019) be adopted
2 That the Floodplain Risk Management Study & Plan for Allans Creek commence as a priority
3 Persons who made submissions be thanked and advised of Council's decision

REPORT AUTHORISATIONS

Report of: Mike Dowd, Manager Infrastructure Strategy + Planning
Authorised by: Andrew Carfield, Director Infrastructure + Works

ATTACHMENTS

1 Allans Creek Flood Study 2019 - Community Engagement Report
2 Allans Creek Flood Study 2019 - Executive Summary
3 Key Themes raised during public exhibition and Council's response

BACKGROUND

The NSW Government's Floodplain Development Manual provides a framework to ensure the sustainable use of floodplain environments and incorporates the NSW Flood Prone Policy. Under the Policy, the management of flood liable land remains the responsibility of Local Government with State Government subsidising flood mitigation works to alleviate existing problems and providing specialist technical advice to assist Councils in performing their floodplain management responsibilities.

The Policy provides for technical and financial support by the State Government through five stages:

1 Flood Study – Determines the nature and extent of flooding.

2 Floodplain Risk Management Study – Evaluates risks and management options for the floodplain in respect of both existing and proposed development.

3 Floodplain Risk Management Plan – Involves formal adoption by Council of a plan of management for the floodplain.

4 Implementation of the Plan – voluntary house purchase, flood readiness and response plans, construction of flood mitigation works to protect existing development and use of planning controls (LEP, DCP) to ensure new development is compatible with the flood hazard.

5 Review – reviews are recommended on average every 5 years and are also generally recommended after significant flood events, policy changes, or land use changes and where impediments to floodplain management plan implementation exist that warrant a review.

Allans Creek Flood Study

In 2017, Advisian was commissioned by Wollongong City Council (WCC) to review the Allans Creek Flood Study (2006) to take into consideration Council's updated Conduit Blockage Policy (2016). The review incorporates new survey data, more detailed modelling techniques, the updated blockage factors, and additional development within the catchment.

New hydrologic and hydraulic models have been developed and calibrated and verified to historic flood data to confirm their ability to simulate catchment flood behaviour.

Attachment 1 to this report provides an executive summary of the final report recommended for adoption by Council.

PROPOSAL

The Allans Creek Flood Study (2019) be adopted. After adoption, undertake the following actions:

- Update the flood planning levels - Planning & Environment
- Update of the relevant Section 10.7 planning certificate - Planning & Environment
- Provide flood level information advice in accordance with -new study results - Infrastructure & Works

CONSULTATION AND COMMUNICATION

On 26 June 2019, the draft flood study was presented to the Central Floodplain Risk Management Committee who recommended public exhibition of the draft report.

The final draft Flood Study report went on public exhibition from 29 July 2019 through to 26 August 2019. Two community drop-in sessions were attended by 74 community members; the first on Wednesday, 7 August 2019 from 4:00 pm – 5:30 pm at the Figtree Community Centre, and the second on Saturday, 10 August 2019 from 10:30 am – 12 noon at the Berkeley Community Centre.

Mailed out a letter to over 7,700 residents and property owners in flood affected areas (all properties within the extent of the probable maximum flood) to advise of the public exhibition process and seek feedback on the document.

Notices of the public exhibition were published in the local newspaper on 31 July and 7 August 2019. Hard copies of the Flood Study and Frequently Asked Questions were placed at the Unanderra and Wollongong Libraries and PDFs were available through Council's "Have Your Say" page. 200 people viewed the Website's project page. 125 people downloaded the documents from the Website. There were a total of 26 submissions throughout the exhibition period.

Comments from the submissions and at drop in sessions related to:

- Australian Rainfall and Runoff
- Flood modelling
- Mapping
- Observations of flooding
- Creek maintenance
- Flood mitigation
- Flood Risk to individual properties
- Perceived causes of flooding
- 1998 Floods
- Planning / Development
- Insurance premiums

Persons who made a submission were thanked and advised of this matter being reported to Council for adoption.

A community engagement report is provided in attachment 2 and outlines in more detail the process and outcomes of the consultation.

Attachment 3 provides responses to all key themes raised during the consultation.

The comments provided can be addressed through on-going education on floodplain management, or considered as part of the future review of the floodplain risk management study and plan for the catchment. Some submissions were very technical in nature and were considered by the consultants, council's flood engineers and flood experts from the NSW Government Department of Planning, Industry and Environment and resulted in additional information and clarifications being provided in the final report.

On 17 October 2019, a presentation was provided to the Central Floodplain Risk Management Committee summarising the outcomes of the exhibition process and how submissions have been addressed. The Committee, by majority, recommended that the Allans Creek Flood study 2019 report be adopted by Council.

The Northview Estate Flooding Residents Action Group (NEFRAG) representatives on the Committee did not support adoption of the plan by Council as the Flood Study does not apply the new National guidelines for flood estimation (AR&R 2016/19). This is consistent with the submission provided by NEFRAG during the exhibition period. Council has committed to implement AR&R 2016/19 as part of the review of the Floodplain Risk Management Study and Plans, with Allans Creek catchment being the first catchment to be reviewed, commencing in early 2020.

PLANNING AND POLICY IMPACT

This report contributes to the delivery of Our Wollongong 2028 goal "We Value and Protect our Environment". It specifically delivers on the following:

Community Strategic Plan	Delivery Program 2018-2021	Operational Plan 2019-20
Strategy	3 Year Action	Operational Plan Actions
1.1.3 The potential impacts of natural disasters, such as those related to flood and landslips are managed and risks are reduced to protect life, property and the environment	1.1.3.2 Establish effective urban stormwater and floodplain management programs	Develop and implement Floodplain Risk Management Plans

FINANCIAL IMPLICATIONS

The Allans Creek Flood Study (2019) cost $146,430 excluding GST. The next stage in the flood planning process for this catchment, being the Floodplain Risk Management Study & Plan, will be funded from existing budget allocations and an application has already been made to the State Government for grant funding. It is expected that the Floodplain Risk Management Study & Plan will commence in early 2020.

CONCLUSION

The Allans Creek Flood Study (2019) was prepared with the cooperation, assistance and support of many stakeholders, including community members and State government representatives and the Central Floodplain Risk Management Committee.

The study improves the accuracy and reliability of flood levels and flood behaviour in the Allans Creek Catchment. The reports and flood models for the Allans Creek Flood Study (2019) will be placed on the NSW Flood data portal so that they can be publicly accessed. This will lead to a greater understanding of flood behaviour and risk and wiser decision making.

ALLANS CREEK FLOOD STUDY

ENGAGEMENT REPORT

SEPTEMBER 2019

Z19/203884

wollongong
city of innovation

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The information in this report is based on data collected from community members who chose to be involved in engagement activities and therefore should not be considered representative.

This report is intended to provide a high-level analysis of the most prominent themes and issues. While it's not possible to include all the details of feedback we received, feedback that was relevant to the project has been provided to technical experts for review and consideration.

Executive Summary

Council is responsible for planning and managing flood prone lands in our area and has updated the Allans Creek Flood Study as part of this commitment. A report on the draft Flood Study was prepared with information on how it was updated and what the results are. The updated Study explains the way flooding happens in the Allans Creek catchment. The study will form a basis for the ongoing management of flood risk in the catchment.

Council's engagement team worked collaboratively with a technical consultant to share the updated Study with the community and key stakeholders. During the public exhibition period, 29 July to 26 August 2019, Council sent letters to more than 7,700 residents and property owners in the catchment area inviting them to learn more about the review. Emails with this information were sent to community, education, Register of Interest (flood), business, government and emergency services' stakeholders. The information was also available at Council's Customer Service Centre. Copies of the draft report, a Frequently Asked Questions sheet and Feedback Form were made available at Unanderra and Wollongong Libraries, as well as information sessions at Figtree Community Hall on 7 August 2019 and Berkeley Community Centre on 10 August 2019. They were also included on the project webpage. Notices of the exhibition were published in the Advertiser on 31 July and 7 August 2019. A media release was distributed on 29 July 2019. The community were invited to provide feedback via Council's website, Customer Service Centre and at the community information sessions.

There were 25 submissions. Some comments were provided at the drop-in information sessions which were attended by a total of 74 community members.

Feedback themes relating to the flood study focused on flood estimation methodology, flood modelling and mapping. Concerns were expressed that Council is not using the most current available data. It was noted that the developers of Cobblers Run took Council to court about using the ARR1987 and were successful, with the new guidelines subsequently being used for that development. Questions were raised about why the new guidelines could not also be used for the rest of Northview Estate. Some detailed technical analyses of the Study were provided, with suggested changes. Comments related to the modelling of calibration events, blockage, hydrologic and hydraulic modelling, estimates, validity, verification, data, catchment delineation, grid size, percentage impervious values, Manning's values and definitions. There was some uncertainty about whether the modelling replicates real events. A comment was made that the mapping confirmed observed flood levels. Some suggested that the resolution of the maps needed to be improved. A method was stepped out as to how to improve this in a way that reduces loss of quality. It was also suggested to remove most maps that are based on "risk management" blockages.

Other feedback themes related to observations of flooding, creek maintenance, flood mitigation, flood risk to individual properties, perceived causes of flooding, 1998 floods, planning/development and insurance premiums.

Background

Wollongong City Council is committed to finding solutions to reduce the social and economic damages of flooding. In 2016, Council updated its Blockage Policy and resolved to review and update its flood studies. The Allans Creek Flood Study is one of 10 studies to undergo review. This catchment is located in Mount Keira, West Wollongong, Figtree, Mount Kembla, Unanderra, Farmborough Heights and Berkeley.

Figure 1 Allans Creek catchment map

The Allans Creek Catchment Flood Study and Floodplain Risk Management Study and Plan were completed by Council in 2006, with addendums to the Flood Study in 2008 and 2009. These studies identified the risk within the Allans Creek catchment and the steps that can be taken to manage this risk now and into the future.

As part of updating the Study, Council's revised Blockage Policy was considered, which helps us work out how blocked stormwater structures might affect flooding. We have improved information, such as recent data from land and waterway surveying. We've included an extended network of drainage pits and pipes and used more improved and detailed modelling techniques. We've also extended the mapping to capture additional flood-prone areas and waterways that were not previously mapped. Data was collected and used to update the computer models used to simulate the flooding in the catchment, and to update flood maps which provide a visual illustration of the flood risk in the catchment.

At the Central Floodplain Risk Management Committee meeting on 26 June 2019, the public exhibition of the draft Allans Creek Flood Study was unanimously supported. The outcomes of the exhibition and resulting amendments to the Study will be reported to the Central Floodplain Risk Management Committee and Council in view of adopting it in 2019.

The study provides an improved understanding of the potential impacts of floods on the local community and will form a basis for the ongoing management of flood risk in the Allans Creek catchment.

Methods

Our Stakeholders

Our Methods

Table 1: Details of Communication and Engagement Methods

Methods	Details of Methods
Communication Methods	
Presentation	Information about the proposal was presented at the Floodplain Risk Management Committee (Central) meeting on 26 June 2019
The Advertiser	Details of the public exhibition, information sessions and Engagement HQ webpage were included in Council's Community Update pages on 31 July and 7 August
Media release	A media release was made available for media outlets
Email to key stakeholders	An email and FAQ were sent to key stakeholders identified through an analysis process
Register of Interest	An email was sent to all participants with registered interest in 'Flood'
Info packs	Frequently asked question sheets and hardcopy feedback forms were made available at Corrimal Library and Customer Service. Hardcopies of the draft report were also made available at Wollongong and Unanderra Libraries.
Letter	A letter about the public exhibition, information sessions and how to submit feedback (via phone, email, in person or post) was mailed to local residents and property owners
Frequently Asked Questions	Responses to questions about updates to the Study and floodplain risk management were distributed with the letter and emails, published on the project webpage and distributed at the information sessions.

Engagement HQ Website	The project webpage hosted background info and supporting documents: • Frequently Asked Questions with information on the Study and flood risk management • News Feed for updates on project progress • Document Library with the Report • Flood modelling video • Flooding in Wollongong video • Online survey tool to capture participant's feedback
Video	The Flooding in Wollongong video was used on the Engagement HQ webpage and a flood modelling video was screened at information sessions and on the Engagement HQ webpage
Engagement Methods	
Engagement HQ Website	An online survey tool was used to capture participant's feedback. The page also hosted background info and supporting documents.
Feedback Form	A hard copy feedback form was made available at libraries and engagement activities.
Community Information Sessions	Two drop-in sessions were held to provide the community with information on the work undertaken to date and findings of the Report. The Report, flood modelling maps, flood modelling video and images of flood mitigation work taking place in the catchment were displayed along with the FAQ and feedback forms. Floodplain management engineers working on the Study were on hand to answer questions.

Results

All stakeholders and the wider community were invited to provide feedback on the draft Study. This section provides details on the participation at engagement activities (Table 2), and the feedback received during the exhibition period.

Engagement Participation

Details of the number of participants for each engagement activity are presented in Table 2.

Table 2: Engagement participation results

Engagement Activities	Participation
Central Floodplain Risk Management Committee Meeting	7
Drop-in Community Information Session at Figtree Community Hall	59
Drop-in Community Information Session at Berkeley Community Centre	15
Online Participation • Aware – Total number of users who viewed the project page • Informed – Total number of users who clicked a hyperlink, e.g. to download a document • Engaged – Total number of users who actively contributed to the project, e.g. submitted feedback via the online form	 200 125 3

Figure 2 Community Information Session at Figtree Community Hall

Submission Results

There were 25 submissions, including 6 group submissions from Figtree Gardens Caravan Park Residents' Committee, Neighbourhood Forum 5, Rienco Consulting, Maddan Investments, Northview Estate Figtree Resident Action Group and Cardno. Discussions from drop-in sessions are also presented in this section.

Feedback themes relating to the flood study focused on flood estimation methodology, flood modelling and mapping.

Australian Rainfall and Runoff (ARR)

Concerns were expressed that Council is not using the most current available data. It was noted that the developers of Cobblers Run took Council to court about using the ARR1987 and were successful, with the new guidelines subsequently being used for that development. Questions were raised about why the new guidelines could not also be used for the rest of Northview Estate.

> Expedite steps to prove up the ARR2016-19 methodology in Wollongong.

> The study should not be formally released until current methodology is used for design flood estimation.

> Council's engineers have said there are concerns with the new ARR2019 method and it needs to be adjusted for local characteristics unique to Wollongong. Is Wollongong so different that it can run its own race.

> Use of the lower ARR2019 design rainfall for the region inevitably would have led to more scientifically correct and even lower flood levels in the Northview Estate.

Flood modelling

Technical comments were provided on modelling calibration events, blockage, hydrologic and hydraulic modelling, estimates, validity, verification, data, catchment delineation, grid size, percentage impervious values, Mannings values and definitions. There was some uncertainty about whether the modelling replicates real events. A comment was made that the mapping confirmed observed flood levels.

> To alleviate confusion surrounding how the modelling has been assembled and its outputs, we recommend a Compendium of Data is published with the adopted Study which documents more of the underlying data that supports the modelling.

> The modelling should include consideration of blockage, calibrated against real world events. It is difficult to see whether this has been done or not.

> Clarify the hydrologic modelling's validity and superiority over conventional WBNM formulations

> Mapping shows American Creek at my location to be increasing in width in the various flood conditions considered. They show increased depth and velocity. This is confirmed by my observations over the years.

Land surveys are required at two key locations where calibration of the model needs additional information to be reliable; these are immediately upstream of the Princes Highway bridge over Byarong Creek and at Figtree Grove Shopping Centre.

For calibration and verification modelling, a more forensic approach to understanding the "apparent blockage" values and harnessing them in cases where their physical significance cannot be reconciled with historical observations.

The definition of floodway includes a criteria that is too low and should be revised to exclude H1 hazard areas

Maps

Some felt the resolution of the maps needed to be improved. A suggestion was made to plot to PDF from GIS software and retain cadastre/contours/velocities as vector data instead of raster data to reduce loss of quality. It was also suggested to remove most maps that are based on "risk management" blockages.

The current maps have a poor resolution and are of little use for examining results at a street or property level.

Other feedback themes were:

Observations of flooding

Experiences of significant flood events in the catchment were recounted.

It went 12 ins up my wife's knee. My son was outside 16 ins in the carport. Within 10 minutes it was gone.

March 2019 - a car drove in floodwaters in Hurt Pde [Unanderra]. SES tried to get them out. Our backyard was underwater.

The area around Figtree Westfield shopping centre was so flooded on The Avenue at the Bowling Club that many cars had been washed over the fence in the front car park. Three houses opposite the Bowling Club were ¾ under water.

I have photographs of the big flood in 1959, 1998 and 1999

Creek Maintenance

Requests were made for creek maintenance on private land, Council land or where the landowner was not identified.

I would like the Council to remove trees that were washed down the creek up against the bridge. The creek needs to be cleared further up so the coral trees won't fall into creek and block the bridge.

Islands of vegetation have been allowed to grow in the middle of the creek, trees have fallen into the creek and in one spot fallen trees have formed a dam.

The banks are eroding toward properties on Leigh Crescent. The waterway needs to be maintained & improved.

The owners of the entry culvert/causeway land at Figtree Gardens Caravan Park have not done any vegetation clearing either side for a number of years. I understand Council can "encourage" them to maintain the area affected and also as it's a public road help with said maintenance to a degree.

Flood mitigation

There was a high level of interest in the next stage of the flood risk management process, i.e. what Council might do to reduce the impact of floods.

How many more studies are Council going to do? And when will we see something being done?

According to the current Wollongong flood map, the M1 is predicted to hold back floodwaters over a length of 1.5km. The American Creek M1 culverts are the most sensitive location along this length. What can Council do to improve this position?

The Forum requests that in the Flood Risk Management Study priority is given to the implementation of flood mitigating infrastructure affecting the Figtree Grove Shopping Centre and the nearby residential areas that are otherwise suitable for redevelopment at higher densities.

There were many bright graphs/pictures and we could all see light and dark blue which was the flood water etc - But what is Council going to do?

A range of potential options for mitigating flood impacts was suggested.

Target the 'low hanging fruit' in terms of the suite of flood mitigation management measures e.g. a well-designed debris trap at the M1 culvert

Open the culvert on Gladstone Avenue at least another metre higher and possibly make the spans wider

Flood risk to individual properties

There was uncertainty about what the outcomes of the Study mean for flood risk to individual properties.

> We still do not know if we are at risk of a flood according to your studies

> What should I expect in significant rain events if your proposed plans are adopted?

Perceived causes of flooding

A range of reasons for what people perceived to be the cause of flooding was presented.

> Potential flooding is mainly caused by blockage of the M1 Culvert

> Water is being diverted towards properties by a bridge constructed in 1979 and is eroding a creek bank less than 1 metre from the main sewerage line

> [Comments in 1999 letter to the Illawarra Mercury] Byarong Creek gets choked with straight willows. These catch the debris and break free of the mud and flow downstream and block the culvert forming a huge damn.

1998 floods

Experiences of the 1998 flood were shared, including those that occurred in other catchments.

> The High Tide was in, the water could not flow back into the ocean. The now Ml had been built and the walls on either side of this highway are about 4 to 5 meters high. The water from the creek built up and water accumulated and pushed onto the Ml wall and therefore Preston Avenue flooded.

> Corrimal Westfield Shopping Centre lower section was totally flooded and all merchandise and equipment etc was ruined. Fairy Meadow Fraternity Club was flooded. Bulli Pass had collapsed. Thirroul Escarpment (Sylvan Way) became a waterfall, creek flooded, water just ran down the mountain.

Planning / development

There was a concern that the Flood Study would add to the cost of making new developments compliant.

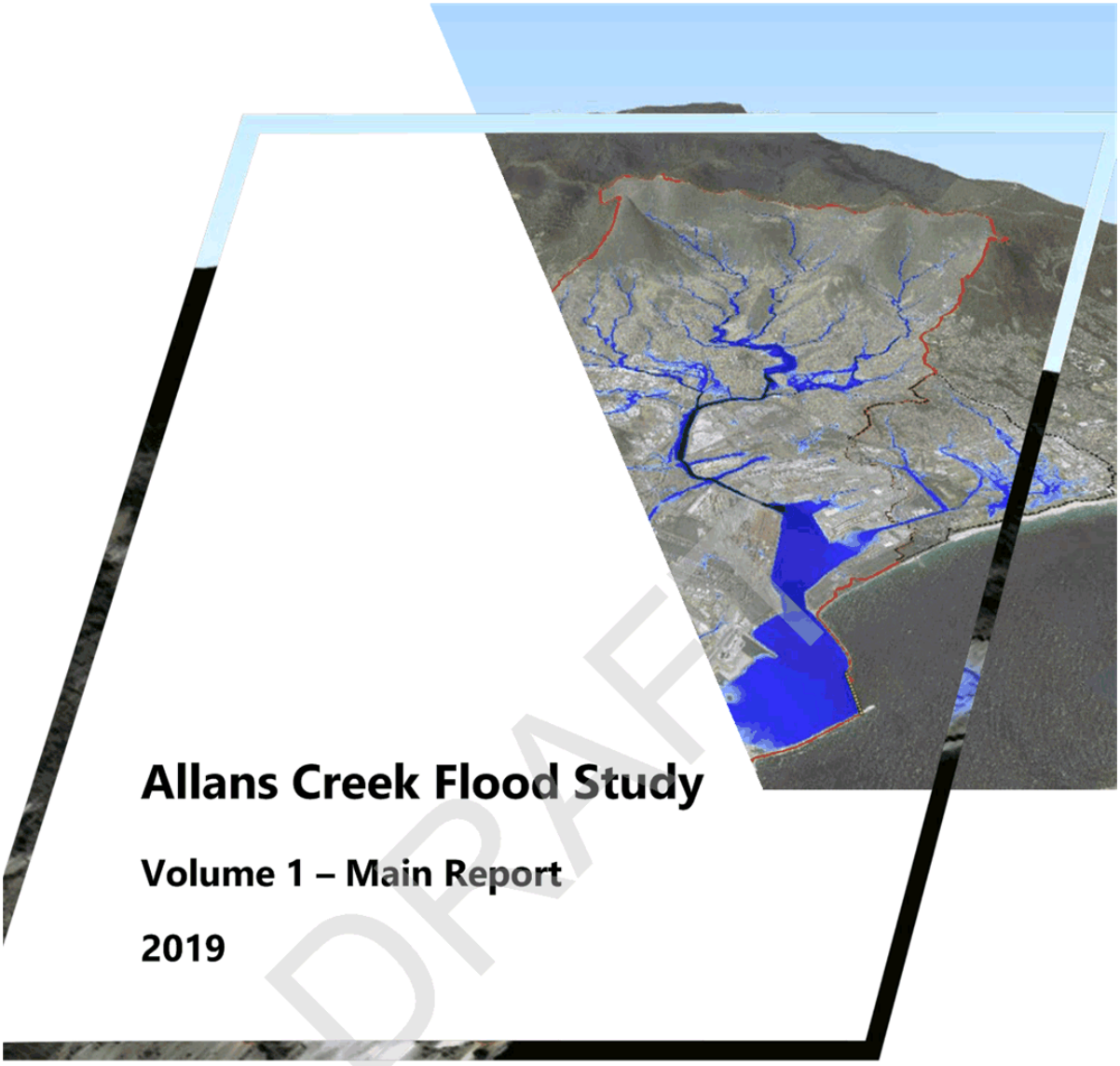
> Many have been told by Council that they would not get planning permission for their build in Cobblers Run unless they built 1.0m above the ground. This adds significant cost to an average family home.

Insurance premiums

Concerns were raised about the impact of the flood study on home insurance premiums.

> The modelling results in the 'flood affected' label being unnecessarily applied to hundreds of homes in Figtree which now require flood insurance when clearly they are not flood prone. This adds further annual costs of flood insurance.

> People that have lived here for more than 30 years have never seen flood waters on the backyards from rising creek water and yet due to Councils classification it is very costly to have any flood insurance



Allans Creek Flood Study

Volume 1 – Main Report

2019

Level 17, 141 Walker St
North Sydney NSW 2060
Australia

Revision B

October 2019

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Wollongong City Council
Allans Creek Flood Study

Disclaimer

Cover Photo: Three-dimensional render of major flowpaths in the Allans Creek & Wollongong City catchments (*Source: Advisian*)

Project: Allans Creek Flood Study
Draft Flood Study Report

Rev	Description	Author	Review	Advisian Approval	Date
0	Draft Report for Internal Review	LC L Collins	CRT C Thomas		18/7/2019
A	Draft Report issued for Public Exhibition	LC L Collins	CRT C Thomas		26/7/2019
B	Final Draft Report	LC L Collins			

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Executive Summary

Introduction

The Allans Creek catchment is located within the Wollongong City Council Local Government Area (LGA) in the Illawarra Region of New South Wales. The catchment drains from the Illawarra Escarpment to Port Kembla Harbour, covering an area of approximately 45 km^2. The study area includes additional areas which drain directly to Port Kembla Harbour totalling about 5 km^2.

The catchment encompasses various suburbs including Mount Keira, Figtree, Mount Kembla, Kembla Heights, Cordeaux Heights, Unanderra and Port Kembla, and incorporates five main tributaries, namely Byarong Creek, American Creek, Charcoal Creek, Allans Creek and the Unanderra Industrial Area Drains. A number of major transport links also pass through the catchment including the Princes Motorway (M1), Princes Highway and the Illawarra Railway.

The catchment has a history of flooding, with extensive damage caused to private and public property located near the creeks and major drainage channels during floods in August 1998 and October 1999.

Previous floodplain risk management activities completed in the study area by Wollongong City Council (Council) have included the *Allans Creek Flood Study* (*Lawson and Treloar 2006a*), *Allans Creek Floodplain Risk Management Study and Plan* (*Lawson and Treloar 2006b*), and the implementation of flood risk management measures including creek modification works, riparian corridor management and voluntary property purchase.

Council engaged Advisian (*part of the Worley Group*) to complete an updated Flood Study for the Allans Creek catchment in response to a range of factors including release of Council's Revised Conduit Blockage Policy (*2016*), recent improvements in flood modelling technology, the availability of new data, and changes in the catchment.

The study provides an improved understanding of the potential impacts of floods on the local community and will form a basis for the ongoing management of flood risk in the Allans Creek catchment.

Flood Model Development

New hydrologic and hydraulic flood models have been developed using the latest available data for the catchment and up-to-date guidelines, modelling software and techniques.

The models underwent calibration and verification to historic flood data to confirm their ability to reliably simulate catchment flood behaviour. The models and their outputs will help inform the subsequent preparation of a Floodplain Risk Management Study and Plan for the Allans Creek catchment including the assessment of potential floodplain risk management measures.

Design Flood Modelling and Mapping

Design flood conditions are estimated from hypothetical design rainfall events that have a particular statistical probability of occurrence. These design floods are used by Council and other agencies to understand flood risk and help plan for the occurrence of flooding.

The probability of a design event occurring can be expressed in terms of percentage Annual Exceedance Probability (AEP), which provides a measure of the relative frequency and magnitude of the flood event. The new WBNM hydrologic and TUFLOW hydraulic models were used to simulate a range of design flood events including the 20%, 10%, 5%, 2% and 1% AEP floods and the Probable Maximum Flood (PMF). These design flood events were assessed for both 'risk management' and 'design' blockage factors as defined in Council's *Revised Conduit Blockage Policy* (2016).

Resultant flood mapping is presented in **Volume 2** of this report. A selection of flood mapping is reproduced at the end of this Executive Summary.

Summary of Flood Behavior

For design flood events up to and including the 1% AEP a critical storm duration of 120-minutes was found for the majority of the study area. This is indicative of a 'flashy' catchment where flooding generally occurs in response to relatively short durations of intense rainfall and flood levels quickly rise and fall over the course of just a few hours.

For design flood events up to and including the 1% AEP a longer critical storm duration of 360-minutes was found for the lower catchment, from where Allans Creek discharges to Port Kembla upstream to the area where Byarong and American Creeks pass beneath the M1 Motorway. This indicates that flooding in these areas is more sensitive to the total volume of rainfall than other parts of the catchment, and that floodwaters may rise somewhat slower and remain elevated for longer.

Flood model results indicate that flooding can be widespread along the various creeks, and numerous minor tributaries and local overland flow paths in the study area. While numerous properties may be affected, many others are located high on ridges and remain unaffected by flooding even during the PMF.

Flood extents along incised creek channels and in steeper areas of the catchment generally increase in relatively small increments with flood magnitude. However, in the lower, flatter areas of the catchment floodwaters from different tributaries converge and flood extents and depths can increase markedly with flood magnitude. Such areas include Byarong and American Creeks in the vicinity of the Princess Highway and M1 Motorway.

During the 1% AEP flood event, areas of high flood hazard that may pose a significant threat to life and property (e.g. ≥ H4 Hazard) are generally constrained to defined water courses, open channels and flood flow paths. However, there are various exceptions including (but not limited to) properties adjacent to Byarong Creek at Koloona Avenue, Arrow Avenue and Preston Street; properties near a low-point in Phillips Crescent, Mangerton, and; parts of Figtree Gardens Caravan Park and O'Donnell Drive adjacent to American Creek. Flood depths and velocities also become significant along various roads in the study area and would affect vehicle stability and pose constraints for evacuation and emergency response.

During the PMF event, the extent and degree of hazard posed to life and property would increase significantly, with buildings vulnerable to structural damage or failure in various areas. Evacuation and emergency response constraints would also be significantly worse, with some areas requiring early evacuation to avoid rapid isolation and inundation.

Potential Impacts of Climate Change

To assess the potential impacts of climate change on flooding in the Allans Creek catchment the following scenarios were investigated:

- **Scenario ID 5A:** 1% AEP event with 20% increase in rainfall intensity
- **Scenario ID 5B:** 1% AEP and PMF events with 0.4m increase in ocean level (2050 conditions)
- **Scenario ID 5C:** 1% AEP and PMF events with 0.9m increase in ocean level (2100 conditions)
- **Scenario ID 5D:** 1% AEP event with 20% increase in rainfall intensity and 0.4m increase in ocean level
- **Scenario ID 5E:** 1% AEP event with 20% increase in rainfall intensity and 0.9m increase in ocean level.

The findings are summarised as follows:

- The investigated sea level rise scenarios of up to 0.9 m would be expected to cause little change to existing flood conditions and impacts. This owes to the steep flood gradient in Allans Creek approaching Port Kembla, and the relatively high surrounding ground elevations.
- Increases in the intensity of heavy rainfall events would be expected to have a more significant impact on flooding. Flood model results indicate that a 20% increase in rainfall intensity for the 1% AEP event would lead to increases in peak flood level of 0.1 m or more along most tributaries, with localised increases of more than 0.5 m.
- Additional impacts caused by up to 0.9 m of sea level rise in conjunction with a 20% increase in rainfall intensity (beyond those caused by the 20% increase in rainfall intensity alone) would be expected to be small and limited to the lower reaches of Allans Creek.

Blockage Policy Sensitivity

As noted previously, Council's *Revised Conduit Blockage Policy* (2016) includes two different sets of blockage factors, namely 'risk management' and 'design' blockage factors. To quantify the relative impact of these blockage factors on peak design flood levels a comparison was undertaken as discussed in the following. Similarly, a comparison was undertaken between the 2016 Blockage Policy and the 2002 Blockage Policy adopted in the previous flood study.

2016 Blockage Policy Risk Management vs Design Blockage Factors

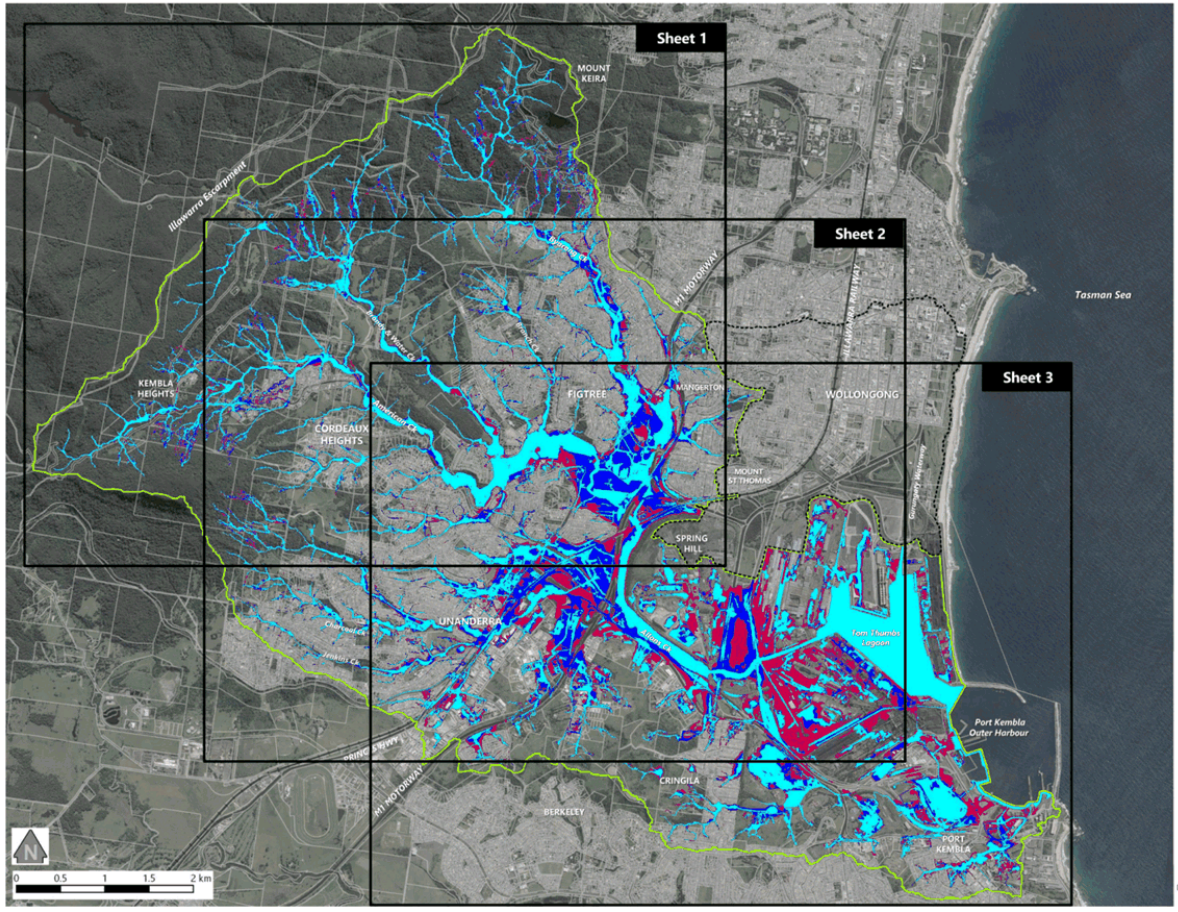
The revised 2016 blockage policy 'risk management' factors were found to result in higher 1% AEP and PMF peak flood levels upstream of many structures relative to the 'design' blockage factors, though the magnitude of increase is often less than 0.1 m. Localised differences in 1% AEP peak flood levels of up to 0.85 m were however observed. The magnitude of flood level difference is generally lower for the PMF event than the 1% AEP event.

2016 Blockage Policy vs 2002 Blockage Policy

To determine the degree of any changes in peak flood levels that are attributable to the adoption of Council's *Revised Conduit Blockage Policy* (2016) a comparison between the following scenarios was made for the 1% AEP and PMF events using the new TUFLOW hydraulic model:

- 2016 policy 'risk management' blockage factors
- 2002 policy blockage factors as described in Chapter 3 of *Allans Creek Flood Study Addendum 1* (*Cardno Lawson Treloar 2008*) and Chapter 7 of *Allans Creek Flood Study* (*Lawson and Treloar 2006a*).

The revised 2016 blockage policy 'risk management' factors were found to result in a decrease in peak flood levels upstream of many structures relative to the 2002 Blockage Policy. No increases in peak flood level were indicated by the model results.



EXECUTIVE SUMMARY FIGURE ES 1

DRAFT

LEGEND

- Allans Creek Catchment
- Wollongong City Catchment
- Major Roads
- Railway

Design Flood Extents

Risk Management Blockage Factors

- 20% AEP Event
- 1% AEP Event
- Probable Maximum Flood (PMF)

Design Flood Mapping Sheet Extents

Prepared by: Advisian Worley Group

Rev: B
File: fj301015-03839_191009_AllansCkFS_ExecSummaryFloodMapping_A3L.pptx
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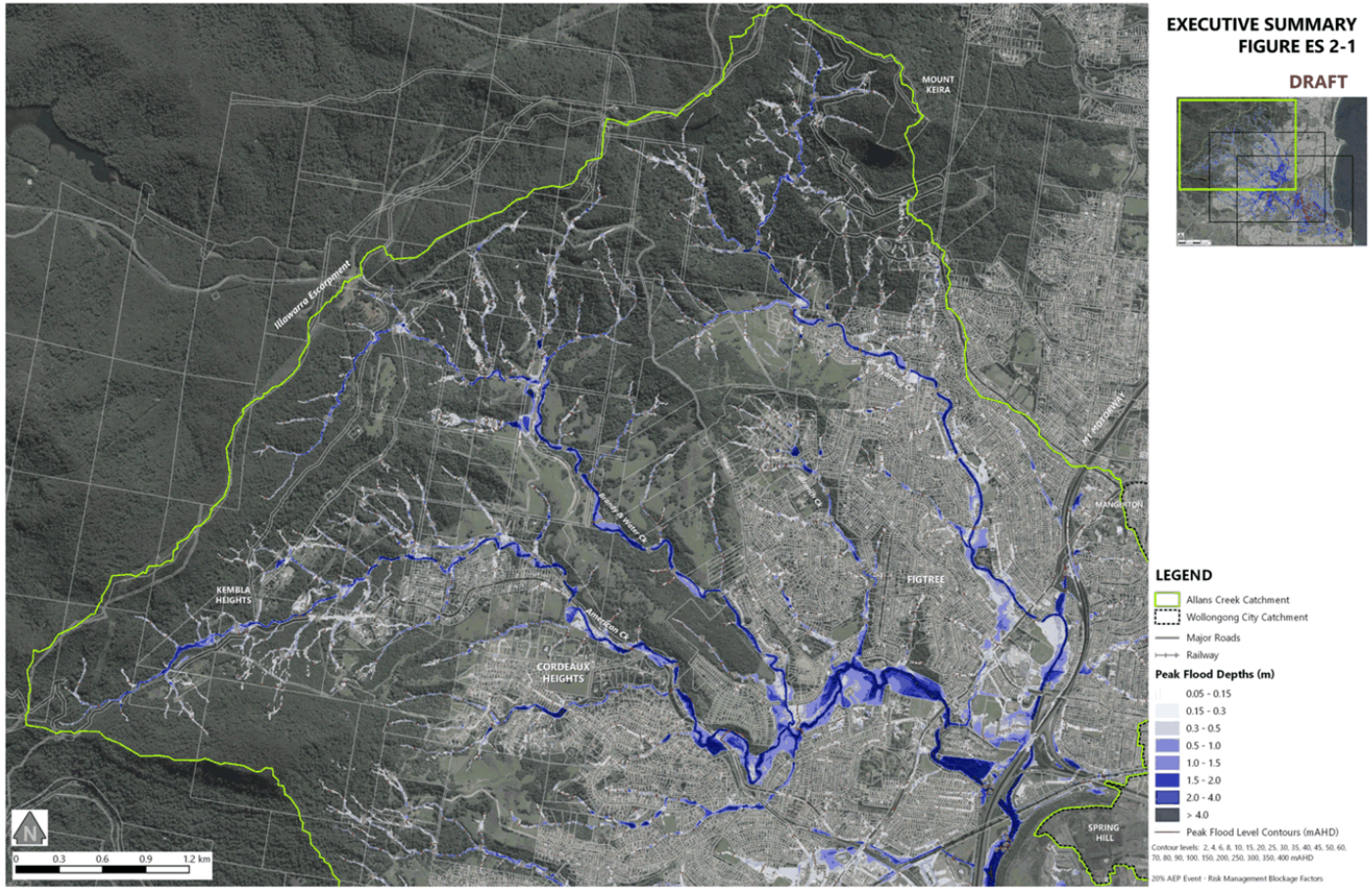
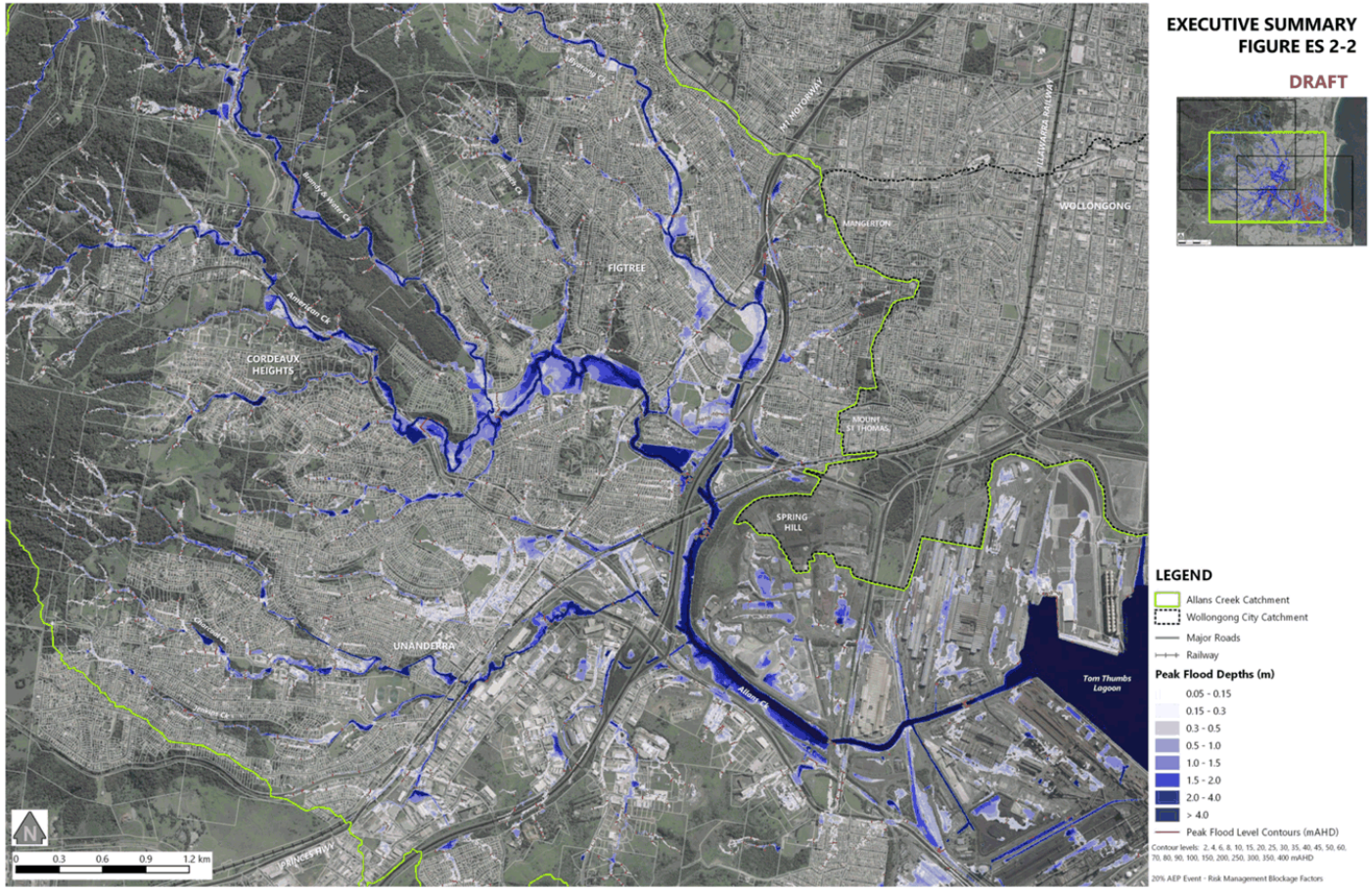
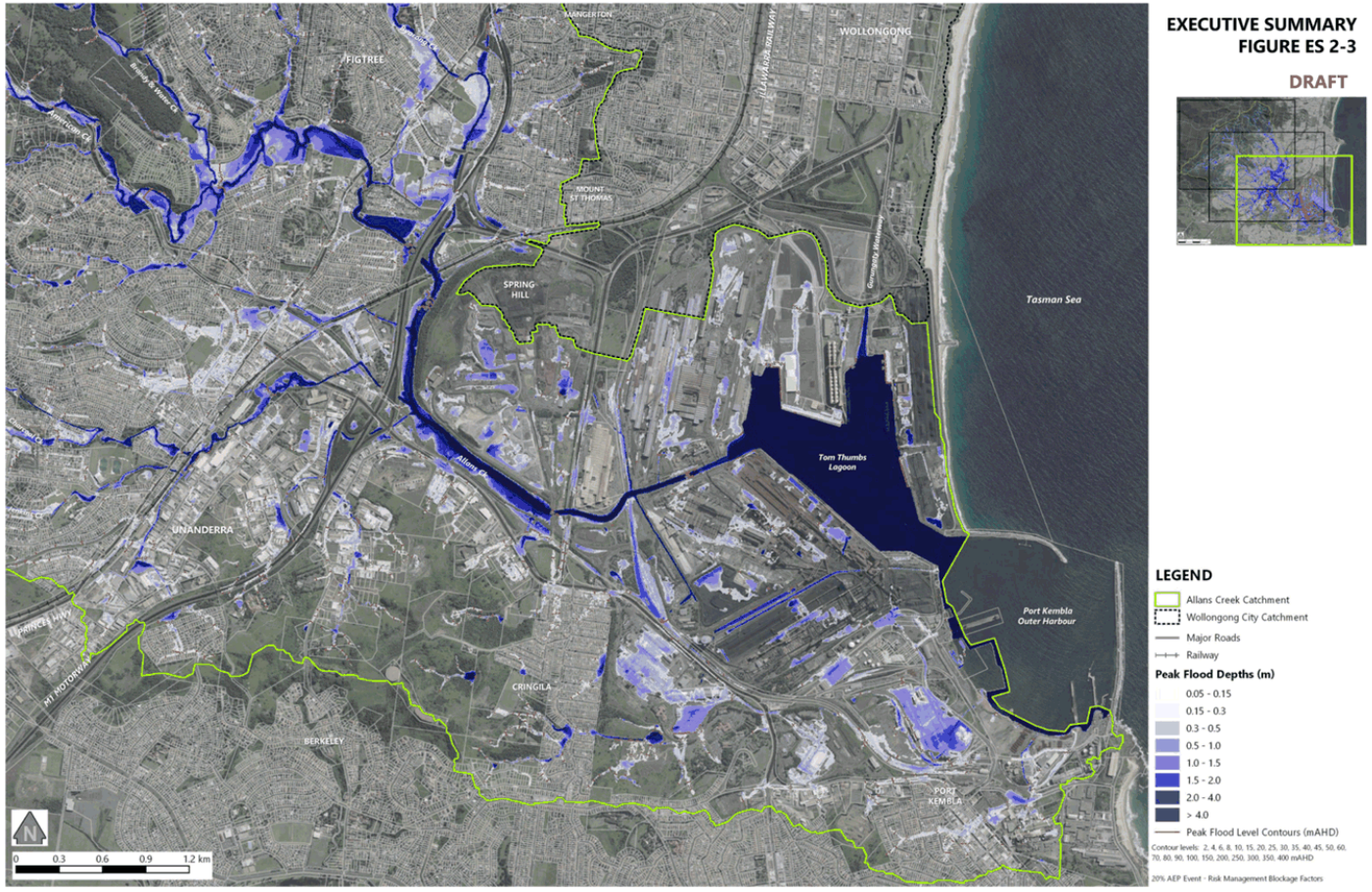
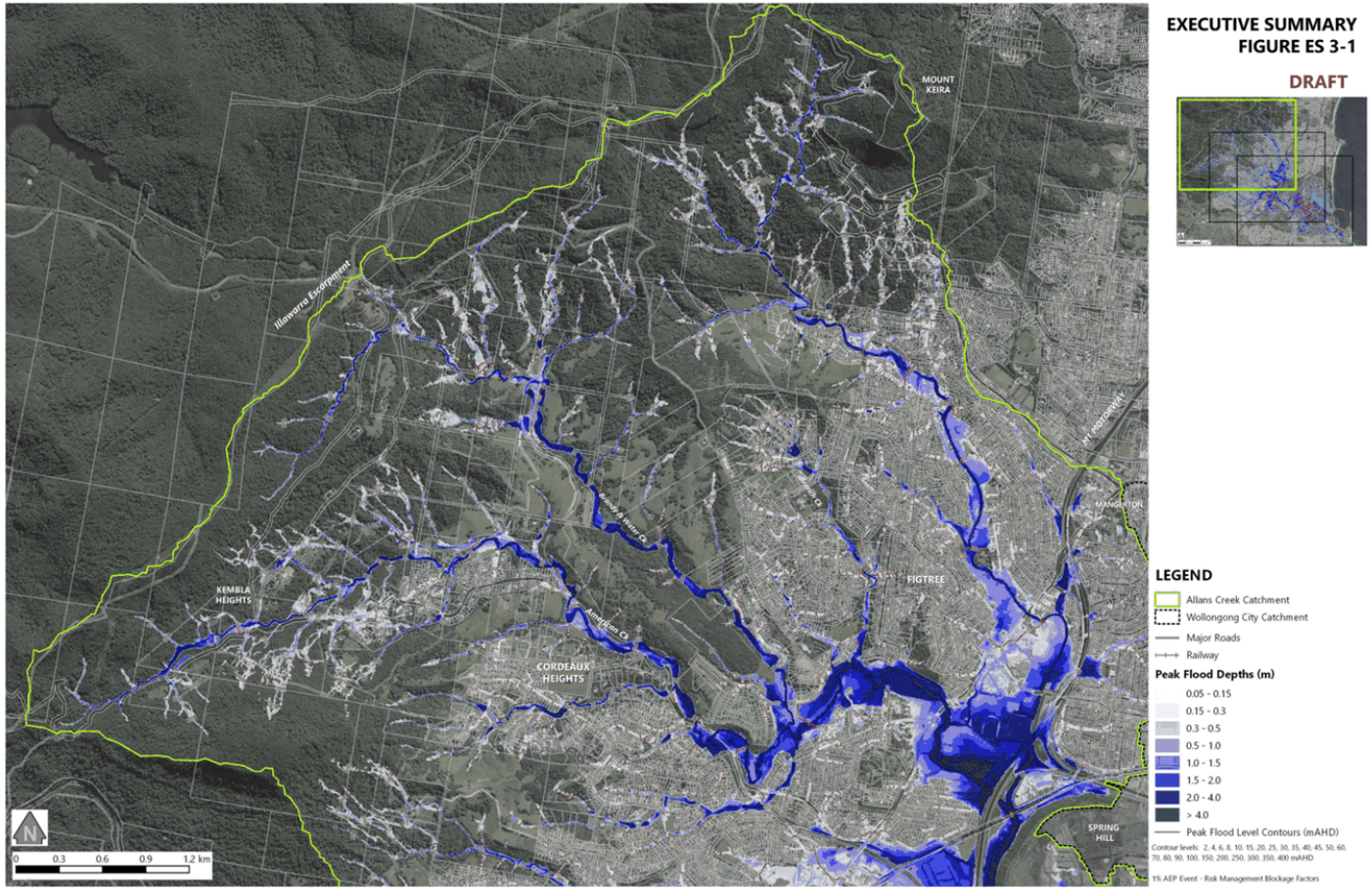
Date: 9/10/2019 Scenario ID: 2

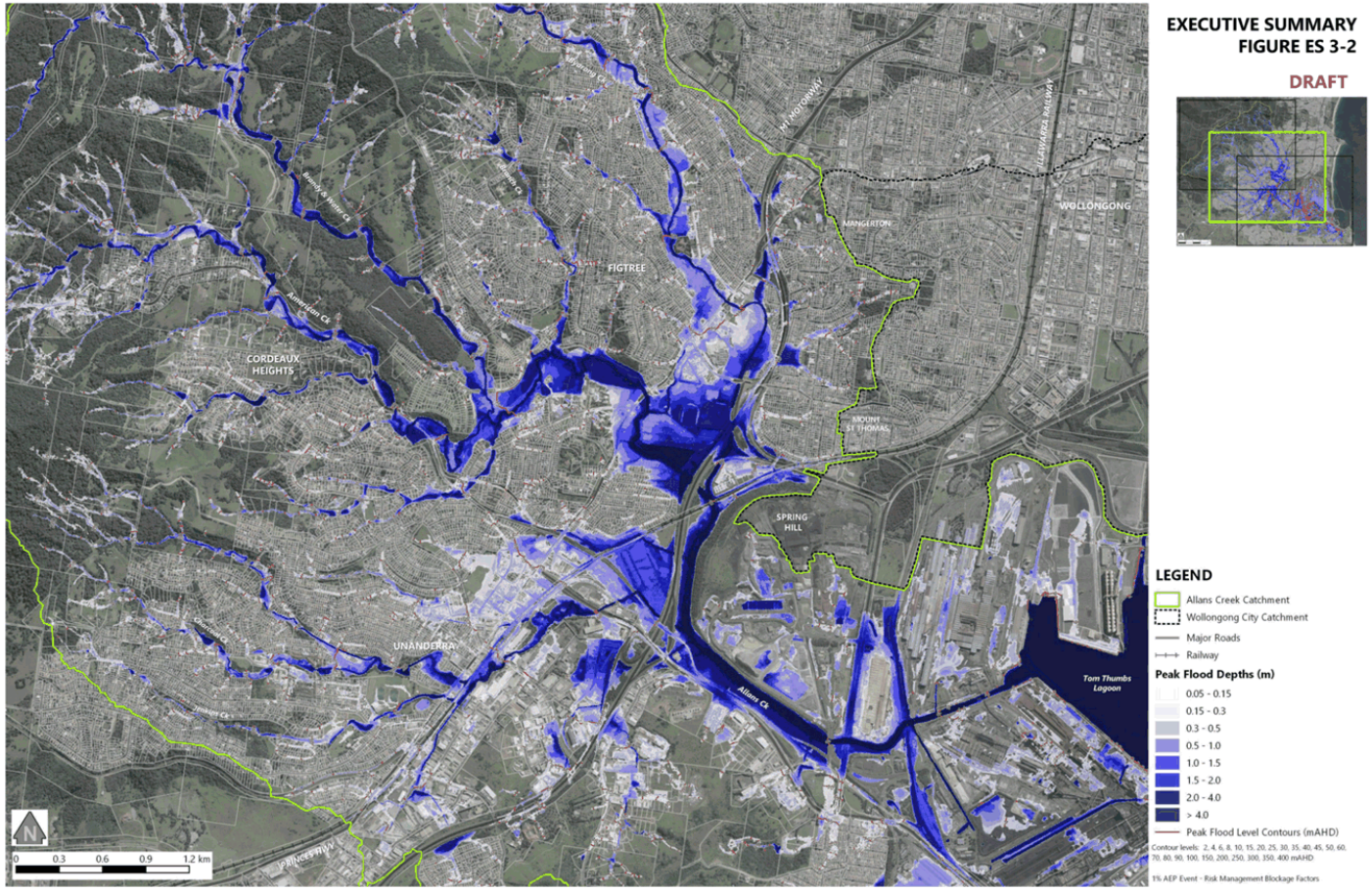
DESIGN FLOOD MAPPING SHEET EXTENTS


EXECUTIVE SUMMARY
FIGURE ES 2-1
DRAFT
MOUNT KEIRA
Illawarra Escarpment
KEMBLA HEIGHTS
CORDEAUX HEIGHTS
FIGTREE
MANGERTON
SPRING HILL
LEGEND
Allans Creek Catchment
Wollongong City Catchment
Major Roads
Railway
Peak Flood Depths (m)
0.05 - 0.15
0.15 - 0.3
0.3 - 0.5
0.5 - 1.0
1.0 - 1.5
1.5 - 2.0
2.0 - 4.0
> 4.0
Peak Flood Level Contours (mAHD)
0 0.3 0.6 0.9 1.2 km
Prepared by:
Advisian
20% AEP EVENT PEAK FLOOD DEPTHS AND LEVELS
RISK MANAGEMENT BLOCKAGE FACTORS – SHEET 1


EXECUTIVE SUMMARY
FIGURE ES 2-2
DRAFT
FIGTREE
MANGERTON
WOLLONGONG
CORDEAUX HEIGHTS
MOUNT ST THOMAS
SPRING HILL
UNANDERRA
Tom Thumbs Lagoon
Allans Ck
Princes Hwy
LEGEND
Allans Creek Catchment
Wollongong City Catchment
Major Roads
Railway
Peak Flood Depths (m)
0.05 - 0.15
0.15 - 0.3
0.3 - 0.5
0.5 - 1.0
1.0 - 1.5
1.5 - 2.0
2.0 - 4.0
> 4.0
Peak Flood Level Contours (mAHD)
Contour levels: 2, 4, 6, 8, 10, 15, 20, 25, 30, 35, 40, 45, 50, 60, 70, 80, 90, 100, 150, 200, 250, 300, 350, 400 mAHD
20% AEP Event - Risk Management Blockage Factors
0 0.3 0.6 0.9 1.2 km
Prepared by:
Advisian
Worley Group
20% AEP EVENT PEAK FLOOD DEPTHS AND LEVELS
RISK MANAGEMENT BLOCKAGE FACTORS – SHEET 2


MANGERTON
FIGTREE
WOLLONGONG
MOUNT ST THOMAS
SPRING HILL
Tasman Sea
Tom Thumbs Lagoon
Port Kembla Outer Harbour
UNANDERRA
CRINGILA
BERKELEY
PORT KEMBLA
0 0.3 0.6 0.9 1.2 km
EXECUTIVE SUMMARY
FIGURE ES 2-3
DRAFT
LEGEND
Allans Creek Catchment
Wollongong City Catchment
Major Roads
Railway
Peak Flood Depths (m)
0.05 - 0.15
0.15 - 0.3
0.3 - 0.5
0.5 - 1.0
1.0 - 1.5
1.5 - 2.0
2.0 - 4.0
> 4.0
Peak Flood Level Contours (mAHD)
20% AEP Event - Risk Management Blockage Factors
Prepared by:
Advisian
20% AEP EVENT PEAK FLOOD DEPTHS AND LEVELS
RISK MANAGEMENT BLOCKAGE FACTORS – SHEET 3


EXECUTIVE SUMMARY
FIGURE ES 3-1
DRAFT
MOUNT KEIRA
Illawarra Escarpment
KEMBLA HEIGHTS
CORDEAUX HEIGHTS
FIGTREE
MANGERTON
SPRING HILL
LEGEND
Allans Creek Catchment
Wollongong City Catchment
Major Roads
Railway
Peak Flood Depths (m)
0.05 - 0.15
0.15 - 0.3
0.3 - 0.5
0.5 - 1.0
1.0 - 1.5
1.5 - 2.0
2.0 - 4.0
> 4.0
Peak Flood Level Contours (mAHD)
0 0.3 0.6 0.9 1.2 km
Prepared by:
Advisian
1% AEP EVENT PEAK FLOOD DEPTHS AND LEVELS
RISK MANAGEMENT BLOCKAGE FACTORS – SHEET 1



Prepared by: Advisian Worley Group

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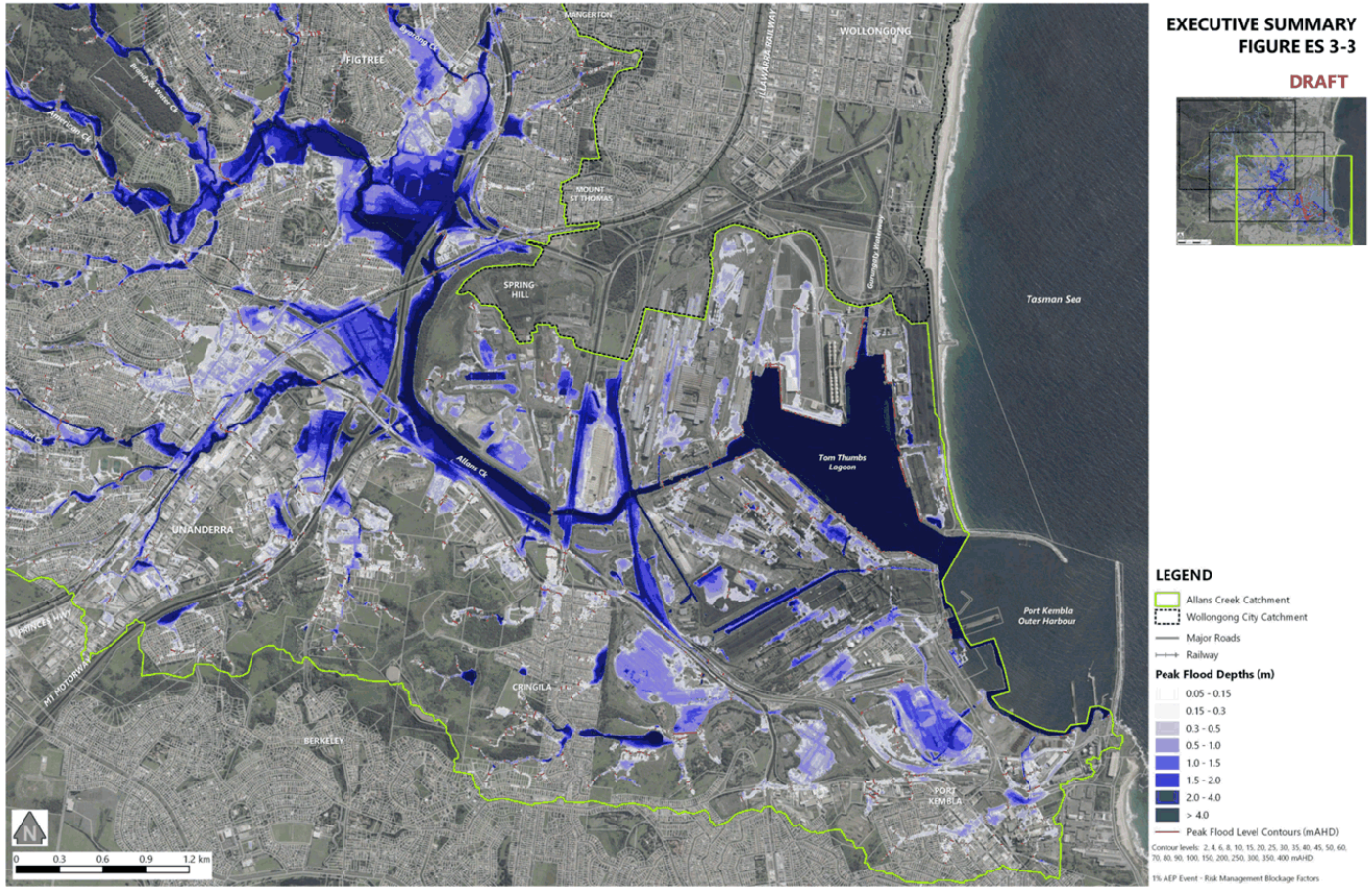
Date: 9/10/2019 Scenario ID: 2

1% AEP EVENT PEAK FLOOD DEPTHS AND LEVELS
RISK MANAGEMENT BLOCKAGE FACTORS – SHEET 2



Prepared by: Advisian

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Date: 9/10/2019
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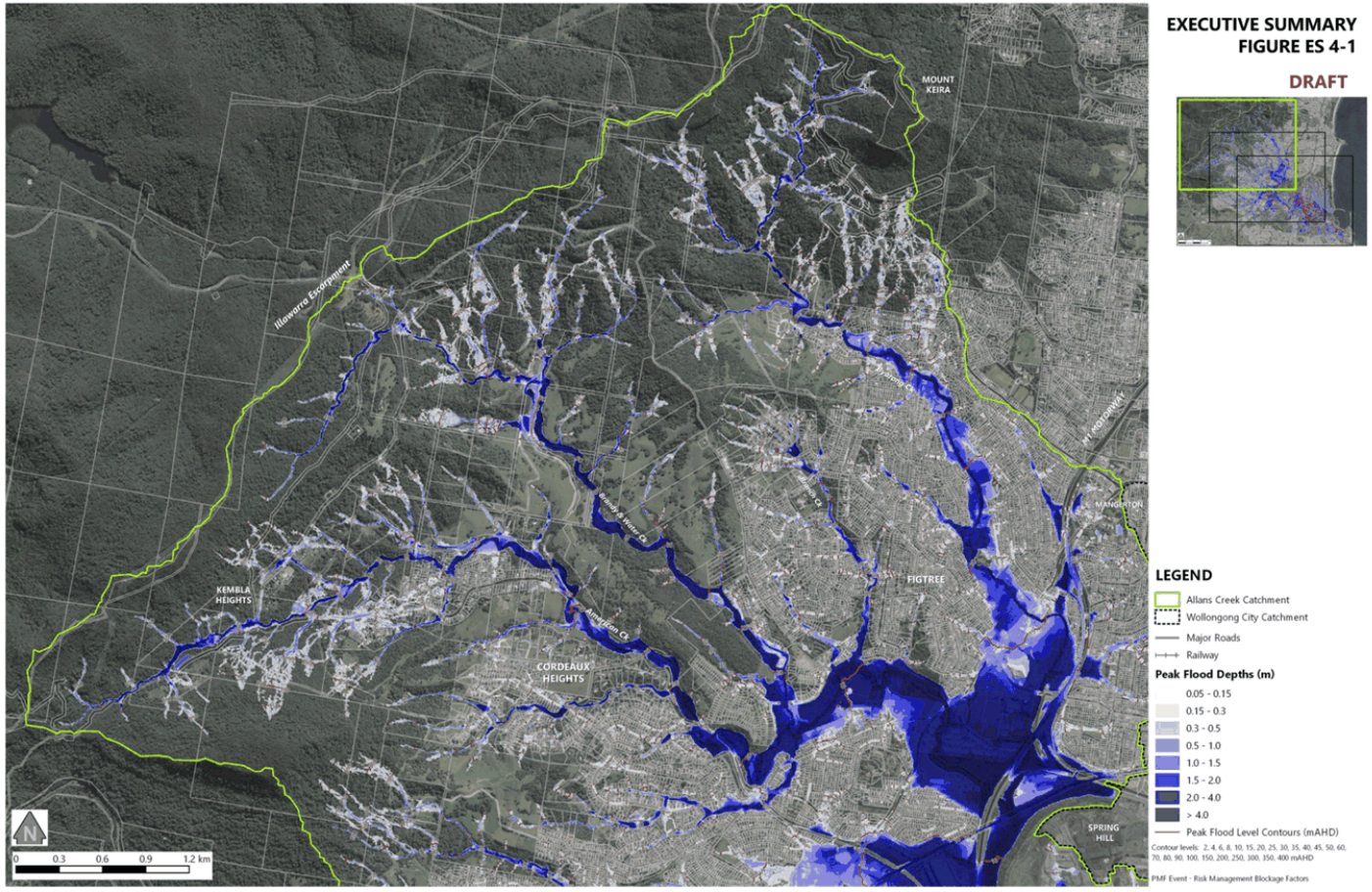
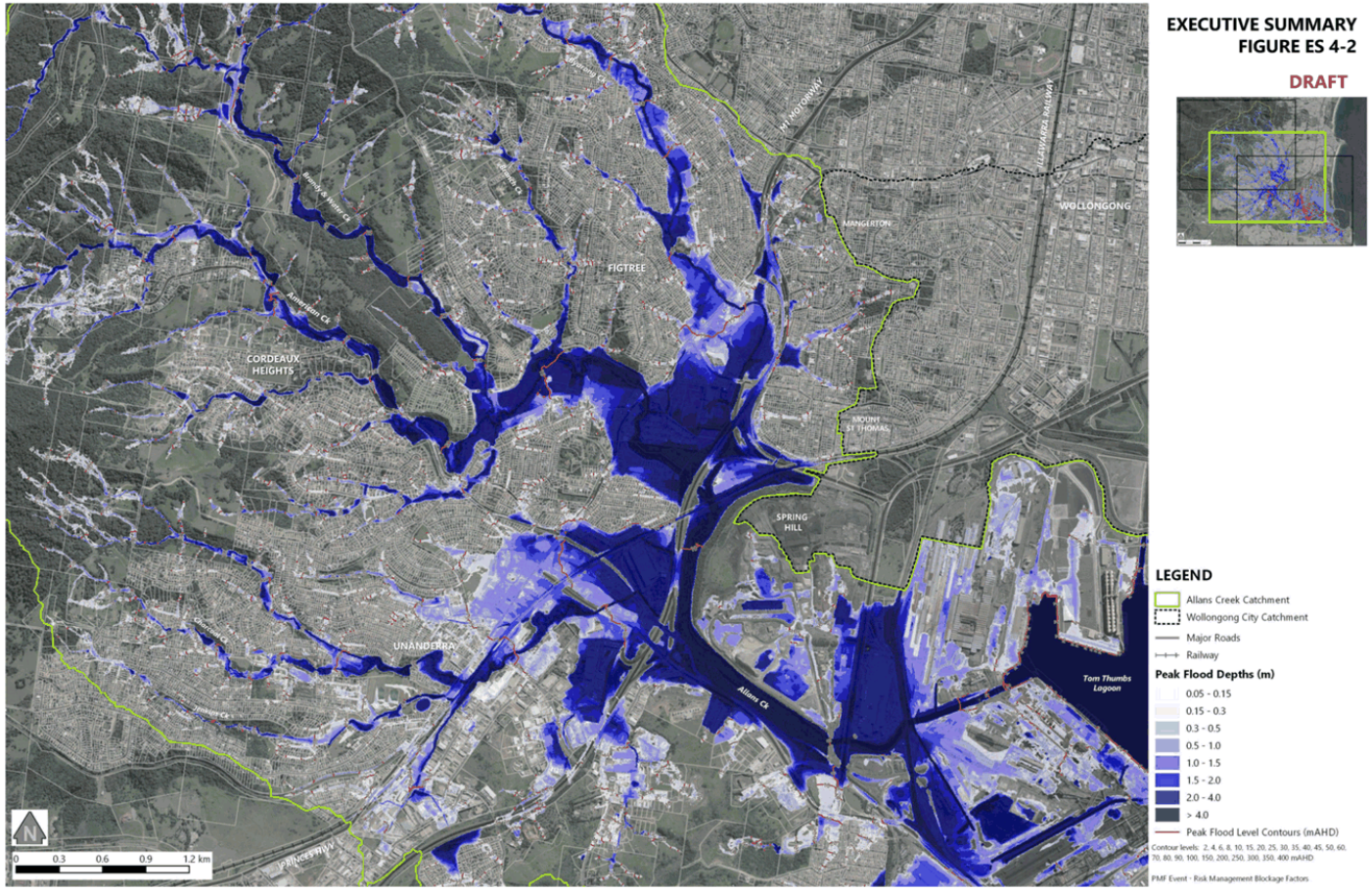
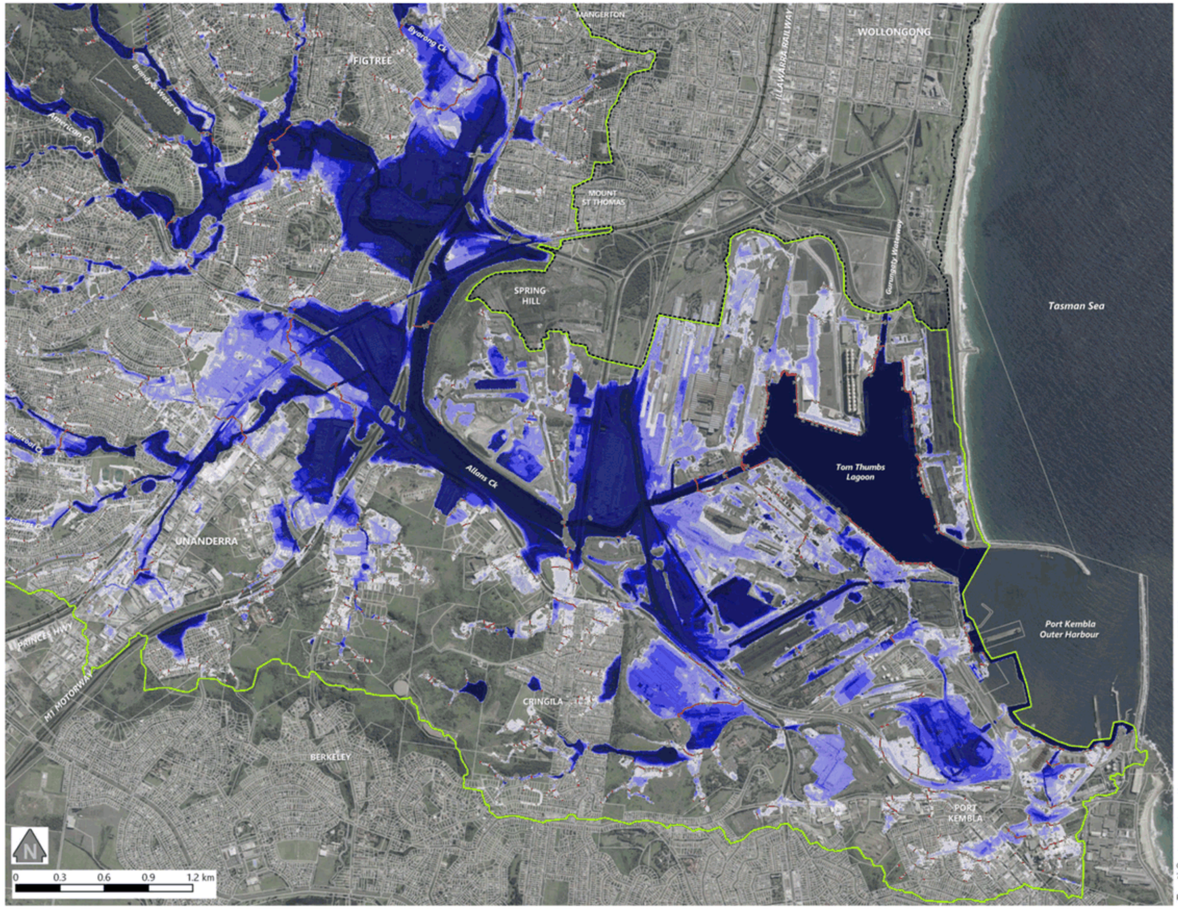
1% AEP EVENT PEAK FLOOD DEPTHS AND LEVELS
RISK MANAGEMENT BLOCKAGE FACTORS – SHEET 3

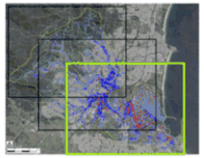

EXECUTIVE SUMMARY
FIGURE ES 4-1
DRAFT
MOUNT KEIRA
Illawarra Escarpment
KEMBLA HEIGHTS
CORDEAUX HEIGHTS
FIGTREE
MANGERTON
SPRING HILL
LEGEND
Allans Creek Catchment
Wollongong City Catchment
Major Roads
Railway
Peak Flood Depths (m)
0.05 - 0.15
0.15 - 0.3
0.3 - 0.5
0.5 - 1.0
1.0 - 1.5
1.5 - 2.0
2.0 - 4.0
> 4.0
Peak Flood Level Contours (mAHD)
Contour levels: 2, 4, 6, 8, 10, 15, 20, 25, 30, 35, 40, 45, 50, 60, 70, 80, 90, 100, 150, 200, 250, 300, 350, 400 mAHD
PMF Event - Risk Management Blockage Factors
N
0 0.3 0.6 0.9 1.2 km
Prepared by:
Advisian
Worley Group
PROBABLE MAXIMUM FLOOD EVENT
PEAK FLOOD DEPTHS AND LEVELS
RISK MANAGEMENT BLOCKAGE FACTORS – SHEET 1


EXECUTIVE SUMMARY
FIGURE ES 4-2
DRAFT
FIGTREE
MANGERTON
WOLLONGONG
CORDEAUX HEIGHTS
MOUNT ST THOMAS
SPRING HILL
UNANDERRA
Allans Ck
Tom Thumbs Lagoon
Princes Hwy
LEGEND
Allans Creek Catchment
Wollongong City Catchment
Major Roads
Railway
Peak Flood Depths (m)
0.05 - 0.15
0.15 - 0.3
0.3 - 0.5
0.5 - 1.0
1.0 - 1.5
1.5 - 2.0
2.0 - 4.0
> 4.0
Peak Flood Level Contours (mAHD)
PMF Event - Risk Management Blockage Factors
0 0.3 0.6 0.9 1.2 km
Prepared by:
Advisian
PROBABLE MAXIMUM FLOOD EVENT
PEAK FLOOD DEPTHS AND LEVELS
RISK MANAGEMENT BLOCKAGE FACTORS – SHEET 2



EXECUTIVE SUMMARY
FIGURE ES 4-3

DRAFT



LEGEND

- Allans Creek Catchment
- Wollongong City Catchment
- Major Roads
- Railway

Peak Flood Depths (m)

- 0.05 - 0.15
- 0.15 - 0.3
- 0.3 - 0.5
- 0.5 - 1.0
- 1.0 - 1.5
- 1.5 - 2.0
- 2.0 - 4.0
- > 4.0
- Peak Flood Level Contours (mAHD)

Contour levels: 2, 4, 6, 8, 10, 15, 20, 25, 30, 35, 40, 45, 50, 60, 70, 80, 90, 100, 150, 200, 250, 300, 350, 400 mAHD

PMF Event - Risk Management Blockage Factors

Prepared by: Advisian Worley Group

Rev: B
Date: 9/10/2019
Scenario ID: 2
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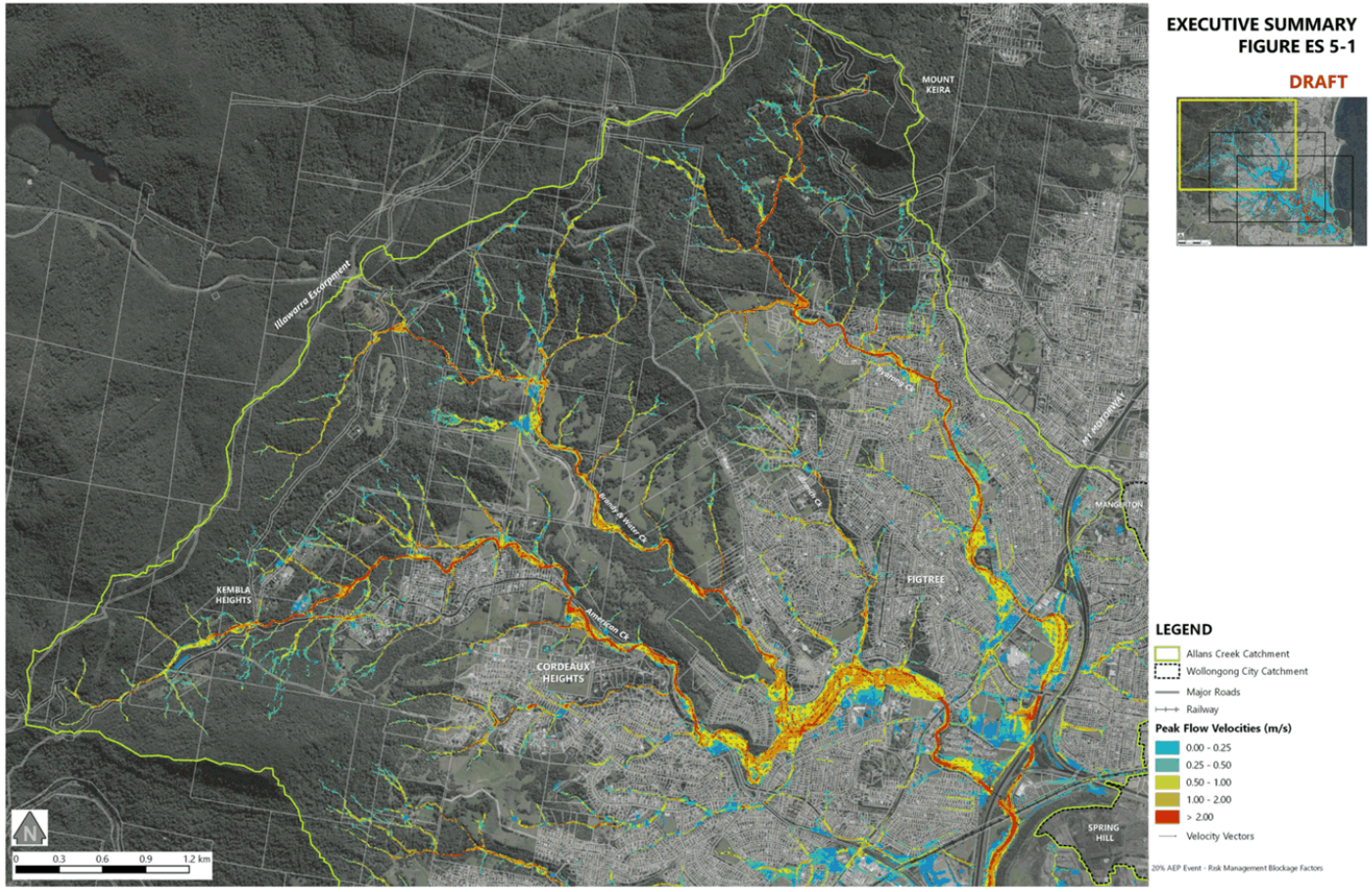
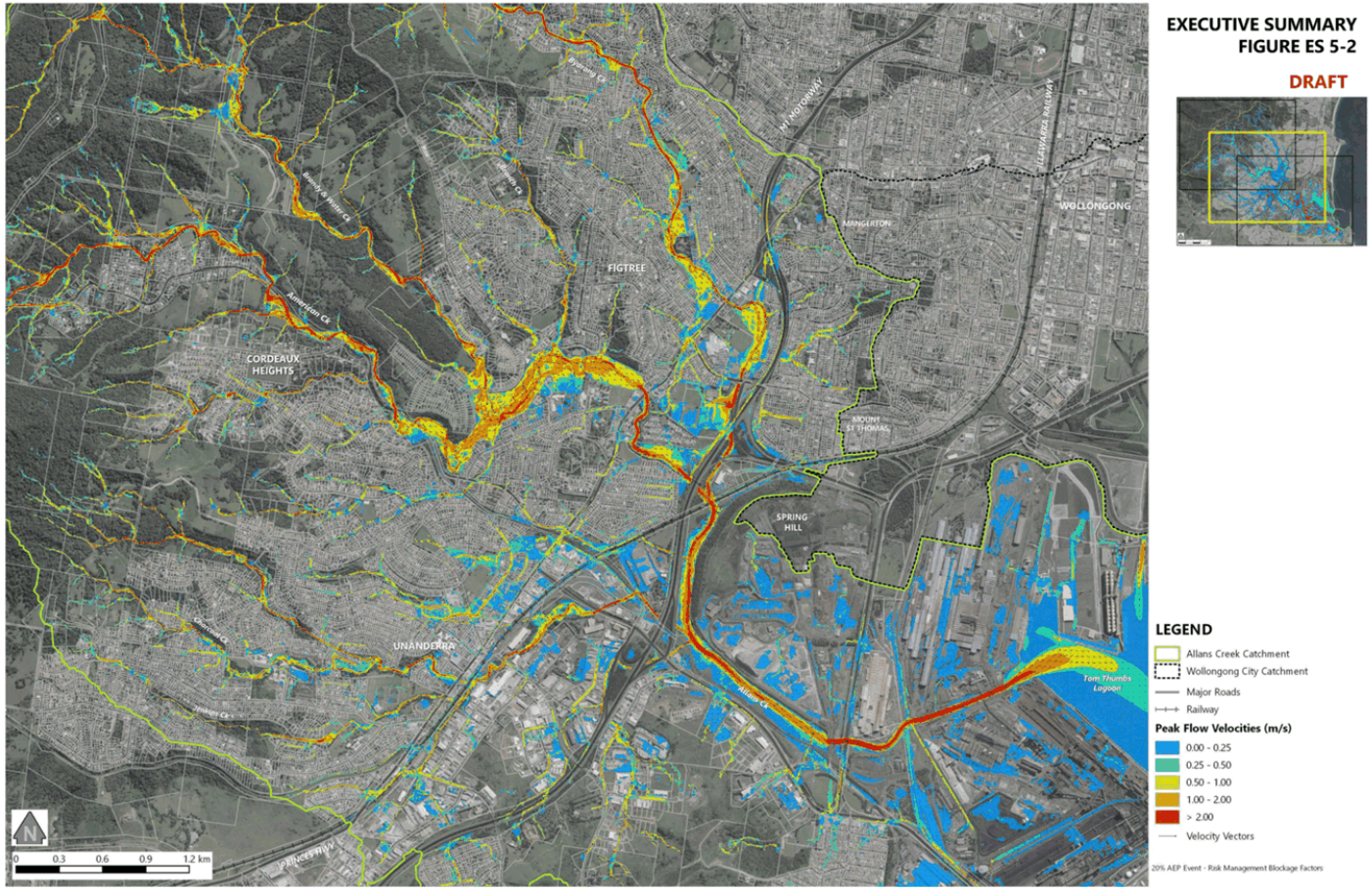
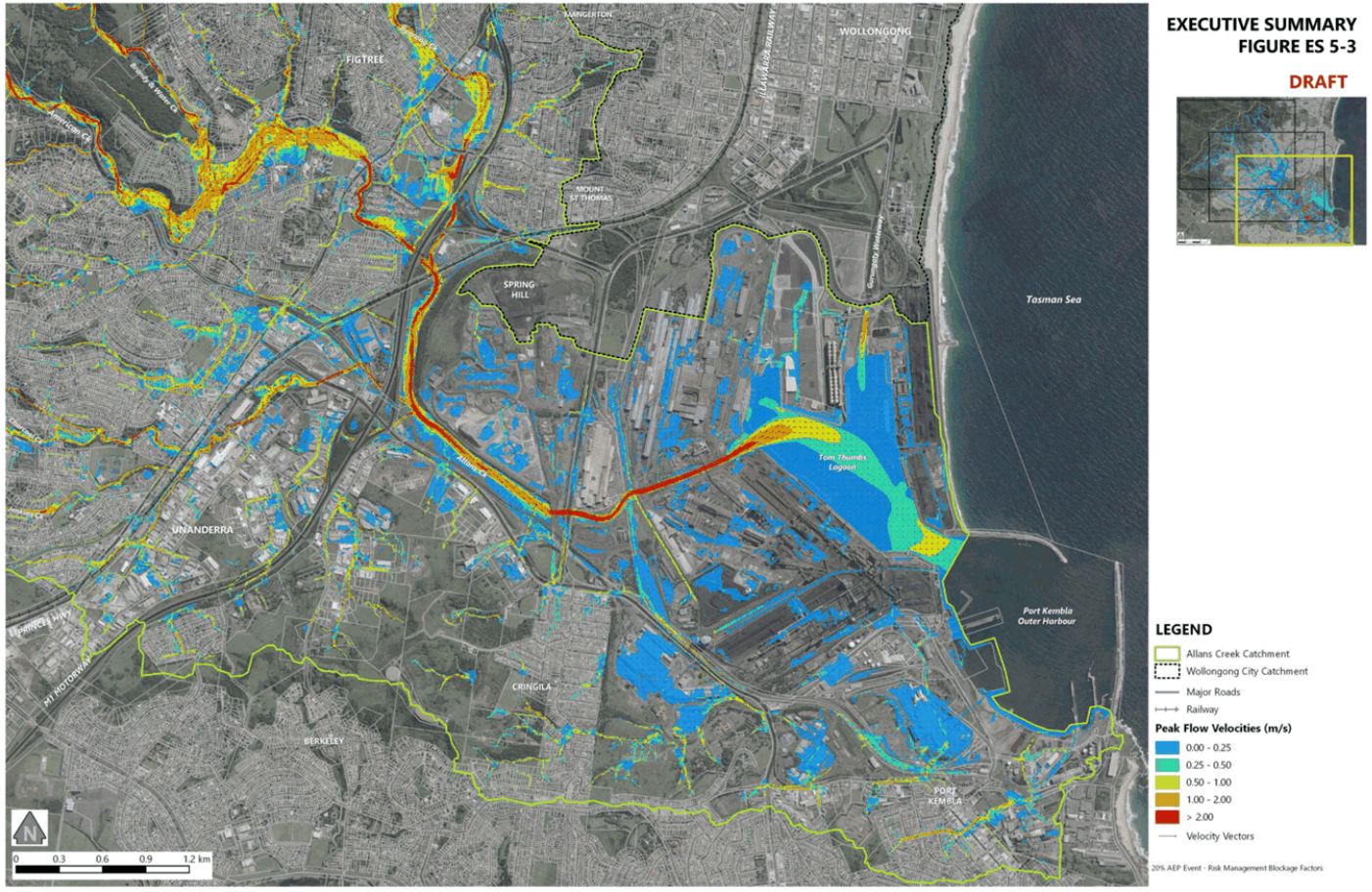
PROBABLE MAXIMUM FLOOD EVENT
PEAK FLOOD DEPTHS AND LEVELS
RISK MANAGEMENT BLOCKAGE FACTORS – SHEET 3


EXECUTIVE SUMMARY
FIGURE ES 5-1
DRAFT
MOUNT KEIRA
Illawarra Escarpment
KEMBLA HEIGHTS
CORDEAUX HEIGHTS
FIGTREE
MANGERTON
SPRING HILL
LEGEND
Allans Creek Catchment
Wollongong City Catchment
Major Roads
Railway
Peak Flow Velocities (m/s)
0.00 - 0.25
0.25 - 0.50
0.50 - 1.00
1.00 - 2.00
> 2.00
Velocity Vectors
20% AEP Event - Risk Management Blockage Factors
0 0.3 0.6 0.9 1.2 km
Prepared by:
Advisian
20% AEP EVENT PEAK FLOW VELOCITIES
RISK MANAGEMENT BLOCKAGE FACTORS – SHEET 1


EXECUTIVE SUMMARY
FIGURE ES 5-2
DRAFT
WOLLONGONG
MANGERTON
FIGTREE
CORDEAUX HEIGHTS
MOUNT ST THOMAS
SPRING HILL
UNANDERRA
Tom Thumbs Lagoon
Allans Ck
Princes Hwy
LEGEND
Allans Creek Catchment
Wollongong City Catchment
Major Roads
Railway
Peak Flow Velocities (m/s)
0.00 - 0.25
0.25 - 0.50
0.50 - 1.00
1.00 - 2.00
> 2.00
Velocity Vectors
20% AEP Event - Risk Management Blockage Factors
0 0.3 0.6 0.9 1.2 km
Prepared by:
Advisian
20% AEP EVENT PEAK FLOW VELOCITIES
RISK MANAGEMENT BLOCKAGE FACTORS – SHEET 2



Prepared by: Advisian Worley Group

Rev: B Date: 9/10/2019 Scenario ID: 2
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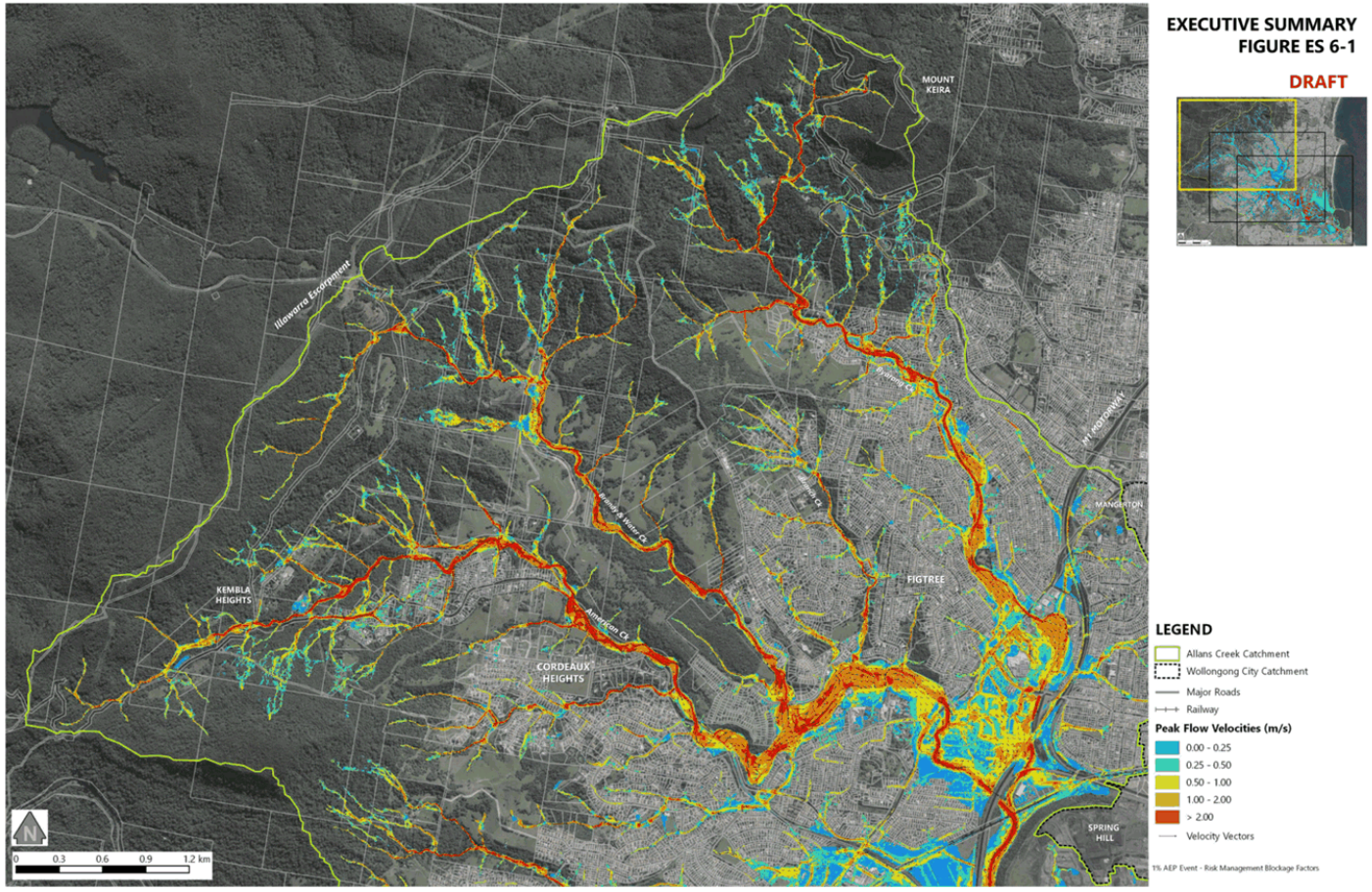
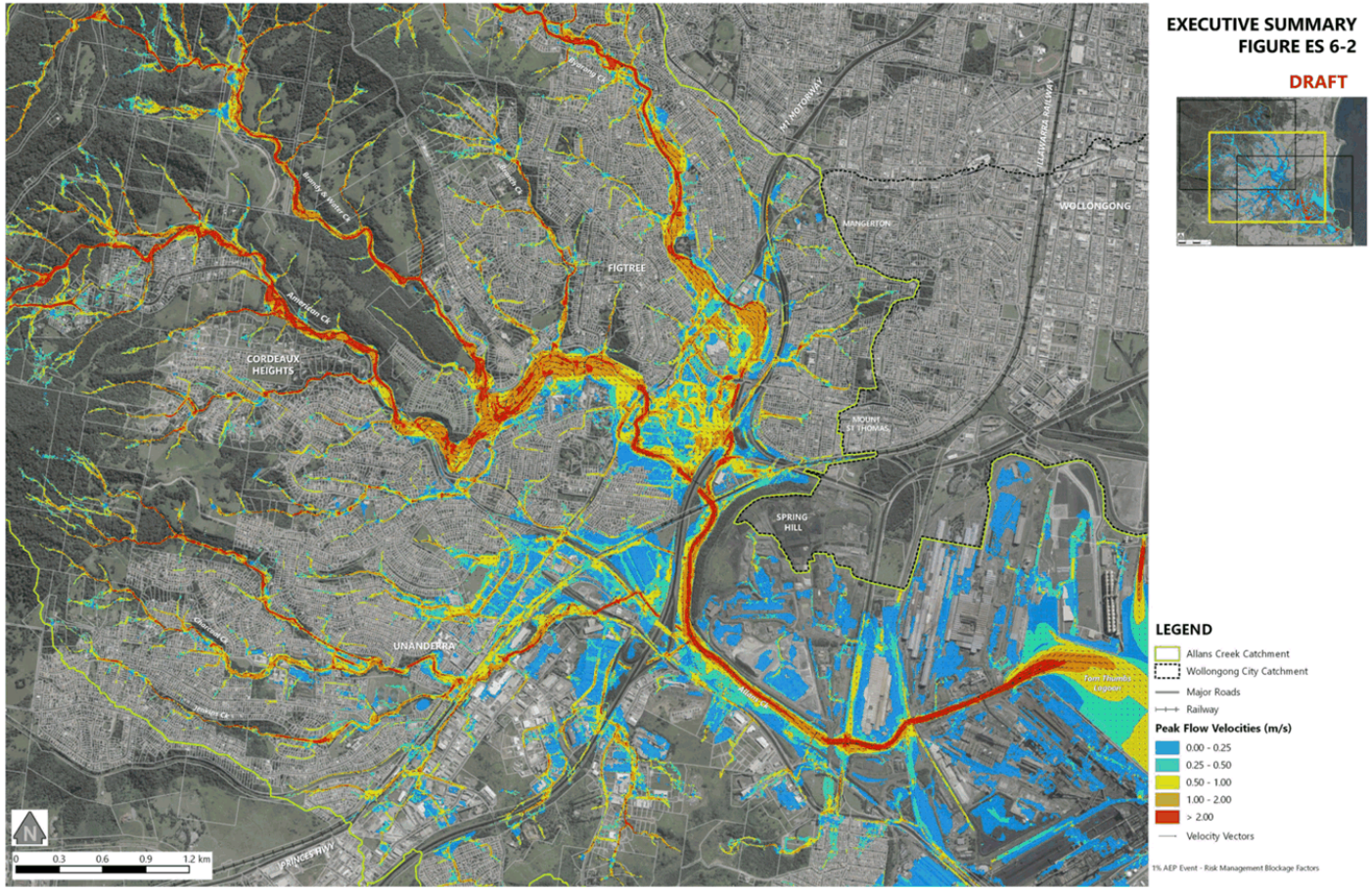
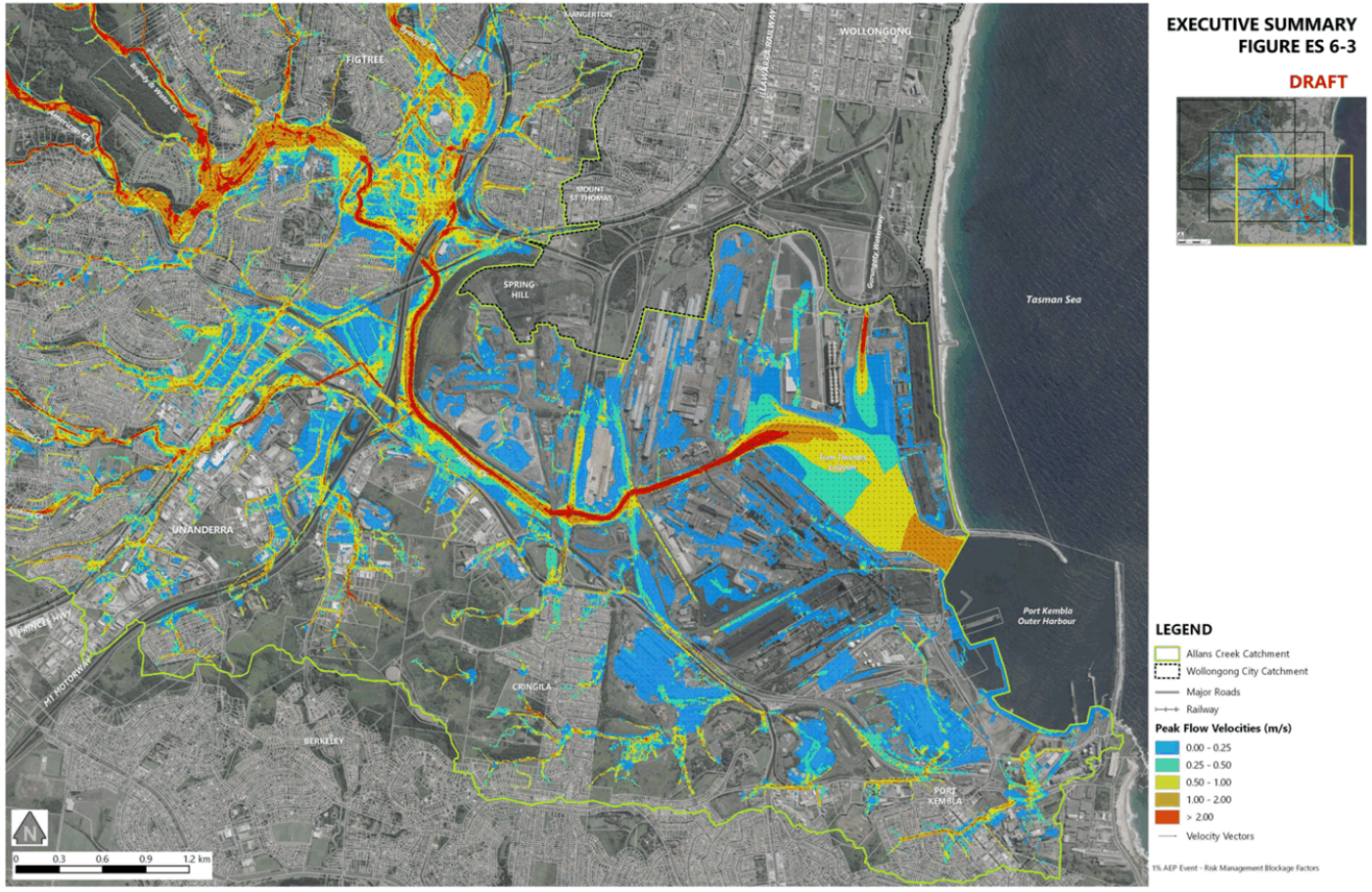
20% AEP EVENT PEAK FLOW VELOCITIES
RISK MANAGEMENT BLOCKAGE FACTORS – SHEET 3

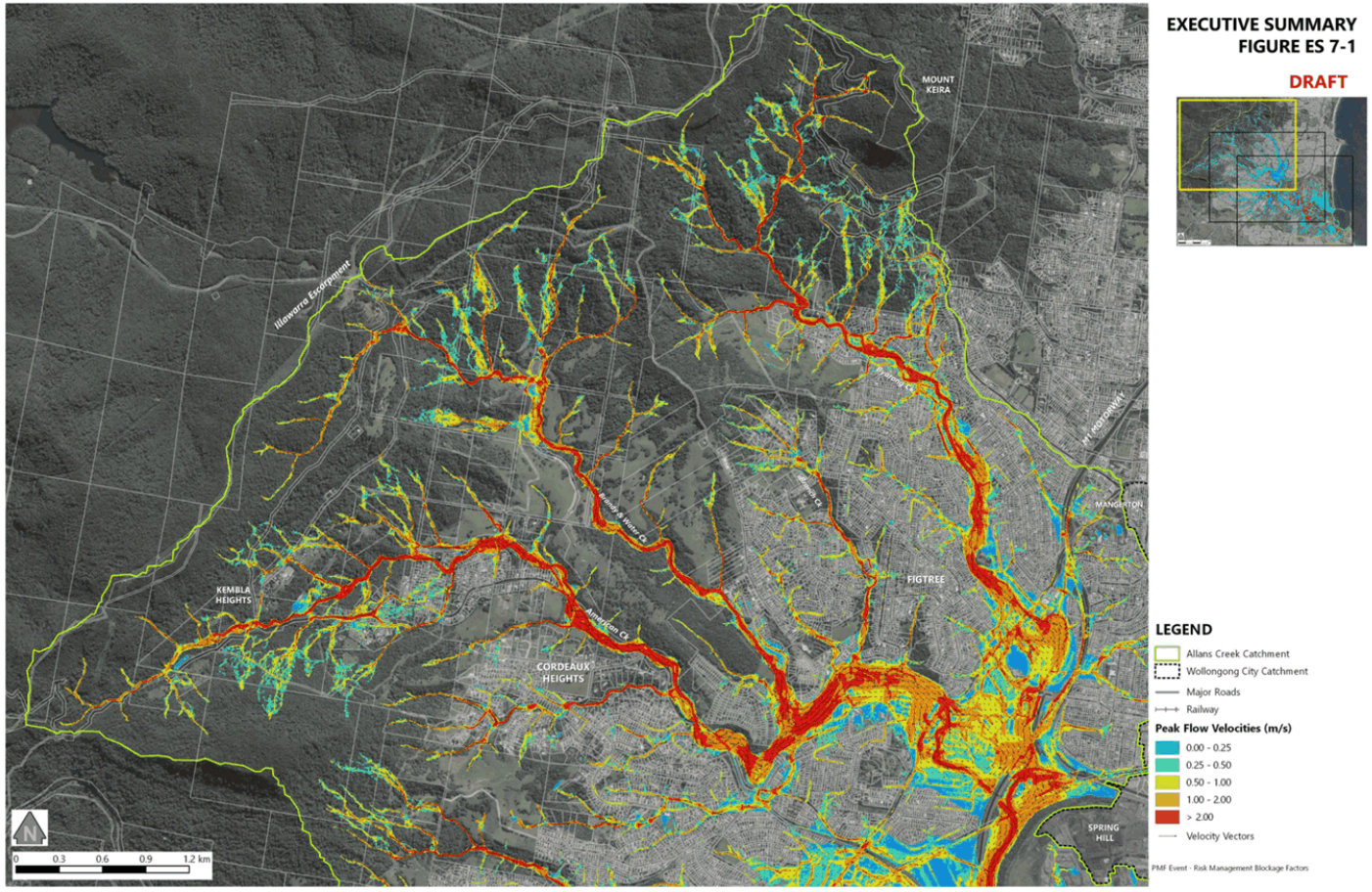

EXECUTIVE SUMMARY
FIGURE ES 6-1
DRAFT
MOUNT KEIRA
Illawarra Escarpment
KEMBLA HEIGHTS
CORDEAUX HEIGHTS
FIGTREE
MANGERTON
SPRING HILL
Prepared by:
Advisian
LEGEND
Allans Creek Catchment
Wollongong City Catchment
Major Roads
Railway
Peak Flow Velocities (m/s)
0.00 - 0.25
0.25 - 0.50
0.50 - 1.00
1.00 - 2.00
> 2.00
Velocity Vectors
1% AEP Event - Risk Management Blockage Factors
1% AEP EVENT PEAK FLOW VELOCITIES
RISK MANAGEMENT BLOCKAGE FACTORS – SHEET 1

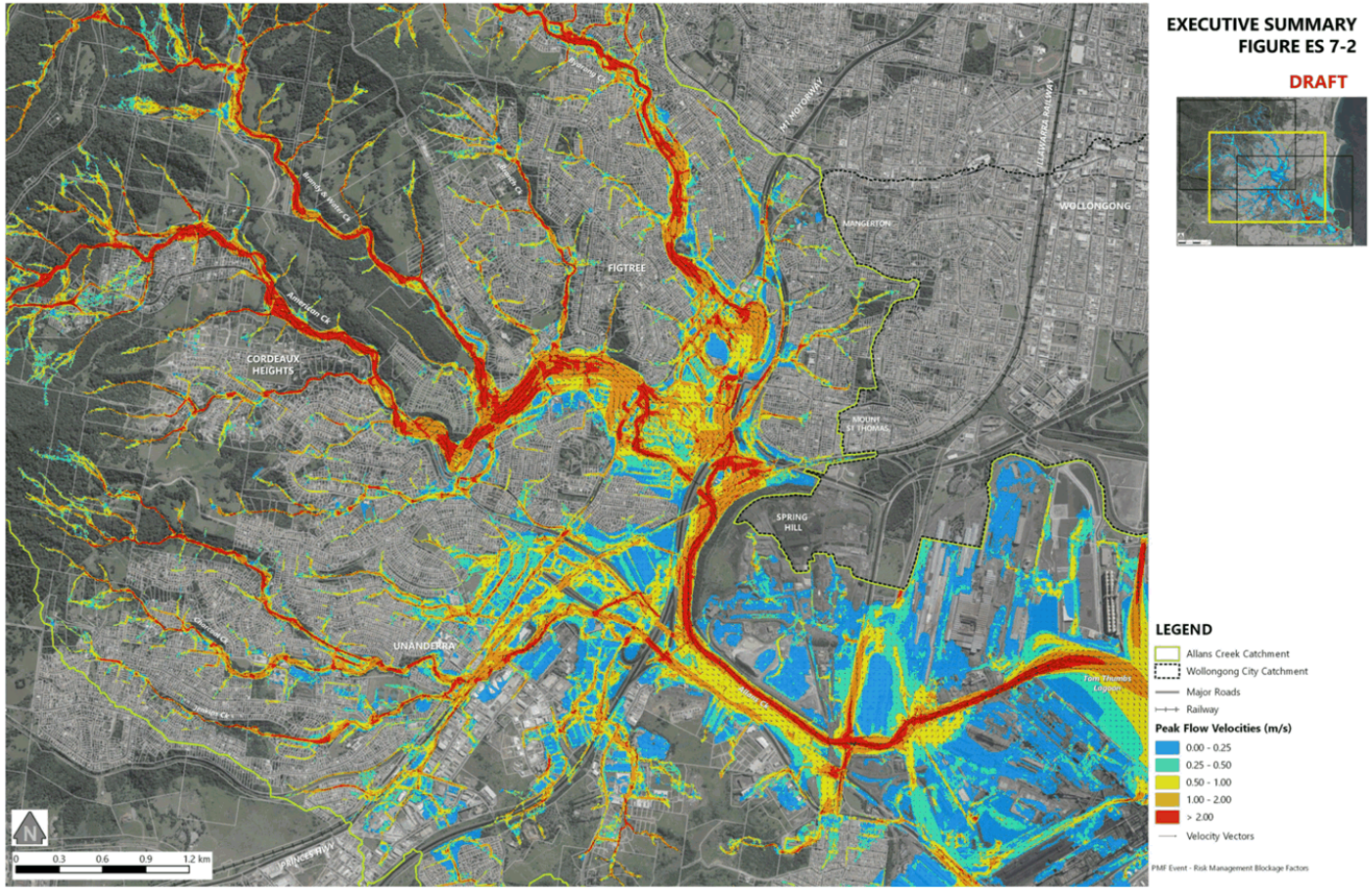

EXECUTIVE SUMMARY
FIGURE ES 6-2
DRAFT
WOLLONGONG
MANGERTON
FIGTREE
CORDEAUX HEIGHTS
MOUNT ST THOMAS
SPRING HILL
UNANDERRA
LEGEND
Allans Creek Catchment
Wollongong City Catchment
Major Roads
Railway
Peak Flow Velocities (m/s)
0.00 - 0.25
0.25 - 0.50
0.50 - 1.00
1.00 - 2.00
> 2.00
Velocity Vectors
1% AEP Event - Risk Management Blockage Factors
0 0.3 0.6 0.9 1.2 km
Prepared by:
Advisian
1% AEP EVENT PEAK FLOW VELOCITIES
RISK MANAGEMENT BLOCKAGE FACTORS – SHEET 2

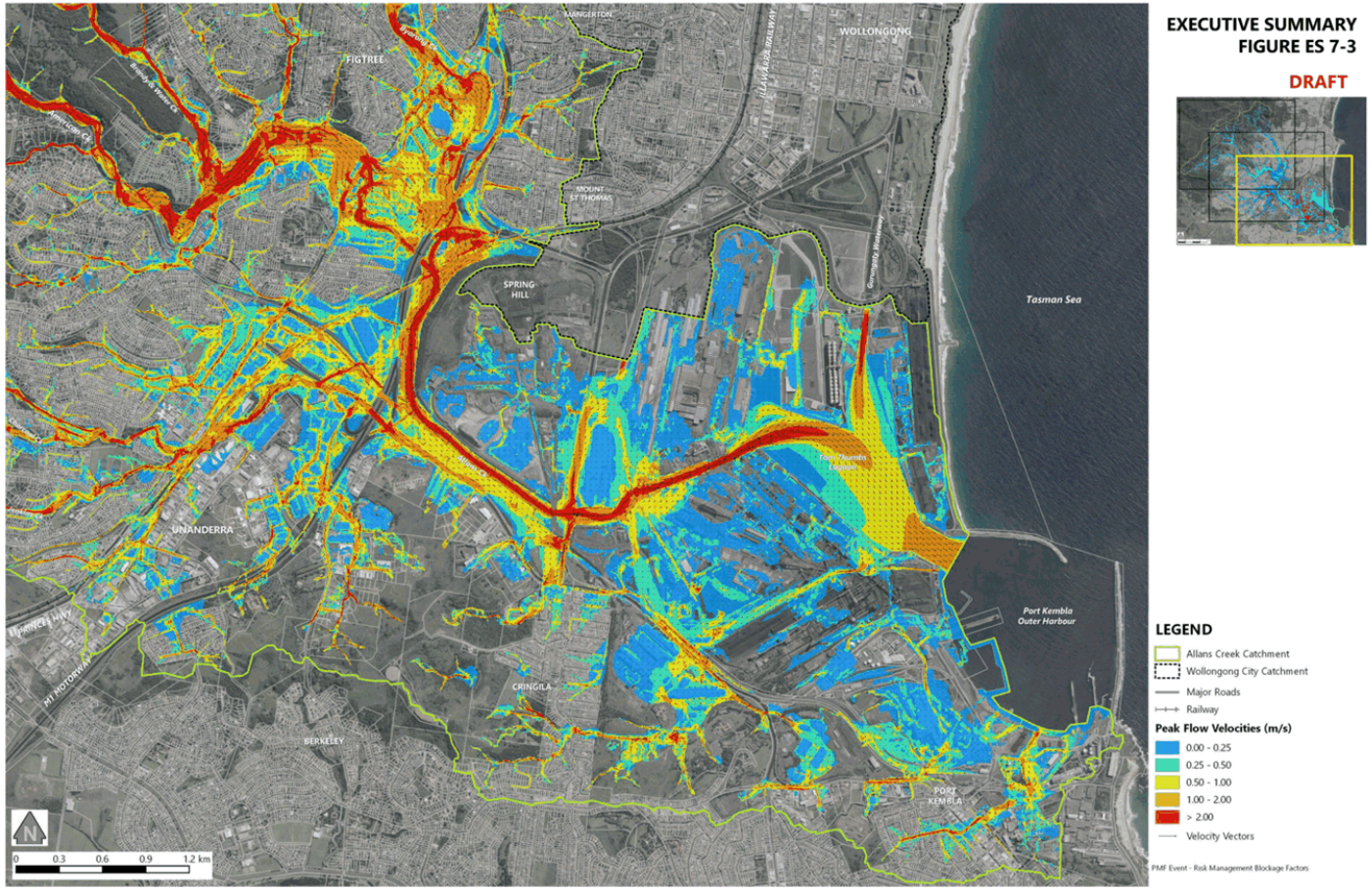


Prepared by: Advisian

1% AEP EVENT PEAK FLOW VELOCITIES
RISK MANAGEMENT BLOCKAGE FACTORS – SHEET 3


EXECUTIVE SUMMARY
FIGURE ES 7-1
DRAFT
MOUNT KEIRA
Illawarra Escarpment
KEMBLA HEIGHTS
CORDEAUX HEIGHTS
FIGTREE
MANGERTON
SPRING HILL
LEGEND
Allans Creek Catchment
Wollongong City Catchment
Major Roads
Railway
Peak Flow Velocities (m/s)
0.00 - 0.25
0.25 - 0.50
0.50 - 1.00
1.00 - 2.00
> 2.00
Velocity Vectors
PMF Event - Risk Management Blockage Factors
0 0.3 0.6 0.9 1.2 km
Prepared by:
Advisian
PROBABLE MAXIMUM FLOOD EVENT
PEAK FLOW VELOCITIES
RISK MANAGEMENT BLOCKAGE FACTORS – SHEET 1


EXECUTIVE SUMMARY
FIGURE ES 7-2
DRAFT
WOLLONGONG
MANGERTON
FIGTREE
CORDEAUX HEIGHTS
MOUNT ST THOMAS
SPRING HILL
UNANDERRA
Tom Thumbs Lagoon
LEGEND
Allans Creek Catchment
Wollongong City Catchment
Major Roads
Railway
Peak Flow Velocities (m/s)
0.00 - 0.25
0.25 - 0.50
0.50 - 1.00
1.00 - 2.00
> 2.00
Velocity Vectors
PMF Event - Risk Management Blockage Factors
0 0.3 0.6 0.9 1.2 km
Prepared by:
Advisian
PROBABLE MAXIMUM FLOOD EVENT
PEAK FLOW VELOCITIES
RISK MANAGEMENT BLOCKAGE FACTORS – SHEET 2

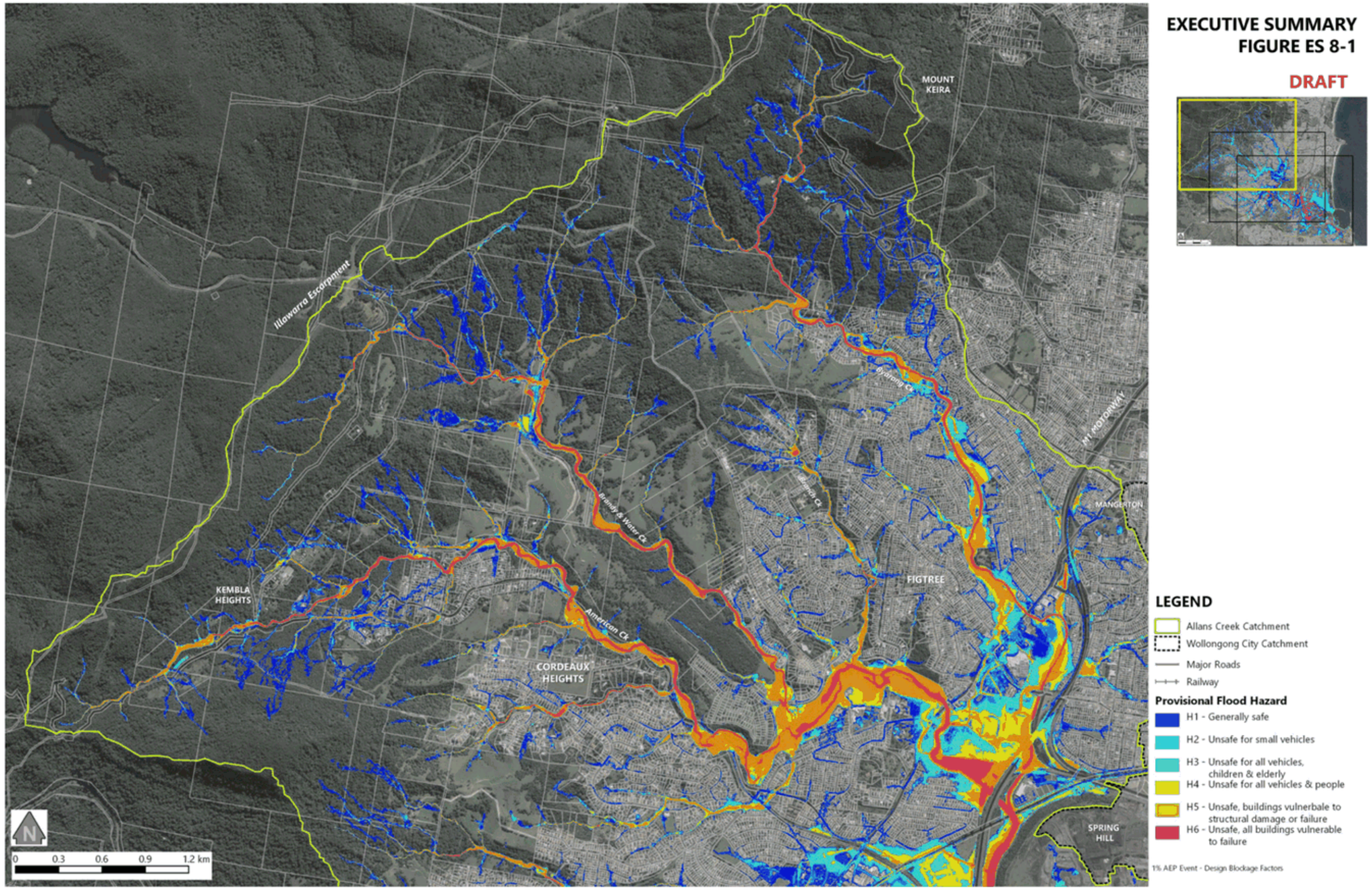


Prepared by: Advisian

PROBABLE MAXIMUM FLOOD EVENT
PEAK FLOW VELOCITIES
RISK MANAGEMENT BLOCKAGE FACTORS – SHEET 3

EXECUTIVE SUMMARY
FIGURE ES 8-1

DRAFT



wollongong city of innovation

Prepared by:
Advisian
Worley Group

Rev: 8
Date: 9/10/2019
Scenario ID: 7
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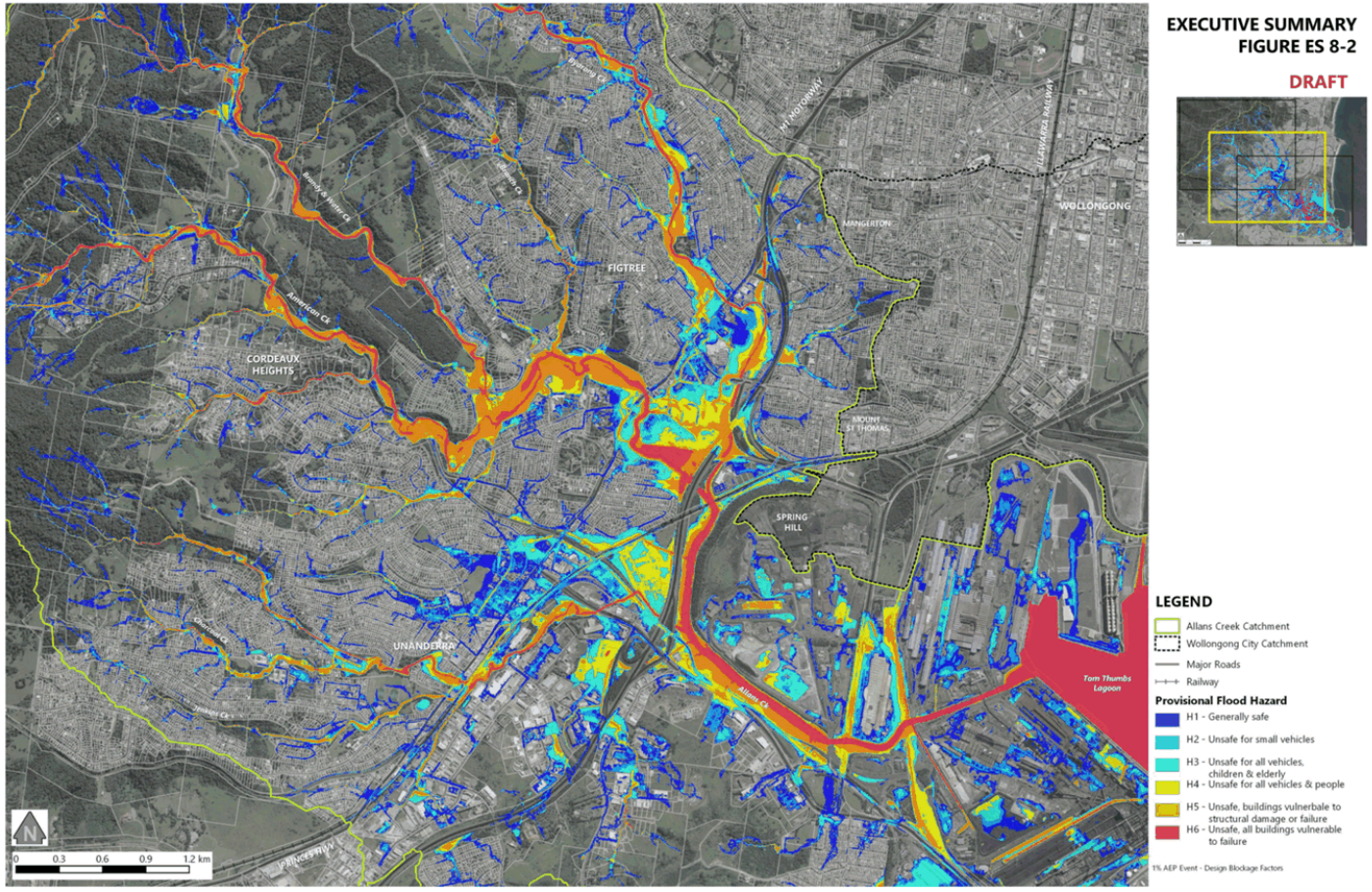
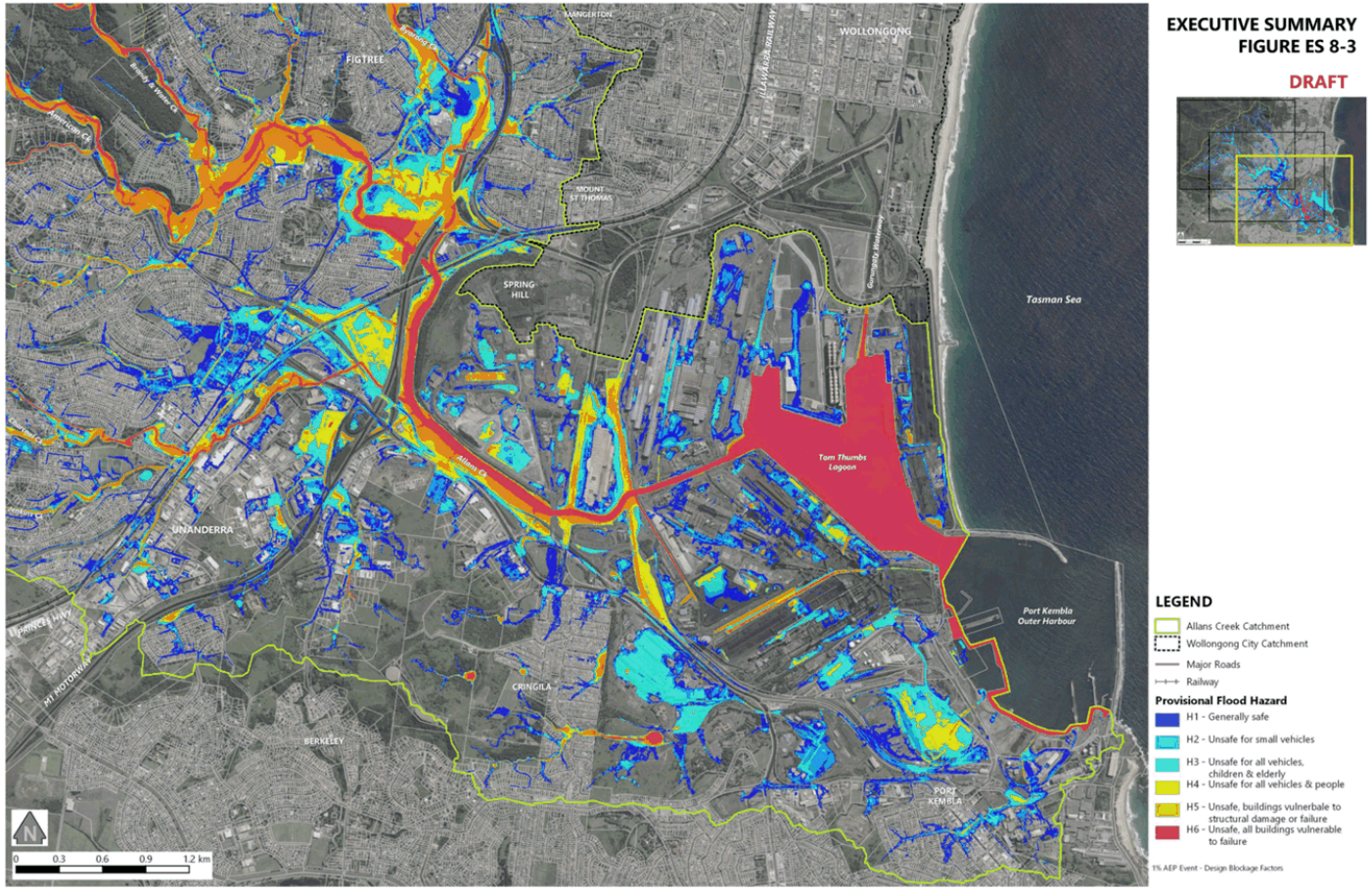
TUFLOW version: AC_190531_~s1~_~e1~_~e2~_~s2~.tcf

1% AEP EVENT PROVISIONAL FLOOD HAZARD
DESIGN BLOCKAGE FACTORS – SHEET 1


EXECUTIVE SUMMARY
FIGURE ES 8-2
DRAFT
WOLLONGONG
MANGERTON
FIGTREE
CORDEAUX HEIGHTS
MOUNT ST THOMAS
SPRING HILL
UNANDERRA
Tom Thumbs Lagoon
Allans Ck
Princes Hwy
LEGEND
Allans Creek Catchment
Wollongong City Catchment
Major Roads
Railway
Provisional Flood Hazard
H1 - Generally safe
H2 - Unsafe for small vehicles
H3 - Unsafe for all vehicles, children & elderly
H4 - Unsafe for all vehicles & people
H5 - Unsafe, buildings vulnerbale to structural damage or failure
H6 - Unsafe, all buildings vulnerable to failure
1% AEP Event - Design Blockage Factors
0 0.3 0.6 0.9 1.2 km
Prepared by:
Advisian
1% AEP EVENT PROVISIONAL FLOOD HAZARD
DESIGN BLOCKAGE FACTORS – SHEET 2


EXECUTIVE SUMMARY
FIGURE ES 8-3
DRAFT
MANGERTON
FIGTREE
WOLLONGONG
MOUNT ST THOMAS
SPRING HILL
Tasman Sea
Tom Thumbs Lagoon
Port Kembla Outer Harbour
UNANDERRA
PRINCES HWY
M1 MOTORWAY
CRINGILA
BERKELEY
PORT KEMBLA
0 0.3 0.6 0.9 1.2 km
LEGEND
Allans Creek Catchment
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1% AEP Event - Design Blockage Factors
Prepared by:
Advisian
Worley Group
1% AEP EVENT PROVISIONAL FLOOD HAZARD
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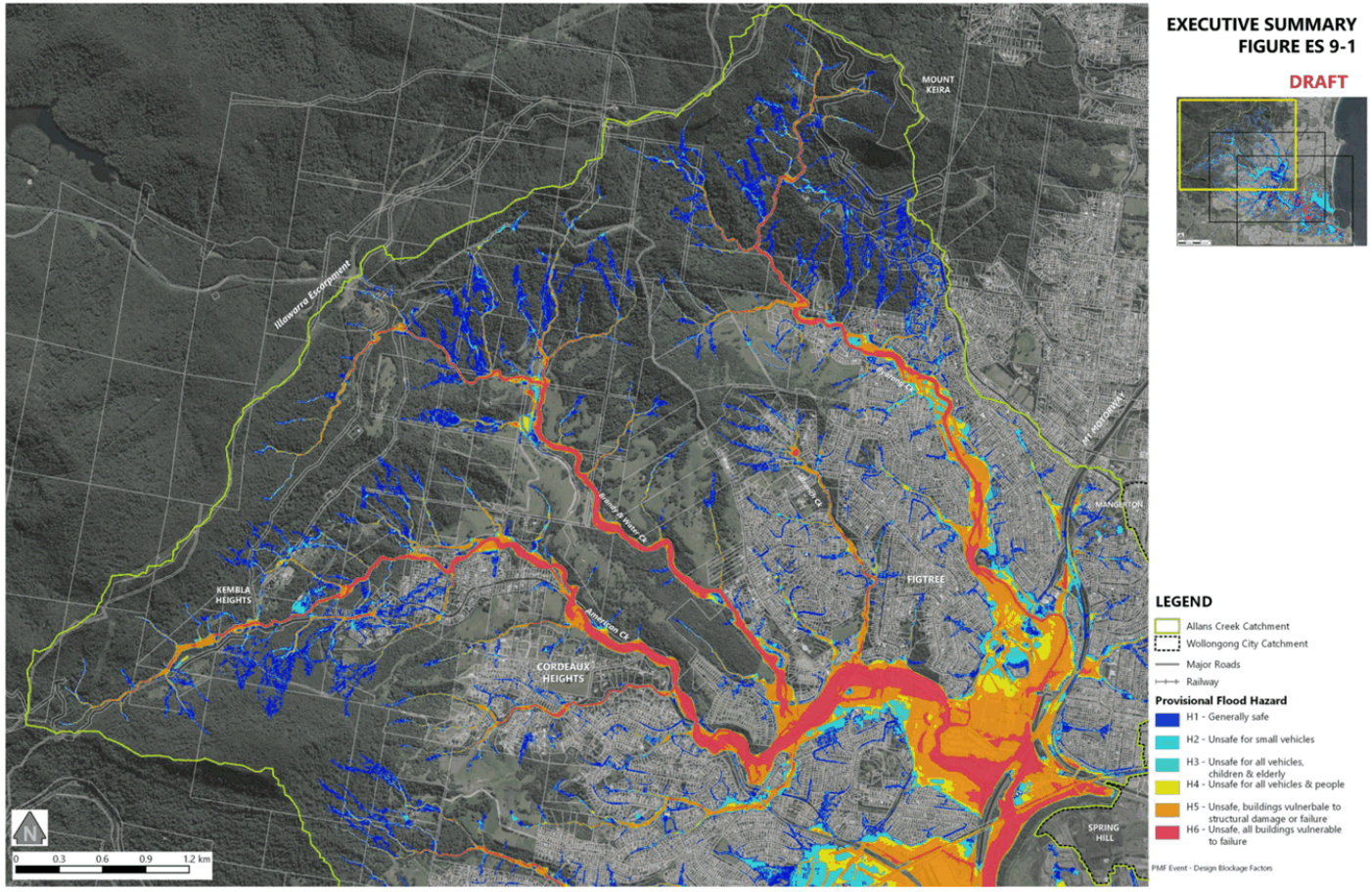
EXECUTIVE SUMMARY
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MOUNT KEIRA
Illawarra Escarpment
KEMBLA HEIGHTS
CORDEAUX HEIGHTS
FIGTREE
MANGERTON
SPRING HILL
LEGEND
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Prepared by:
Advisian
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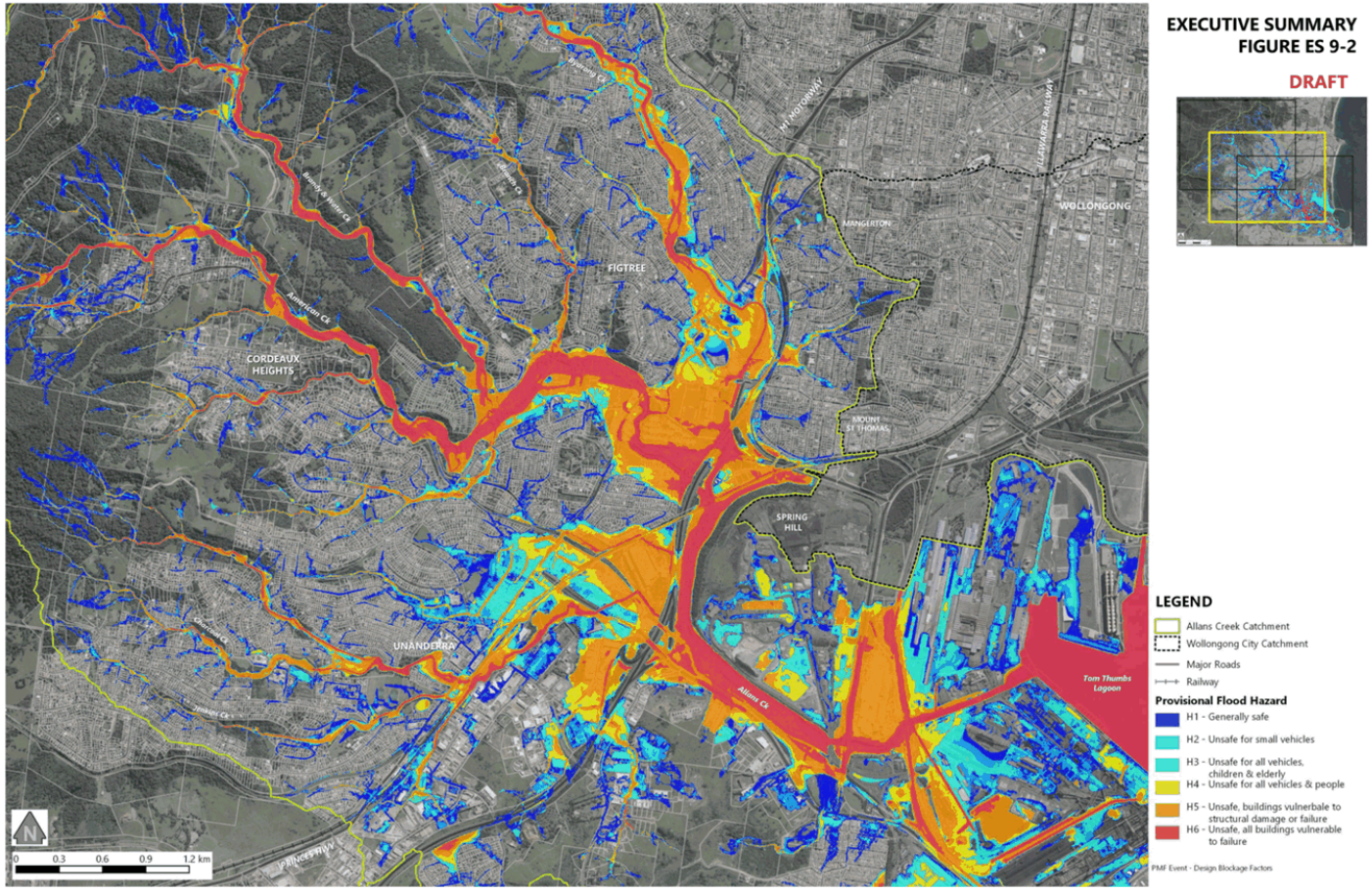
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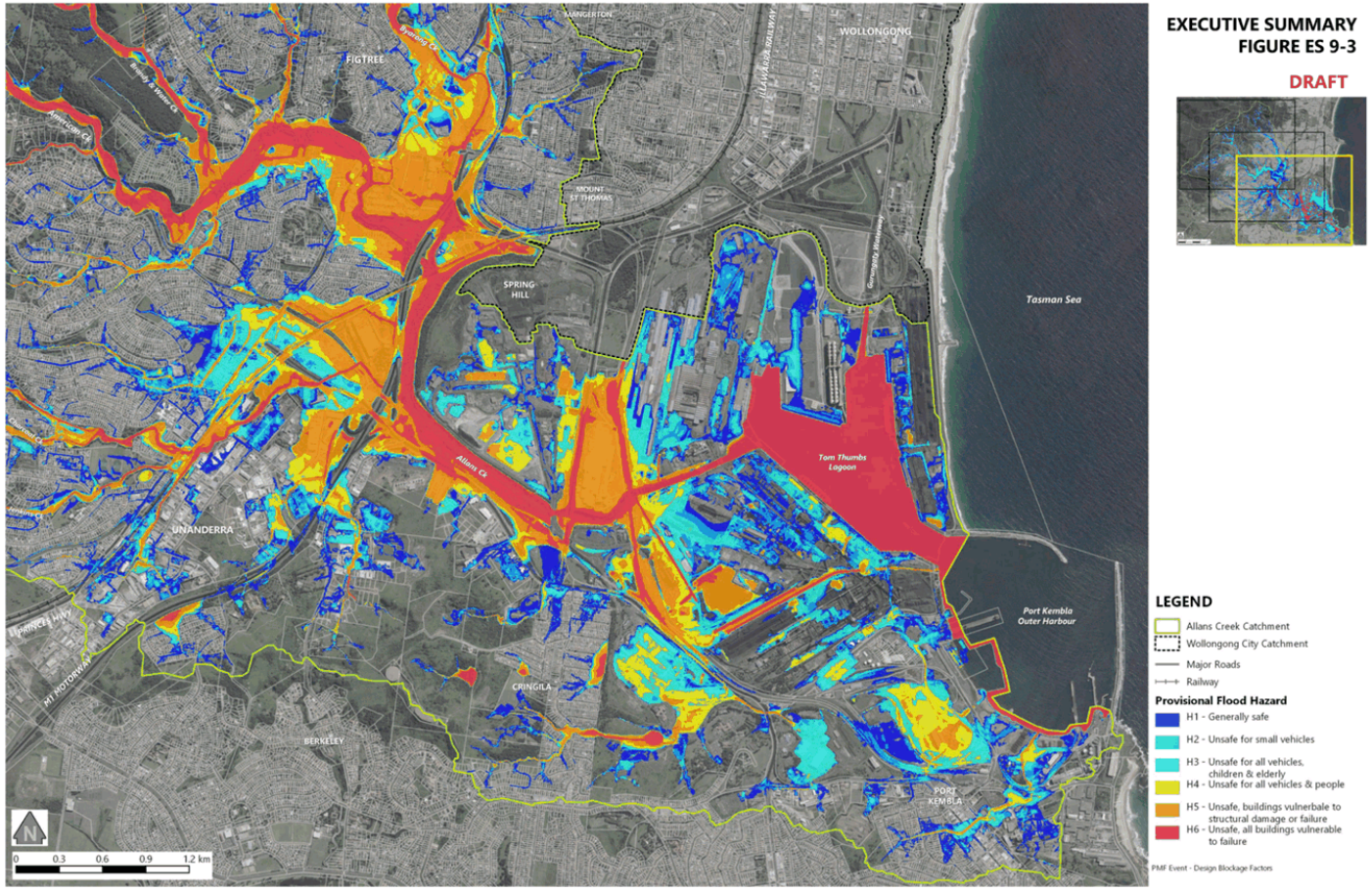
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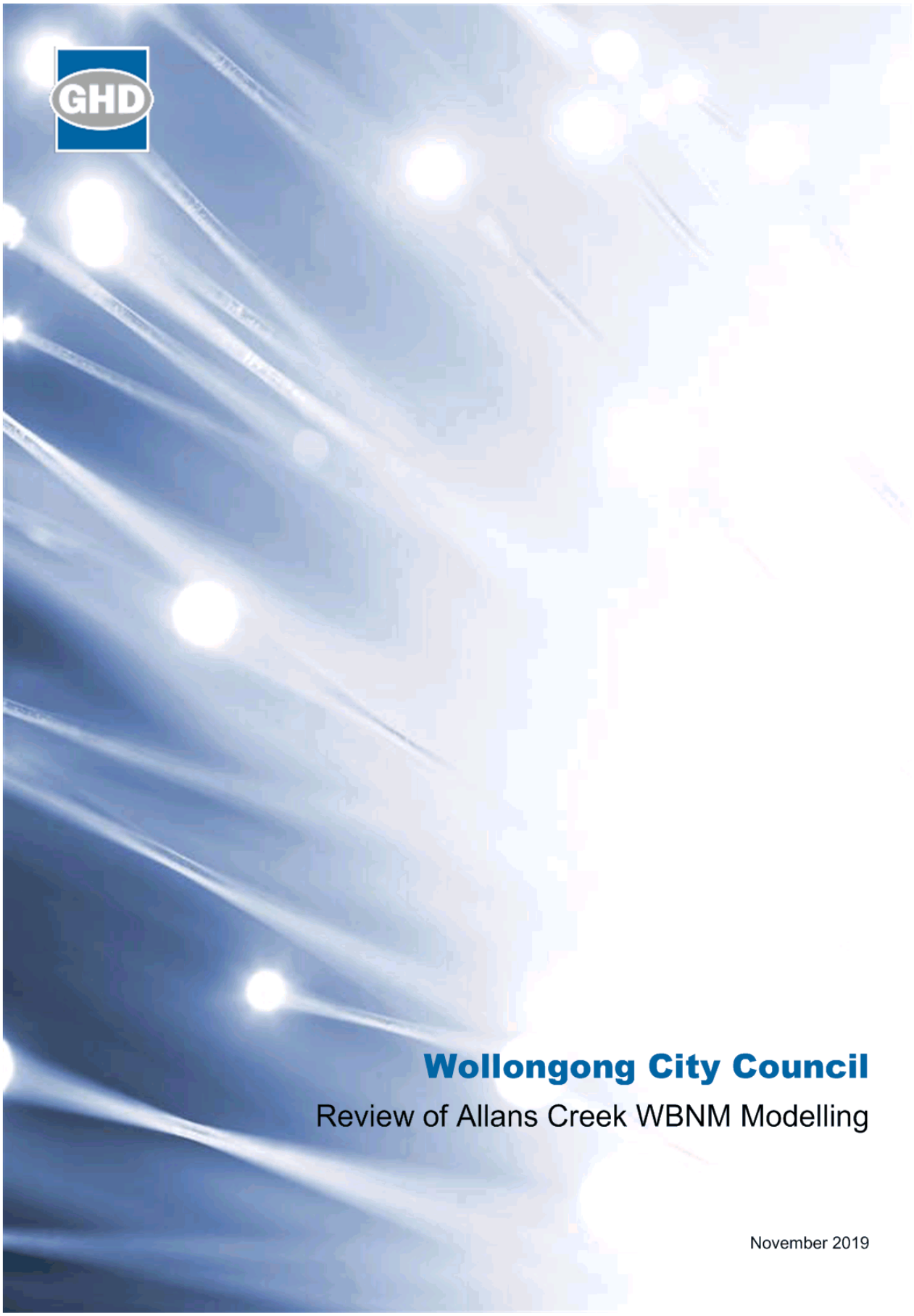
PROVISIONAL FLOOD HAZARD
DESIGN BLOCKAGE FACTORS – SHEET 3

Allans Creek Flood Study 2019

Comments from the submissions and at drop in sessions related to:

Key themes	Council's response
Adoption of **Australian Rainfall and Runoff (ARR) 2016/2019** methodology	In accordance with the NSW Government, *Floodplain Risk Management Guide, Incorporating 2016 Australian Rainfall and Runoff in studies*, and in accordance with Book 1, Chapter 1 of ARR2019, Council is currently finalising procedures and data that are more appropriate for our region so that ARR2019 can be implemented. The ARR 2019 methodology will be considered in the future review of the floodplain risk management study and plan for which Council has allocated resources this financial year and has applied for funding under the NSW Flood Program. Until then, we will continue to use ARR1987.
Flood modelling validity	The 2019 flood study has developed a detailed and catchment wide flood model with all catchment topography, streams, hydraulic structures and stormwater drainage represented. To confirm the models' ability to simulate actual flood behaviour the hydraulic model was calibrated to a series of surveyed historical flood levels and the Byarong Creek gauge record. No previous model of the study area has undergone calibration to water level gauge data to indicate that the timing or magnitude of flood hydrographs is appropriate. This study has been carried out by experienced flood engineers who have undertaken numerous catchment wide flood studies in accordance with the NSW Floodplain Development Manual. The study was subject to a rigorous technical review process involving Council and NSW Government, DPIE, technical staff.
Resolution of the **maps**	The resolution of the flood mapping was selected in order to cover the large study area with a practical number of 'tiles'. Increasing the number of flood maps and tiles does not necessarily increase their value and, rather, can negatively impact the community's desire or ability to digest the information presented. Owing to the large catchment size mapped and relatively narrow waterways which exhibit a high level of spatial variation in flood result parameters, it can be difficult to determine specific values at an individual property from the flood mapping. However, it is not the purpose of the flood mapping to inform individual property owners or developers of specific details at a property. It is intended to place all output files on the SES flood data portal so that they can be downloaded by local consultants, they provide finer scale resolution.
Observation of flooding	Council acknowledged and recorded information provided on observed historical flood behaviour. This was used to confirm the model calibration/verification results.
Request for creek maintenance	Where maintenance was requested for sections of creek on Council's property, they were forwarded to Council's maintenance crews for action. Where it was brought to Council's attention that maintenance was required on private land, residents were advised on their responsibilities in person or by letter.
Flood mitigation works in the catchment	Council has undertaken/is currently undertaking various flood mitigation projects in the catchment including debris control structures, creek

	restoration works along Council – owned portions of creeks, creek bed and bank stabilisation and voluntary purchase of severely flood affected properties. Council's website includes information on mitigation works in the catchment.
Flood mitigation options	Potential flood mitigation options will be considered as part of the future review of the floodplain risk management study and plan. At that time, consultation will be undertaken with residents to get their thoughts on potential options. Council is committed to undertake the review of floodplain risk management study and plan and has applied for financial assistance from the State Government for this project.
Flood risk to individual properties	The purpose of a flood study is to describe existing flood behaviour. Options to reduce flooding on individual properties will be considered as part of the future review of the floodplain risk management study and plan.
Perceived causes of flooding	The draft flood study takes into consideration factors which may affect flooding such as the alignment and capacity of the existing drainage system (much of which is verified by detailed survey) and the level of vegetation within the waterways. The study also incorporates the developments that have occurred since the completion of the 2006 flood study.
1998 floods	The 1998 floods that caused significant disruption and damage in the catchment were not as big as a 1% AEP flood. This explains why residents in some areas mapped as flood affected may not have experienced flooding will be affected by the 1% AEP and larger flood events. A 1% AEP is extreme. There is a 1% chance of a flood of this size occurring at a particular location in any given year.
Impacts of flood study on Planning/development	The draft flood study has been prepared in accordance with the NSW Government's Floodplain Development Manual and incorporates the NSW Flood Prone Policy. The study was overseen by the Central Area Floodplain Risk Management Committee. The NSW Government's Floodplain Development Manual provides a framework to ensure the sustainable use of floodplain environment and incorporates the NSW Flood Prone Policy. Under the Policy, the management of flood liable land remains the responsibility of Local Government. Council's policies are consistent with the framework and ensure minimal damages and less flood risk to newly developed properties.
Impact of the flood study on home insurance premiums	Fact sheets on insurance were provided to residents. People were advised that the standard definition of 'flood 'for insurance purpose may or may not apply to their properties and that the standard definition does not include overland flows and that overland flows are typically covered as a standard inclusion in home insurance policies. Council doesn't have any say in what and how flood data is used for setting flood premiums. We recommend that homeowners contact their insurer about the flood premium for their properties.


GHD
Wollongong City Council
Review of Allans Creek WBNM Modelling
November 2019
WATER | ENERGY & RESOURCES | ENVIRONMENT | PROPERTY & BUILDINGS | TRANSPORTATION

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Appendices

1. Summary of Findings

Wollongong City Council (WCC) engaged GHD to carry out a review of two alternative hydrologic models that have been prepared for the Allans Creek catchment. These are:

- A WBNM model prepared for Council by Advisian as documented in the Allans Creek Flood Study, Volume 1 – Main Report, 2019 Revision B; and
- A WBNM model prepared separately by NEFRAG

GHD's findings are summarised as follows:

1. The Council model has been calibrated to a TUFLOW model (a 2 dimensional hydrodynamic flood model) which has itself been calibrated to historic flood marks.

2. The Council model contains the floodplain storage and flow diversions that occur downstream of the Princes Highway which are essential to model the complex flood behaviours including cross catchment transfers that occur in this part of the catchment. The NEFRAG model omits these features.

3. The Council model catchment has been subdivided outside of recommended guidelines for model subdivision. However the model has been demonstrated to match the catchment response determined using the calibrated TUFLOW model and the degree of subdivision does not therefore affect the ability of the model to achieve a good calibration to TUFLOW.

4. The whole of catchment Council WBNM model is not the primary determinant of flooding behaviour for the Allans Creek flood study. Flooding behaviour has been determined using TUFLOW as the primary means of determining catchment response. The whole of catchment WBNM model has then been calibrated to match the flood response predicted by TUFLOW.

5. The NEFRAG WBNM model generally adheres to recommended modelling practice however this model omits floodplain storage and flow diversions contained in the Council model. It is therefore not an accurate predictor of flood behaviour in those areas downstream of the Princes Highway where cross catchment flow transfers occur.

6. The NEFRAG model is not calibrated. Rather the NEFRAG model adopts regional model parameters and is therefore what is termed a "regional flood model".

7. Australian Rainfall and Runoff (ARR) 2019, Book 7, Chapter 6 discusses the differences between Regional models and calibrated models and states:

> *"In all cases the reliability of regional relationships is likely to be less than parameter estimates derived from calibration from several recorded flood events on the catchment of interest. Regional relationships should be used with due caution, as most derived relations incorporate considerable scatter of the data from individual catchments".*

8. In accordance with the guidance provided in ARR 2019 and, because the NEFRAG model excludes floodplain storage and cross catchment flow diversions that are observed to occur in the Alans Creek catchment, flowrates derived using the Council model (a calibrated model) are expected to be more reliable than flowrates derived using the NEFRAG model (a regional model).

2. Introduction

2.1 Introduction

Wollongong City Council (WCC) engaged GHD to carry out a review of two alternative hydrologic models that have been prepared for the Allans Creek catchment. These models were prepared respectively by:

- Advisian, a consultant engaged by Council to prepare the Allans Creek Flood Study (2019); and
- NEFRAG, an independent organisation.

The models were prepared using the Watershed Bounded Network Model (WBNM) computer program.

The purpose of this report is to document GHD's review of these models and to provide GHD's opinion as to whether the models provided for review are reasonable in their structure and input parameters.

2.2 Scope and limitations

This report has been prepared by GHD for Wollongong City Council and may only be used and relied on by Wollongong City Council for the purpose agreed between GHD and the Wollongong City Council. The scope of this investigation is limited to:

- Review of the Advisian WBNM model (referred to in this report as Council's model); and
- Review of the NEFRAG WBNM model.

The review objective is to ascertain:

- whether there are material structural differences between the Council and NEFRAG models;
- whether appropriate input parameters have been adopted in each model;
- why the respective models may produce different discharges and if so the cause of these differences;
- whether there are clear reasons why the Council model should not be considered reasonable.

GHD's review was for the purposes stated above only. GHD has not reviewed every aspect of the model and has not commented on the overall adequacy or accuracy of the models. GHD's disclaims any ownership, responsibility or warranty pertaining to the models that were reviewed.

This report does not constitute a review of the Allans Creek Flood Study. It is noted that the Allans Creek Flood study has relied on a TUFLOW model to simulate the passage of flood waters through the catchment stream network. GHD has not reviewed the TUFLOW model other than to read what is reported in the Flood Study as background information. This review does not consider any aspect of the Allans Creek flood study, other than to review the full catchment WBNM model and compare this to the NEFRAG model, and to consider model sub area parameters in general.

This review has been limited to consideration of the following aspects of the WBNM flood models:

Council Model Review Limitations

Due to the very large number of model subareas in the Council model (4268 sub areas) the model parameters and model connectivity have not been reviewed at a sub area level. However inspections have been made of a sample of individual sub area input parameters and overall volumetric outputs have been checked at the catchment outlet as a way of assessing whether the sub areas have been broadly connected in their entirety.

NEFRAG Model Review Limitations

The review has been limited to the 59 sub area NEFRAG model. The review is based only on the model supplied to GHD, an accompanying Disclosure Statement, and a map of the model sub areas, indicating sub area labels.

GHD otherwise disclaims responsibility to any person other than Wollongong City Council arising in connection with this report. GHD also excludes implied warranties and conditions, to the extent legally permissible.

The opinions, conclusions and any recommendations in this report are based on conditions encountered and information reviewed at the date of preparation of the report. GHD has no responsibility or obligation to update this report to account for events or changes occurring subsequent to the date that the report was prepared.

3. Information Provided

The following information has been provided to GHD for this review:

3.1 Council Model

- Allans Creek Flood Study, Volume 1 – Main Report, 2019 Revision B;
- WBNM model input and output files ((START_STATUS_BLOCK comment: "last edited 28/06/2018;
- GIS layers indicating sub areas and streams.

3.2 NEFRAG Model

- WBNM model input and output (1% AEP event only) (START_STATUS_BLOCK comment: "Last edited 22/12/2015");
- Map of 59 sub catchment model sub areas ;
- Disclosure Statement (Mathieson, Version 2, 03 November 2019).

4. Review Findings

The Council and NEFRAG WBNM model extents were initially superimposed using GIS software. The NEFRAG model layout provided only as an image so this image was manually aligned with the Council provided GIS model layout. The individual and overlain model extents are shown on Figures 1, 2 and 3. The Council model extends to include sub catchments draining to Port Kembla Harbour beyond the NEFRAG model outlet. The superimposed models shown on Figure 3 indicate general agreement between the models as to the contributing catchment to the outlet of Allans Creek at Port Kembla.

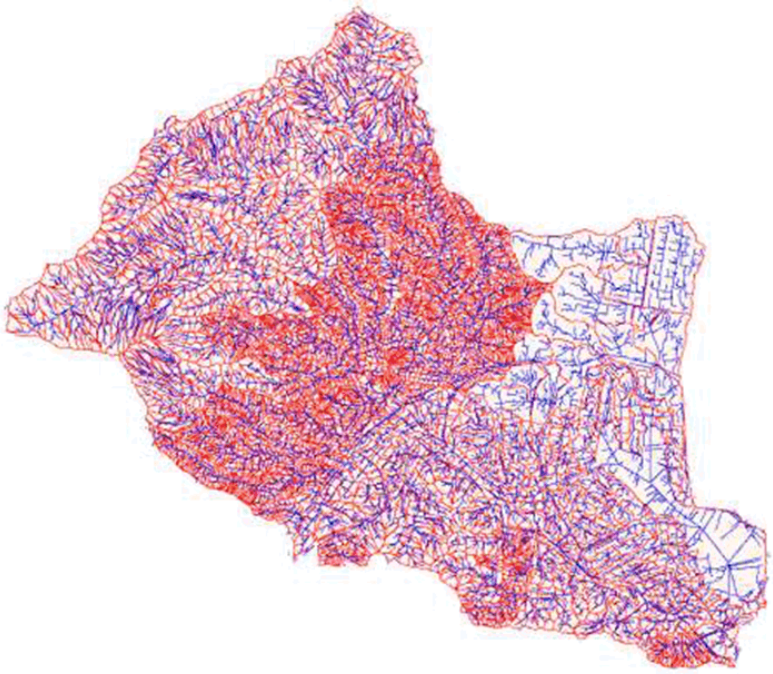

Figure 1: Council WBNM Model Extent

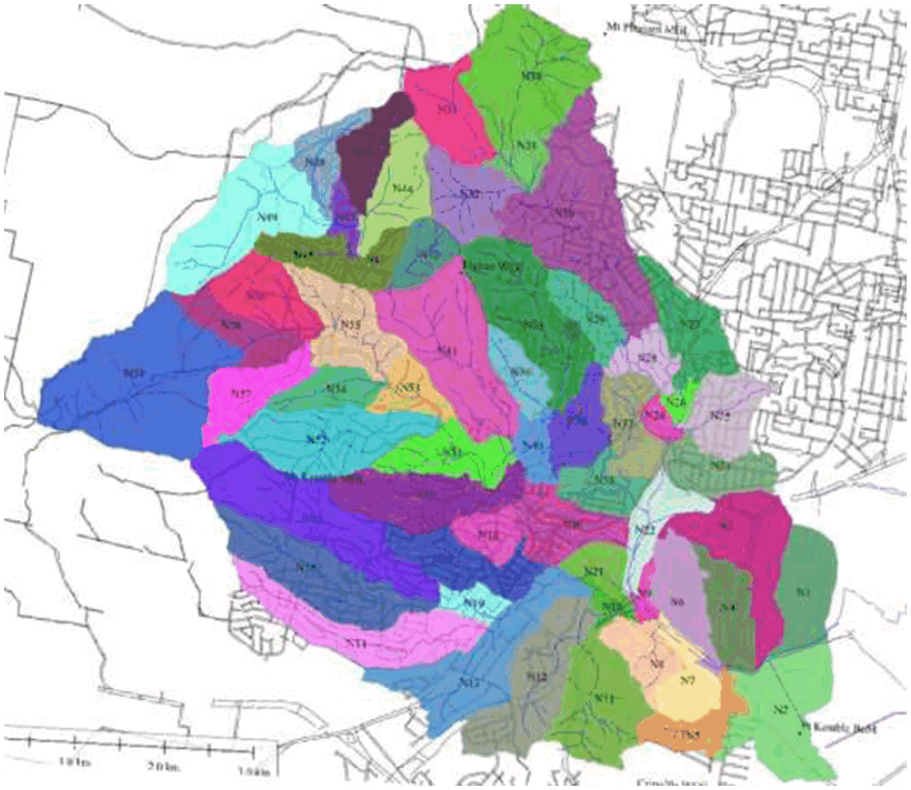

Figure 2: NEFRAG WBNM Model Extent (Source: NEFRAG)

Figure 3: Council Model and NEFRAG Model superimposed

The 1% AEP, 6 hour duration flood hydrograph at the Allans Creek outlet of each model (Council sub area 1.133, NEFRAG sub area N23) was extracted and is plotted on Figure 4.

The peak discharge predicted by the Council and NEFRAG models are 864 m^3/s and 854 m^3/s respectively. The Council model peak is delayed by approximately 30 minutes compared to the NEFRAG model. The relative runoff volumes are within 3.7%.

The adopted global model parameters for the Council and NEFRAG models are shown in Table 1.

Table 1: Council and NEFRAG Model Parameters

Parameter	Council Model	NEFRAG Model
C (lag parameter)	1.5	1.29
Stream Lag	Variable	1.0 globally
n (linearity)	0.23	0.23
Initial Loss (pervious)	10 mm	0 mm
Continuing Loss (pervious)	2.5 mm/h	2.5 mm/h
Initial Loss (impervious)	0 mm	0 mm

The global parameters adopted by each model, while not identical, lie within the bounds of industry recommended WBNM model parameters.

The lag parameter C determines the overall model response time. Australian Rainfall and Runoff (ARR) 2019 recommends a WBNM C parameter of 1.6 for un-calibrated models based on numerous studies. Many studies in Wollongong have adopted a C value of 1.29 and the NEFRAG C parameter is considered reasonable.

The Council model has adopted a C value of 1.5. This has then been adjusted within individual model reaches using a TUFLOW model to determine stream response behaviour as shown on Figure 4, extracted from the Flood Study. In the upper reaches of the catchment, lower lag values have been applied. Lower lag values are justified on the basis that watercourses in the upper reaches are steeper and may therefore respond faster compared to the lower reaches.

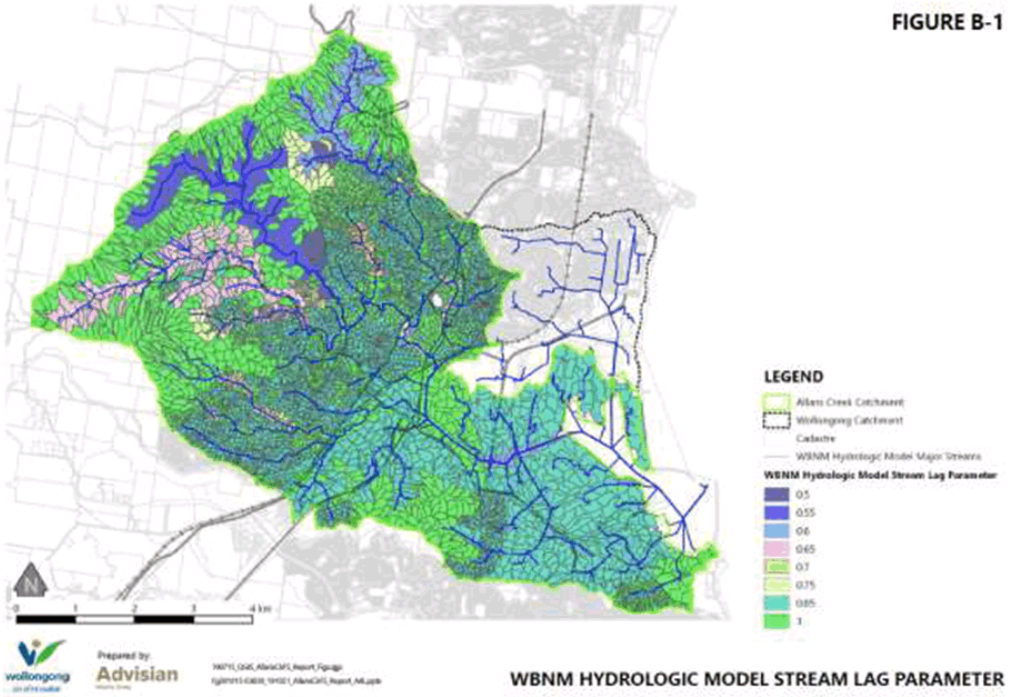

Figure 4: Council Model Adjustment of WBNM Stream Lag Parameter

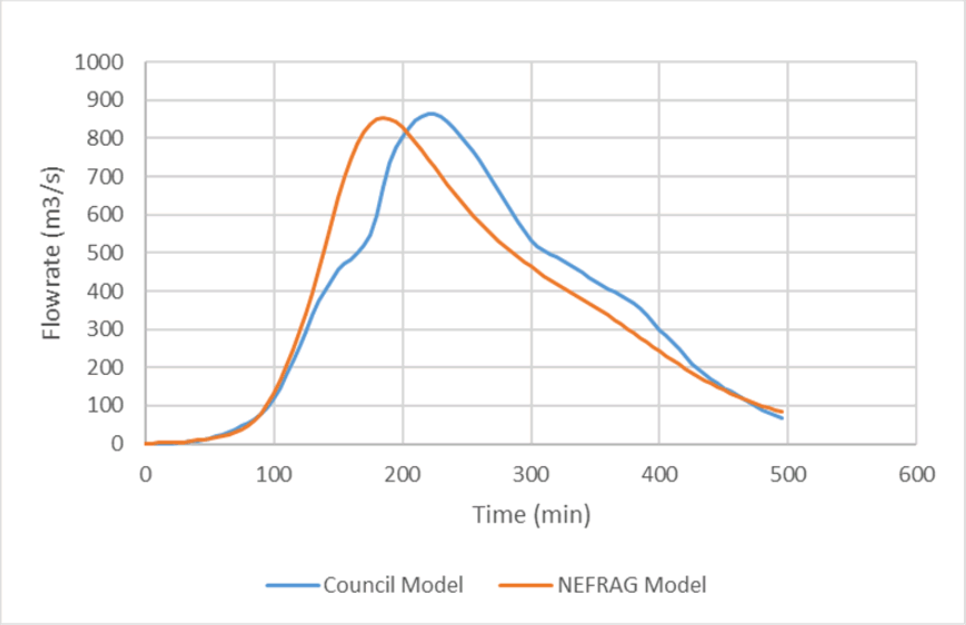

Figure 5: Council and NEFRAG Model Discharge - Allans Creek at Port Kembla Harbour

Review of the impervious fraction of each model shows that the Council model adopts an overall impervious fraction of 32% compared to 22% for the NEFRAG model to the same location at the NEFRAG model outlet. The overall impervious percentage has not been measured as part of this review but the difference may account to some extent for the 3.7% volumetric difference and possibly to a small extent for internal flow differences within the models.

Despite the use of different C values, at a whole of catchment scale, the two models perform similarly, although timing of peaks is delayed in the Council model when compared to the NEFRAG model. This timing difference is likely to be due to structural differences between the models and is discussed further below.

4.1 Council Model

The Council WBNM model has two functions and configurations:

- At a sub area level - to provide fine scale sub area input hydrographs to a TUFLOW hydrodynamic model (which models the catchment response by solving unsteady flow equations). The TUFLOW model is the primary predictor of flood levels and stream discharges within the catchment.
- As a whole of catchment model, to model flood behaviour, by utilising the TUFLOW predicted behaviour to calibrate the model stream links and fit appropriate parameters to represent this behaviour.

As a general rule, non-linear rainfall runoff routing models such as WBNM should be subdivided in accordance with guidance by Boyd (1985) in relation to the recommended minimum and maximum number of sub areas (this is particularly the case if the model will not be calibrated and is reliant on applying a recommended C parameter to estimate discharges).

The model subdivision guidelines suggested by Boyd are shown in Table 2. Boyd also notes that values outside these guidelines can be used without problems. GHD's experience is that the number of sub areas does affect the predicted peak discharge and timing and too few or too many sub areas affects the model response. This effect is also reported by a number of

researchers wherein too many sub areas is reported to result in delayed response time and higher discharges (eg Weeks, 1980). It is therefore likely that the applicable C value would differ depending on the degree of model subdivision.

Table 2: Boyd (1985) Guidance on Model Subdivision

Catchment area (km2)	0.1	1	10	100	1000	10000
Minimum sub areas	4	5	7	9	15	20
Maximum sub areas	20	26	35	45	60	80

The process for calibration of Council's model was to firstly calibrate a TUFLOW model to historic flood marks and installed flood height recorders. This TUFLOW model adopted individual sub area inflows from the WBNM model but was not dependent on the whole of catchment WBNM model to route the flows through the catchment.

The stream lag parameters within the whole of catchment model were then calibrated to the calibrated TUFLOW model predicted discharges. Therefore the Council WBNM model is a calibrated, rather than regional (ie un-calibrated model that adopts regional parameters) flood model.

With 4268 model sub areas, the Council WBNM model exceeds the guidance on maximum number of sub areas suggested by Boyd. Also it was observed that, probably as a result of the automated subdivision process applied, some sub area catchment shapes and sizes are not optimal. However the calibration process applied has mitigated these model structural issues by using TUFLOW as the primary stream routing mechanism, then adjusting WBNM stream lags to achieve a fit to the TUFLOW model predicted catchment response. The TUFLOW model response is governed by the selection of stream roughness values. The adopted Manning n values are noted to be reasonable and in line with industry recommended values and include:

- Watercourses – 0.04
- Concrete open channels – 0.03
- Vegetation – Medium Density - 0.08
- Vegetation – High Density – 0.15

The Council model also includes floodplain storage (input to the model at 13 locations as stage vs storage relationships) and diversions (input to the model at 13 locations as stage vs discharge relationships) that occur within the catchment, mostly at and downstream of the Princes Highway (notably in Byarong Creek, American Creek, Allans Creek, Charcoal Creek). These have been incorporated to simulate two dimensional flood behaviour at these locations, informed by the TUFLOW model.

An example of the WBNM model fit to TUFLOW response is shown on Figure 6, which is extracted from the Flood Study. Figure 6 shows the TUFLOW and WBNM model hydrograph comparisons in Byarong Creek for the 1998 flood event, provided in the Flood Study, Appendix B. The WBNM model is seen to closely match the TUFLOW model predicted response and it is therefore considered that the adopted Council model WBNM stream lag times are reasonable. Similar results are also presented for other tributaries.

Appendix B

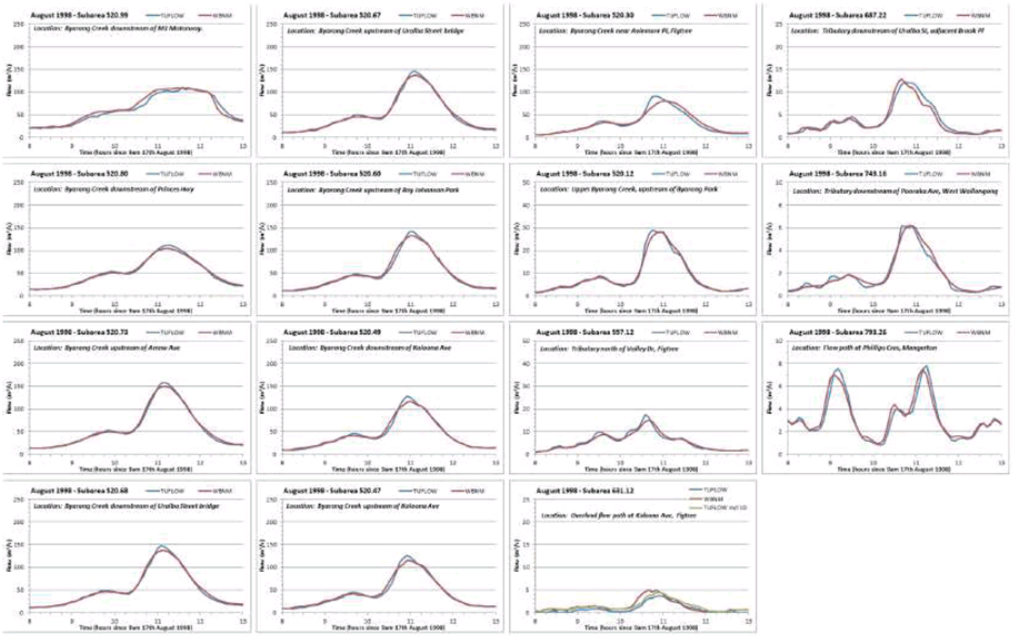

Figure B 10 Comparison of WBNM and TUFLOW simulated August 1998 hydrographs along Byarong Creek and tributaries

Figure 6: WBNM and TUFLOW Hydrograph Comparisons

The WBNM model fit has been achieved through adjustment of stream lags in individual reaches within the WBNM model, which has, in general reduced the model response time (compared to application of a default stream lag multiplier of 1.0 as adopted by NEFRAG) in the upper reaches and also to a lesser extent the lower reaches.

The TUFLOW fit to flood marks generally reasonable with a number of outliers which are explainable. This suggests that discharges predicted by Council's WBNM model are reasonable.

4.2 NEFRAG model

The NEFRAG model comprises 59 sub areas. The number of sub areas, loss rates, C and m value adopted by NEFRAG is in line with ARR guidance for ungauged catchments. The NEFRAG model is not calibrated and as such is a regional flood model - ie a model which is not calibrated but adopts recommended regional parameters which may or may not be suitable to a particular catchment. Regional models are normally used in the absence of calibration data and are considered to be less accurate than calibrated models.

The model structure is reasonable as a predictor of overall catchment behaviour although the model omits important components that are necessary to model internal complex catchment behaviour that exists in this catchment including diversions and floodplain storage. This is acknowledged by NEFRAG in its Disclosure Statement. The model is therefore unsuitable for flow estimation between the Princes Highway and M1 Motorway due to the fact that the extensive interchange of water between tributaries at this location during major flood events has not been represented.

There are a number of poorly represented stream reaches within the model downstream of M1 motorway where a number of catchments have been routed through large sub areas with very short main stream length. This then incorrectly models the stream routing process by over

estimating the lag in the reach in question. Sub areas where this is apparent include: N3, N4, N6, N7, N13.

As an un-calibrated regional hydrologic model, and subject to the omissions described above the NEFRAG model is reasonable, however compared to Council's model the NEFRAG model lacks any form of calibration and is reliant on generally recommended regional parameter values which do not account for catchment specific behaviours.

5. Conclusions

The Council and NEFRAG WBNM models of Allans Creek have been reviewed and compared at a high level.

It should be noted that the WBNM models, on their own and without input to a hydraulic model, will only approximate flooding behaviour, in particular in areas of significant floodplain storage and two dimensional flooding behaviour such as occurs in the lower reaches of the Allans Creek catchment. For this reason Council has developed a TUFLOW model as the primary tool to assess flooding behaviour, complemented by distributed inputs from fine scale WBNM models.

It should also be noted that Council's whole of catchment WBNM model was not developed as input to the flood study, but rather as a tool for further hydrologic investigation outside of the Flood Study. The Flood Study modelling relies on the TUFLOW model as for the flood routing mechanism, with numerous small scale WBNM models providing distributed rainfall runoff hydrographs inputted this model. The TUFLOW model does not rely on the whole of catchment WBNM model routing along the main streams.

Despite having different model structures, the Council and NEFRAG models were found to produce similar overall discharges and runoff volumes at the NEFRAG mode outlet location in Allans Creek at Port Kembla, albeit with the Council model having a longer time to peak.

Internally flow differences were apparent between the two models. The NEFRAG model was found to be a relatively basic model which adopted uniform lag parameters throughout and an overall lag parameter (C) which is in line with values that have been adopted by other practitioners in Wollongong. No attempt was made to calibrate this model and therefore flow rates estimated by this model are subject to usual uncertainty associated with un-calibrated hydrologic models which adopt regional rather than catchment specific model parameters.

It was noted that the NEFRAG model does not make allowance for storage and diversion of flow that occurs downstream of the Princes Highway. This diversion is significant and therefore runoff hydrographs extracted from the NEFRAG model downstream of the Princess Highway will not be accurate without further detailed hydraulic modelling to accurately route and distribute these flows, as has been done by Council using TUFLOW.

Other than the omission of diversions and flood plain storage there were no obvious structural errors noted in the NEFRAG model. However it was noted that in the lower reaches some sub areas would be expected to over-attenuate the discharges due to the sub area shape and size being unrepresentative.

The Council model was found to be complex in terms of the number of sub areas, variable stream lag parameters and inclusion of important floodplain storage and diversions which dictate flood behaviour in the lower portion of the catchment. Most importantly the ability of the Council model to represent catchment response was validated using a TUFLOW model and it was demonstrated that the Council model mimics the stream response behaviour as predicted by the TUFLOW model. By selection of appropriate stream lag parameters, the WBNM model was fitted to the TUFLOW model behaviour. The TUFLOW model itself was calibrated to flood marks from historic events.

Australian Rainfall and Runoff (ARR) 2019, Book 7, Chapter 6 discusses the differences between regional models and calibrated models and states:

> *"In all cases the reliability of regional relationships is likely to be less than parameter estimates derived from calibration from several recorded flood events on the catchment of interest. Regional relationships should be used with due caution, as most derived relations incorporate considerable scatter of the data from individual catchments".*

In accordance with the guidance provided in ARR 2019 and, because the NEFRAG model excludes floodplain storage and cross catchment flow diversions that are observed to occur in the Alans Creek catchment, flowrates derived using the Council model (a calibrated model) are expected to be more reliable than flowrates derived using the NEFRAG model (a regional model).

Appendices

Appendix A – Addendum 1

Following completion of the review of Council and NEFRAG WBNM models described in the main body of this report, the following documents were provided to GHD for further review and comment as relevant to GHD's WBNM model review:

- Northview Estate Flooding Residents Action Group, "Feedback to Wollongong City Council Concerning Draft Report: Allans Creek Flood Study 2019 Revision A, July 2019". Version 2.3b- 26 August 2019;
- Addendum 1 to the above report;
- Addendum 2 to the above report.

These documents have been read and matters relevant to GHD's review have been considered. There is no change to GHD's findings as a result of reading and considering the contents of these documents.

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