7. WSUD Concept Design

7.1 Background

To assist in better determining the Section 94 contributions for the trunk stormwater infrastructure and water sensitive design facilities, concept design was undertaken. These concept designs were prepared for:

- 34 co-located detention/water quality basins; and
- 8 diversions and/or other engineered trunk drainage creeks.

The level of detail for the concept designs was discussed and approved by Council.

7.2 Concept Design Methodology

The methodology for the basin concept designs was the following:

- First-cut estimate of basin designs was undertaken to check volumes, using 3D ground modelling software (12D);
- Revised estimate of basin designs was undertaken to check volumes, using 3D ground modelling software (12D);
- Workshop were held with the planners, to finalise basin positions in the context of the master planning;
- Final estimate of basin design was undertaken to confirm position and balance cut versus fill, plus confirmation of volume;
- Hydraulic concept design of outlet structures and spillways, using spreadsheets and RAFTS modelling. Multi-staged outlet dimensions were confirmed where required;
- Definition of bio-retention in basin invert was undertaken, and configuration of bio-retention drainage outlets was undertaken;
- The concept design civil elements were transferred to CAD; and
- Erosion protection requirements for the basins were nominated.

The methodology for the engineered trunk drainage creeks was the following:

- Creek vertical alignment to correspond with upstream and downstream inverts determined;
- The engineered trunk drainage channel was configured within 3D ground modelling software (12D);
- The concept design civil elements were transferred to CAD; and

- Erosion protection requirements were nominated.

The methodology for the proposed culverts was the following:

- The locations of culverts to be considered in the Section 94 Contributions costing was determined in consultation with Council and DoP based on the current ILP and stormwater management strategy;
- The 100-year ARI event post development flows at each culvert was determined using the rafts modelling developed for the basin design;
-

The methodology for the proposed bridges was the following:

7.3 Concept Design Parameters

Key design parameters for the basins, drainage channels, bridges and culverts were determined in consultation with Council. These included:

- Embankment side slopes of 1:6;
- Active storage depths in basins of 1.2m;
- Extended storage depths over bio-retention media in basin inverts of 0.3m;
- Freeboard above 100-year ARI basin level of 0.5m;
- Basin low flow outlets to consist of pit and pipe configuration, and in some instances dual pit and pipe. When high flow requires larger capacity, a 1,500mm x 900mm box culvert configuration (or multiples of) is used;
- Minimum channel slope of 0.5%;
- Maximum channel side slopes of 1:6;
- Channels designed for 1 in 100-year ARI flow containment, with 0.5m freeboard allowance;
- Minimum channel depth of 1.5m;
- Culvert dimensions determined such that no increase in flood levels occurs upstream of the culverts for the unblocked scenario during the 100-year ARI event. The overall width of the set of culverts was increased by 50% such that the increase in flood levels is less than 300 mm when the culverts are 50% blocked.; and
- Bridge spans determined based upon the width of the riparian corridor and the 100-year ARI event flood extents. Where the riparian corridor width is greater than the width of the 100-year ARI event extents the riparian corridor width was adopted as the span of the bridge. Where the 100-year ARI event flood extents extend beyond the riparian corridor the width of the bridge was determined such that the resulting increase in flood levels does not exceed 50 mm.

7.4 Opportunities for Reducing Excavation and Cart-Away Cut by providing Stepped or Raised Basins

Council has identified that the cart-away costs of excess cut from the basin construction would be prohibitively high and that Council has no other means of disposing this material other than to landfill. In addition, given the constraints imposed by the undulating topography, the need to incorporate the current fragmented ownership and the existing lot layouts, a number of opportunities were investigated to reduce the cart-away cut volume for each basin. The aim was to better balance cut and fill in the basin designs, reducing the cart-away volumes.

As a first attempt, the opportunities to step basins were investigated. This included providing a raised basin floor, cascading into a lower basin floor thereby reducing cut. In general only two floor elevations were investigated, and the basin embankments adjusted accordingly. This assessment was undertaken for the basins with the most significant cart-away volumes, to maximise the benefit. The outcome is presented in Table 3. This shows that in general, by stepping a number of basins, a 213,200m^3 savings in cart-away volume could be achieved.

Table 3 Cart-Away Cut Volume Reduction for Five Basins with Significant Cart-Away Cut Volumes

Basin	Original Cart-Away Cut Volume (m^3)	Modified Cart-Away Cut Volume (m^3)	Cart-Away Cut Volume Reduction (m^3)	Percentage Reduction
E8	63,600	13,900	49,700	78%
F40a	62,660	13,800	48,900	78%
F28	58,500	21,000	37,500	64%
F32	46,400	2,500	43,900	95%
E20	42,230	9,000	33,200	79%
Total	273,390	60,200	213,200	78%

Council, in an independent investigation explored the opportunities to raise entire basins without providing a step in the basin floor. Detention basins were raised where possible. To date no details have been provided, however it is anticipated that this would also lead to an overall reduction in the cart-away volume.

The above investigations show that the stepping of basins could lead to a significant reduction in cart-away volumes, and these matters including opportunities to raise entire basins, should be further investigated during detailed design.

7.5 Opportunities for Online Basins

In order to further rationalise the drainage infrastructure, the option of providing more online basins was considered. The main advantages of providing online basins are:

- Less reliance on offsetting catchments with larger detention basins in other catchments;
- A reduction in the total number of basins with a number of offline basins being consolidated into a larger online basin; and
- Basins are located in flood prone land and hence there is a reduction in the land-take of the trunk drainage infrastructure.

The disadvantages would be the impact on riparian zones, and thus this assessment was only investigated in a few select locations to maximise the riparian outcomes for the precinct. In investigating the online basins, factors considered include the impact of downstream water levels on discharge rates, the impact of adjacent catchments in Riverstone East, and the need for low flow channels to mimic the existing creek for frequent rainfall events.

The hydraulic performance of the online basins was investigated using Mike 11 to ensure that backwater effects through basin outlets and the associated impact on basin volumes were adequately considered.

Referring to Appendix B, the following online basins were considered:

Online Basin F10a

A potential for locating a basin immediately upstream of Schofields Road on First Ponds Creek was investigated. Through the introduction of this basin, basins F10 and F11 would no longer be required and smaller raingardens would need to provide stormwater quality treatment. Schofields Road would form part of the basin embankment. The basin was simulated and shown to meet the design criteria for stormwater quantity.

Online Basin F16

This basin would be located approximately 300m downstream of Schofields Road on First Ponds Creek. Basin F20 would no longer be required and replaced with a smaller raingarden to provide stormwater quality treatment. A vegetated low flow channel through the invert of the basin would provide for regular rainfall events and help to achieve positive ecological outcomes for First Ponds Creek. The basin was simulated and shown to meet the design criteria for stormwater quantity.

Online Basin F28

This basin would be located First Ponds Creek at the location where catchment F28 discharges to First Ponds Creek. Basin F28 would no longer be required and a raingarden would need to be provided at the location of the basin, as well as providing a green and gold bell frog habitat in the area. This basin would utilise a low flow channel for regular rainfall events. The basin was simulated and shown to meet the design criteria for stormwater quantity.

Online Basin E22

This basin would be located immediately upstream of Railway Terrace. Basins E22 and E25 would no longer be required. The online basin is in a location that minimises the amount of cart-away cut when compared to the offline basins that are inefficient in terms of earthworks, due to the steeper terrain in their locations. The basin was simulated and shown to meet the design criteria for stormwater quantity.

8. Climate Change Assessment

8.1 Climate Change Considerations

Climate change is expected to cause increased rainfall intensities in extreme rainfall events, sea level rise and increased evapotranspiration. The NSW Government's Floodplain Risk Management Guideline entitled 'Practical Consideration of Climate Change' (2007) outlines the recommended basis for examining climate change, as required by the NSW Floodplain Development Manual (2005).

GHD has assessed the impact of climate change through simulation of increased rainfall intensities in the 100-year ARI design storm event. Increases in sea level and evapotranspiration have not been addressed in this study.

8.2 Climate Change Hydrological Modelling

GHD has modified the current developed-case RAFTS hydrological models of Eastern Creek and First Ponds Creek to simulate a 20% increase in rainfall intensity in the 100-year ARI design storm event. This 20% increase is the median of the three values for sensitivity analysis recommended in 'Practical Consideration of Climate Change'.

8.2.1 Peak Flow Increases

The results of this modelling show a resultant increase in 100-year ARI design flood flow of around 25% when a 20% climate change rainfall increase is applied. Flood flows at key locations have been summarised in Table 4, comparing existing climate and future climate simulations.

Table 4 Peak Flows with 20% Increase in Rainfall

Sub-Catchment	Max Peak Flow in Creek Reach (m^3/s)		Percentage Flow Increase
(refer to Appendix C)	Current Climate	20% Increased Rainfall	
First Ponds Creek	285	348	22%
Eastern Creek A	13.8	16.8	22%
Eastern Creek B	26.5	34.3	29%
Eastern Creek C	18.4	22.7	23%
Eastern Creek D	9.1	11.3	24%
Eastern Creek E	23.5	29.5	26%

8.2.2 Flood Volume Increases

The percentage increase in runoff volume for all simulated creek reaches is shown in Table 5.

Table 5 100-year ARI Runoff Volume Increase

Sub-Catchment (refer to Appendix C)	Total Runoff Volume (m^3)		Percentage Volume Increase
	Current Climate	20% Increased Rainfall	
First Ponds Creek	15700	20100	28%
Eastern Creek A	380	470	24%
Eastern Creek B	1770	2260	27%
Eastern Creek C	730	950	30%
Eastern Creek D	110	130	23%
Eastern Creek E	1080	1340	24%

8.3 Climate Change Hydraulic Modelling

100-year ARI design flood hydrographs under a future climate 20% rainfall increase have been simulated in the MIKE11 hydraulic models of First Ponds Creek and five tributaries of Eastern Creek.

8.3.1 Flood Level Increases

The increase in peak flood flows under the 20% rainfall increase scenario results in an increase in modelled 100-year ARI flood levels. The resulting average increase in flood level has been summarised below in Table 6 for all modelled creeks within the precincts.

Table 6 Average 100-year ARI Flood Level Increase

Sub-Catchment (refer to Appendix C)	Average 100-Year Water Level Increase
First Ponds Creek	88 mm
Eastern Creek A	59 mm
Eastern Creek B	76 mm
Eastern Creek C	50 mm
Eastern Creek D	64 mm

Sub-Catchment (refer to Appendix C)	Average 100-Year Water Level Increase
Eastern Creek E	67 mm

8.3.2 Increased Flood Extent

Increased flood levels under the climate change rainfall scenario will result in an increase in 100-year ARI flood extent. The increase in flood extent will vary depending on the shape of the channel cross-section, slope of the bank, local channel roughness, and the increase in flood flow and velocity.

Mapping the results from the existing climate and future climate 20% rainfall increase scenarios shows that typical increases in flood extent are in the order of 0.5m to 10m. Increases in extent of up to 10m are anticipated in areas with very low bank slopes – the average increase is in the order of 2-4m.

8.3.3 Flood Velocity Increases

In addition to impacting flood levels, an increase of 20% in rainfall intensity results in increased flow velocities. The average increase in flow velocity is shown in Table 7 for each modelled creek reach.

Table 7 Average 100-year ARI Flood Velocity Increase

Sub-Catchment (refer to Appendix C)	Current Climate	Future Climate 20% Increased Rainfall	Average 100-Year Velocity Increase
First Ponds Creek	1.05 m/s	1.12 m/s	7%
Eastern Creek A	0.89 m/s	0.97 m/s	9%
Eastern Creek B	1.05 m/s	1.13 m/s	8%
Eastern Creek C	1.02 m/s	1.09 m/s	7%
Eastern Creek D	0.93 m/s	0.99 m/s	7%
Eastern Creek E	0.88 m/s	0.98 m/s	11%

8.4 Climate Change Impacts on Detention Basins

To assess the sensitivity of impacts of the precinct detention basins to climate change, a 20% rainfall increase has been simulated in the detention basin RAFTS model. Three typical basins have been selected for analysis, covering the full range of basin sizes – Basin F0 (small), Basin F25 (medium) and Basin F58 (large).

8.4.1 Climate Change Basin Performance Assessment

Design storm events with 20% increased rainfall intensity were simulated for the proposed detention basin designs, with no basin design modifications for climate change. The results of this simulation have been summarised below in Table 8.

Table 8 Impact of 20% Rainfall Increase on Detention Basins

Item	Basin F0		Basin F25		Basin F58	
Rainfall Increase	None	20%	None	20%	None	20%
100-yr ARI Depth (m)	1.41	1.62	1.49	1.61	1.48	1.62
100-yr ARI Peak Outflow (m^3/s)	0.91	1.30	3.31	5.44	7.12	11.48
5-yr ARI Peak Outflow (m^3/s)	0.78	0.82	1.96	2.46	4.11	5.16
Freeboard to Spillway (mm)	93	-117	9	-105	21	-124
100-yr ARI Storage required for no overflow (m^3)	4,300	5,400	20,400	22,700	39,300	48,900

As the basins have been designed such that the spillways are at the current climate 100-year ARI flood level, basins are expected to spill when subject to a 20% increase in rainfall intensity and volume. Basins are expected to spill more frequently with increases in 100-year ARI basin outflow (due to spill through the outlet and over the crest). Simulated climate change flows increasing by up to 65% over current climate flows.

For the three basins modelled, the spillway immunity level is reduced from the 100-year ARI design flood event to approximately the 50-year, 25-year and 25-year ARI design flood events respectively for the three basin sizes investigated.

8.4.2 Climate Change Basin Adaptation Options

An adaptive climate change response may be implemented in the future to address climate change impacts as they arise. The available options for climate change adaptation are outlined below:

- The 'do nothing' option - the existing basin designs will spill with increasing frequency if rainfall intensities increase. Attenuation to pre-development flood flows will not be possible for events which overtop the basin spillways;

- Increase spillway level - basin spillways could potentially be raised in the future to contain the future climate 100-year ARI event within the basin. This would decrease the capacity of the spillway since issues may arise with raising the crest due to draining adjacent overland flows to the basin. The basin crest would be overtopped under more frequent events than under existing climate;
- Increase spillway level and width - basin spillways could potentially be raised in the future to contain the future climate 100-year ARI event within the basin with the spillway width increased to provide the necessary spillway capacity. This may require reconfiguration of the downstream channels;
- Increase spillway level and basin crest level - basin spillways can be raised in the future to maintain a 100-year ARI spillway immunity level, with the basin crest level increased to maintain the 10,000-year ARI basin crest capacity. This would be possible by either increasing the embankment level or building levee walls on top of the basin embankments. This may not be possible where increasing crest levels would prevent runoff from entering the basin;
- Increase outlet size – the outlet structures (intake pit, outlet pipes, high-flow culverts) could be re-configured to allow the basin to contain the 100-year ARI flood event under future climate rainfall. Basin outflows in this scenario would not be attenuated to the pre-development, current climate peak flow; and
- Increase basin size – the basin size could be increased to contain the 100-year ARI climate change flood flow, while maintaining the flood attenuation and spillway design criteria.

8.4.3 Climate Change Additional Basin Storage

GHD has investigated increasing the volume of three typical basins to meet Council's design requirements in the 20% increased rainfall future climate scenario. A storage approximation was adopted by factoring the concept design storage curves to determine indicative volume and land-take increase required. Intake structures and spillway levels have not been redesigned, as the existing designs meet Council's design requirements.

The results of this investigation are presented below in Table 9. Analysis of storage vs. land-take for all basins indicates that a 40-50% increase in active detention storage volume will require an additional 30-40% land-take per basin.

Table 9 Typical Basin Climate Change Storage Volumes

Basin	Active Detention Storage Volume (m^3)		Percentage Volume Increase
	Current Climate	20% Rainfall Increase	
F0	4,800	6,600	40%
F25	20,700	30,900	50%
F58	44,000	66,000	50%

9. Summary and Conclusions

- Precinct planning for the Growth Centres Alex Avenue and Riverstone precincts has been underway for some time. Infrastructure delivery and funding of the works are co-ordinated by the Department of Planning and Blacktown Council;
- Following public exhibition of the draft Precinct Plans, it has been determined that the Section 94 contribution rates in Council's draft Contributions Plan No. 20 are excessively high. A review of the draft ILP would potentially deliver efficiencies in the provision of open space and drainage land, maximise the area of developable land, rationalise the current drainage strategy and provide better supporting data to allow costing of facilities with a higher level of confidence;
- The Growth Centres Development Code (GCC, 2006), Blacktown City Council Engineering Guideline for Development (BCC, 2005), Blacktown Development Control Plan 2006 (BCC, 2006), Blacktown City Council WSUD DCP (BCC, 2008), and the NSW Floodplain Development Manual, 2005 define the requirements for management of stormwater quantity, quality and flooding at the precincts.
- Numerical modelling was used to assess the flood and stormwater management, which included RAFTS, Mike 11 and MUSIC;
- The rationalisation of stormwater management facilities was undertaken in an iterative manner, involving planners, stakeholders and Council. This was achieved in a number of meetings throughout the course of the project, and in by means of correspondence. Key items investigated included rationalising riparian corridors across the precinct, and adjusting the Indicative Layout Plan;
- A discussion on the rationalisation on a catchment by catchment basis is provided in the document. Key positive outcomes include:
  - Consolidation of catchments into single basins, and reduction of the total number of basins from 53 in the draft Precinct Plans to 34 in the final plans;
  - Better definition of basin footprint through concept design;
  - Better definition of issues such as fill, routing of overland flow; and consideration of downstream flooding;
- The revised proposed WSUD strategy for the precincts is provided as two figures in Appendix B.
- To assist in better determining the Section 94 contributions for the trunk stormwater infrastructure and water sensitive design facilities, concept design was undertaken. The level of detail for the concept designs was discussed and approved by Council. Key design parameters for the basins and drainage channels were determined in consultation with Council. The concept designs were used to undertake the costing for Section 94 contribution purposes;

- Council has identified that the cart-away cut costs of excess material from the basin construction would be prohibitively high and that Council has no other means of disposing this material, other than to landfill. To this end investigations were undertaken to:
  - Reduce cart-away volume by stepping basins or raising basin floor levels; and
  - Providing further online basins in a few locations, having due regard to riparian outcomes;

  Given the cart-away cut reduction achieved in particular through stepping the basins, these initiatives should be further developed during the detailed design stage.
- Future climate impacts on flooding and the detention strategy for the precincts have been assessed for a 20% increase in rainfall intensity and volume. Key findings were:
  - An increase in modelled 100-year ARI flood levels by between 50 and 88 mm;
  - Increases in flood extent are in the order of 0.5m to 10m depending on location;
  - Detention basins are expected to spill under future climate conditions. The spillway immunity level could be reduced from the 100-year ARI design flood event to approximately the 25-year ARI design flood event;
  - An adaptive climate change response may be implemented in the future to address climate change impacts as they arise. These could be raising the embankments, increasing spillway levels and outlets, and increasing basin volumes.
  - Analysis of storage vs. land-take for all basins indicates that a 40-50% increase in active detention storage volume (required under a modelled 20% reinfall intensity increase) will require an additional 30-40% land-take per basin, if flows are throttled to existing climate conditions.
- This study has shown the importance of:
  - Having well advanced drainage solutions at planning stages of projects;
  - Being highly collaborative as a project team, between surface water practitioners, Council (and future owners), Stakeholders and planners; and
  - Respecting the existing topography when considering road and lot layouts.

10. References

- GHD, *Alex Avenue and Riverstone Precincts – Integrated Natural Environment Management Part 1 – Ecological Assessment*, September 2006.
- GHD, *Alex Avenue and Riverstone Precincts – Integrated Natural Environment Management Part 2 – Riparian Assessment*, September 2006.
- GHD, *Alex Avenue and Riverstone Precincts – Integrated Natural Environment Management Part 3 – WSUD and Flooding*, September 2006.
- Growth Centres Commission, *Growth Centres Development Code*, October 2006.
- Department of Environment, Climate Change and Water (DECCW), *Western Sydney Growth Centres – Stormwater Guidance for Precinct Planning*, November 2006;
- Department of Environment, Climate Change and Water (DECCW), *Interim Recommended Parameters for Stormwater Modelling – North-West and South-West Growth Centres*;
- Blacktown City Council, *Engineering Guide for Development*, 2005;
- Blacktown City Council, *Draft WSUD DCP*, February 2008;
- Blacktown City Council, *Blacktown Development Control Plan,* 2006;
- CRC for Catchment Hydrology, *Music Model User Guide,* April 2005
- CRC for Catchment Hydrology, *Stormwater Flow and Quality, and the Effectiveness of Non-Proprietary Stormwater Treatment Measures – A Review and Gap Analysis, Technical Report 04/8*, December 2004.
- Department of Water Resources, *Eastern Creek Flood Study Report*, February 1992;
- SMEC, *Riverstone Trunk Drainage Study for Blacktown City Council*, November 1999;
- XP Software, *XP-RAFTS User's Manual*;
- DHI, *Mike 11 Reference Manual*, 2004:
- NSW Government, *Floodplain Development Manual,* 2005;
- NSW Government, *Practical Consideration of Climate Change*, 2007; and
- Landcom 2004, *Soils and Construction, Managing Urban Stormwater*, March 2004.