Ripley Valley Secondary Urban Centre East

Flood Study

7901/47-027

Prepared for
AMEX Corporation Pty Ltd

4 February 2013

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Shaping the Future

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Document Information

Prepared for	AMEX Corporation Pty Ltd
Project Name	Ripley Valley Secondary Urban Centre East
File Reference	O:\7901-47-027 Amex West\wp\R1_SUCE Flood Studyv5\SUCE Flood Studyv5.docx
Job Reference	7901/47-027
Date	4 February 2013

Document Control

Version	Date	Author	Author Initials	Reviewer	Reviewer Initials
1	15 June 2012	Netsanet Ejigayehu	NE	Martin Giles	MG
2	22 June 2012	Netsanet Ejigayehu	NE	Martin Giles	MG
3	29 June 2012	Netsanet Ejigayehu	NE	Martin Giles	MG
4	14 December 2012	Netsanet Ejigayehu/ Helen Doherty	NE/HMD	Martin Giles	MG
5	4 February 2013	Netsanet Ejigayehu/ Helen Doherty	NE HMD	Martin Giles	MG

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1 Introduction

1.1 Overview

This flood report has been prepared in support of the application lodged with respect to the Southern and Eastern portions of the proposed Ripley Valley Secondary Urban Centre East (SUCE) development. However, the flood report also deals with the entire Secondary Urban Centre East area controlled by AMEX.

The SUCE area and its key features are shown below on Image 1.

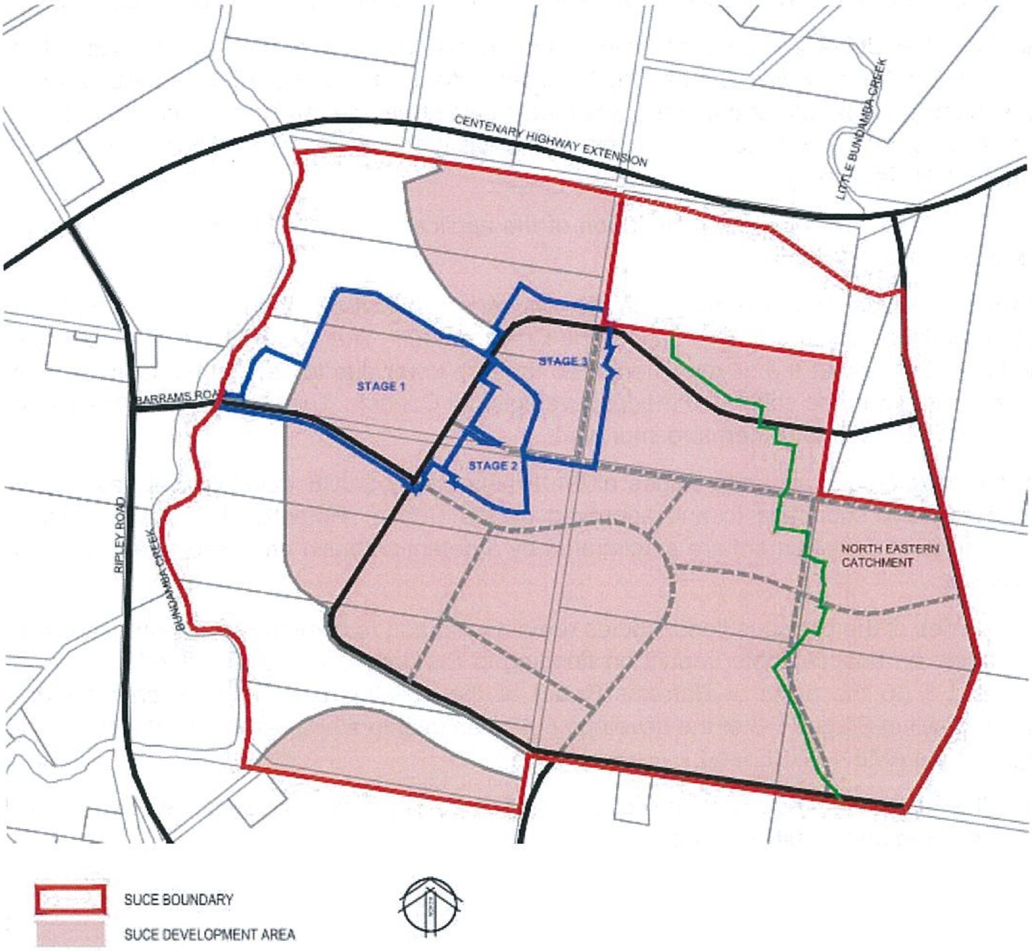


Image 1 SUCE Area and Key Features

With reference to Figure 1, the SUCE site is located to the south of the Centenary Highway Extension and to the east of Bundamba Creek. Ripley Road, which provides access to the site from the Centenary Highway Extension, is located to the west of Bundamba Creek. As part of the SUCE development, Barrams Road is to be upgraded to provide a connection from Ripley Road to the site across Bundamba Creek. The upgrading of the presently low level Barrams Road will include a bridge crossing of Bundamba Creek and culverts to provide for local catchment flows to the west and east of Bundamba Creek that currently cross Barrams Road.

Stages 1 to 3 of the development are located immediately to the north of Barrams Road. To offset the impact of development of the SUCE development, detention areas are to be created to the north and south of Barrams Road. The detention areas will be integrated into the open space associated with SUCE, providing open space areas that achieve an appropriate level of flood immunity while also providing flood storage.

While the majority of the SUCE site drains to Bundamba Creek in the west, the north-eastern portion of the site (refer Image 1) drains to Little Bundamba Creek in the north-east. A number of detention basins are proposed to ameliorate the impact of development of the portion of the SUCE development that drains to the north-east.

1.2 Description of Modelling

A previous version of this flood study submitted for approval (Version 3, June 2012) presented the results of modelling completed using a two-dimensional flood model of Bundamba Creek developed for AMEX Corporation. Subsequent to the completion of the flood study, a flood study of the entire Bundamba Creek area was completed by consultants acting on behalf of Council. Additional work was completed by the consultants at the request of the ULDA to improve the resolution of the model in the vicinity of Ripley Valley.

For consistency purposes, the ULDA and Council have recommended that any proposed development in Ripley Valley be tested using the new Bundamba Creek model (referred to as the KBR model). As the model extends downstream to the mouth of the creek, the model also offers the ability to confirm the nature of any impacts with respect to flood levels, flows, and timings in areas presently subject to flooding which are located well downstream of Ripley Valley.

The information request received following the submission of the application (refer Section 2) also refers to the use of the new Bundamba Creek model.

To address the information request and to comply with the request of Council and the ULDA, the proposed development has been modelled using the new Bundamba Creek model. The use of the new model has produced peak flood levels throughout the development area that are lower due to several reasons such as reduced peak flows associated with the calibrated model developed by Council. The flood immunity reported in previous versions of the flood reports is therefore improved.

It can be noted that the development of early stages of the Ripley Valley SUCE development have been addressed in reports previously submitted to and approved by the ULDA. Potential flood level impacts associated with these stages of development are ameliorated by a detention basin and associated works to the north of Barrams Road.

To confirm that the outcomes of the previous flood studies remain valid and to confirm that interim stages of development will not cause an unacceptable impact on flooding in Bundamba Creek, the flood study has also considered Stages 1-3 (to the north of Barrams Road) of the development. The report therefore presents the results of modelling Stages 1-3 of the development as an interim stage, as well as development of the remaining stages of the AMEX SUCE land.

A detailed response to the information request is provided in Section 2. The remaining sections of the report detail the modelling undertaken and results obtained.

2 Information Request

2.1 Formal Information Request

On behalf of the ULDA, consultants Sinclair Knight Merz reviewed the previous version of the flood study (June 2012) and provided comments in the form of an information request on 17 August 2012. Each of the items relating to flooding issues is listed below with responses as appropriate.

2.1.1 Use of ICC Model

KBR has recently developed a calibrated 2D/1D flood model of Bundamba Creek for Ipswich City Council (ICC). This study will form the basis of future flood risk management for the waterway and its floodplain. The KBR model has not been used as the basis for this study.

As per previous RFIs, the impacts of the proposal must be assessed using the ICC model. Revise modelling and reporting accordingly.

Modelling has been revised using the KBR model. The results of the analysis are discussed in this report.

2.1.2 Reporting Methods

KBR has recently developed a calibrated 2D/1D flood model of Bundamba Creek for Ipswich City Council (ICC). This study will form the basis of future flood risk management for the waterway and its floodplain. The reporting methods used in the KBR study have not been adopted for the Ripley Valley study.

The reporting methods used in the report prepared for ICC by KBR are to be used in this study. This includes reporting at the each of the 12 downstream nodes for all key indicators such as levels, velocities, rates of rise, etc. Revise reporting accordingly.

The flood study includes outputs in a format that match the reporting methods used by KBR. While preparing the flood study, we have liaised with KBR in relation to the location of the downstream nodes and their reporting (the final report had not been prepared at the time the models were supplied to Cardno for use).

Ultimately, KBR only adopted 11 reporting points, as shown on Figure 1. Of these points, 9 (points 1 to 9) were located in the 1-D domain. KBR has adopted an approach of calculating hydrographs (to allow the rate of rise to be assessed) at these 9 points, with peak levels reported at the remaining points (points 10 and 11). Cardno has followed this approach. Appendix A presents the flow hydrographs calculated at reporting points 1 to 9 for each event modelled. Peak flood levels at reporting points 1 to 11 are presented in Tables 4-1 to 4-4, while peak flow velocities at reporting points 1 to 11 are presented in Tables 4-5 to 4-8.

With reference to the results presented in Appendix A and Tables 4-1 to 4-8, it is considered that the impact of development (both the interim Stage 1-3 development and ultimate development) on regional conditions in Bundamba Creek is negligible. For example, for the 100 year event, a reduction in level (of up to 44 mm) is obtained at the majority of reporting points, with a negligible increase in level of 6 mm recorded at one point (Point 11).

2.1.3 Incremental impacts

The study has assessed impacts of the relevant stages using a previous study (with stages 1 - 3 in place) as the base case. This does not provide an assessment of the cumulative impact of all planned development. Cumulative impact assessment is required. The base case should be the undeveloped case, not including stages 1 - 3.

The impact of the entire proposed development should be compared with the base case. Incremental impacts should also be assessed.

The analysis has been revised to assess the cumulative impacts of development. The analysis has considered the impact of Stages 1 to 3 relative to the base case, and the development of the remainder of the AMEX SUCE area relative to the base case. In both cases, the results are considered to be acceptable (refer Appendix C and Tables 4-1 to 4-4) and the development does not result in unacceptable impacts external to the SUCE area.

2.1.4 RAFTS Model Initial Loss

RAFTS model discussed in Section 5.4.2 assumes an initial loss of 0 mm for both impervious and pervious areas. Recommended initial loss for pervious areas is 15 mm.

RAFTS model discussed in Section 5.4.2 should be run and calibrated with an initial loss of 15 mm for pervious areas (0 mm for impervious areas).

To allow the flood modelling presented in this report to be completed, a copy of the calibrated model of Bundamba Creek developed by KBR was provided to Cardno.

The RAFTS hydrologic model, which was developed as part of the overall calibrated model, adopts different initial loss values varying between 5 mm and 15 mm:

- 100 year ARI - 5 mm initial loss and a 2.5 mm/h continuing loss;
- 50 year ARI - 10 mm initial loss and a 2.5 mm/h continuing loss;
- 20 year ARI - 15 mm initial loss and a 2.5 mm/h continuing loss;
- 10 year ARI - 15 mm initial loss and a 2.5 mm/h continuing loss;
- 5 year ARI - 15 mm initial loss and a 2.5 mm/h continuing loss;
- 2 year ARI - 15 mm initial loss and a 2.5 mm/h continuing loss; and
- 1 year ARI - 15 mm initial loss and a 2.5 mm/h continuing loss.

As the model supplied to Cardno was based on a lengthy calibration process, the adoption of different initial loss values (which equal the suggested value of 15 mm for events with recurrence intervals up to and including the 20 year event in any case) is not considered to be warranted.

Consequently, modelling was based on the loss rates provided in the KBR RAFTS model. It can be noted that an initial loss of zero was adopted for impervious areas.

2.1.5 Land Ownership

Detention basin discussed in Section 5 is not owned by AMEX (i.e. the basin is located outside the proposed development). No land owner consent has been provided for the purpose.

Development should only be permitted on the condition that approval is gained to alter the detention basin discussed in Section 5.

This issue and response relates to the drainage of the north-eastern part of the site.

The single detention basin discussed in the previous report (June 2012) to the north-east of the AMEX SUCE land would require land owner consent for its construction. While this would be a valid means of achieving the required level of detention and is expected to be pursued in the future, to confirm that the development can proceed without the need for such consent, the modelling has been revised to reflect the construction of detention basins in the north-eastern part of the site in areas controlled by AMEX. As runoff drains from the AMEX land at a number of points, it is necessary for a number of detention basins to be provided rather than a single basin. The indicative location and footprint of the basins is shown in Figure 5.

It can be noted that the final configuration of the basins will be determined in support of future development applications. The purpose of the modelling completed for the flood study is to confirm that the use of detention basins will provide a satisfactory amelioration of development impacts and that the combined effect of the basins will not produce an unacceptable impact with respect to peak flood levels, flows, and the timing of flow in Bundamba Creek downstream of the site.

This was achieved by adapting the KBR RAFTS model to reflect the proposed level of development and to then size basins appropriately to offset the impact of development at each point of discharge from the AMEX SUCE land. The resultant outflow hydrographs were input to the TUFLOW model.

Reference to the detention basin located outside of the land currently owned by AMEX has been removed, and the report now focuses on the alternate options previously presented, namely the inclusion of a number of basins within the AMEX SUCE land to collect and attenuate runoff from the North-Eastern portion of the site

2.1.6 Detention Basin Impacts

The study has not demonstrated that there will be no impacts upstream or downstream of the detention basin discussed in Section 5 due to changes in flood storage or flow being impeded.

Upstream and downstream impacts need to be addressed adequately in the study. This includes impacts caused by the detention basin due to changes in storage or flow being impeded.

The detention basins were added to the KBR RAFTS model of the catchment and the basins adjusted until a satisfactory attenuation of flow was obtained. To ensure that the combined effect of the detention basins (in terms of timing of peak outflow) and filling associated with the AMEX SUCE development did not produce unacceptable impacts in Bundamba Creek, the outflow hydrographs from the detention basins derived from the RAFTS model were applied to the TUFLOW model. It can be noted that the grid resolution of the TUFLOW model in this area is 20 metres rather than the 4 metres used elsewhere in Ripley Valley. As a consequence of this large grid size, direct modelling of the detention basins in TUFLOW was not possible.

With reference to the results presented in Section 4 and Appendices B, C, and D, it is considered that the detention basins will satisfactorily offset the impact of development and will not produce unacceptable impacts in downstream areas when acting in combination.

2.1.7 Scour from Detention Basin

High velocities have been identified entering Bundamba Creek from the proposed detention basin (Section 4.5.1) outlet pipes. These velocities are approximately 2 m/s for the 1:1 AEP event, 2.5 m/s for the 1:10 AEP event and 4 m/s for the 1:100 AEP event.

Scour in this area has not been investigated. The potential impacts in terms of scour in Bundamba Creek should be investigated and appropriate mitigation measures developed.

The velocities nominated in the information request reflect the previous model of Bundamba Creek. As part of the use of the new model of Bundamba Creek, conditions at the point of discharge from the detention basin have been reviewed.

The results of this review are presented in Section 4.7.6 of the report. Overall, the velocities predicted at the outlet of the detention basin are significantly lower than those nominated in the information request and it is considered that the velocities can be adequately dealt with using appropriate erosion control measures. It is proposed that any approval be conditioned to require the detailed design of the detention basin to include the preparation of a report detailing the design of scour protection at the outlet from the basin.

2.1.8 Flood Hazard

The study has not demonstrated that no downstream change in flood hazard is caused by the development.

The study should demonstrate that no change in flood hazard downstream is caused by the development. Any reduction in warning time or increased rate of floodwater rise should be investigated and reported. Graphs that demonstrate no increase in flood hazard at the 12 downstream reporting nodes should be included in the report.

With reference to the response in relation to reporting methods (Section 2.1.2), Appendix A presents the flow hydrographs calculated at reporting points 1 to 9 for each event modelled. Peak flood levels at reporting points 1 to 11 are presented in Tables 4-1 to 4-4, while peak flow velocities at reporting points 1 to 11 are presented in Tables 4-5 to 4-8.

Flood hazard and any change in flood hazard were interpreted relative to the graphs and peak values presented in the tables. It can be noted that the typical method of assessing flood hazard (namely depth-velocity) product was not considered to be applicable in this case due to the high depth of flow that occurs at the main reporting points (which are located in the main watercourse). The preparation of comparative depth-velocity plots would be inconclusive as all points would have a significantly high depth-velocity product for the existing case and any impact due to development (even if relatively significant) would be minor incrementally.

Given this, recourse was made to the graphs (Appendix A) and Tables (Section 4) which present the modelled results for the base case, Stages 1 to 3 and ultimate development.

With respect to the graphs presented in Appendix A, it is considered that development will not produce a significant reduction in the warning time or rate of floodwater rise.

2.2 Additional Queries

Subsequent to the Information Request being issued a number of flood-related issues have been raised during negotiations with the ULDA. This section details the identified issues and the response based on detailed modelling presented in this report.

2.2.1 Immunity of Residential Areas

All residential areas will have 100 year ARI flood immunity, with appropriate freeboard to lot levels and floor levels.

2.2.2 Impact on Third Parties

There is no actionable nuisance to the buildings on Lot 1 RP68799 (shown as BLD1 and BLD2 on Figure 1 immediately to the south of Barrams Road) in accordance with the agreement existing with that land owner.

Other buildings potentially affected by flooding are not subjected to increased flood levels (refer Table 4-9 of the report).

2.2.3 Safety and Immunity of Open Space Areas

Open Space areas will achieve the flood immunity levels required by the ULDA *Park Planning and Design Guidelines* of November 2011. In particular, the following will be achieved:

- Recreation parks have a maximum of 30 percent of any park below the 5 year ARI flood level;
- Sports parks have 20 year ARI flood immunity (including the sports fields to the north of Barrams Road); and
- Clubhouses, courts, toilets and amenities blocks and other buildings have 100 year ARI flood immunity.

It can be noted that these immunity levels were conservatively based on dense revegetation of the waterway corridor which resulted in higher flood levels than those derived using the model as supplied by Council.

The district sports park and district recreation park will have an equivalent or improved depth velocity risk profile compared to that previously identified.

For the district recreational parks to the north of Barrams Road bridge, a maximum depth of 0.7 metres was obtained for the 100 year event together with a depth velocity product significantly less than 0.6 m^2/s.

The peak depth of flooding for the district sports park was found to be 0.25 m for the 100 year event. The depth velocity product for the 100 year event of significantly less than 0.6 m^2/s.

The district playground area has a maximum depth of 0.2 metres for the 100 year event and a depth velocity product significantly less than 0.6 m^2/s. The playground area has immunity to the 50 year event.

The major sports park will achieve relevant flood risk performance criteria required by the guidelines, with a peak depth during the 100 year event of 0.65 metres and a depth velocity product less than 0.6 m^2/s.

2.2.4 Immunity of Road Access

For the first stages of development, access to the site can be gained from the Centenary Highway Extension, via Ripley Road and the upgraded Barrams Road crossing. Detailed modelling using the Bundamba Creek flood model provided by Council indicated that both the Centenary Highway Extension and Ripley Road between the Centenary Highway and Barrams Road are immune to flooding for the 100 year recurrence interval event in Bundamba Creek.

Further, modelling of the proposed configuration (drainage and vertical alignment) has indicated that the road will be immune to flooding for the 100 year recurrence interval event.

Given that the route to the site will be immune to flooding for the 100 year recurrence interval event, it is considered that the access provided to the SUCE development is adequate.

2.3 Previous Stage 1 Approval

When approval was gained with respect to Stage 1 of the development, queries were raised with regard to a number of flood-related issues. A response was ultimately prepared in relation to the issues (Cardno August 2011). For consistency with the previous approval, the previously raised issues are discussed below.

2.3.1 Bridge and Road Levels

As part of the Stage 1 approval process, a review was completed with respect to the potential for the Centenary Highway Extension to flood and for Bundamba Creek to break its banks and cross Barrams Road to a point to the east of Bundamba Creek.

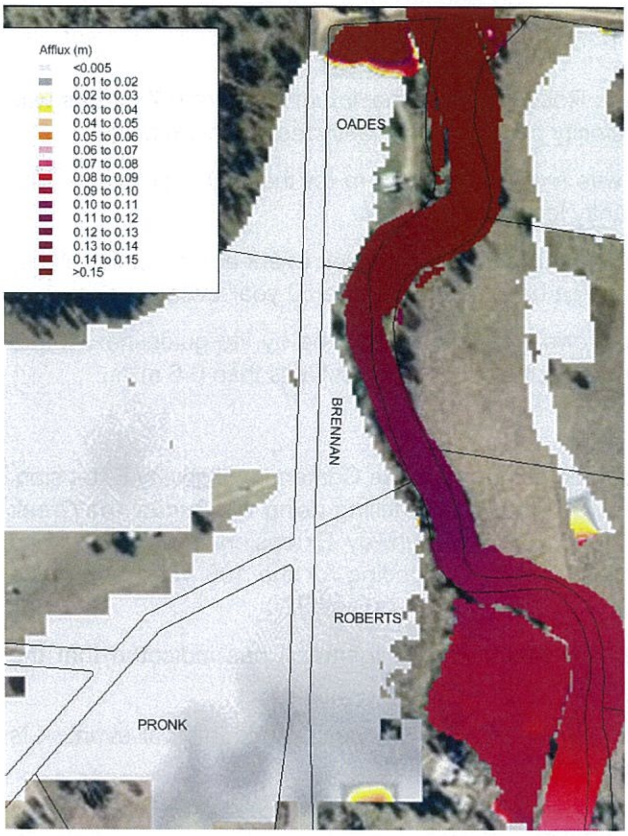
In both cases, it was previously demonstrated that adequate immunity existed with respect to both the Centenary Highway and Barrams Road. As the flood levels calculated for Bundamba Creek using Council's model are lower than those previously calculated with respect to Stage 1, it can be concluded that adequate immunity will continue to exist based on the results presented in the current flood study.

2.3.2 Adjacent Properties

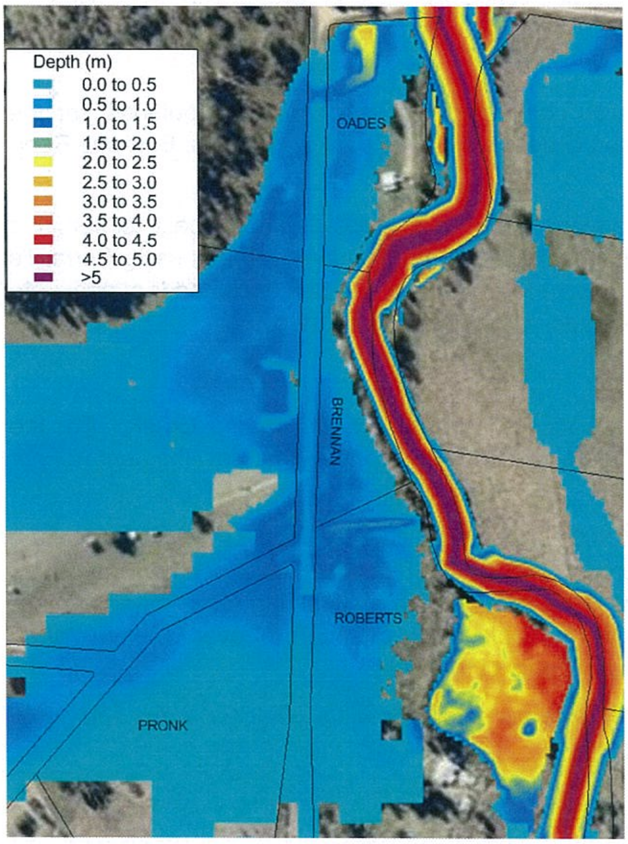
With reference to Figure 1, a number of properties are located adjacent to Bundamba Creek. For the Stage 1 approval, attention was paid to the conditions at each property to confirm that development will not produce an actionable nuisance.

Firstly, an afflux is recorded on the property to the south of Barrams Road owned by Mr Keith Oades. Buildings noted as BLD1 and BLD2 (refer Figure 1) are located on the property. An agreement has been reached with the property owner to accept an increase in level subject to maintaining a minimum 300 mm freeboard to the floor level of his dwelling. With reference to Table 4-9, a freeboard of over 900 mm will be achieved following the works, thereby satisfying the requirements of the owner.

To the south of this property is the Brennan property. The images below show the predicted afflux and depth of flow for the 100 year event in the vicinity of the property.



Afflux in Vicinity of Brennan Land



Peak Water Depths- 100 Year Event in Vicinity of Brennan Land

With respect to the Brennan Land, the main channel of Bundamba Creek extends into the property. As per the previous Stage 1 approval, an increase in flood level is predicted within the main channel of the creek. However, as per the conclusion accepted as part of the previous Stage 1 approval, any increase in the depth of flow in the main channel is considered insignificant with respect to flood level increases as the area in question would not be able to be used for any purpose by the land owner.

On the Roberts property further to the south, the predicted approximate increase in flood level is no greater than 90 mm. However, the existing depth of flow within the property is of the order of 2.5 metres or more for the 100 year event, reflecting the fact that the site forms a significant floodplain area for Bundamba Creek.

Given the above, as per the previous Stage 1 approval, it is therefore concluded that for such an inconsequential change in the depth of flooding, the minor impacts on the existing open space and gardens are not sufficient to produce an actionable nuisance with respect to flooding, particularly given the rural nature of the properties and the intended ultimate land use. In any event, this land is designated future park in Part 15 of the Ipswich City Council Planning Scheme (refer Section 2.3.3) and therefore has no urban development potential.

A similar conclusion is drawn with respect to the land to the north of Barrams Road owned by Francis (refer Section 2.3.3). It is noted that at present there is no building on the land. An afflux is predicted within the Francis land, within an area that already acts as a flow path. As the area currently affected by flooding is identified as future open space and is not presently used, as per the previous Stage 1 approval it is considered that the increase in level is not of significance.

In preparing the previous Stage 1 response, a review was made of recent judgements in relation to court actions that featured flooding issues. The results of the review are repeated below.

While precedent exists with respect to impacts in urban areas, the potential for damage to occur in rural areas is considerably different and less than that associated with urban development. Whilst there are a number of potentially relevant cases, e.g. that of Marshall vs Department of Transport (Land Court 1998, Case A92-77) which involved a claim in relation to the impact of a flood level increase in a non-urban area, the judgements have not been specific in nominating a particular extent of flood level increase in relation to actionable nuisance.

QUDM Section 3.1 outlines that a nuisance occurs where *there has been a substantial or unreasonable interference with another person's use and enjoyment of land. If a person's actions result in the concentration of additional surface water over and above flows that would occur naturally which cause a direct impact to another person's land, liability for nuisance may arise. The impact may be in the form of actual physical injury to land or impairment of the owner's ability to enjoy their land.*

Given that the increase in the depth of flooding is a small fraction of the overall flood depth and is over non-habitable land, it is considered that this does not constitute 'unreasonable interference' and will not result in 'physical injury' or 'impairment'.

Further, available flood damage guidelines such as the Department of Natural Resources and Water (DNRW) publication *Guidance on the Assessment of Tangible Flood Damages* (September 2002) and the CSIRO publication *Floodplain Management in Australia: Best Practice Principles and Guidelines* (SCARM Report 73, 2000) indicate that the impact of flood damage in rural areas is generally much less than in urban areas.

While the DNRW publication provides damage figures for residential and commercial property, for rural and other areas the consideration of flood damage is limited to impacts on roads. The CSIRO publication notes that 'compared to urban flood damage, *the cost of rural flood damage per unit area of affected land is significantly less*', noting that '*in addition to obvious losses, such as crop and stock losses, other types of flood damage suffered by rural enterprises include loss of topsoil and fertiliser, damage to fences and weed infestation*' (p84). The guideline notes that flood damage depends on '*both the type and growth stage of crops, and duration and depth of flooding*'.

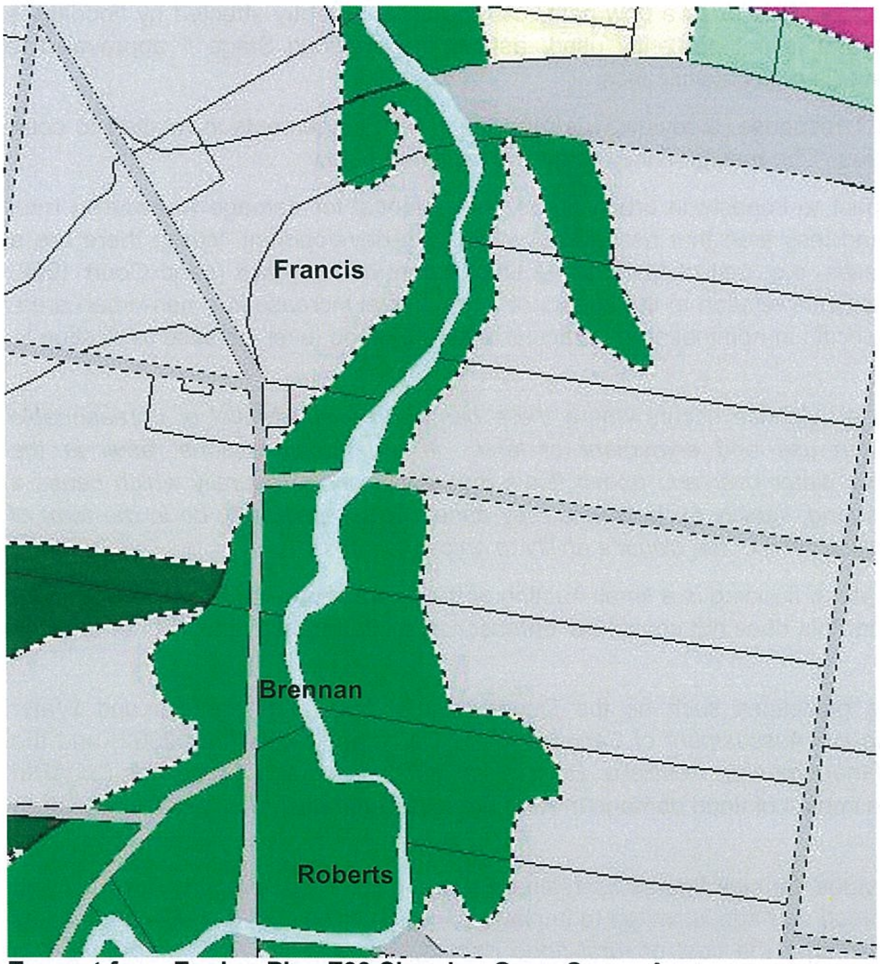
In this case, the area in question is not under cultivation. However, using the elements listed in the CSIRO publication, it is considered that the slight increase in flood depth would not result in any measurable change in the amount of topsoil and fertiliser loss, damage to fences, or weed infestation resulting from flooding. Further, the duration of flooding will essentially not change from that occurring at present. Given this, it is considered that the additional flood impacts resulting from the change in flood level will be negligible, again reinforcing the conclusion that the change in level will not cause an actionable nuisance.

It is considered that this conclusion remains valid for the results obtained from the updated modelling reported in this report.

2.3.3 Development Potential

In addition to the review of flood level impacts, for the previous Stage 1 approval consideration was also given to the potential loss of development potential on lots impacted by any change in flood level.

The Ipswich City Council Planning Scheme Zoning Plan Z33 (excerpt below) indicates that the properties to the south of Barrams Road that are impacted by flooding are designated open space areas. It is therefore considered that in these locations an increase in flood level will not impact upon the development potential of the lots.



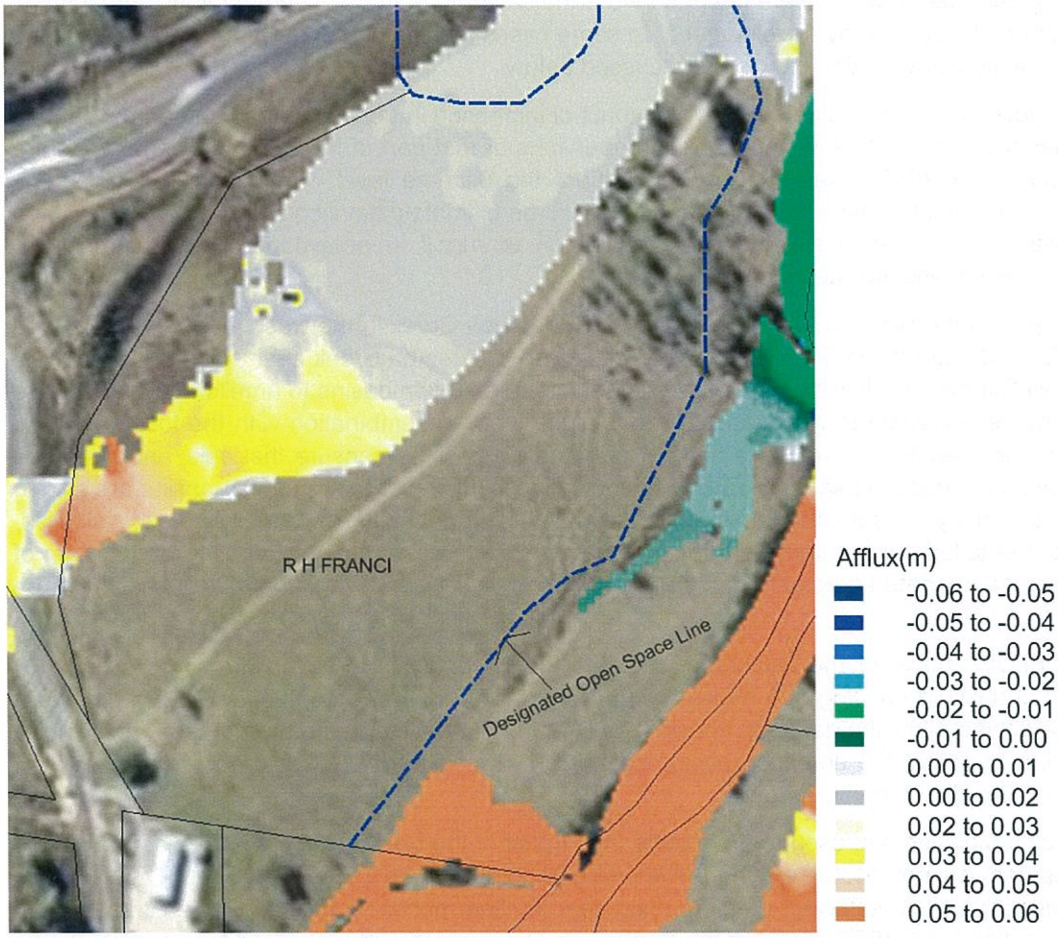
Excerpt from Zoning Plan Z33 Showing Open Space Areas

The open space area to the north of Barrams Road shown on the Francis land only extends partially into the site, with the remainder potentially available for development. The potential impact of the AMEX development upon the development potential of the Francis land is limited to the increase in the extent of inundation within the area otherwise available for development.

For the Stage 1 approval, it was determined that the impact of the AMEX development on the development potential of the site was negligible. Based on the results obtained from the use of the model supplied by Council, an even more certain outcome is obtained. The image below shows the increase in level caused by the AMEX development. Adjacent to Bundamba Creek, the extent of inundation is contained within the open space area next to the creek. Consequently, the AMEX development has no adverse impact whatsoever on the development potential of the site.

It can be noted that the image shows a small increase in level within a flowpath that passes through the northern part of the site. Following a detailed review of the model it was determined that the change in level can be attributed to model stability issues rather than being the result of any impact of development.

Given this, it is considered that the development potential of the Francis land is not adversely impacted by the proposed construction of Barrams Road and the development of SUCE land owned by AMEX.



Afflux at Francis Property

2.3.4 One Year Event

The flood report includes the results of modelling of the 1 year recurrence interval event. It is considered that the impact of development on conditions in Bundamba Creek for the 1 year event (refer Section 4.6) is negligible.

3 Hydrology

3.1 General

A detailed RAFTS model of the Bundamba Creek catchment has been developed and calibrated by consultants KBR. This model, in combination with a calibrated 1D/2D TUFLOW model also prepared by KBR, provides a basis for future floodplain risk management within the catchment.

To demonstrate that the development of the AMEX SUCE site will not produce an unacceptable impact on flooding in Bundamba Creek the calibrated RAFTS model was therefore obtained and subsequently modified to simulate the effects of the proposed development, and to provide hydrographs for use as inputs for flood modelling. The catchment delineation adopted for the RAFTS model is shown on Figure 2. As the model is calibrated, the only parameters which were changed were the catchment areas and impervious percentages for those sub catchments affected by development. In some cases, sub catchments were further subdivided to allow for the simulation of detention basins as discussed below.

In the case of the developed case, to determine the impact of increased impervious areas and earthworks on the timing and magnitude of peak flows, the fraction impervious of that part of the Secondary Urban Centre East to be developed by AMEX was increased to reflect the ultimate level of proposed development. Modelling has assumed that the owners of properties that will be ultimately developed and that drain to land controlled by AMEX will be responsible for the attenuation of runoff in accordance with common law principles relating to actionable nuisance.

In addition to that part of the SUCE that drains directly to Bundamba Creek in the west, a portion of the land controlled by AMEX will drain to the north-east (and ultimately to Bundamba Creek after draining beneath the Centenary Highway Extension). It will be necessary to construct detention basins to ameliorate the increase in runoff caused by development in this area. The fall of the land, in combination with the location of the property boundary, necessitates the use of a number of detention basins to ensure that adjacent properties are not affected by an increase in peak flow rate. The indicative locations of the proposed basins are shown in Figure 5. For the analysis, detention basins located within land controlled by AMEX were considered. However, as part of detailed design, consideration may be given to the use of a single basin downstream of the site provided an appropriate agreement can be reached with the owner of the land that the basin will be sited on.

The hydraulic TUFLOW model of the catchment supplied for the analysis is based on a grid size of 20 metres. A nested grid with a spacing of 4 metres has been provided in the Ripley Valley area to provide a greater level of detail and allow the detailed modelling of development. Due to the existence of the 4 metre grid, it was possible to model the detention basins catering for runoff from the western part of the SUCE development area within the hydraulic model.

However, the detention basins proposed to ameliorate the impact of the runoff from the north-eastern part of the SUCE development are not located within the 4 metre grid portion of the TUFLOW model. The hydraulic model therefore does not have sufficient detail to allow the detailed modelling of the north-eastern basins. Consequently, the calibrated RAFTS model of the Bundamba Creek catchment was used to determine basin sizes and outlet requirements. Outflow hydrographs from the basins were then incorporated into the TUFLOW model to ensure that the combined effect of the detention basins (in terms of timing of peak outflow) and filling associated with the AMEX SUCE development does not produce unacceptable impacts in Bundamba Creek. The extent of inundation produced by flooding in Bundamba Creek and its tributaries was reviewed and it was determined that the basins are located a sufficient distance upslope of the extent of inundation produced by the 100 year event that tailwater conditions in the creek system will not impact on the discharge capacity of the basins. Given the lack of tailwater control on the basins, it was concluded that it was acceptable to size the basins using the hydrologic model and then to input the resultant computed outflow hydrographs to the hydraulic model to allow the combined performance of the basins with respect to flood levels and in particular the rate of rise and time of peak flow to be assessed.

It can be noted that the final location and dimensions (i.e. footprint) of the basins will be determined as part of work completed in support of future development applications with respect to the site. The work completed in support of this report confirms that adequate detention can be provided and the overall area required for detention.

The hydrologic modelling that was undertaken is detailed in the following sections.

3.2 Catchment Parameters

3.2.1 Overall Parameters

Typically, catchment parameters defined in the KBR RAFTS model were adopted. The only changes made were to the proportion of pervious and impervious sub catchments within those catchments affected by the development. In some cases, catchments in the model were further subdivided to allow for more detailed analysis, particularly in the vicinity of detention basins where outlet hydrographs were required. For areas to be developed a fraction impervious of between 70 and 80 percent was adopted depending on the extent of development proposed.

A ridge that passes through the development area results in runoff draining to the west and north-east. The majority of the development drains to the main channel of Bundamba Creek in the west, while the remainder of the catchment drains to a tributary of Bundamba Creek (Little Bundamba Creek) to the north-east of the development.

3.2.2 Western Catchments

The original and modified catchments are shown in Figure 5. The catchment areas that have been modified are listed below in Table 3-1.

Table 3-1 Catchment Areas

Catchment Name	Area (ha)					
	Existing		Stage 1 to 3		Ultimate Case	
	Pervious	Impervious	Pervious	Impervious	Pervious	Impervious
BC16	106.75	3.75	N/A	N/A	92.80	17.70
BC18	208.75	12.25	N/A	N/A	206.67	14.33
BC19	151.75	5.00	N/A	N/A	129.27	27.49
BC26	73.50	11.75	68.48	16.77	60.80	24.50
BC29	73.75	2.00	73.30	2.45	43.70	32.00
BC30	73.25	3.75	66.14	10.86	14.80	62.20

3.2.3 North-Eastern Catchments

The proposed development area is located within two sub catchments of the KBR RAFTS model. In order to determine the impact of the proposed detention basins, it was necessary to further subdivide these sub catchments. The details of the catchment areas and percent impervious are contained in Table 3-2.

It was assumed that developed areas were undeveloped in the existing case. Therefore, only the pervious areas were reduced in size to accommodate the additional sub catchments. It was also assumed that the slope determined for the main sub catchment also applied to its sub catchment. Sub catchments applicable to the proposed development are suffixed with a letter ('a' through 'd').

Table 3-2 Catchment Areas – Existing and Developed Cases

Catchment	Existing				Developed (Ultimate)			
	Pervious Area		Impervious Area		Pervious Area		Impervious Area	
	Area (ha)	Percent Impervious (%)	Area (ha)	Percent Impervious (%)	Area (ha)	Percent Impervious (%)	Area (ha)	Percent Impervious (%)
18	208.75	0	12.25	100	206.15	0	12.25	100
18a					0.52	0	2.08	100
19	151.75	0	5.00	100	119.63	0	5.00	100
19a					1.16	0	2.70	100
19b					1.84	0	4.29	100
19c					5.01	0	11.69	100
19d					1.63	0	3.81	100

3.3 Rainfall and Losses

Rainfall intensities and initial and continuing losses as used by the KBR RAFTS model were adopted.

Therefore, the losses for pervious areas were as follows:

- 100 year ARI - 5 mm initial loss and a 2.5 mm/h continuing loss;
- 50 year ARI - 10 mm initial loss and a 2.5 mm/h continuing loss;
- 20 year ARI - 15 mm initial loss and a 2.5 mm/h continuing loss;
- 10 year ARI - 15 mm initial loss and a 2.5 mm/h continuing loss;
- 5 year ARI - 15 mm initial loss and a 2.5 mm/h continuing loss;
- 2 year ARI - 15 mm initial loss and a 2.5 mm/h continuing loss; and
- 1 year ARI - 15 mm initial loss and a 2.5 mm/h continuing loss.

As for all modelling conducted to date, and in accordance with the calibrated RAFTS model, no losses were applied to impervious areas.

3.4 Detention Basin Sizing- North-Eastern Catchments

It is proposed to provide a detention basin at the downstream end of each of the sub catchments (within land controlled by AMEX) to offset the increase in peak flow caused by development. In order to satisfy no worsening and waterway stability objectives, the detention basins have been designed to ameliorate the increase in discharge for events from the 1 year ARI through to the 100 year ARI.

As noted in Section 3.1, the level of detail in the hydraulic model at each detention basin location is not sufficient to allow the direct modelling of the basins in the hydraulic model. The RAFTS model was therefore used to determine the size of detention storage required and the outlet requirements for each basin. It was assumed for all basins that a batter slope of 1(H):4(V) would be used, and there would be a freeboard of 0.3 metres. The details for each basin are summarised in Table 3-3 below.

Table 3-3 Proposed North-Eastern Detention Basins

Parameter	Basin				
	18a	19a	19b	19c	19d
Storage					
Base Area (m^2)	720	1140	1728	5607	1472
Max depth for 100 year ARI event	1.31	1.29	1.33	1.40	1.34
Flood storage volume at max depth	1358	1964	2936	9264	2583
Outlet					
Pipe	0.018 m^2 orifice	0.031 m^2 orifice	0.049 m^2 orifice	0.040 m^2 orifice	0.040 m^2 orifice
Weir	1.00m wide @ 1.0 m depth	1.7m wide @ 1.02 m depth	1.75m wide @ 0.98 m depth	1.5m wide @ 0.75 m depth	1.2m wide @ 0.95 m depth

Note: Refer to Figure 5 for location of basins

It can be noted that the analysis assumed that the pipe outlet will take the form of an orifice. For subsequent (more detailed) design, it is expected that the orifices will be provided as part of an overall system that will include a grated inlet (to capture debris) and a pipe of sufficient capacity to not govern discharge, with discharge from the site controlled by an orifice plate located at the inlet (downstream of the grate).

Table 3-4 lists the comparison in peak flow discharges calculated with the RAFTS model for both existing and developed (with detention basins) conditions at the outlet point of each basin.

Table 3-4 RAFTS Peak Outflows- North-Eastern Detention Basins

ARI (yr)	Basin 18a		Basin 19a		Basin 19b		Basin 19c		Basin 19d	
	Exist Peak Flow (m^3/s)	Devel Peak Flow (m^3/s)	Exist Peak Flow (m^3/s)	Devel Peak Flow (m^3/s)	Exist Peak Flow (m^3/s)	Devel Peak Flow (m^3/s)	Exist Peak Flow (m^3/s)	Devel Peak Flow (m^3/s)	Exist Peak Flow (m^3/s)	Devel Peak Flow (m^3/s)
100	0.35	0.28	0.52	0.40	0.77	0.63	1.79	1.39	0.69	0.57
50	0.29	0.28	0.42	0.39	0.62	0.62	1.45	1.36	0.56	0.55
20	0.22	0.20	0.31	0.28	0.46	0.45	1.05	1.01	0.41	0.41
10	0.17	0.14	0.24	0.19	0.35	0.33	0.82	0.78	0.32	0.30
5	0.13	0.10	0.19	0.12	0.28	0.24	0.65	0.60	0.25	0.23
2	0.08	0.05	0.12	0.08	0.17	0.12	0.37	0.33	0.16	0.10
1	0.04	0.04	0.06	0.06	0.10	0.10	0.21	0.18	0.09	0.09
Depth for 20 year ARI event										
20		1.20		1.18		1.20		1.18		1.20

The results presented in the above tables indicate that for all events from 1 to 100 years the peak flow rate draining from the developed site is less than that obtained for the existing case, thus demonstrating that the proposed detention basins attenuate the runoff increase derived from the proposed development. It can be noted that the final configuration of the detention basins will be determined as part of detailed design.

To ensure that the combined effect of the detention basins (in terms of timing of peak outflow) and filling associated with the AMEX SUCE development did not produce unacceptable impacts in Bundamba Creek, the hydraulic model supplied by Council was modified to reflect the discharge from the basins. The hydraulic modelling of the development is described in Section 4.

4 Hydraulic Analysis

4.1 General

The calibrated TUFLOW model of Bundamba Creek catchment was used to analyse the proposed development. The changes made to the model to reflect the proposed development are discussed below.

4.2 Inflows

As described in Section 3, the calibrated RAFTS model of the catchment was used to assess the impact of detention basins on the north-eastern side of the development and to derive runoff hydrographs which were subsequently applied to the hydraulic model.

4.3 Roughness Values

The Secondary Urban Centre East will include sportsgrounds, parks and other open space areas. With the exception of the sports grounds, these areas will be mainly grassed with a few trees. Therefore a roughness value of 0.08 was considered to be appropriate for use within basin areas, and 0.035 within sports fields. In areas of Bundamba Creek to be revegetated in association with the SUCE development (refer Section 4.5.1), a value of 0.10 was adopted. For comparative purposes, the calibrated Council model adopted roughness values of 0.08 and 0.05 respectively for the main channel and floodplain of Bundamba Creek.

4.4 TUFLOW Model Scenarios

The calibrated TUFLOW hydraulic model of Bundamba Creek supplied by Council was used to confirm that the development can proceed without causing an unacceptable impact on flood levels. For this relative analysis, a number of scenarios were considered. For these scenarios, only limited modification of the model occurred in order to provide additional detail in the area of interest (all cases) and to reflect the proposed development (with modifications relevant to the development scenario being considered).

Following the completion of the relative analysis, the model was modified to more conservatively represent development external to the SUCE site and the flood response of the catchment. The resultant model was used to calculate flood levels relevant for the specification of minimum development levels across the site.

For the relative analysis of impacts, the following scenarios were modelled.

- **Existing Case**

  This scenario represents the base case flood model in accordance with the KBR flood model.

- **Stages 1 to 3 Scenario**

  This scenario was based on only Stages 1 to 3 fully developed

- **Ultimate Case Scenario**

  This scenario was based on all the stages of SUCE being fully developed, including community greenspace (parks, sportsfields).

For the analysis, the 100, 20, 2, and 1 year ARI events were modelled. In each case, to ensure that the storm duration producing peak conditions at all points in the catchment was modelled, the analysis considered the 2, 3, 4.5 and 6 hour storm durations for each recurrence interval modelled.