Blacktown City Council Qualification

We developed the NWGC Stormwater Management Strategy Review to investigate coordination and rationalisation of stormwater detention across our growth centre area due to it's special location and flooding conditions. Our NWGC is located in the downstream reaches of the Eastern and South Creek Catchments and the majority of flood planning levels are set by Hawkesbury River backwater flooding not local catchment flows. In these special circumstances our strategy is considered appropriate and feasible in managing flood impact, however this approach would not be appropriate in the majority of cases.

Blacktown City Council

NWGC Stormwater Management Strategy Review

February 2018

Executive Summary

GHD was engaged by Blacktown City Council to assess potential rationalisation of the precinct stormwater management strategies for the North West Growth Centres, focussing on potentially reducing the numbers of detention basins, identified as part of individual precinct planning. The potential for this rationalisation was identified from the regional hydrologic conditions in Eastern Creek and South Creek. This considered a comparison of flood peaks in Eastern Creek and South Creek rather than in creek tributaries at the boundary of individual precincts. This identified that removal of basins may possibly be feasible with respect to hydrologic conditions.

Hydrologic modelling was therefore undertaken through collation and updating of existing XP-RAFTS models. The modelling demonstrated that 16 of the approximately 50 basins proposed in individual precinct plans can potentially be removed, and not results in impacts beyond acceptability criteria specifically developed in consultation with Council for this assessment. In some locations compensatory works to manage localised increases in flood peaks were identified.

Cost savings could be anticipated, with a preliminary calculation of the net cost savings of $119,500,000 in construction costs and 56 hectares of land. In addition to these figures, savings in ongoing maintenance could potentially be achieved.

This review should be considered an early-stage investigation indicating whether rationalisation of detention basins is feasible. As part of future stages, further detailed hydrologic/hydraulic assessment should be undertaken along with detailed design of any required compensatory measures.

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Appendices

1. Introduction

1.1 Overview

The North West Growth Centres (NWGC) are priority growth areas in greater Sydney. Over time, some 70,000 new dwellings will be built in the centres for around 200,000 residents. Planning for the NWGC is currently undertaken by the Department of Planning and Environment (DP&E), with the precinct planning completed for seven precincts within the Blacktown Local Government Area (LGA). Blacktown City Council (BCC) is seeking to review the delivery of public infrastructure, including stormwater management facilities to support the planned urban growth.

As part of the overall stormwater management strategy review, GHD was engaged by Blacktown City Council to assess potential rationalisation of the precinct stormwater management strategies, focussing on reducing the numbers of detention basins identified as part of individual precinct planning.

The purpose of this review was to assess the impact on developed conditions flooding hydrographs, discharging from key precincts identified by BCC, under conditions of reduced numbers of detention basins. The review was based entirely on simulating hydrological models (XP-RAFTS). Required compensatory measures (relocated detention basin and additional conveyance channels) were investigated, together with an estimate of potential cost savings using BCC supplied rates and quantities.

This review should be considered an early-stage investigation indicating whether rationalisation of detention basins is feasible. At implementation of each rationalisation (if applicable) further detailed hydrologic/ hydraulic assessment should be undertaken along with detailed design of any required compensatory measures.

1.2 Background

The NWGC is generally located in the lower reaches of the South Creek and Eastern Creek Catchments and the First Ponds Creek Catchment.

South Creek flows in a generally northern direction into the Hawkesbury River near Windsor. South Creek is over 60 kilometres long with its catchment located on the Western Cumberland Plain. The South Creek catchment includes both rural and urban areas. The creek has been impacted over a long period of time by human activity including agricultural, urban, industrial and wastewater activities.

Eastern Creek flows into South Creek, also in a generally northern direction, entering South Creek approximately 3 km to the South of Windsor. Its catchment likewise includes both rural and urban areas and is impacted by historical and current human activities. There are a number of tributaries contributing to Eastern Creek including Bells Creek, which is within the project study area.

To date, provision of detention basins to manage post development flood hydrographs has generally been considered on an individual precinct basis. This study provides the opportunity to assess if rationalisations in numbers of basins are possible, when considering flood hydrographs downstream of the precincts. The locations of the key precincts identified by BCC are shown in Appendix A.

At the time of this review, Watercycle Management Plans have been prepared for the following Precincts:

- Riverstone
- Alex Avenue
- Area 20
- Schofields
- Marsden Park Industrial
- Marsden Park
- Riverstone West

For areas which do not have prepared Watercycle Management Plans, for example Shanes Park, Colebee, Marsden Park North and West Schofields the water management strategy has also been considered by applying a standard volume of detention per developed hectare, as directed by BCC.

1.3 Limitations

This report has been prepared by GHD for Blacktown City Council (BCC) and may only be used and relied on by BCC for the purpose agreed between GHD and BCC as set out in this report.

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

The services undertaken by GHD in connection with preparing this report were limited to those specifically detailed in the report and are subject to the scope limitations set out in the report.

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.

The opinions, conclusions and any recommendations in this report are based on assumptions made by GHD described in this report .GHD disclaims liability arising from any of the assumptions being incorrect.

GHD has prepared this report on the basis of information provided by BCC, which GHD has not independently verified or checked beyond the agreed scope of work. GHD does not accept liability in connection with such unverified information, including errors and omissions in the report which were caused by errors or omissions in that information. Hydrologic models, provided by BCC were used in this review on the basis that they were adequate to inform only the outcomes of this review, and should not be used for any other purpose.

The cost estimates prepared in this report are based on rates and quantities supplied by BCC and are for preliminary decision making purposes only. They should not be relied upon for budgeting, tendering or any other purpose. The accuracy of the cost estimates is anticipated to be appropriate only for providing an indicative order of magnitude cost estimate to indicate the general range of cost savings achievable through the potential rationalisations.

2. Basis for Rationalisation

This section discusses, at a conceptual level, the hydrological basis for rationalisation of detention basin numbers.

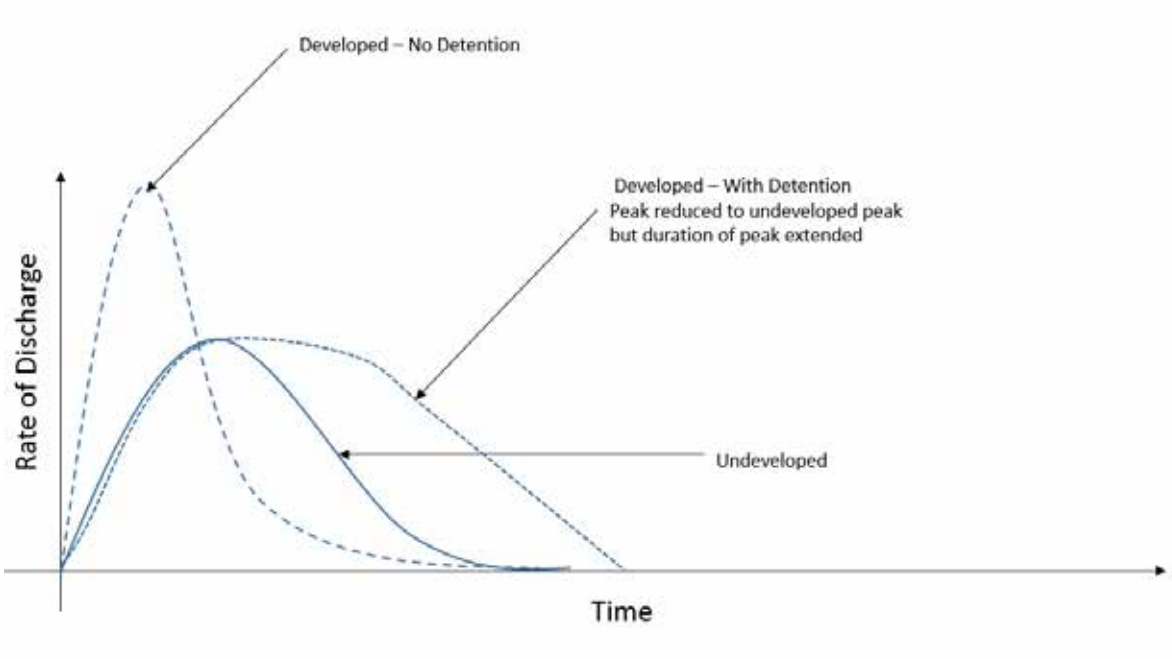
2.1 Typical Detention Strategy

Without the provision of any detention basins the increased imperviousness of a catchment, once developed, would result in both an increase in the volume and flood peak. This in turn has potential to impact on downstream flooding conditions.

Typically, in order to manage this increase in imperviousness, detention basins are provided with the primary aim to manage flood peaks and possibly hydrographs at the outlet of the precincts, to match existing conditions. The detention basins detain the flood hydrographs and release these over a longer time frame in a controlled manner through outlet structures. Figure 2-1 conceptually shows the general nature of hydrographs resulting at the outlet of a precinct for a typical detention strategy.

Generally, due to the individual planning of the NWGC precincts, with Watercycle Management Plans developed independently and at different points in time, the broader impact of multiple precincts could not be considered.

Figure 2-1 Typical Detention Hydrographs



2.2 Broader Impact of Multiple Precincts

When considering multiple precincts under developed conditions, the longer time frame of discharge from detention basins, could occur at the same time downstream (i.e. stacked hydrograph outflows). This in turn has the potential to increase the flow rate in the downstream creeks even though flood peaks from individual precincts have not increased. This concept is conceptually shown on Figure 2-2 and Figure 2-3.

Figure 2-2 Undeveloped Scenario Hydrographs

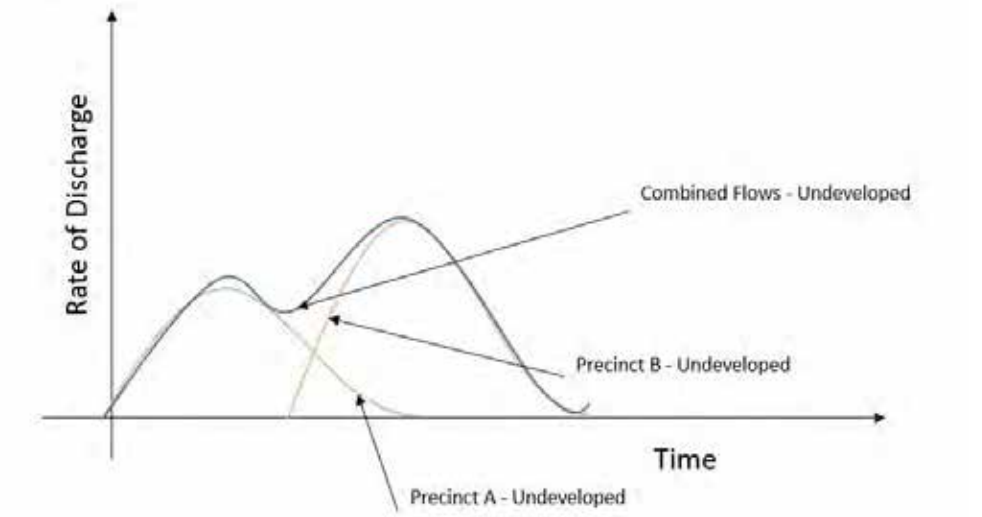
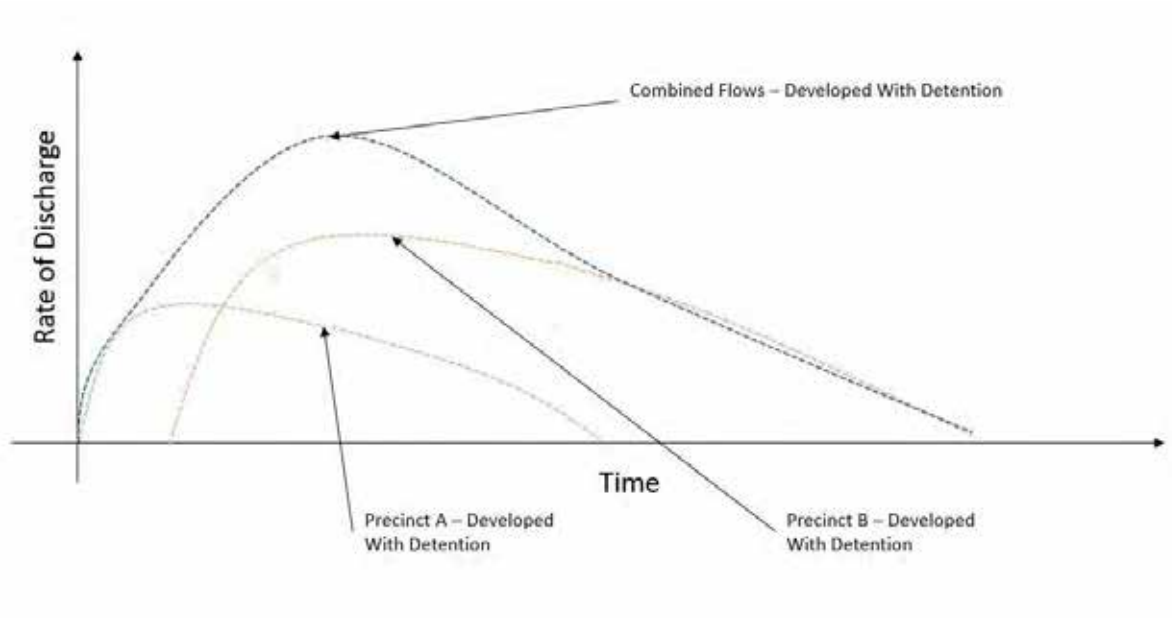


Figure 2-3 Developed Scenario Hydrographs – With Detention



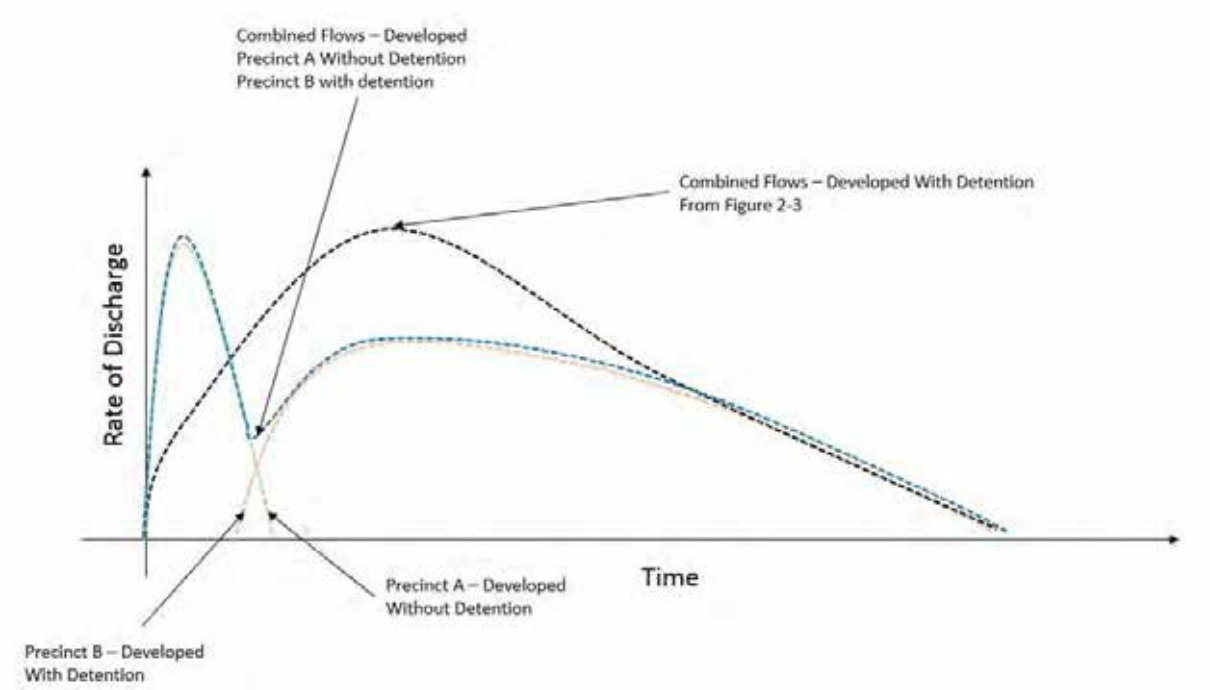
2.3 Potential for Rationalisation of Detention Basins

It is important to note that whilst provision of no detention (or reduced detention) for a precinct will likely result in an increase in flood peaks at the precinct outlet (above existing conditions), the period of elevated flows would be shorter.

Notwithstanding the increased flood peak, the shorter precinct outflow hydrographs under no detention (or reduced detention) may provide a benefit downstream, because flood peaks from different upstream, precincts are less likely to coincide (i.e. stacked hydrograph outflows).

This concept is likely to be more noticeable further downstream in a catchment (such as the NWGC precincts relative to the South Creek catchment) where the early discharge of local flood peaks, before the arrival of flood peaks from further upstream could be beneficial. This concept is demonstrated in Figure 2-4.

Figure 2-4 Rationalisation Hydrographs



2.4 Rationalisation Constraints

There are a number of constraints to reducing basin numbers:

- Water quality treatment is commonly co-located with detention basins which is often cost effective. If the detention basin is removed water quality measures are still required.
- Some basins are already constructed or in the final stages of design. Furthermore, conveyance infrastructure downstream may already be designed/constructed and may not be easily upsized to receive increased flood peaks.
- In some locations provision of drainage conveyance infrastructure (e.g. channels and culverts) may now be required to offset local flood peak increases. There is potential that the cost associated with these works negates the cost benefit from reduced basin numbers.

2.5 Precincts currently without a Detention Strategy

The precincts of Shanes Park, Marsden Park North and West Schofields are currently in the earlier stages of planning and do not have a confirmed Water Cycle Management Plan or detention strategy. For these precincts a standard volume of detention of 455m^3 per developed hectare, as directed by BCC, has been applied.

2.6 Structure of this Review

The general structure of the review is outlined in the following sections of this report:

- **Section 3**: Opportunities for potential basin removal were identified with BCC, based on BCC knowledge of precinct planning and hydrological model outputs.
- **Section 4**: Criteria were developed to assess if impacts of basin removal on downstream creeks are acceptable.
- **Section 5:** A list of scenarios were agreed with BCC, being baseline, no rationalisation, maximum rationalisation, potential rationalisation and cumulative impacts.
- **Section 6**: Hydrological models for the assessments were developed using XP-RAFTS by compiling existing XP-RAFTS models provided by BCC.
- **Section 7:** Compilation and review of results, both with respect to hydrographs and flood peaks and confirmation of the Potential Rationalisation scenario.
- **Sections 8 and 9**: A comparative construction cost estimate was developed using rates and quantities supplied by BCC, to determine the benefit of the basin removal.

3. Rationalisation Opportunities and Constraints

The basins identified for potential rationalisation, based on the identified opportunities and constraints as well as in collaboration with BCC are identified in Figure 3-1 .The figure also includes the areas within the precincts for which a standard rate of detention provision is assumed.

295,000
300,000
6,275,000
6,270,000
6,265,000

RICKABYS
BLACKTOWN ROAD
GEORGE STREET
THE NORTHERN ROAD
KILLARNEY CHAIN OF PONDS
WINDSOR ROAD
WINDSOR ROAD
WINDSOR ROAD
FIRST PONDS
GARFIELD ROAD EAST
SOUTH
MS 1.0
Basin 4
RICHMOND ROAD
Basin 8
MM 1.0
GARFIELD ROAD WEST
EASTERN
Basin A3
MS 2.0
Basin A1
MS 3.0
Basin 2
ML 5.0
SE 1.4
Basin 7A
MB 1.0
SE 4.2
Basin 6B
MM 3.4
Basin 6A
MM 3.1
Basin 7B
MB 2.0
Basin K
M 2.2
SE 6.2
SOUTH ROPES
BELLS
SE 7.1
RICHMOND ROAD
SE 8.1
CARLISLE AVENUE
WESTLINK M7
WESTLINK M7
SE 9.1
BREAKFAST
ROPES

295,000
300,000

- Basin: Potential Rationalisation
- Basin: No Potential Rationalisation
- Standard Detention Strategy: Potential Rationalisation

Paper Size A3
0 195 390 780 1,170 1,560
Metres
Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

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GHD

Blacktown City Council
NWGC Stormwater Management Strategy Review

Identified Feasible Rationalisations

Job Number	21-25478
Revision	A
Date	29 Jan 2018

Figure 3.1

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Data source: Imagery, Roads - NSW LPI, Boundaries - BCC Created by:rgtowner

4. Criteria for assessing Impacts

Basin removal is anticipated to have impacts on the hydrology of downstream creeks, which depending on location and hydrograph timing, does not necessarily need to be a flood peak increase. It could be a reduction in flood peak or have marginal effect.

Criteria were developed with BCC to compare the impacts of basin removal and rationalisation scenarios as follows:

- Within major creeks such as Eastern Creek, South Creek and Bells Creek there should be no changes in flood peaks greater than 3%.
- Within tributary creeks located within precinct boundaries, changes in flood peaks in the order of 10% or less were considered acceptable. It was considered that these flood peak increases could potentially be managed during detailed design of the precincts.

5. Scenario Development

A range of scenarios were agreed with BCC to assess the impact of basins removal. The scenarios were as follows:

- Baseline: The baseline conditions for comparisons, noting that due to the ongoing development, a simple “existing undeveloped” scenario was not feasible and a baseline point in time (advised by BCC) was considered more appropriate. There are no detention basins included in this scenario other than basins within Colebee which BCC noted were already constructed. Figure 5-1 indicates the basins included in this scenario.
- No Rationalisation: The currently proposed water management strategies and detention basins within each of the precincts. Given that this scenario is based on strategies already approved and planned, this scenario also provided for comparison of rationalisations and basin removal. Figure 5-2 shows the basins included in this scenario as well as the areas where standard volume of detention per developed hectare, as directed by BCC, was applied for precincts without a strategy as discussed in Section 2.5.
- Maximum Rationalisation: The no rationalisation scenario, with all detention basins removed where feasible. Figure 5-3 shows the basins removed in this scenario compared to the no rationalisation scenario as well as the areas where standard volume of detention of per developed hectare was not applied for precincts without a current strategy as discussed in Section 2.5. This scenario is considered an intermediate scenario used in the formulation of the potential rationalisation scenario, rather than a final scenario for which results should be analysed in detail.
- Potential Rationalisation: The rationalisation scenario but with some detention basins to generally meet the criteria discussed in Section 4. Figure 5-4 shows the basins required in this strategy which were developed based on the results of the hydrologic modelling.
- Cumulative Impacts: Inclusion of the South West Growth Centre and Western Sydney Employment Areas to understand the impacts on South Creek. Figure 5-5 shows the cumulative precincts included with respect to the location of the NWGC.

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6,275,000 6,270,000 6,265,000

RICKABYS
BLACKTOWN ROAD
GEORGE STREET
THE NORTHERN ROAD
KILLARNEY CHAIN OF PONDS
WINDSOR ROAD WINDSOR ROAD
WINDSOR ROAD
FIRST PONDS
GARFIELD ROAD EAST
SOUTH
RICHMOND ROAD
GARFIELD ROAD WEST
EASTERN
SOUTH ROPES
BELLS
RICHMOND ROAD
CARLISLE AVENUE
WESTLINK M7
WESTLINK M7
BREAKFAST
ROPES

295,000 300,000

- Basin Not Included In Scenario
- Basin Included In Scenario
- Standard Detention Strategy Not Included In Scenario

Paper Size A3

0 195 390 780 1,170 1,560

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

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Blacktown City Council
NWGC Stormwater Management Strategy Review

Baseline Sceanio

Job Number	21-25478
Revision	A
Date	12 Sep 2017

Figure 5.1

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Data source: Data Custodian, Data Set Name/Title, Version/Date. Created by:rgtowner

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BLACKTOWN ROAD
GEORGE STREET
THE NORTHERN ROAD
KILLARNEY CHAIN OF PONDS
WINDSOR ROAD WINDSOR ROAD
WINDSOR ROAD
FIRST PONDS
GARFIELD ROAD EAST
SOUTH
RICHMOND ROAD
GARFIELD ROAD WEST
EASTERN
SOUTH ROPES
BELLS
RICHMOND ROAD
CARLISLE AVENUE
WESTLINK M7
WESTLINK M7
BREAKFAST
ROPES
© Land and Property Information 2015

Basin Not Included In Scenario

Basin Included In Scenario

Standard Detention Strategy Included in Scenario

Paper Size A3

0 195 390 780 1,170 1,560

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

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NWGC Stormwater Management Strategy Review

No Rationalisation Sceanio

Job Number	21-25478
Revision	A
Date	12 Sep 2017

Figure 5.2

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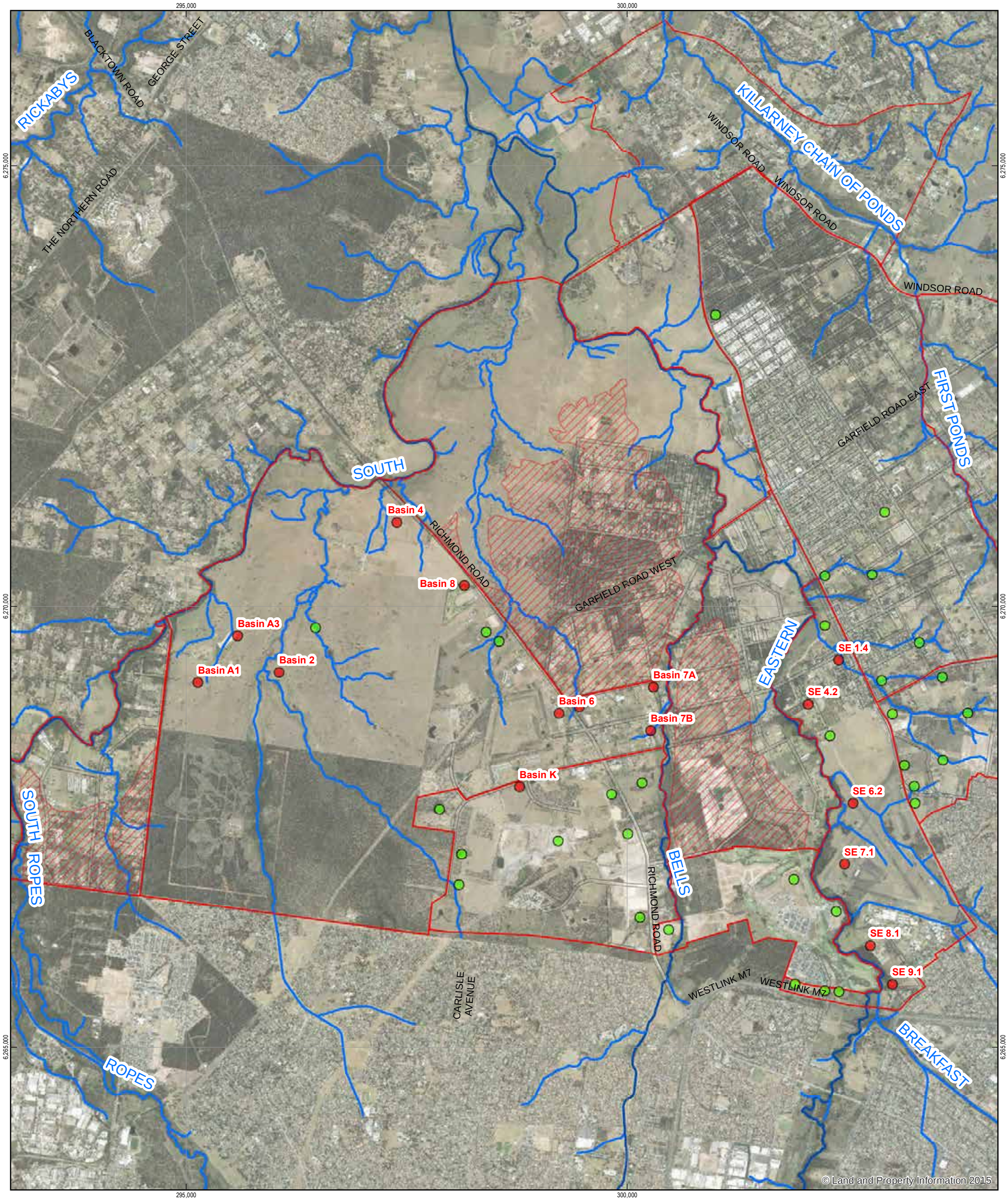

- Basin Not Included in Scenario
- Basin Included in Scenario
- Standard Detention Strategy Not Included In Scenario

Paper Size A3

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Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

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Blacktown City Council
NWGC Stormwater Management Strategy Review

Maximum Rationalisation Sceanio

Job Number	21-25478
Revision	A
Date	12 Sep 2017

Figure 5.3

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Data source: Data Custodian, Data Set Name/Title, Version/Date. Created by:rgtowner

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RICKABYS
BLACKTOWN ROAD
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THE NORTHERN ROAD
KILLARNEY CHAIN OF PONDS
WINDSOR ROAD
WINDSOR ROAD
WINDSOR ROAD
FIRST PONDS
GARFIELD ROAD EAST
SOUTH
RICHMOND ROAD
GARFIELD ROAD WEST
Garfield Rd
West Basin
EASTERN
SOUTH ROPES
BELLS
RICHMOND ROAD
CARLISLE AVENUE
WESTLINK M7
WESTLINK M7
BREAKFAST
ROPES
© Land and Property Information 2015

Basin Not Included in Scenario
Basin Included in Scenario
Standard Detention Strategy Not Included In Scenario

Paper Size A3
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Metres
Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

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Blacktown City Council
NWGC Stormwater Management Strategy Review

Potential Rationalisation Sceanio

Job Number 21-25478
Revision A
Date 12 Sep 2017

Figure 5.4

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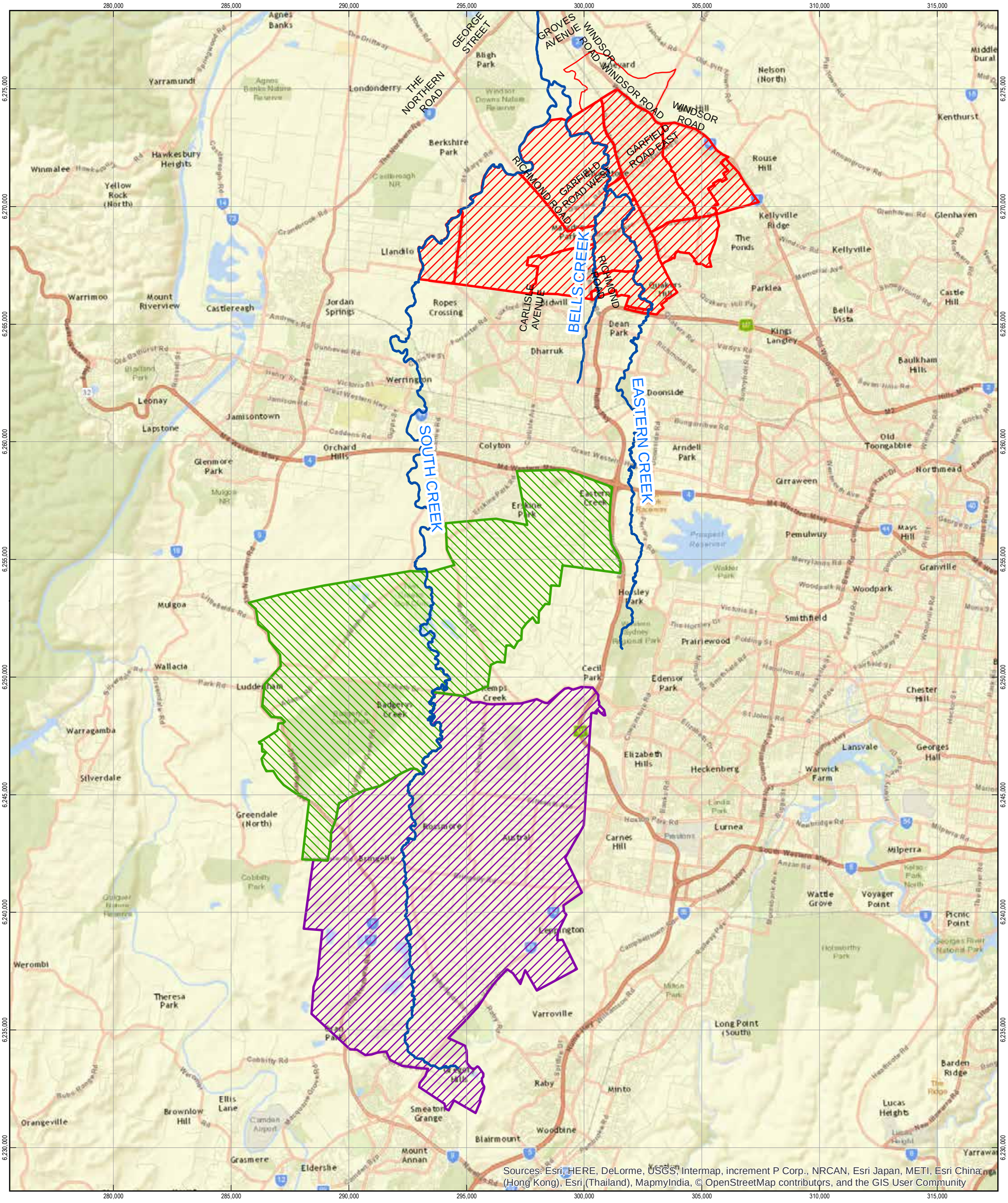

North West Growth Centres

Western Sydney Employment Area

South West Growth Centres

Paper Size A3

0 700 1,400 2,800 4,200 5,600

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

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Blacktown City Council
NWGC Stormwater Management Strategy Review

Cumulative Scenario

Job Number	21-25478
Revision	A
Date	12 Sep 2017

Figure 5.5

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Data source: Data Custodian, Data Set Name/Title, Version/Date. Created by:rgtowner

6. Hydrologic Model Development

6.1 Supplied Models

BCC supplied existing XP-RAFTS hydrologic models which were reviewed and undated in some cases:

- Supplied Model 1: Models simulating the Eastern Creek catchment including both a Baseline model and a No Rationalisation model including the currently proposed NWGC detention strategy. This model (both the Baseline and No Rationalisation version) was originally developed for the assessment documented in *Eastern Creek Hydrological Assessment, Final Report, WMA Water, May 2013*, but was subsequently modified by others with links between catchments represented as a routing node rather than a simple translation node.
- Supplied Model 2: A model simulating South Creek catchment upstream of the NWGC catchments but not including the NWGC or catchments further downstream. This model was developed for the assessment documented in *Updated South Creek Flood Study, Worley Parsons, 30th January 2015 (Worley Parsons, 2015.*
- A number of models developed for assessment of the individual precincts. Of particular relevance to this review are the following:
    - Supplied Model 3: The Marsden Park Residential Precinct model developed for the assessment documented in Post Exhibition Water Cycle and Flood Management Strategy Report (Winten Property Group, July 2013).
    - Supplied Model 4: The Marsden Park Industrial Precinct model developed for the assessment documented in *Water Cycle Management Assessment, GHD 2009.*

6.2 Supplied Model Review

The supplied models were reviewed as follows:

- Supplied Model 1: A comparison of simulated flood peaks and hydrographs and the most applicable WMA Water Report (May 2013) was made. There were differences between the hydrographs and flood peaks, however the magnitude of the differences were considered consistent with the representation of link lagging undertaken in the subsequent modifications to the model. It was noted that the volume and configuration of basins in the developed model differed from some of the modelling undertaken for the individual precinct assessments. However, based on discussion with BCC it is understood that this is because of a more recent representation of the proposed basins in the model.
- Supplied Model 2: A comparison of simulated flood peaks and hydrographs and the most applicable Worley Parsons Report (January 2015) was made. The flood peaks were found to be consistent. It should be noted that two versions of the model were provided by Council. For this assessment the model provided with the suffix of "_36hr" was adopted based on its consistency with previous reporting.
- Supplied Model 3: A comparison of simulated flood peaks and hydrographs and the most applicable Winton Property Report (July 2013) was made. The flood peaks were found to be consistent. However, inspection of the model showed that the developed case for the upstream Marsden Park Industrial Precinct (MPIP) has been included in both the existing and developed scenarios of the Marsden Park Residential Precinct Model. Therefore the model was considered appropriate for this review based on its consistency with previously

reported and accepted results, except for the undeveloped scenario representation of the MPIP which needed to be adjusted for this review.

- Supplied Model 4 was reviewed with comparison of the flood peaks between the model and the most applicable GHD Report (2009). The peak flow rates were found to be consistent.

On the basis of the above discussion, all the models were found to be generally useable for the current review, though some modifications were required and models needed to be combined together. Further information on the review of the supplied models is provided in Appendix C.

6.3 Model Compilation

The supplied models were compiled into the following project models:

- Eastern Creek Project Model
- South Creek Regional Project Model
- South Creek Local Project Model: Which receives inflow hydrographs from both the Eastern Creek Project Model and South Creek Regional Project Model to assess the combined flows in South Creek.

The compilation into project models was due to XP-RAFTS software and supplied model constraints as follows:

- BCC requested that the hydrology of the South Creek system must be assessed to the Richmond Road Bridge, which is downstream of the extent of any of the supplied models.
- Supplied Model 2 has been developed using a “global storm” approach, which differs from the other supplied models. This would make re-simulating a range storm intensities and durations arduous.
- Supplied Model 3 does not represent the undeveloped scenario hydrology of the MPIP area appropriately.

On the basis of the above, the Eastern Creek Project Model was developed based on Supplied Model 1. The South Creek Regional Project Model was developed based on Supplied Model 2, however the downstream extent of the model was trimmed to match the upstream extent of the South Creek Local Model. The South Creek Local Project Model was developed based on:

- Catchment delineation undertaken for this review for catchments downstream of Supplied Model 3.
- Supplied Model 3 for its entire extent, other than for the un-developed representation of the MPIP area.
- Supplied model 4 for the un-developed representation of the MPIP area.

6.4 Standard Detention Volume

The precincts of Shanes Park, Marsden Park North and West Schofields (non-gazetted precincts) are currently in the early stages of planning and do not have a confirmed Water Cycle Management Plan or detention strategy. For these areas a standard volume of detention of 455 m^3 per developed hectare, as directed by BCC has been applied.

BCC advised that this standard volume of detention per developed hectare was estimated using the Upper Parramatta River OSD spreadsheet, a copy of which was provided. This standard volume of detention was only applied to areas in the precincts located above the current 100-year ARI flood extents on the basis that only these areas of the precincts will be developed. Areas below the 100-year ARI extents were not provided with detention and their impervious areas were not increased above the baseline scenario.

The outlet discharge relationship was adjusted iteratively, such that the detention storage modelled during the 100-year ARI event was approximately 455 m^3/ha. The discharge relationship during lower flows was set on the basis of matching the pre and post development flood peaks to the 2- and 100-year ARI flood peak as closely as was practicable.

6.5 Rainfall Parameters

Rainfall was reviewed and adopted as per the supplied models. This rainfall was in accordance with Australian Rainfall and Runoff 1987, since Australian Rainfall and Runoff 2016 had not been accepted at the start of the project and was beyond the scope of the engagement.

The 2-year, 20-year, 50-year and 100-year design rainfall events were simulated. Initially the 2-year and 100-year ARI events were simulated, since the impact of rationalisations are likely to be captured between these two events. Intermediate events were checked subsequently to developing the scenarios.

The impacts of climate change were assessed through increasing the rainfall intensity for the 100-year ARI event by 15%, which is consistent with the climate change sensitivity standard adopted for the North West Growth Centres precinct planning studies.

Review of the models should be considered in the future with relation to inclusion of the most up to date representation of rainfall including Australian Rainfall and Runoff 2016. This should also include consideration of culvert blockages and consideration of all downstream locations.

6.6 Rainfall Loss Parameters

The South Creek Local Project was configured with the ARBM loss method to calculate rainfall losses in model as outlined in the BCC Engineering Guide, Appendix D, Section 10.2: Parameters for Hydrological Models. This method was already used in the Supplied Models 3 and 4.

The South Creek Regional Project Model and Eastern Creek Project Model were both configured with the initial/continuing loss methods. This was on the basis that Provided Models 1 and 2 both utilised this method and it is understood they were reviewed/confirmed during previous assessments.

6.7 Cumulative Impact Scenario Representation

A cumulative impact scenario was developed to allow assessment of the impact of other growth areas such as South West Growth Centre (SWGC) and Western Sydney Employment Area (WSEA) and implications of combining of peak discharges on a broader whole catchment scale. Figure 5-5 indicates the cumulative precincts included with respect to the NWGC.

Hydrologic modelling of the cumulative scenario required adjustment to the South Creek Regional Project model, outputting of resulting hydrographs from the model then inputting them into the South Creek Local Project Model. To create the South Creek Regional Cumulative Project Model, the South Creek Regional Model was adjusted with impervious areas of catchments within the SWGC and WSEA increased accordingly. For these areas a standard volume of detention per developed hectare, as directed by BCC has been applied.

The cumulative upstream catchment conditions were applied when simulating the No Rationalisation and Potential Rationalisation scenarios for the NWGC, but not applied when simulating the Baseline Scenario for the NWGC.

7. Hydrologic Model Results

For the purpose of the review, key results to be extracted from the hydrologic modelling were:

- The impact of the No Rationalisation Scenario, compared to the Baseline Scenario. This allows for assessment of the combined impact of development with detention within the NWGC.
- The impact of the Potential Rationalisation Scenario, compared to the No Rationalisation Scenario. This allows assessment of the acceptability of the potential rationalisations for the criteria, compared to a scenario based on strategies already approved and planned to be implemented.
- The impact for both of the above comparisons, when cumulative development in the SWGC and WSEA is included.

Results of the 2- and 100-year ARI events are documented in figures, whilst results for intermediate events and climate change are presented in tables. Flood peaks are compared at key locations as agreed with BCC (refer Figure 7-1).

Figure 7-2 to Figure 7-6 and Table 7-1 Table 7-2 show the results of the review with key results summarised in the following sections.

295,000 300,000

6,280,000 6,275,000 6,270,000

RICKABYS LONGNECK MCKENZIES KILLARNEY CHAIN OF PONDS SOUTH EASTERN FIRST PONDS ROPES BELLS

C_18 C_17 C_13 C_32 C_14 C_25 C_43 C_16 C_24 C_3 C_2 C_1 C_31 C_15 C_36 C_0 C_30 C_44 C_11 C_35 C_33 C_34 C_5 C_42 C_23 C_19 C_4 C_46 C_12 C_38 C_39 C_41 C_6 C_10 C_37 C_40 C_26 C_29 C_8 C_45 C_20 C_9 C_28 C_7 C_22 C_27 C_21

Figure 7.1.1 Figure 7.1.2 Figure 7.1.3

295,000 300,000

Paper Size A3

0 215 430 860 1,290 1,720

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

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Blacktown City Council
NWGC Stormwater Management Strategy Review

Flow Comparison Locations

Job Number 21-25478
Revision A
Date 29 Jan 2018

Figure 7.1

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Data source: Imagery, Roads - NSW LPI; Boundaries - BCC; Created by:rgtowner

295,000

SECOND ROAD
TENTH ROAD
WILLEROO DRIVE
SOUTH
THIRD ROAD
ST MARYS ROAD
FOURTH ROAD
NINTH ROAD
RICHMOND ROAD
GLENGARRIE ROAD

C_0
C_1
C_2
C_3
C_33
C_34
C_36
C_38
C_39
C_40

6,270,000

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295,000

Paper Size A3
0 55 110 220 330 440
Metres
Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

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Blacktown City Council
NWGC Stormwater Management Strategy Review

Flow Comparison Locations

Inset 1

Job Number	21-25478
Revision	A
Date	29 Jan 2018

Figure 7.1.1

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Data source: Imagery, Roads - NSW LPI; Boundaries - BCC; Created by:rgtowner

300,000

6,270,000

C_30
C_5
C_4
C_42
C_41
C_6
C_8
C_26
C_29
C_28
C_7
C_27

CHARLOTTE STREET
PARK ROAD
LOFTUS STREET
BARTON STREET
GRAINGER STREET
ROBERT STREET
CHARLES STREET
HERBERT STREET
LYNHURST STREET
CORCORAN STREET
KELVEDON LANE
GARFIELD ROAD
JACKSON STREET
ARTHUR STREET
LINCOLN TERRACE
CLIFTON ROAD
TRAFALGAR STREET
KENDALL STREET
ARGYLE STREET
BURFITT ROAD
DROMANA ROAD
FERMOY ROAD
GARFIELD ROAD
VINE STREET
PIUS LANE
GRANGE AVENUE
RICHMOND ROAD
BELLS
SOUTH STREET
GLENGARRIE ROAD
FULTON ROAD
MEADOW ROAD
TOWNSON ROAD
HOLLINSWORTH ROAD

300,000

Paper Size A3

0 55 110 220 330 440

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

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NWGC Stormwater Management Strategy Review

Flow Comparison Locations

Inset 2

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Revision	A
Date	29 Jan 2018

Figure 7.1.2

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Data source: Imagery, Roads - NSW LPI; Boundaries - BCC; Created by:rgtowner

Paper Size A3

0 55 110 220 330 440

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

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Blacktown City Council
NWGC Stormwater Management Strategy Review

Flow Comparison Locations

Inset 3

Job Number	21-25478
Revision	A
Date	29 Jan 2018

Figure 7.1.3

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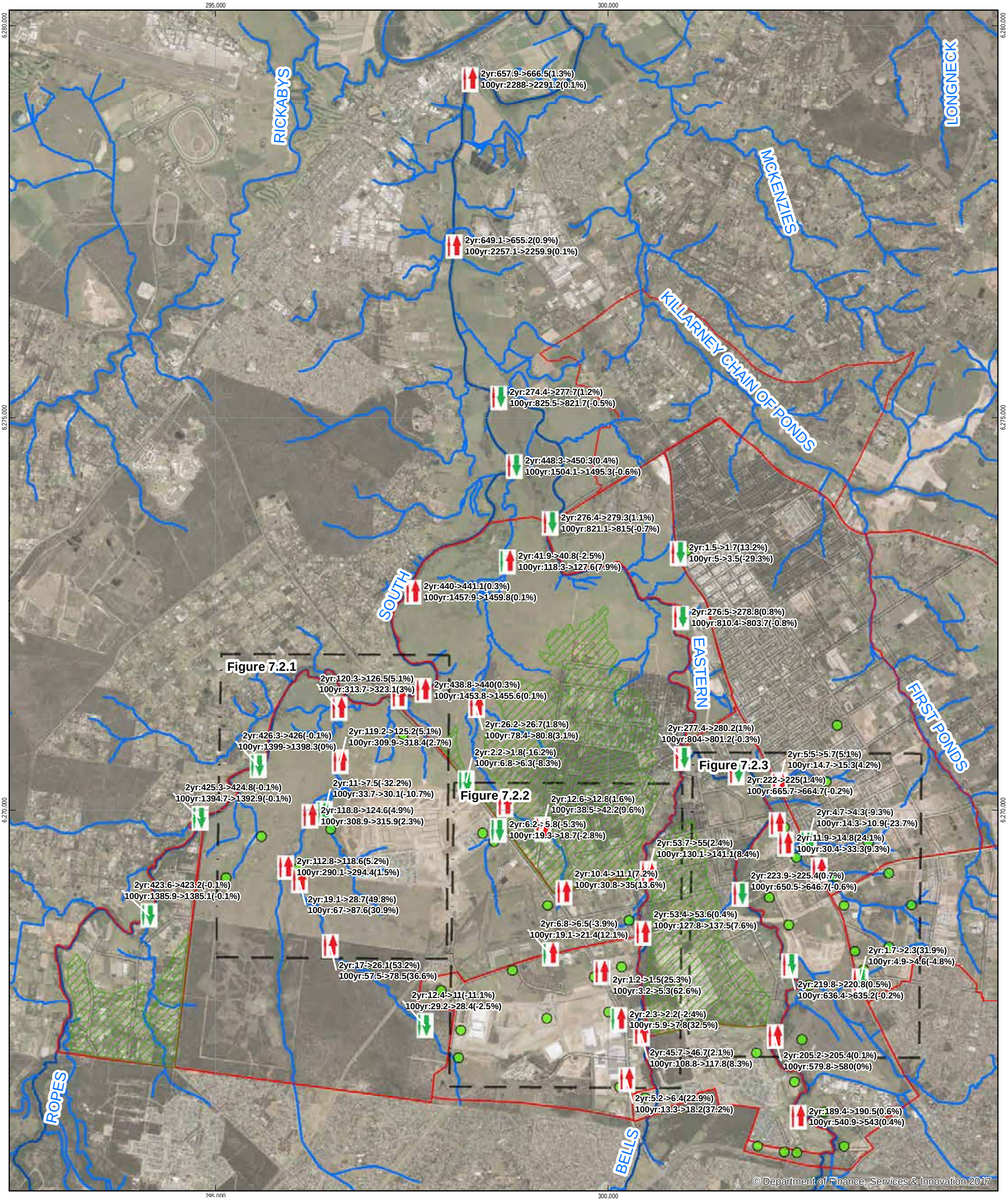
Data source: Imagery, Roads - NSW LPI; Boundaries - BCC; Created by:rgtowner

7.1 No Rationalisation Scenario Compared to Baseline Scenario

The results for the No Rationalisation Scenario compared to the Baseline Scenario showed the following:

- In the major waterways of South Creek and Eastern Creek the currently proposed detention strategy appropriately manages flood peaks to within the criteria developed for this review.
- In some locations increases in flood peaks are predicted, which is likely due to the combination of flows as discussed in Section 2.2. This has not been considered in the development of the strategies to date. These locations include Bells Creek in the vicinity of the Marsden Park, the Marsden Park Industrial Precincts and within the Marsden Park Precinct downstream of the Marsden Park Industrial Precinct.
- Review of the hydrographs demonstrates how development of the catchment, along with provision of detention generally matches flood peaks however increases the rate of rise of the hydrograph at the beginning of the storm. Review of the hydrographs for Comparison Point C6 shows how development of the catchment along with detention alters the critical duration storm for that location on a smaller waterway.
- For the cumulative scenario there are significant impacts associated with the combination of flows for the currently proposed detention strategy, from the North West Growth Centres with the upstream precincts of the SWGC and WSEA. This shows that development of individual precinct detention strategies to date has not considered the broader catchment hydrology.



Indicates Change in 2-year peak flow from baseline

Indicates change in 100-year peak flow from baseline

2yr: a -> b (x %)
100yr: c -> d (y%)

Indicates % change in flow from baseline [positive equals increase]

Indicates the peak flow (m3/s) in the baseline and no rationalisation scenarios respectively

Currently Proposed Strategy

- Basin
- Standard Detention Strategy

Paper Size A3

0 215 430 860 1,290 1,720

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

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NWGC Stormwater Management Strategy Review

Peak Flow Rates: No Rationalisation Scenario Compared to Baseline Scenario

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Date	29 Jan 2018

Figure 7.2

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Data source: Imagery, Roads - NSW LPI; Boundaries - BCC; Created by:rgtowner

295,000

SECOND ROAD
TENTH ROAD
WILLEROO DRIVE
SOUTH
THIRD ROAD
ST MARYS ROAD
FOURTH ROAD
NINTH ROAD
RICHMOND ROAD
GLENGARRIE ROAD

2yr:438.8->440(0.3%)
100yr:1453.8->1455.6(0.1%)

2yr:438->438.7(0.2%)
100yr:1451->1451.4(0%)

2yr:120.3->126.5(5.1%)
100yr:313.7->323.1(3%)

2yr:119.2->125.2(5.1%)
100yr:309.9->318.4(2.7%)

2yr:426.3->426(-0.1%)
100yr:1399->1398.3(0%)

2yr:11->7.5(-32.2%)
100yr:33.7->30.1(-10.7%)

2yr:118.8->124.6(4.9%)
100yr:308.9->315.9(2.3%)

2yr:112.8->118.6(5.2%)
100yr:290.1->294.4(1.5%)

2yr:19.1->28.7(49.8%)
100yr:67->87.6(30.9%)

2yr:17->26.1(53.2%)
100yr:57.5->78.5(36.6%)

6,270,000

295,000

Currently Proposed Strategy

- Basin
- Standard Detention Strategy

Paper Size A3
0 55 110 220 330 440
Metres
Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

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NWGC Stormwater Management Strategy Review

Job Number 21-25478
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Peak Flow Rates: No Rationalisation Scenario Compared to Baseline Scenario
Inset 1

Figure 7.2.1

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Data source: Imagery, Roads - NSW LPI; Boundaries - BCC; Created by:rgtowner

300,000

6,270,000

2yr:2.2->1.8(-16.2%)
100yr:6.8->6.3(-8.3%)

2yr:20.5->20.6(0.5%)
100yr:62.8->64.1(2.1%)

2yr:6.2->5.8(-5.3%)
100yr:19.3->18.7(-2.8%)

2yr:12.6->12.8(1.6%)
100yr:38.5->42.2(9.6%)

2yr:53.7->55(2.4%)
100yr:130.1->141.1(8.4%)

2yr:10.4->11.1(7.2%)
100yr:30.8->35(13.6%)

2yr:53.4->53.6(0.4%)
100yr:127.8->137.5(7.6%)

2yr:6.8->6.5(-3.9%)
100yr:19.1->21.4(12.1%)

2yr:1.2->1.5(25.3%)
100yr:3.2->5.3(62.6%)

2yr:2.3->2.2(-2.4%)
100yr:5.9->7.8(32.5%)

2yr:45.7->46.7(2.1%)
100yr:108.8->117.8(8.3%)

2yr:5.2->6.4(22.9%)
100yr:13.3->18.2(37.2%)

CHARLOTTE STREET
HERBERT STREET
LYNHURST STREET
CHARLES STREET
CORCORAN STREET
PARK ROAD
LOFTUS STREET
BARTON STREET
GRAINGER STREET
ROBERT STREET
KELVEDON LANE
GARFIELD ROAD
JACKSON STREET
ARTHUR STREET
LINCOLN TERRACE
CLIFTON ROAD
TRAFALGAR STREET
KENDALL STREET
ARGYLE STREET
BURFITT ROAD
DROMANA ROAD
FERMOY ROAD
GARFIELD ROAD
VINE STREET
PIUS LANE
GRANGE AVENUE
RICHMOND ROAD
BELLS
SOUTH STREET
GLENGARRIE ROAD
FULTON ROAD
MEADOW ROAD
TOWNSON ROAD
HOLLINSWORTH ROAD

300,000

Currently Proposed Strategy

- Basin
- Standard Detention Strategy

Paper Size A3
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Metres

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Peak Flow Rates: No Rationalisation Scenario Compared to Baseline Scenario
Inset 2

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Figure 7.2.2

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Data source: Imagery, Roads - NSW LPI; Boundaries - BCC; Created by:rgtowner

2yr:277.4->280.2(1%)
100yr:804->801.2(-0.3%)

2yr:222->225(1.4%)
100yr:665.7->664.7(-0.2%)

2yr:5.5->5.7(5.1%)
100yr:14.7->15.3(4.2%)

2yr:13.5->16.4(21.3%)
100yr:33.9->38.1(12.4%)

2yr:11.9->14.8(24.1%)
100yr:30.4->33.3(9.3%)

2yr:6.7->9.7(45%)
100yr:17.3->18.4(6.4%)

2yr:223.9->225.4(0.7%)
100yr:650.5->646.7(-0.6%)

2yr:219.8->220.8(0.5%)
100yr:636.4->635.2(-0.2%)

2yr:1.7->2.3(31.9%)
100yr:4.9->4.6(-4.8%)

2yr:205.2->205.4(0.1%)
100yr:579.8->580(0%)

BELLS
EASTERN
DENMARK ROAD
CREEK STREET
GIG WAY
CARLTON STREET
RIVERSTONE ROAD
BRIGHTON STREET
PICCADILLY STREET
WOLSLEY AVENUE
BLIGH STREET
CRANBOURNE STREET
KENSINGTON PARK ROAD
WEST PARADE
NEVILLE ROAD
WESTMINSTER STREET
CHESTER STREET
LAMBETH ROAD
ST ALBANS ROAD
BOUNDARY ROAD
GORDON ROAD
KENSINGTON PARK ROAD
PRINCES ROAD
CARMAN STREET
SCHOFIELDS FARM ROAD
NELSON STREET
TRAFALGAR STREET
MILTON STREET
ARGYLE STREET
BURFITT ROAD
BLENHEIM ROAD
NORTH STREET
CARNARVON ROAD
GEORGE STREET
WILLIAM STREET
VINE STREET
ELLESMERE AVENUE
ELGIN STREET
OBAN STREET
ROTHWELL LANE
STATION STREET
GILL PLACE
AULD PLACE
JUNCTION ROAD
LEWIS STREET
HUNT STREET
ADVANCE STREET
TAIN PLACE
LANE
EOS GROVE PLACE
RAILWAY TERRACE
SCHOFIELDS ROAD
BRIDGE STREET
GRANGE AVENUE
ARGOWAN ROAD
VERON ROAD
SOUTH STREET
ANGUS ROAD
DURHAM ROAD
KERRY ROAD
JERSEY ROAD
MEADOW ROAD
TOWNSON ROAD
PELICAN ROAD
MADISON PLACE
TONKIN CRESCENT
ALEX AVENUE
BURDEKIN ROAD
CAMILLERI AVENUE
SELDON STREET
REYCROFT AVENUE
GRACELANDS DRIVE
WALPA PLACE
REFALO PLACE
PRISCILLA PLACE
AUDREY PLACE
SONTER STREET
MORRELL CRESCENT
BALI DRIVE
KERSTIN STREET
WALKER STREET
CHATEAU TERRACE
MANSION COURT
MANORHOUSE BOULEVARD
WHITEHAVEN AVENUE
GILBIRD COURT

6,270,000

Currently Proposed Strategy

- Basin
- Standard Detention Strategy

Paper Size A3
0 55 110 220 330 440
Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
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Peak Flow Rates: No Rationalisation Scenario Compared to Baseline Scenario
Inset 3

Figure 7.2.3

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Data source: Imagery, Roads - NSW LPI; Boundaries - BCC; Created by:rgtowner

Table 7-1 Peak Flow Rates (m^3/s): Baseline, No Rationalisation and Potential Rationalisation (All ARIs)

	2-year ARI			20-year ARI			50-year ARI			100-year ARI			100-year ARI + Climate Change		
Location	Baseline	No Rationalisation	Potential Rationalisation	Baseline	No Rationalisation	Potential Rationalisation	Baseline	No Rationalisation	Potential Rationalisation	Baseline	No Rationalisation	Potential Rationalisation	Baseline	No Rationalisation	Potential Rationalisation
C_0	119.2	125.2	125.6	234.3	240.2	240.7	275.6	282.0	282.4	309.9	318.4	318.4	363.0	373.5	372.1
C_1	120.3	126.5	126.9	236.8	243.3	243.7	278.7	286.2	286.4	313.7	323.1	323.2	367.4	379.1	377.7
C_2	438.0	438.7	438.0	1016.0	1016.3	1015.1	1257.3	1258.1	1256.4	1451.0	1451.4	1449.8	1754.7	1755.3	1753.2
C_3	438.8	440.0	439.0	1017.8	1018.9	1017.3	1259.8	1261.8	1259.6	1453.8	1455.6	1453.4	1758.0	1760.7	1757.5
C_4	6.2	5.8	5.8	13.9	12.8	12.8	16.4	15.9	15.9	19.3	18.7	18.7	23.7	25.3	25.1
C_5	20.5	20.6	30.2	47.4	47.1	51.0	53.8	55.0	59.7	62.8	64.1	67.7	76.7	78.1	81.8
C_6	53.7	55.0	54.7	97.9	104.4	104.5	115.0	124.9	124.9	130.1	141.1	140.9	158.4	170.3	170.2
C_7	45.7	46.7	46.7	81.8	88.7	88.7	96.9	104.7	104.7	108.8	117.8	117.8	130.0	140.0	140.0
C_8	53.4	53.6	53.6	96.3	103.1	103.1	113.3	122.9	122.9	127.8	137.5	137.5	155.5	165.8	165.8
C_9	12.4	11.0	11.0	23.0	21.2	21.2	25.6	24.7	24.7	29.2	28.4	28.4	34.7	34.8	34.7
C_10	223.9	225.4	223.0	469.9	471.4	466.9	563.6	564.2	559.2	650.5	646.7	641.6	775.5	771.4	766.0
C_11	5.5	5.7	5.7	10.4	11.2	11.2	12.5	13.4	13.4	14.7	15.3	15.3	18.1	20.6	20.6
C_12	6.7	9.7	9.7	12.7	14.4	14.4	15.0	16.5	16.5	17.3	18.4	18.4	21.1	23.2	23.2
C_13	274.4	277.7	274.9	587.9	591.4	586.6	711.4	711.7	705.5	825.5	821.7	815.5	989.0	983.1	976.5
C_14	276.4	279.3	276.2	589.0	591.0	585.7	707.4	708.9	703.1	821.1	815.0	808.9	984.7	976.8	970.3
C_15	277.4	280.2	276.8	580.9	582.7	577.5	693.5	696.1	690.4	804.0	801.2	795.2	960.2	953.3	946.7
C_16	440.0	441.1	440.2	1020.4	1021.6	1020.0	1263.5	1265.5	1263.4	1457.9	1459.8	1457.6	1762.8	1765.5	1762.4
C_17	649.1	655.2	651.8	1565.1	1572.8	1560.0	1937.9	1944.2	1932.0	2257.1	2259.9	2248.3	2735.0	2732.8	2721.1
C_18	657.9	666.5	660.5	1588.9	1596.9	1584.1	1965.7	1972.3	1960.0	2288.0	2291.2	2279.5	2770.5	2773.4	2764.5
C_19	4.7	4.3	4.3	10.2	8.4	8.4	12.3	9.6	9.6	14.3	10.9	10.9	17.4	13.4	13.4
C_20	1.7	2.3	2.3	3.4	3.9	3.9	4.2	4.2	4.2	4.9	4.6	4.6	5.9	6.0	6.0
C_21	189.4	190.5	190.1	391.1	395.5	394.8	469.2	472.9	472.1	540.9	543.0	542.3	643.9	648.5	648.0
C_22	205.2	205.4	204.9	420.0	421.4	420.6	504.5	506.2	505.6	579.8	580.0	579.6	691.2	694.0	693.6
C_23	13.5	16.4	16.7	25.2	28.8	31.0	29.2	33.5	35.8	33.9	38.1	40.0	41.6	45.5	47.7
C_24	276.5	278.8	275.6	582.8	583.9	578.5	702.6	702.5	696.6	810.4	803.7	797.7	970.8	964.4	958.1
C_25	1.5	1.7	1.7	3.6	2.8	2.8	4.3	3.2	3.2	5.0	3.5	3.5	6.0	4.8	4.8
C_26	6.8	6.5	10.8	14.1	14.6	18.2	16.3	17.6	20.3	19.1	21.4	22.8	23.3	27.6	28.2
C_27	5.2	6.4	6.4	9.5	12.8	12.8	11.5	15.6	15.6	13.3	18.2	18.2	16.4	22.3	22.3
C_28	2.3	2.2	2.2	4.5	5.5	5.5	5.2	6.6	6.6	5.9	7.8	7.8	7.1	11.0	11.0
C_29	1.2	1.5	1.5	2.5	3.7	3.7	2.9	4.5	4.5	3.2	5.3	5.3	3.8	7.1	7.1
C_30	2.2	1.8	8.3	4.7	4.1	14.2	5.9	5.1	15.7	6.8	6.3	17.6	8.4	7.9	20.4
C_31	26.2	26.7	41.1	59.6	59.3	68.5	67.2	69.1	79.3	78.4	80.8	90.3	96.4	97.5	107.9
C_32	448.3	450.3	448.6	1038.6	1040.9	1037.6	1288.6	1293.6	1288.1	1504.1	1495.3	1485.3	1827.7	1820.5	1810.9
C_33	11.0	7.5	7.5	24.3	21.2	21.2	28.9	25.6	25.6	33.7	30.1	30.1	41.6	36.9	36.8
C_34	118.8	124.6	125.0	233.7	238.8	239.3	274.8	280.1	280.6	308.9	315.9	315.9	361.8	370.6	369.1
C_35	425.3	424.8	424.4	981.3	980.0	979.1	1207.2	1205.8	1204.4	1394.7	1392.9	1391.6	1688.1	1685.8	1684.2
C_36	426.3	426.0	425.5	984.1	983.4	982.5	1211.0	1210.6	1209.1	1399.0	1398.3	1396.9	1693.3	1692.2	1690.6
C_37	423.6	423.2	422.9	975.7	975.0	974.2	1199.4	1198.8	1197.4	1385.9	1385.1	1383.7	1677.7	1676.6	1675.0
C_38	112.8	118.6	119.1	220.6	225.1	225.6	258.2	262.2	262.7	290.1	294.4	294.6	338.8	345.1	343.7
C_39	19.1	28.7	30.1	46.4	61.9	64.3	57.6	75.4	77.5	67.0	87.6	89.9	81.4	107.5	109.2
C_40	17.0	26.1	26.1	40.0	56.0	56.0	49.5	67.6	67.6	57.5	78.5	78.5	69.8	96.1	95.7

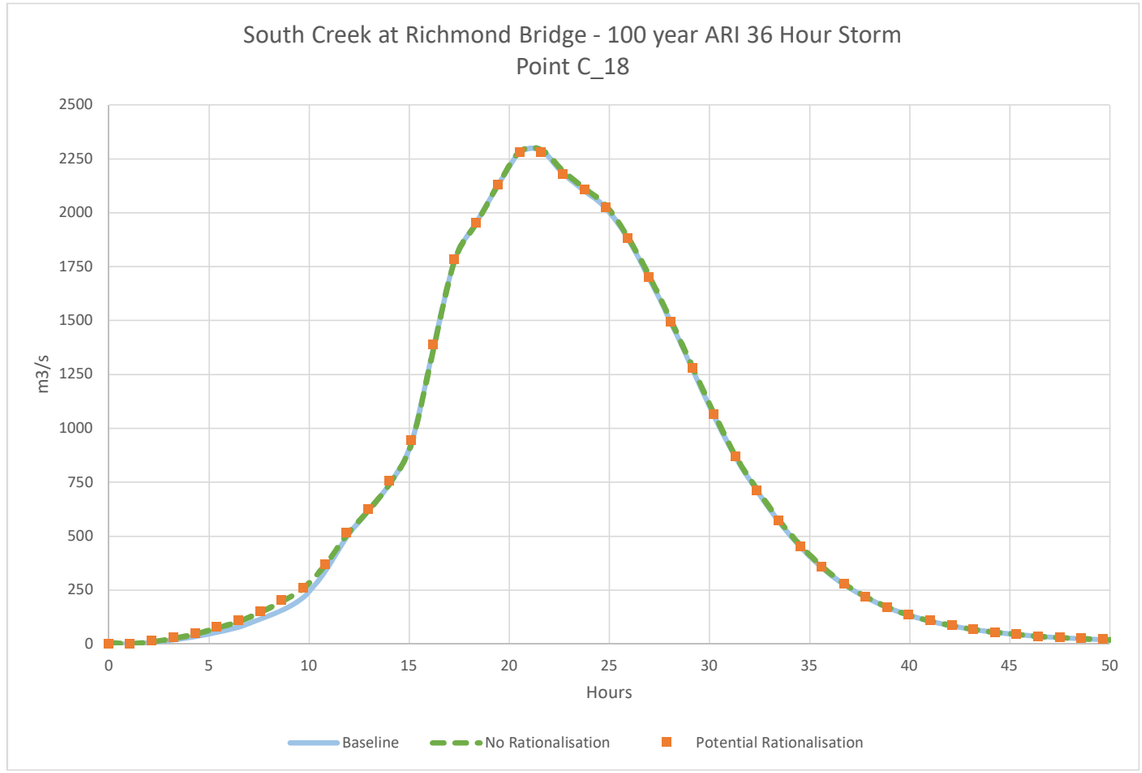
	2-year ARI			20-year ARI			50-year ARI			100-year ARI			100-year ARI + Climate Change		
Location	**Baseline**	**No Rationalisation**	**Potential Rationalisation**	**Baseline**	**No Rationalisation**	**Potential Rationalisation**	**Baseline**	**No Rationalisation**	**Potential Rationalisation**	**Baseline**	**No Rationalisation**	**Potential Rationalisation**	**Baseline**	**No Rationalisation**	**Potential Rationalisation**
C_41	10.4	11.1	22.8	22.4	25.3	38.3	26.0	29.8	42.6	30.8	35.0	47.5	37.6	41.0	54.4
C_42	12.6	12.8	19.6	28.8	30.4	34.6	32.8	35.8	39.4	38.5	42.2	44.8	47.6	49.2	53.3
C_43	41.9	40.8	61.6	93.7	93.3	119.7	105.5	108.9	137.5	118.3	127.6	155.8	142.4	149.0	184.2
C_44	222.0	225.0	222.3	474.5	477.5	472.6	572.7	576.1	570.9	665.7	664.7	659.4	793.2	791.6	785.9
C_45	219.8	220.8	218.7	457.5	460.8	456.4	551.3	553.6	548.7	636.4	635.2	630.2	754.5	754.1	749.0
C_46	11.9	14.8	15.7	22.1	25.4	27.8	26.1	29.6	32.0	30.4	33.3	35.9	37.0	39.4	41.8

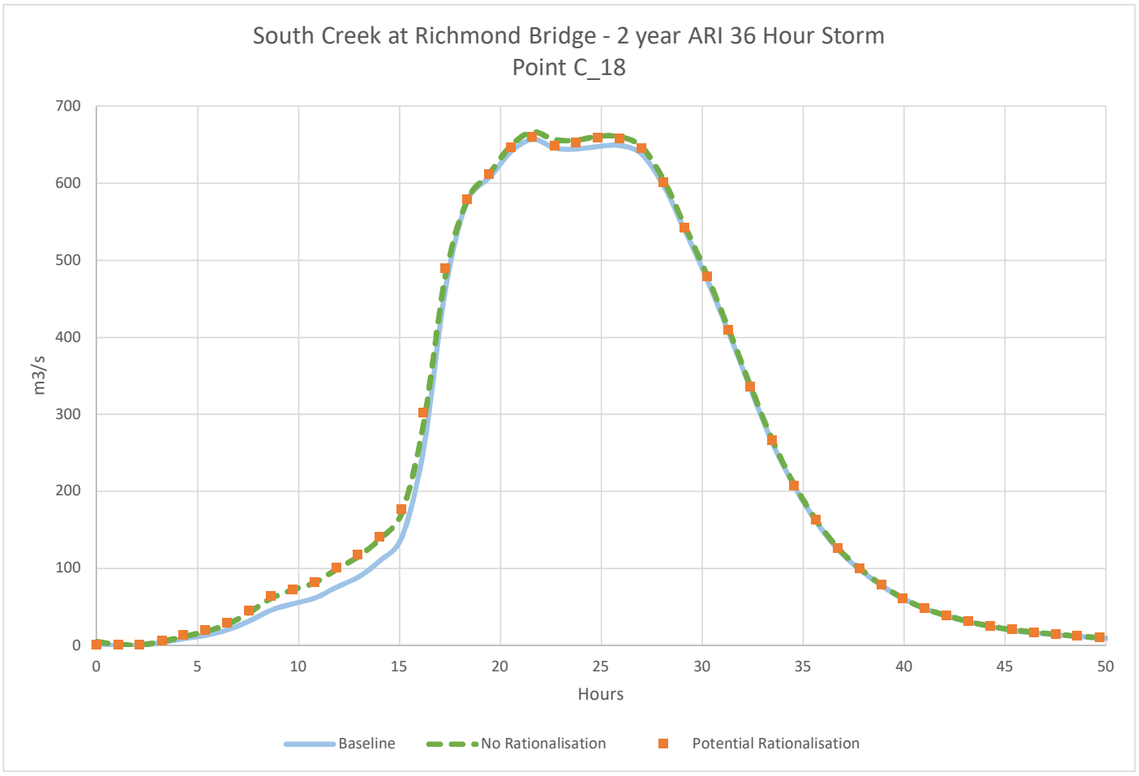
Table 7-2 Critical Storm Durations: Baseline, No Rationalisation and Potential Rationalisation (All ARIs)

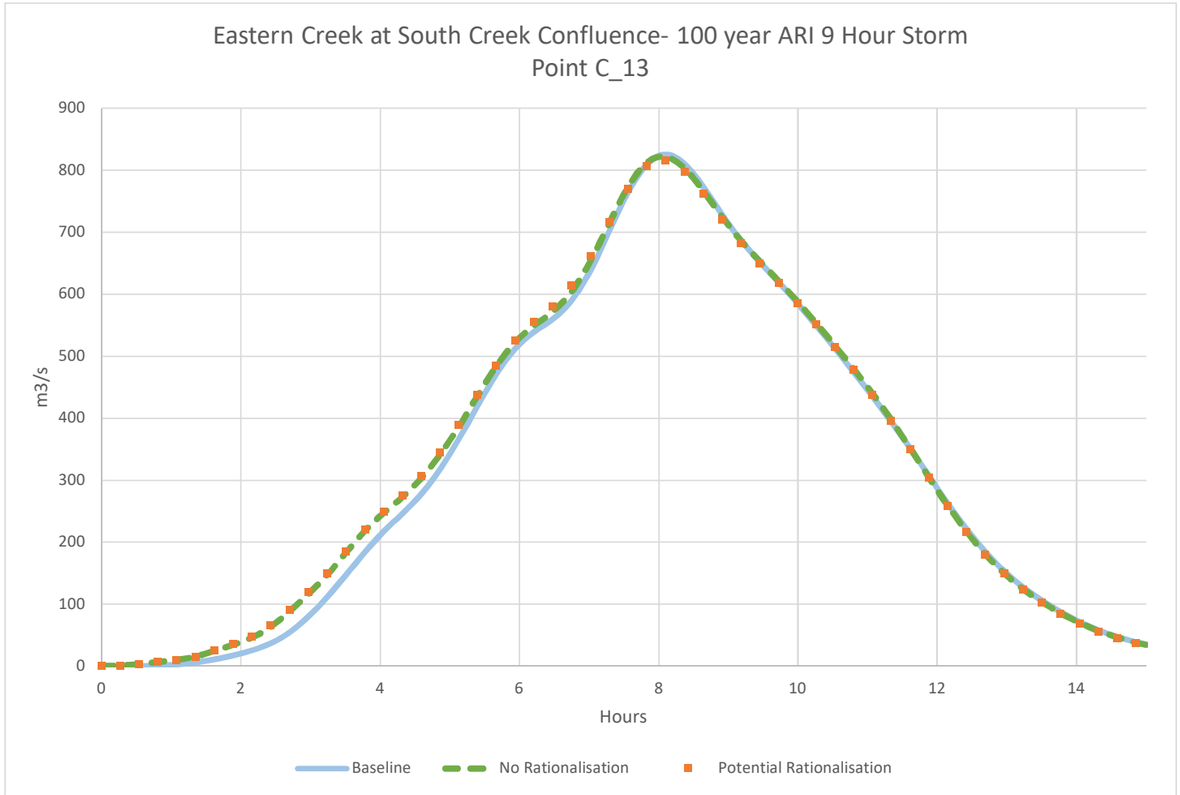
	2-year ARI			20-year ARI			50-year ARI			100-year ARI			100-year ARI + Climate Change		
Location	**Base**	**No Rat**	**Pot Rat**	**Base**	**No Rat**	**Pot Rat**	**Base**	**No Rat**	**Pot Rat**	**Base**	**No Rat**	**Pot Rat**	**Base**	**No Rat**	**Pot Rat**
C_0	2h	2h	2h	2h	2h	2h	2h	2h	2h	2h	2h	2h	2h	2h	2h
C_1	2h	2h	2h	2h	2h	2h	2h	2h	2h	2h	2h	2h	2h	2h	2h
C_2	36h	36h	36h	36h	36h	36h	36h	36h	36h	36h	36h	36h	36h	36h	36h
C_3	36h	36h	36h	36h	36h	36h	36h	36h	36h	36h	36h	36h	36h	36h	36h
C_4	9h	2h	2h	9h	2h	2h	2h	2h	2h	2h	2h	2h	2h	2h	2h
C_5	9h	1.5h	1.5h	9h	9h	2h	2h	2h	2h	2h	4.5h	2h	2h	2h	1.5h
C_6	9h	9h	9h	6h	2h	2h	2h	2h	2h	2h	2h	2h	2h	2h	2h
C_7	9h	9h	9h	2h	2h	2h	2h	2h	2h	2h	2h	2h	2h	2h	2h
C_8	9h	9h	9h	6h	2h	2h	2h	2h	2h	2h	2h	2h	2h	2h	2h
C_9	1.5h	2h	2h	1.5h	2h	2h	1.5h	2h	2h	1.5h	2h	2h	1.5h	2h	2h
C_10	9h	9h	9h	9h	9h	9h	9h	9h	9h	9h	9h	9h	9h	9h	9h
C_11	9h	9h	9h	6h	4.5h	4.5h	2h	4.5h	4.5h	2h	2h	2h	2h	2h	2h
C_12	9h	2h	2h	6h	2h	2h	6h	1.5h	1.5h	6h	1.5h	1.5h	2h	2h	2h
C_13	9h	9h	9h	9h	9h	9h	9h	9h	9h	9h	9h	9h	9h	9h	9h
C_14	9h	9h	9h	9h	9h	9h	9h	9h	9h	9h	9h	9h	9h	9h	9h
C_15	9h	9h	9h	9h	9h	9h	9h	9h	9h	9h	9h	9h	9h	9h	9h
C_16	36h	36h	36h	36h	36h	36h	36h	36h	36h	36h	36h	36h	36h	36h	36h
C_17	48h	48h	36h	36h	36h	36h	36h	36h	36h	36h	36h	36h	36h	36h	36h
C_18	48h	36h	48h	36h	36h	36h	36h	36h	36h	36h	36h	36h	36h	36h	36h
C_19	4.5h	1.5h	1.5h	2h	1.5h	1.5h	2h	1.5h	1.5h	2h	1.5h	1.5h	2h	1.5h	1.5h
C_20	9h	2h	2h	6h	4.5h	4.5h	2h	4.5h	4.5h	2h	4.5h	4.5h	2h	2h	2h
C_21	9h	9h	9h	12h	12h	12h	9h	9h	9h	9h	9h	9h	9h	9h	9h
C_22	9h	9h	9h	9h	9h	9h	9h	9h	9h	9h	9h	9h	9h	9h	9h
C_23	9h	2h	2h	9h	2h	2h	6h	2h	1.5h	2h	2h	2h	2h	1.5h	2h
C_24	9h	9h	9h	9h	9h	9h	9h	9h	9h	9h	9h	9h	9h	9h	9h
C_25	4.5h	2h	2h	2h	9h	9h	2h	9h	9h	2h	9h	9h	2h	2h	2h
C_26	1.5h	9h	2h	1.5h	9h	2h	1.5h	2h	2h	1.5h	2h	2h	1.5h	2h	4.5h
C_27	9h	2h	2h	6h	2h	2h	2h	2h	2h	2h	2h	2h	2h	2h	2h
C_28	9h	36h	36h	9h	9h	9h	9h	2h	2h	9h	2h	2h	6h	2h	2h
C_29	9h	2h	2h	9h	2h	2h	9h	2h	2h	9h	2h	2h	9h	2h	2h
C_30	9h	2h	0.5h	9h	2h	2h	2h	2h	2h	2h	2h	2h	2h	2h	2h
C_31	9h	1.5h	1.5h	9h	9h	4.5h	9h	2h	4.5h	2h	4.5h	4.5h	2h	1.5h	4.5h
C_32	36h	36h	36h	36h	36h	36h	36h	36h	36h	48h	48h	36h	48h	48h	36h
C_33	9h	9h	9h	9h	9h	9h	2h	9h	9h	2h	9h	9h	2h	9h	9h
C_34	2h	2h	2h	2h	2h	2h	2h	2h	2h	2h	2h	2h	2h	2h	2h
C_35	36h	36h	36h	36h	36h	36h	36h	36h	36h	36h	36h	36h	36h	36h	36h
C_36	36h	36h	36h	36h	36h	36h	36h	36h	36h	36h	36h	36h	36h	36h	36h
C_37	36h	36h	36h	36h	36h	36h	36h	36h	36h	36h	36h	36h	36h	36h	36h
C_38	2h	2h	2h	2h	2h	2h	2h	2h	2h	2h	2h	2h	2h	2h	2h
C_39	1.5h	1.5h	1.5h	2h	2h	1.5h	2h	2h	2h	2h	2h	1.5h	2h	2h	1.5h

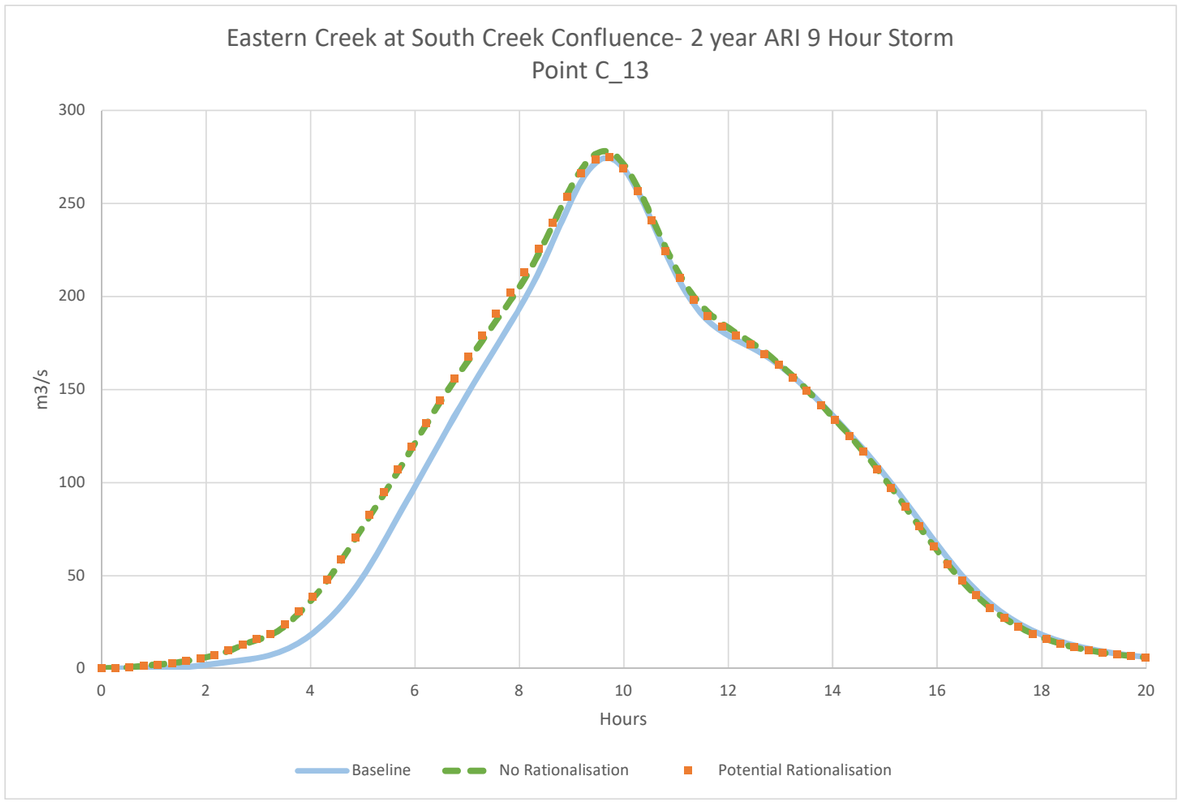
	2-year ARI			20-year ARI			50-year ARI			100-year ARI			100-year ARI + Climate Change		
C_40	1.5h	1.5h	1.5h	2h	2h	2h	2h	2h	2h	2h	2h	2h	2h	2h	2h
C_41	1.5h	9h	0.5h	1.5h	9h	0.5h	1.5h	4.5h	0.5h	1.5h	4.5h	0.5h	1.5h	2h	1.5h
C_42	9h	9h	1.5h	9h	9h	1.5h	2h	4.5h	4.5h	1.5h	4.5h	4.5h	1.5h	6h	4.5h
C_43	9h	9h	1.5h	12h	9h	4.5h	12h	4.5h	4.5h	12h	4.5h	4.5h	1.5h	6h	4.5h
C_44	9h	9h	9h	9h	9h	9h	9h	9h	9h	9h	9h	9h	9h	9h	9h
C_45	9h	9h	9h	9h	9h	9h	9h	9h	9h	9h	9h	9h	9h	9h	9h
C_46	9h	2h	1.5h	6h	1.5h	1.5h	2h	1.5h	1.5h	2h	1.5h	1.5h	2h	1.5h	1.5h

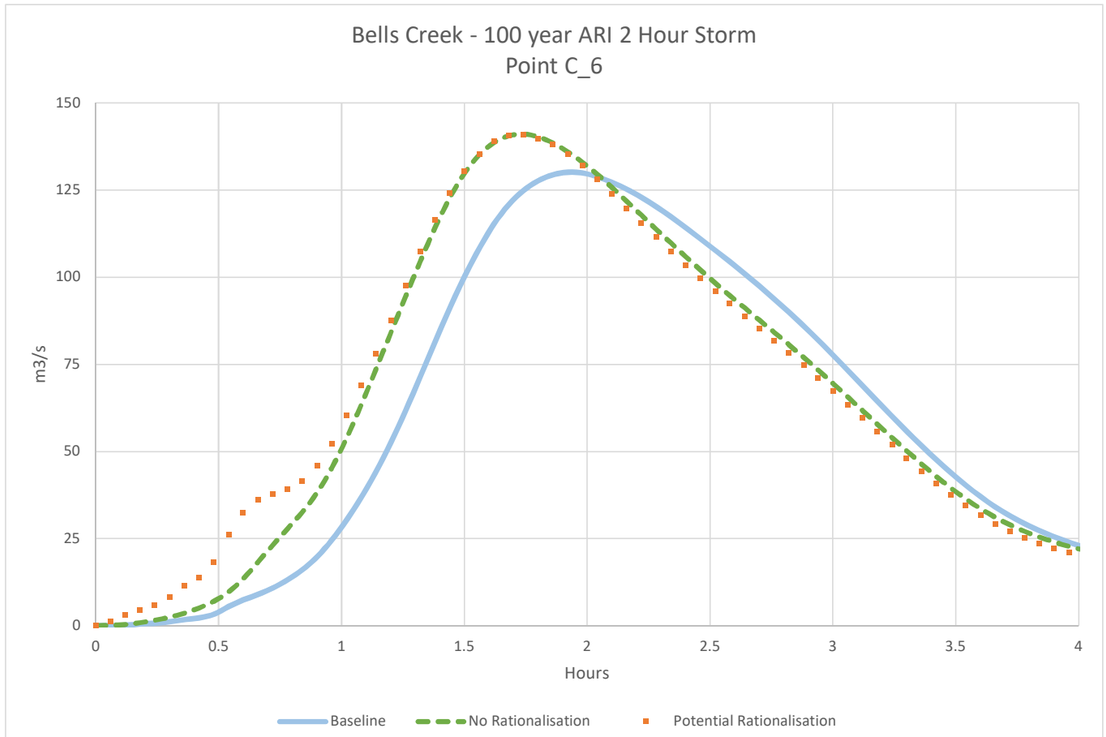
Figure 7-3: Hydrographs

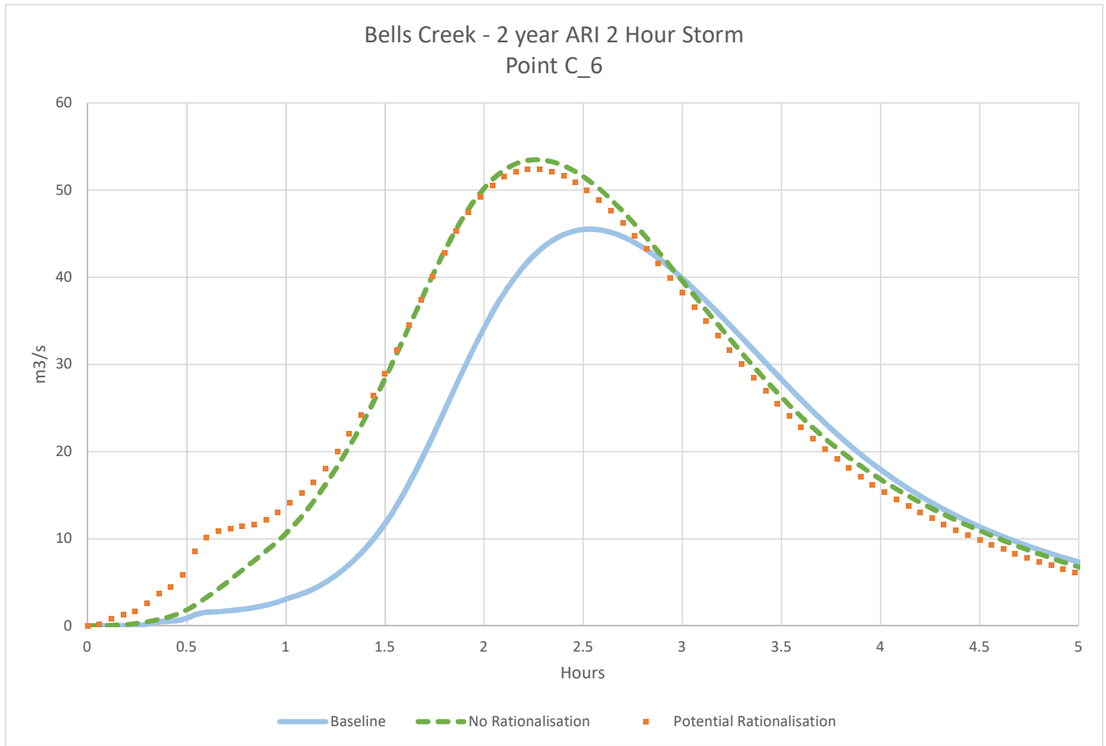





Eastern Creek at South Creek Confluence- 100 year ARI 9 Hour Storm
Point C_13
m3/s
900
800
700
600
500
400
300
200
100
0
0
2
4
6
8
10
12
14
Hours
Baseline
No Rationalisation
Potential Rationalisation


Eastern Creek at South Creek Confluence- 2 year ARI 9 Hour Storm
Point C_13
m3/s
300
250
200
150
100
50
0
0
2
4
6
8
10
12
14
16
18
20
Hours
Baseline
No Rationalisation
Potential Rationalisation


Bells Creek - 100 year ARI 2 Hour Storm
Point C_6
m3/s
Hours
Baseline
No Rationalisation
Potential Rationalisation


Bells Creek - 2 year ARI 2 Hour Storm
Point C_6
m3/s
Hours
Baseline
No Rationalisation
Potential Rationalisation

295,000 300,000

6,280,000 6,275,000 6,270,000

2yr:657.9->777.6(18.2%)
100yr:2288->2411.3(5.4%)

2yr:649.1->763.6(17.6%)
100yr:2257.1->2366.9(4.9%)

2yr:448.3->533.8(19.1%)
100yr:1504.1->1584.5(5.3%)

2yr:440->493.5(12.1%)
100yr:1457.9->1521.1(4.3%)

2yr:438.8->488.1(11.2%)
100yr:1453.8->1513(4.1%)

2yr:438->482.9(10.2%)
100yr:1451->1505.1(3.7%)

2yr:426.3->419.4(-1.6%)
100yr:1399->1408.1(0.7%)

2yr:425.3->415.5(-2.3%)
100yr:1394.7->1400.6(0.4%)

2yr:423.6->411(-3%)
100yr:1385.9->1390.8(0.4%)

RICKABYS
MCKENZIES
LONGNECK
KILLARNEY CHAIN OF PONDS
SOUTH
EASTERN
FIRST PONDS
BELLS
ROPES

295,000 300,000

Indicates Change in 2-year peak flow from baseline

Indicates change in 100-year peak flow from baseline

2yr: a -> b (x %)
100yr: c -> d (y%)

Indicates % change in flow from baseline
[positive equals increase]

Indicates the peak flow (m3/s) in the baseline and no rationalisation scenarios respectively

Currently Proposed Strategy

- Basin
- Standard Detention Strategy

Paper Size A3
0 215 430 860 1,290 1,720
Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

N

GHD

Blacktown City Council
NWGC Stormwater Management Strategy Review

Job Number 21-25478
Revision A
Date 29 Jan 2018

Peak Flow Rates: No Rationalisation Scenario Compared to Baseline Scenario
Cumulative Assessment

Figure 7.4

N:\AU\Coffs Harbour\Projects\21\25478\GIS\Maps\Deliverables\21061028_Flow_Comparison_Locations\20161028_Flow_Comparisons_Figure1.mxd

Data source: Imagery, Roads - NSW LPI; Boundaries - BCC; Created by:rgtowner

7.2 Potential Rationalisation Scenario Compared to No Rationalisation Scenario

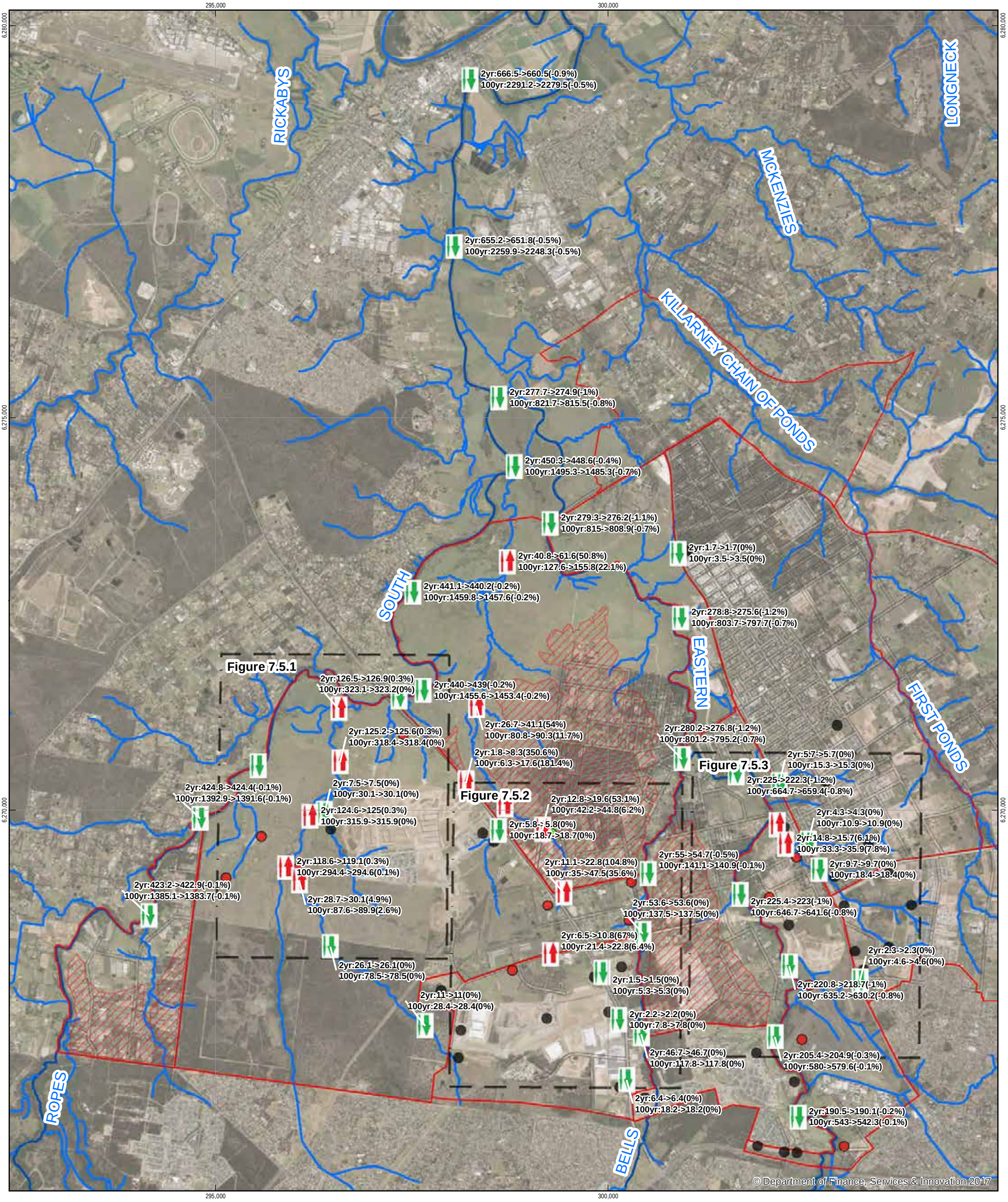
Review of the results for the Potential Rationalisation scenario compared to the No Rationalisation scenario shows that the predicted changes inflood peaks are within the criteria proposed in Section 4 with the exception of the following locations where compensatory works may be required:

- Downstream of currently proposed Basin K/MM 2.2 in Marsden Park Industrial continuing downstream under Richmond Road, Vine Street West and Garfield Road West, then through the Marsden Park North Precinct down to the point of joining South Creek.
- Downstream of currently proposed Basin 2/ML 5.0 in Schofields down to the confluence with Eastern Creek.

As discussed in Section 5 the potential basin at Garfield Road West was included in the Potential Rationalisation Scenario and is therefore a compensatory item required, in addition to those listed above.

Review of the hydrographs shows that these remain generally unchanged in the main creeks. The hydrographs for Comparison Point C6 indicate that in smaller waterways such as Bells Creek the change in flow timing is larger, with the rationalisations increasing the rate of rise of the hydrograph compared to the No Rationalisation Scenario.

Review of the cumulative scenario results shows that any changes predicted are minimal and within the criteria developed for the review. Therefore, it is expected that the potential rationalisations would not worsen and could potentially improve the predicted cumulative impacts resulting from development of the NWGC, SWGC and WSEA.



Indicates Change in 2-year peak flow from No Rationalisation

Indicates change in 100-year peak flow from No Rationalisation

2yr: a -> b (x %)
100yr: c -> d (y%)

Indicates % change in flow from No Rationalisation [positive equals increase]

Indicates the peak flow (m3/s) in the No Rationalisation and Potential Rationalisation scenarios respectively

Potential Rationalisations

- Basin Removed
- Basin Remains
- Basin Added
- Standard Detention Strategy Removed

Paper Size A3

0 215 430 860 1,290 1,720

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

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Revision A
Date 29 Jan 2018

Peak Flow Rates: Potential Rationalisation Scenario Compared to No Rationalisation Scenario

Figure 7.5

N:\AU\Coffs Harbour\Projects\21\25478\GIS\Maps\Deliverables\21061028_Flow_Comparison_Locations\20161028_Flow_Comparisons_Figure1.mxd

Data source: Imagery, Roads - NSW LPI; Boundaries - BCC; Created by:rgtowner

295,000

SECOND ROAD
TENTH ROAD
WILLEROO DRIVE
THIRD ROAD
SOUTH
ST MARYS ROAD
FOURTH ROAD
NINTH ROAD
RICHMOND ROAD
GLENGARRIE ROAD

2yr:440->439(-0.2%)
100yr:1455.6->1453.4(-0.2%)

2yr:438.7->438(-0.2%)
100yr:1451.4->1449.8(-0.1%)

2yr:126.5->126.9(0.3%)
100yr:323.1->323.2(0%)

2yr:125.2->125.6(0.3%)
100yr:318.4->318.4(0%)

2yr:426->425.5(-0.1%)
100yr:1398.3->1396.9(-0.1%)

6,270,000

2yr:7.5->7.5(0%)
100yr:30.1->30.1(0%)

2yr:124.6->125(0.3%)
100yr:315.9->315.9(0%)

2yr:118.6->119.1(0.3%)
100yr:294.4->294.6(0.1%)

2yr:28.7->30.1(4.9%)
100yr:87.6->89.9(2.6%)

2yr:26.1->26.1(0%)
100yr:78.5->78.5(0%)

295,000

Potential Rationalisations

- Basin Removed
- Basin Remains
- Basin Added
- Standard Detention Strategy Removed

Paper Size A3

0 55 110 220 330 440

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

N

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NWGC Stormwater Management Strategy Review

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Revision	A
Date	29 Jan 2018

Peak Flow Rates: Potential Rationalisation Scenario Compared to No Rationalisation Scenario

Inset 1

Figure 7.5.1

N:\AU\Coffs Harbour\Projects\21\25478\GIS\Maps\Deliverables\21061028_Flow_Comparison_Locations\20161028_Flow_Comparisons_Figure1.mxd

Data source: Imagery, Roads - NSW LPI; Boundaries - BCC; Created by:rgtowner

300,000

6,270,000

2yr:1.8->8.3(350.6%)
100yr:6.3->17.6(181.4%)

2yr:20.6->30.2(46.9%)
100yr:64.1->67.7(5.5%)

2yr:5.8->5.8(0%)
100yr:18.7->18.7(0%)

2yr:12.8->19.6(53.1%)
100yr:42.2->44.8(6.2%)

2yr:55->54.7(-0.5%)
100yr:141.1->140.9(-0.1%)

2yr:11.1->22.8(104.8%)
100yr:35->47.5(35.6%)

2yr:53.6->53.6(0%)
100yr:137.5->137.5(0%)

2yr:6.5->10.8(67%)
100yr:21.4->22.8(6.4%)

2yr:1.5->1.5(0%)
100yr:5.3->5.3(0%)

2yr:2.2->2.2(0%)
100yr:7.8->7.8(0%)

2yr:46.7->46.7(0%)
100yr:117.8->117.8(0%)

2yr:6.4->6.4(0%)
100yr:18.2->18.2(0%)

CHARLOTTE STREET
HERBERT STREET
LYNHURST STREET
PARK ROAD
LOFTUS STREET
BARTON STREET
GRAINGER STREET
ROBERT STREET
CHARLES STREET
KELVEDON LANE
CORCORAN STREET
GARFIELD ROAD
JACKSON STREET
ARTHUR STREET
LINCOLN TERRACE
CLIFTON ROAD
TRAFALGAR STREET
KENDALL STREET
ARGYLE STREET
BURFITT ROAD
DROMANA ROAD
FERMOY ROAD
GARFIELD ROAD
VINE STREET
PIUS LANE
GRANGE AVENUE
RICHMOND ROAD
SOUTH STREET
GLENGARRIE ROAD
FULTON ROAD
BELLS
MEADOW ROAD
TOWNSON ROAD
HOLLINSWORTH ROAD

300,000

Potential Rationalisations

- Basin Removed
- Basin Remains
- Basin Added
- Standard Detention Strategy Removed

Paper Size A3
0 55 110 220 330 440
Metres
Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

N

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Blacktown City Council
NWGC Stormwater Management Strategy Review

Job Number 21-25478
Revision A
Date 29 Jan 2018

Peak Flow Rates: Potential Rationalisation Scenario Compared to No Rationalisation Scenario
Inset 2

Figure 7.5.2

N:\AU\Coffs Harbour\Projects\21\25478\GIS\Maps\Deliverables\21061028_Flow_Comparison_Locations\20161028_Flow_Comparisons_Figure1.mxd

Data source: Imagery, Roads - NSW LPI; Boundaries - BCC; Created by:rgtowner

2yr:280.2->276.8(-1.2%)
100yr:801.2->795.2(-0.7%)

2yr:225->222.3(-1.2%)
100yr:664.7->659.4(-0.8%)

2yr:5.7->5.7(0%)
100yr:15.3->15.3(0%)

2yr:16.4->16.7(1.8%)
100yr:38.1->40(4.9%)

2yr:14.8->15.7(6.1%)
100yr:33.3->35.9(7.8%)

2yr:9.7->9.7(0%)
100yr:18.4->18.4(0%)

2yr:225.4->223(-1%)
100yr:646.7->641.6(-0.8%)

2yr:220.8->218.7(-1%)
100yr:635.2->630.2(-0.8%)

2yr:2.3->2.3(0%)
100yr:4.6->4.6(0%)

2yr:205.4->204.9(-0.3%)
100yr:580->579.6(-0.1%)

BELLS
EASTERN
CREEK
DENMARK ROAD
GIG WAY
CARLTON STREET
RIVERSTONE ROAD
BRIGHTON STREET
PICCADILLY STREET
WOLSLEY AVENUE
BLIGH STREET
CRANBOURNE STREET
KENSINGTON PARK ROAD
WEST PARADE
NEVILLE ROAD
WESTMINSTER STREET
CHESTER STREET
LAMBETH ROAD
ST ALBANS ROAD
BOUNDARY ROAD
GORDON ROAD
KENSINGTON PARK ROAD
PRINCES ROAD
CARMAN STREET
SCHOFIELDS FARM ROAD
NELSON STREET
TRAFALGAR STREET
MILTON STREET
ARGYLE STREET
BURFITT ROAD
BLENHEIM ROAD
NORTH STREET
CARNARVON ROAD
GEORGE STREET
WILLIAM STREET
VINE STREET
ELLESMERE AVENUE
ROTHWELL LANE
STATION STREET
GILL PLACE
AULD PLACE
JUNCTION ROAD
LEWIS STREET
HUNT STREET
ADVANCE STREET
ELGIN STREET
OBAN STREET
TAIN PLACE
LANE
EOS GROVE PLACE
BRIDGE STREET
RAILWAY TERRACE
SCHOFIELDS ROAD
GRANGE AVENUE
ARGOWAN ROAD
VERON ROAD
SOUTH STREET
ANGUS ROAD
KERRY ROAD
DURHAM ROAD
JERSEY ROAD
MEADOW ROAD
TOWNSON ROAD
PELICAN ROAD
ALEX AVENUE
MADISON PLACE
TONKIN CRESCENT
BURDEKIN ROAD
BURDEKIN ROAD
CAMILLERI AVENUE
GRACELANDS DRIVE
SELDON STREET
REYCROFT AVENUE
WALPA PLACE
REFALO PLACE
PRISCILLA PLACE
AUDREY PLACE
SONTER STREET
MORRELL CRESCENT
BALI DRIVE
KERSTIN STREET
WALKER STREET
CHATEAU TERRACE
MANSION COURT
WHITEHAVEN AVENUE
MANORHOUSE BOULEVARD
6,270,000

Potential Rationalisations

- Basin Removed
- Basin Remains
- Basin Added
- Standard Detention Strategy Removed

Paper Size A3
0 55 110 220 330 440
Metres
Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

N

GHD

Blacktown City Council
NWGC Stormwater Management Strategy Review

Job Number 21-25478
Revision A
Date 29 Jan 2018

Peak Flow Rates: Potential Rationalisation Scenario Compared to No Rationalisation Scenario
Inset 3

Figure 7.5.3

N:\AU\Coffs Harbour\Projects\21\25478\GIS\Maps\Deliverables\21061028_Flow_Comparison_Locations\20161028_Flow_Comparisons_Figure1.mxd

Data source: Imagery, Roads - NSW LPI; Boundaries - BCC; Created by:rgtowner

295,000 300,000

6,280,000 6,275,000 6,270,000

2yr:777.6->770.5(-0.9%)
100yr:2411.3->2406.1(-0.2%)

2yr:763.6->756.4(-0.9%)
100yr:2366.9->2361.6(-0.2%)

2yr:533.8->525.9(-1.5%)
100yr:1584.5->1580.4(-0.3%)

2yr:493.5->490.2(-0.7%)
100yr:1521.1->1517(-0.3%)

2yr:488.1->484.9(-0.7%)
100yr:1513->1508.9(-0.3%)

2yr:482.9->481(-0.4%)
100yr:1505.1->1502.4(-0.2%)

2yr:419.4->417.3(-0.5%)
100yr:1408.1->1405.2(-0.2%)

2yr:415.5->413.7(-0.4%)
100yr:1400.6->1398.2(-0.2%)

2yr:411->409.2(-0.4%)
100yr:1390.8->1388.4(-0.2%)

RICKABYS
MCKENZIES
LONGNECK
KILLARNEY CHAIN OF PONDS
SOUTH
EASTERN
FIRST PONDS
BELLS
ROPES

295,000 300,000

Indicates Change in 2-year peak flow from No Rationalisation

Indicates change in 100-year peak flow from No Rationalisation

2yr: a -> b (x %)
100yr: c -> d (y%)

Indicates % change in flow from No Rationalisation [positive equals increase]

Indicates the peak flow (m3/s) in the No Rationalisation and Potential Rationalisation scenarios respectively

Potential Rationalisations

- Basin Removed
- Basin Remains
- Basin Added
- Standard Detention Strategy Removed

Paper Size A3

0 215 430 860 1,290 1,720

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

N

GHD

Blacktown City Council
NWGC Stormwater Management Strategy Review

Job Number	21-25478
Revision	A
Date	29 Jan 2018

Peak Flow Rates: Potential Rationalisation Scenario Compared to No Rationalisation Scenario
Cumulative Assessment

Figure 7.6

N:\AU\Coffs Harbour\Projects\21\25478\GIS\Maps\Deliverables\21061028_Flow_Comparison_Locations\20161028_Flow_Comparisons_Figure1.mxd

Data source: Imagery, Roads - NSW LPI; Boundaries - BCC; Created by:rgtowner

8. Conceptual Designs

Concept designs were developed for compensatory works identified, to provide an order of magnitude costing. The concept designs were preliminary in nature and for the purpose of high level cost estimation and may be subject to change/optimisation in the future.

The compensatory works required were classified into three different categories and concept designs undertaken as follows:

- The Garfield Road West Basin included in the Potential Rationalisation Scenario. This basin was concept designed and is shown on Sketch 005 of Appendix A.
- Open channels conveying flows through the regional floodplain. In a number of locations where basins were removed on the edge of the floodplain, flood peaks after rationalisation are predicted to increase downstream. In these locations a drainage channel would potentially be required. Based on discussion with BCC channels were concept designed in these locations to convey the 2-year ARI event as shown on Sketches 001 and 002 of Appendix A. Costing of these channels was based on a per metre length rate applied to all of the required channels under this category (refer Section 9).
- Open channels conveying flows outside of the regional floodplain. Where basin removal increased flood peaks in areas where channels were proposed under the precinct plans, channel upsizing may be required. A sample channel was concept designed, for both the pre and post rationalisation flows, as indicated on Sketches 003 and 004 of Appendix A, Costing of these channels was based on a per metre length rate for the upsizing applied to all of the required channels under this category (refer Section 9).

All concept designs were developed using the 12D software, the results of the hydrologic modelling and the following key design parameters compiled in discussion with BCC:

- Maximum batter slope of 1 vertical to 6 horizontal
- Target channel longitudinal grade: 0.5 %
- Channel Manning's n: 0.085
- Channel maximum shear stress 40 N/m^2 such that an appropriate channel lining material can be provided
- 5 metre wide access track on one side

9. Comparative Construction Costs

A comparative construction cost estimate was developed to assess the potential benefits, if any, of the proposed basin removal. The cost estimate calculations are provided in Appendix B. In undertaking the costings, unit rates, contingencies, allowances and quantities were supplied by BCC. All costs are excluding GST and do not allow for future price fluctuations subsequent to the dates that the provided costing rates applied

It should be noted that cost savings could only be directly calculated for gazetted precincts as watercycle management plans and Section 94 costing has not been undertaken for the non-gazetted precincts. Therefore, the cost savings calculated for the basin removals within the gazetted precincts were extrapolated over the non-gazetted precincts.

The following sections detail the calculation of cost savings and their subsequent extrapolation.

9.1 Gazetted Precincts

9.1.1 Cost Savings of Basin Removals

Figure 5-3 and Figure 5-4 shows the basins removed under the Potential Rationalisation scenario. The cost saving was calculated as follows:

- The cost savings for removal of the basins was calculated, other than for SE 4.2, SE 8.1 and SE 9.1, on the basis of advice from BCC.
- For each of the removed basins the schedule of quantities and rates were extracted from the Section 94 contributions plans (provided by BCC). This was undertaken for each costed item (e.g. cut to fill, provide culvert, provide bio-retention).
- Each line item in the extracted costing calculations was separated into categories as follows. The aim of developing these categories was to assess the cost saving whilst retaining the water quality facilities:
    - Remain: Water quality items such as bio-retention filter media which would still be required for water quality purposes were included as proposed.
    - Reduce by Area: Earthworks activities, which would still be required for water quality purposes but over a smaller extent and volume, were reduced down proportionally based on the ratio of the water quality area to the total basin area in the designs developed for the precinct reports. A 20% buffer was added around the bio-retention areas and included in the total water quality area considered for scaling. This was to allow for earthworks surrounding the bio-retention.
    - Remove: Items specific to the detention basins and not applicable to water quality, such as basin high flow outlets, were assumed to be removed.
    - Reduce by Cost: Overhead and contingencies percentages, which were applied to the current costings as a percentage of total cost, were proportionally reduced based on the savings associated with the above categories.
- The cost savings were estimated based on:
    - Calculating the revised cost for each item based on the quantities and rates supplied by BCC, and adjusting based on the category of each item.
    - Subtracting the revised cost from the original cost to calculate the saving.

9.1.2 Cost of Compensatory Works

The cost estimate of compensatory works was undertaken as follows:

- The cost associated with the potential Garfield West Basin (Refer Sketch 005) was estimated based on quantities output from the concept design of the basin and the costing rates provided by BCC.
- The total cost for the channels in the regional floodplain (Refer Sketches 001 and 002) was estimated from quantities output from the concept design and Section 94 rates provided by BCC. This total cost of the channels was then converted to a per metre cost by dividing the total cost by the combined length of the channels. This per metre cost was then multiplied by the total length of floodplain channels required (Refer Figure 9-1).
- For a length of reach within Marsden Park North where only stream protection works are proposed (as highlighted on Figure 9-1), rather than full construction of an engineered channel a lower per metre rate was applied. This was based on the contribution plan rates (supplied by BCC) applied only to ground protection works rather than full reconstruction of a channel.
- The cost associated with both the pre and post rationalisation channels outside of the flood plain (Refer Sketches 003 and 004) was estimated as per the above items. The cost difference per metre of channel length was then estimated and applied to the total length of non-floodplain channels required (Refer Figure 9-1). This approach was on the basis that channels would still be required outside the floodplain however they would be smaller to convey a lower flow rate.
- BCC advised that culverts proposed as part of Richmond Road upgrades adjacent to Excelsior Avenue have been designed by RMS to convey flows assuming no detention in the upstream catchments. Therefore, these culverts were excluded from drainage elements requiring compensatory works should flows increase at this location.

295,000
300,000
6,275,000
6,270,000
6,265,000

RICKABYS
BLACKTOWN ROAD
GEORGE STREET
THE NORTHERN ROAD
KILLARNEY CHAIN OF PONDS
WINDSOR ROAD WINDSOR ROAD
WINDSOR ROAD
FIRST PONDS
GARFIELD ROAD EAST
SOUTH
RICHMOND ROAD
GARFIELD ROAD WEST
EASTERN
SOUTH ROPES
BELLS
RICHMOND ROAD
CARLISLE AVENUE
WESTLINK M7
WESTLINK M7
ROPES
BREAKFAST

Compensatory Channels

- In Floodplain
- Out of Floodplain
- Stream ProtectionWorks Only

- Non-Gazetted Areas above 100-yr Flood Extent
- Gazetted Rationalisation Areas

Paper Size A3

0 195 390 780 1,170 1,560

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

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Blacktown City Council
NWGC Stormwater Management Strategy Review

Compensatory Works Extent

Job Number	21-25478
Revision	A
Date	13 Dec 2017

Figure 9.1

N:\AU\Coffs Harbour\Projects\21\25478\GIS\Maps\Deliverables\Figure9.1.mxd

Data source: Data Custodian, Data Set Name/Title, Version/Date. Created by:rgtowner

9.2 Non-Gazetted Precincts

The net cost savings described in Section 9.1 are achieved totally within catchment areas for which the following two criteria both apply:

- Within precincts that have a current defined detention strategy (i.e. gazetted precincts).
- Within catchment areas draining to basins that have been demonstrated through this review to have the potential for basin removal.

The catchment areas satisfying the above two criteria are herein referred to as 'gazetted rationalisation areas.'

However, the potential rationalisation scenario results (refer Section 7.2) also demonstrate that rationalisation of all of the assumed standard detention strategy for precincts currently without a confirmed strategy (the non-gazetted precincts) (refer Section 2.5) is also feasible.

Therefore, there is potential for cost saving in addition to the savings calculated for the gazetted precincts.

For this review, this potential saving for the non-gazetted precincts was estimated as follows:

- The cost saving achieved per hectare of catchment area in the gazetted rationalisation areas was calculated based on the costs calculated as per Section 9.1 and then dividing them by the total gazetted rationalisation area (Refer Figure 9-1).
- The total area of the non-gazetted precincts above the 100-year ARI flood extent was calculated.
- The above cost saving per hectare of the gazetted rationalisation areas was then applied to the area of non-gazetted precincts outside the floodplain.

As a comparison alternative calculations were also undertaken on the basis of extrapolating costs based on the volume of detention rationalised, rather than catchment areas. These calculations suggested a very similar cost saving and are presented in Appendix B. The cost savings presented in following sections of this report are for the extrapolations based on catchment area.

These extrapolated costs are based on a number of assumptions and should be considered as only indicative of the general magnitude of cost savings anticipated.

9.3 Costing Results

Appendix B presents a summary of the calculations undertaken for the costing with key results as follows:

- The cost of compensatory works was estimated as follows:
    - $1,600,000 for upsizing non-floodplain channels to convey increased flows
    - $5,100,000 for provision of floodplain channels
    - $700,000 for provision of floodplain stream protection works
    - $1,330,000 for provision of the Garfield West Basin
- The estimated net saving for the potential basin rationalisations and associated compensatory works is $44,940,000 in construction costs and 21.2 hectares of land.
- The estimated total net saving when also including extrapolated savings for the precincts without a current detention strategy (non-gazetted precincts) is $119,500,000 and 56 hectares of land.

- In addition to the above savings in ongoing maintenance would be achieved, that are not reflected in the figures above.
- Furthermore, a reduction in Council's ongoing stormwater management portfolio decreases risks associated with basins such as blockage and embankment failure.

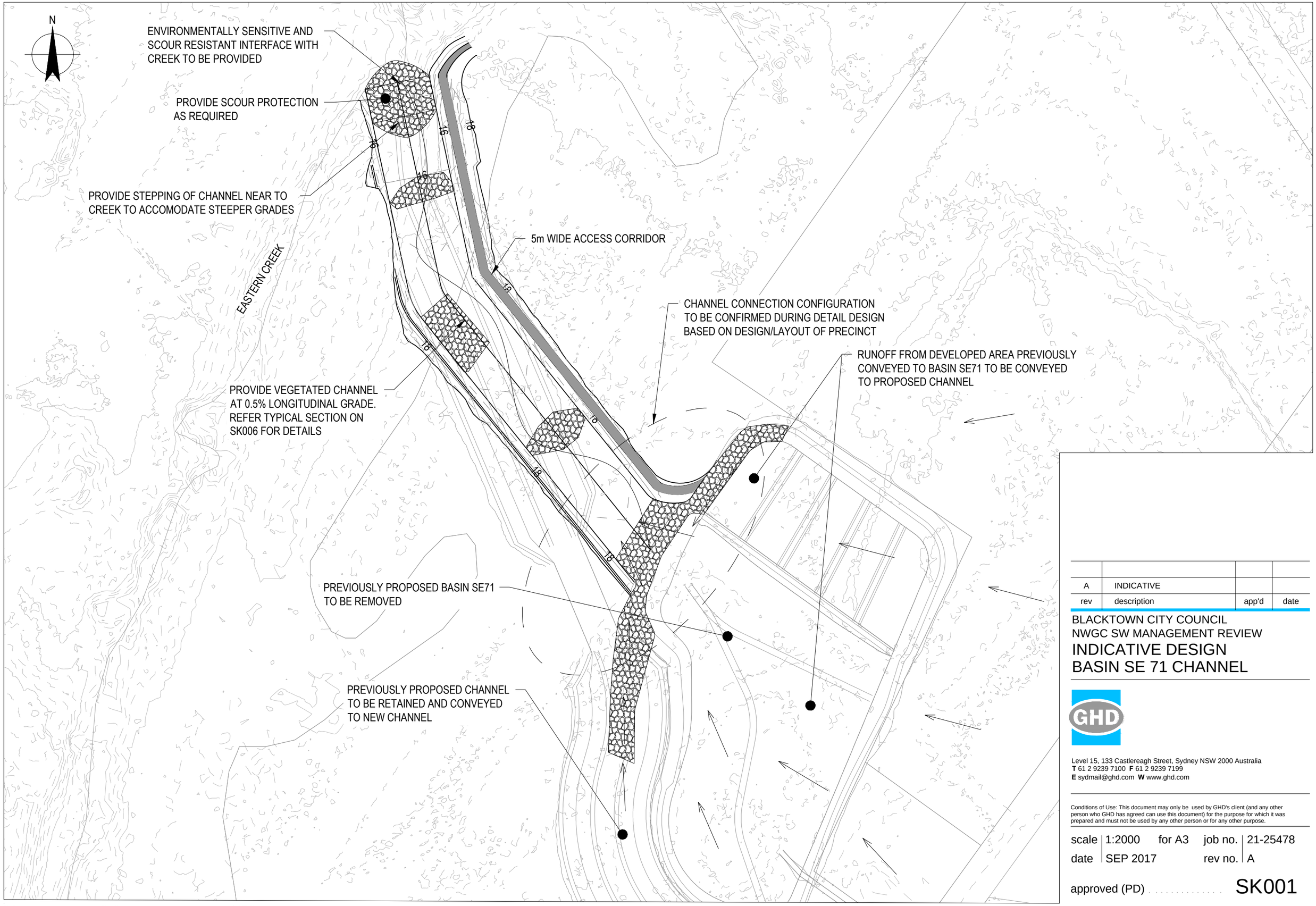
10. Summary

- The North West Growth Centres (NWGC) are priority growth areas in greater Sydney . Blacktown City Council (BCC) is seeking to review the delivery of public infrastructure, including stormwater management facilities to support the planned urban growth. GHD was engaged by BCC to assess potential rationalisation of the precinct stormwater management strategies, focussing on reducing the numbers of detention basins identified as part of precinct planning. The review was based entirely on simulating hydrological models (XP-RAFTS). This review should be considered an early-stage investigation indicating whether rationalisation of detention basins is feasible.
- To date, provision of detention basins to manage post development flood hydrographs has generally been considered on an individual precinct basis. This study provides the opportunity to assess if rationalisations in numbers of basins are possible, when considering flood hydrographs downstream of the precincts on a holistic basis.
- There are a number of constraints to reducing basin numbers, namely co-located water quality treatment within detention basins, basins which are already constructed or in the final stages of design and in some locations provision of drainage conveyance infrastructure (e.g. channels and culverts) may be required to offset local flood peak increases.
- Criteria were developed with BCC to compare the impacts of basin removal and rationalisation scenarios, namely within major creeks such as Eastern Creek, South Creek and Bells Creek there should be no changes in flood peak flows greater than 3%. Within tributary creeks located within precinct boundaries, changes in flood peak flows in the order of 10% or less were considered acceptable.
- A range of scenarios were agreed with BCC to assess the impact of basins removal. The scenarios were Baseline, No Rationalisation, Maximum Rationalisation and Potential Rationalisation. Cumulative impacts including the South West Growth Centre and Western Sydney Employment Areas were also considered.
- Hydrological XP-RAFTS models were supplied by BCC. These were reviewed and compiled into three XP-RAFTS project models. The precincts of Shanes Park, Marsden Park North and West Schofields (non-gazetted precincts) are currently in the early stages of planning and do not have a confirmed Water Cycle Management Plan or detention strategy. For these areas a standard volume of detention of 455 m^3 per developed hectare, as directed by BCC was applied.
- The review and modelling showed the following results:
  - For the No Rationalisation Scenario compared to the Baseline Scenario, in the major waterways of South Creek and Eastern Creek the currently proposed detention strategy appropriately manages flood peaks to within the criteria developed for this review (3% in major creeks and 10% within precinct boundaries). In some locations increases in flood peaks are predicted, which is likely due to timing of flood peaks. This has not been considered in the development of the strategies to date.
  - Review of the results for the Potential Rationalisation scenario compared to the No Rationalisation scenario shows that the predicted changed flood peaks are generally within the criteria proposed with the exception of a few locations where compensatory works may be required. Review of the hydrographs showed that these remain generally unchanged in the main creeks.

  - For the cumulative No Rationalisation Scenario compared to the Baseline Scenario there are significant impacts associated with the combination of flows for the currently proposed detention strategy from the North West Growth Centres with the upstream precincts of the SWGC and WSEA. For the cumulative Potential Rationalisation Scenario compared to the cumulative No rationalisation Scenario any changes predicted are minimal and within the criteria developed for the review.
- Concept designs were developed for compensatory works identified, and to provide order of magnitude costing. The concept designs were preliminary in nature and for the purpose of high level cost estimation, and may be subject to change/optimisation in the future.
- A comparative construction cost estimate was developed to assess the potential finacial benefits, if any, of the rationalisations.
- An indicative cost estimate of the potential savings corresponding to this rationalisation is $119,500,000 and 56 hectares of land, plus savings in ongoing maintenance costs.

Appendices

Appendix A – Conceptual Designs



rev	description	app'd	date
A	INDICATIVE		

BLACKTOWN CITY COUNCIL
NWGC SW MANAGEMENT REVIEW

INDICATIVE DESIGN BASIN SE 71 CHANNEL

Level 15, 133 Castlereagh Street, Sydney NSW 2000 Australia
T 61 2 9239 7100 **F** 61 2 9239 7199
E sydmail@ghd.com **W** www.ghd.com

scale	1:2000 for A3	job no.	21-25478
date	SEP 2017	rev no.	A

approved (PD) SK001

Plot Date: 7 September 2017 - 3:53 PM Plotted by: Dinesh Thapa Cad File No: G:\21\25478\CADD\Drawings\21-25478-SK001.dwg

N

MEANDERING NATURALISED LOW-FLOW CHANNEL

INDICATIVE POOL AND RIFFLE ARRANGEMENT

EXISTING DAM TO BE DECOMMISIONED

5m WIDE ACCESS CORRIDOR

PREVIOUSLY PROPOSED BASINS A1 AND A3 TO BE REMOVED

RUNOFF FROM DEVELOPED AREA PREVIOUSLY CONVEYED TO BASIN A1 AND A3 TO BE CONVEYED TO PROPOSED CHANNEL

LOCALISED MEANDERING (INCLUDING POOLS AND RIFFLES) OF CHANNEL TO BE PROVIDED DURING DETAILED DESIGN FOR CHANNEL NATURALISATION

PROVIDE VEGETATED CHANNEL AT 0.5% LONGITUDINAL GRADE. REFER TYPICAL SECTION ON SK006 FOR DETAILS

5m WIDE ACCESS CORRIDOR

ENVIRONMENTALLY SENSITIVE AND SCOUR RESISTANT INTERFACE WITH CREEK TO BE PROVIDED

SOUTH CREEK

PROVIDE STEPPING OF CHANNEL NEAR TO CREEK TO ACCOMODATE STEEPER GRADES

FLOOD RESISTANT MATERIALS AND VEGETATION TO BE PROVIDED IN VICINITY OF SOUTH CREEK

PROVIDE SCOUR PROTECTION AS REQUIRED

rev	description	app'd	date
A	INDICATIVE		

BLACKTOWN CITY COUNCIL
NWGC SW MANAGEMENT REVIEW

INDICATIVE DESIGN BASINS A1 & A3 CHANNEL

GHD

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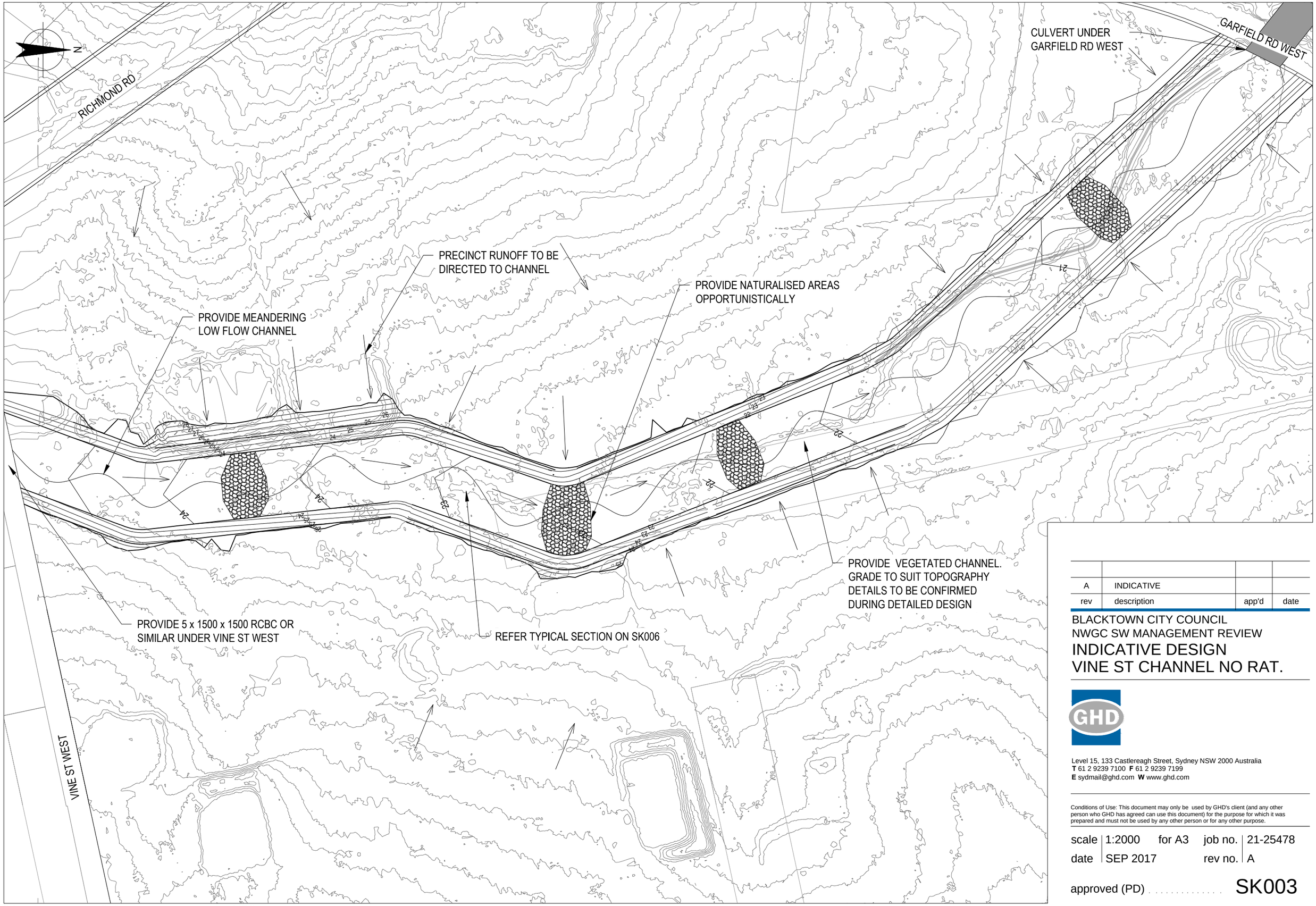
scale	1:2500 for A3	job no.	21-25478
date	SEP 2017	rev no.	A

approved (PD) SK002

Plot Date: 7 September 2017 - 3:55 PM Plotted by: Dinesh Thapa Cad File No: G:\21\25478\CADD\Drawings\21-25478-SK002.dwg



rev	description	app'd	date
A	INDICATIVE		

BLACKTOWN CITY COUNCIL
NWGC SW MANAGEMENT REVIEW

INDICATIVE DESIGN
VINE ST CHANNEL NO RAT.

GHD

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E sydmail@ghd.com **W** www.ghd.com

scale	1:2000 for A3	job no.	21-25478
date	SEP 2017	rev no.	A

approved (PD) SK003

Plot Date: 8 September 2017 - 10:59 AM Plotted by: Dinesh Thapa Cad File No: \\ghdnet\ghd\AU\Sydney\Projects\21\25478\CADD\Drawings\21-25478-SK003.dwg