- Lake Macquarie City Council Development Control Plans 1 and 2 – outlines requirements for development within or near water bodies, floodplains, steep lands, acid sulphate soils, mine subsidence districts and heritage conservation areas;
- The Australian and New Zealand Guidelines for Fresh and Marine Water Quality, 2000 ;and
- NSW Floodplain Development Manual, 2005 - which outlines guidelines relating to floodplain management.

3. Design Criteria and Supporting Simulations

3.1 Design Criteria and Environmental Objectives

3.1.1 Stormwater Quality

The ANZECC Guidelines (ANZECC, 2000) nominate default trigger values for south-east Australian aquatic ecosystems, below which environmental impacts are not expected to occur. The values most applicable to stormwater pollution are Total Nitrogen (TN) and Total Phosphorous (TP). For these two constituents, trigger values of 0.5 mg/L (TN) and 0.05 (TP) are nominated in the guidelines. Ideally baseline field data would be used to assess potential impact of the development, however this data is not available.

LMCC guidelines (DCP 1) nominate target pollutant removal efficiencies aimed at a range of pollutants for residential developments greater than 2 hectares as indicated in Table 1 below.

Table 1 LMCC Stormwater Treatment Measure Effectiveness

Pollutant	Target Pollutant Removal Efficiency
Gross Pollutants (kg/yr)	High - Very High (80 – 100%)
Total Suspended Solids (kg/yr)	Moderate – High (30 – 80%)
Total Phosphorus (kg/yr)	Moderate (30 – 50%)
Total Nitrogen (kg/yr)	Moderate (30 – 50%)

NCC guidelines nominate target maximum event mean concentrations for a range of pollutants for developments as indicated in Table 2 below.

Table 2 NCC Stormwater Treatment Measure Effectiveness

Pollutant	Maximum Event Mean Concentration
Sediment	100 mg/l
Hydrocarbons	500 µg/l
Total Nitrogen	1000 µg/l
Ammonia	15 µg/l
Phosphorus	100 µg/l

For this project, it is nominated that the LMCC guidelines (DCP 1) for determining the effectiveness of stormwater treatment strategies be adopted. These guidelines are considered better suited for the range and concentration of pollutants associated with a residential development.

3.1.2 Stormwater Quantity and Flood Risk

If not managed, increased impervious areas on account of development could increase flood peaks and discharge from the site. It is therefore necessary to manage increased discharges according to the requirements of the relevant DCP. In the Link Road North and South sites, the relevant DCP is LMCC DCP 1, which stipulates:

- Post development 20-year Average Recurrence Internal (ARI) flood peaks should not exceed 5-year existing condition flood peaks; and
- Post development 100-year ARI flood peaks should not exceed 100-year existing condition flood peaks.

In addition, development and land-use in flood prone areas should be in accordance with LMCC Floodplain Management Policy and the NSW Floodplain Development Manual, 2005.

For the NCC LGA (Minmi), development should not increase flood risk over and above existing conditions. It is therefore necessary to control discharges from the site according to the requirements of NCC's DCP 2005 and Stormwater and Water Efficiency for Development Technical Manual.

- Stormwater management measures are to be installed within the public domain area (including easement under council control) and are to be sized on the assumption that 60% of new road reserve areas plus 20% of allotment areas are impervious;
- Development is to be designed so that peak runoff from the site for all events including the 1 Year Average Recurrence Interval (ARI) through to the 100 year ARI, is not greater than for the "natural" drainage conditions;
- On-lot storage provision, in accordance with Table 3; and
- The above, combined with storage requirements for on-lot detention, should satisfy the objectives. All public stormwater management assets are to be installed outside the riparian zone of creek lines.

Development and land-use in flood prone areas should be in accordance with NCC Flood Management Technical Manual and the NSW Floodplain Development Manual, 2005.

Table 3 NCC's DCP 2005 On-site Storage Requirements

		Impervious area									
		100 m2	250 m2	300 m2	350 m2	500 m2	600m2	750 m2	1000 m2	1,500 m2	2,000 m2
Site area	100 m2	2.5 m3									
	250 m2	1.2 m3	6.3 m3								
	500 m2	1.2 m3	3.1 m3	4.4 m3	6.0 m3	12.5 m3					
	600 m2	1.2 m3	3.1 m3	3.6 m3	5.0 m3	10.3 m3	15.0 m3				
	750 m2	1.2 m3	3.1 m3	3.6 m3	4.2 m3	8.2 m3	11.9 m3	18.8 m3			
	1000 m2	1.2 m3	3.1 m3	3.6 m3	4.2 m3	6.0 m3	8.8 m3	13.9 m3	25.0 m3		
	1,500 m2	1.2 m3	3.1 m3	3.6 m3	4.2 m3	6.0 m3	7.2 m3	9.0 m3	16.3 m3	37.5 m3	
	2,000 m2	1.2 m3	3.1 m3	3.6 m3	4.2 m3	6.0 m3	7.2 m3	9.0 m3	12.0 m3	27.8 m3	50.0 m3

3.2 Supporting Simulations

Numerical modelling was used to assess the existing flood risk and evaluate the proposed stormwater quantity and quality management system. This modelling allowed an assessment of:

- Existing conditions flood peaks and flood levels for the creeks across the site and future climate change impact, for a range of design storm events (using XP -RAFTS and HECRAS);
- Appropriate volumes and strategies for detention throughout the site, that responded, as best possible, to the Concept Plan and which controlled post development flows (using XP-RAFTS); and
- The performance of stormwater quality strategies to be incorporated which would mitigate impacts from the development (using MUSIC) and which achieved the pollution load export requirements set by Council.

All modelling should be considered as preliminary for the purposes of planning and a more detailed investigation will be required as the project progresses to a more detail design phase.

3.2.1 Existing Flood Risk

Flood Peaks and Detention

Flood peaks for calculating flood extent associated with all the creeks at the site were simulated using the RAFTS hydrological model. Compilation of the model included:

- Catchment delineation;
- Hydrological parameter determination; and
- Intensity -Frequency -Duration (IFD) determination for generating storm rainfall events.

Detention requirements for the site were determined using three “pilot” catchments, two in the Minmi and Link Road North development area, and one in the Link Road South development area. Since hydrological conditions and proposed development are similar for this site, the results were transposed for the entire development. In addition, as will be shown later, the proposed strategy relies on a combination of on-lot and precinct scale detentions. To this end, the “pilot” approach was deemed acceptable.

RAFTS simulations were undertaken for a number of design storms (2-, 5-, 10-, 20- and 100-year ARI events and the PMF) and for durations ranging from 25 minutes to 9 hours (PMF 15 minutes to 6 hours). For each event the critical duration was determined. Three scenarios were simulated, namely:

- Existing (undeveloped) conditions;
- Developed conditions in response to the concept plan; and
- Developed conditions in response to the concept plan with detention storage. The increases in impervious area on account of the development will, amongst other effects increase runoff peaks from the development areas. The scenario was used to determine the required volume of detention to mitigate increased flow rates on account of the development.

Percentage impervious areas for the developed conditions hydrology model were stipulated as follows:

- Residential = 70%; and
- Road = 100%.

Key infiltration parameters assumed in the RAFTS modelling are provided in Table 4 below.

Table 4 Infiltration Parameters

	Pervious	Impervious
Initial loss (mm)	15	2.5
Continuing loss (mm/hr)	2.5	0

Existing 100-year and PMF Flood Levels

Flood levels, velocities, flood extents and flood hazard were determined with the 2 dimensional TUFLOW hydraulic model. TUFLOW is a hydraulic model for simulating depth-averaged, two and one-dimensional free surface flows. Data is input through the use of text files for controlling simulations and simulation parameters. MapInfo files are used to represent spatially distributed data such as topography, hydraulic structures and boundary conditions. The TUFLOW model compilation was undertaken as follows:

» The available 2 m contour data for the site was imported into the digital terrain model program 12D. The creek areas were extracted and triangulated into a Digital Terrain Model (DTM) to represent the ground surface;

» A TUFLOW grid was generated with a cell size of 2 m. Each point in the grid was given an elevation based on its location in the 12D DTM. The grid size was chosen because this is a compromise between the accuracy of the DTM data, simulation run time, model stability, and the accuracy of the results;

» No road crossings were simulated at this early planning stage, and thus the modelling represents conservative scenario (worst case) of blocked culverts;

» Supplied cadastral information was imported into GIS program and the aerial photography geo-referenced;

» The sub-catchments used in the RAFTS hydrologic modelling were applied as inflows over the 2-D model, with inflows distributed and divided over the model grid points;

» Based on aerial photography and site inspections, hydraulic roughness coefficients for the floodplain were recorded for the model. These coefficients were digitised into MapInfo as polygons to represent the various surfaces; and

» Downstream flood level control was in the form of flood levels in Hexham Swamp. These were derived from the DHI flood study for the Lower Hunter River.

In the absence of corresponding rainfall (hyetograph) and runoff data, calibration of the TUFLOW model was not possible. Furthermore no historic flood markers were available for calibrating of overland flood depths. Calibration of the model was thus limited to checking the “reasonableness” of the overland flow routes and depths, and qualitatively comparing the findings to known flooding occurrences.

3.2.2 Stormwater Quality Management

The water quality assessment for the Minmi Link Road development site was undertaken using, MUSIC. MUSIC is a computer simulation model developed by the Cooperative Research Centre for Catchment Hydrology (CRC) as a Model for Urban Stormwater Improvement Conceptualisation.

MUSIC simulates both quantity and quality of stormwater generated from a range of stormwater catchment types, including urban, rural and forest, using historical rainfall data. The pollution treatment devices available model includes swales, bio-retention areas, wetlands gross pollutant traps, sediment basins, ponds and filter strips. In undertaking the MUSIC model for this site, the following parameters were considered:

» Pollutant generation rates; and

» Pollutant removal rates.

The model was configured and simulated for the existing and post-development conditions in response to the Concept Plan. Three “pilot” catchments, two in the Minmi and Link Road North development area, and one in the Link Road South development area were configured. Since hydrological conditions and proposed development are similar for this site, the results were transposed for the entire development. To this end, this “pilot” approach was deemed acceptable. Potential pollution treatment devices were assessed in the model, which included swales, bio-retention areas, wetlands, gross pollutant traps, sediment basins, ponds and filter strips.

Historical rainfall for this assessment was obtained from the Bureau of Meteorology (BOM) pluviograph data for Williamtown RAAF base for the period December 1952 to January 2005. Williamtown rainfall was chosen for this assessment as it had the longest and most complete period on record of 6 minute rainfall for the Lower Hunter.

For this simulation period there were several high rainfall events as well as periods of low rainfall with an average rainfall for the period of 1023 mm/year. The evaporation data used in the model was obtained from the Bureau of Meteorology long-term averages for each month with the average annual evaporation for Williamtown being 1732 mm/year.

In pursuing WSUD, Newcastle City Council and Lake Macquarie City Council are paying specific attention to the regular low, or base, flows from catchment areas. These flows are of particular importance as they convey the majority of pollutants from catchments to downstream locations, in this case Minmi Creek and subsequently Hexham Swamp for the Minmi East and West and Link Road North sites, and Brush Creek and subsequently Cockle Creek for the Link Road South Site.

3.3 Climate Change

The DECCW Practical Consideration of Climate Change (October ,2007) guidelines recommend that the following sensitivity analyses be undertaken in relation to the climate change impacts on rainfall intensities. It recommends assessment of increases of rainfall intensities considering:

» 10% increase in peak rainfall and storm volume;

» 20% increase in peak rainfall and storm volume; and

» 30% increase in peak rainfall and storm volume.

For the Minmi Link Road site the 30% increase in storm rainfall intensity and storm volume was adopted. This was considered an upper envelope of climate change for a 2100 planning horizon. On this basis, the RAFTS and TUFLOW models were resimulated.

4. Concept Plan and Potential Stormwater Impacts

Development results in increased impermeable surfaces (roofs, driveways, roads, pavements etc.). These affect the hydrological cycle, and if not managed effectively, this 'hardening' of the surfaces has the potential to:

- Increase stormwater peak flows, leading to increased flood risk and erosion (on-site and off-site);
- Increase stormwater runoff volumes, which could impact downstream sensitive habitats in terms of flushing regimes (frequency, volume and rate), water quality, and wetting cycles;
- Increase stormwater pollution discharged to receiving environments as a result of pollutant entrainment in the increased runoff. The type of development and associated activities may introduce differing pollutant profiles, for example vehicular traffic could increase hydrocarbon introduction. In general, typical pollutants include litter, sediment, suspended solids, nutrients, hydrocarbons and toxicants;
- Reduce rainfall infiltration to the soil leading to impacts to the water balance, (including groundwater recharge and salinity impacts); and
- Impact groundwater flow due to site compaction, fill, landform reshaping and underground structures. Ground water aspects are dealt with in a separate groundwater report.

During construction there are additional impacts to pollution, erosion and sedimentation. Increased sedimentation on account of landform disturbances and accidental spills within unbunded areas of the site could discharge to the receiving environment. Clearing and earthmoving activities have the potential to impact on surface water quality in the vicinity of the site, especially during high rainfall events. The activities and aspects of the works that have potential to lead to erosion, sediment transport, siltation and contamination of natural waters include:

- Earthworks undertaken immediately prior to rainfall periods;
- Work areas that have not been stabilised and clearing of land in advance of construction works;
- Stripping of topsoil, particularly in advance of construction works;
- Bulk earthworks and construction of pavements;
- Washing of construction machinery;
- Works within drainage paths, including depressions;
- Stockpiling of excavated materials;
- Storage and transfer of oils, fuels, fertilisers and chemicals; and
- Maintenance of plant and equipment.

To reduce the potential pollutant export during construction, a detailed Water Management Plan and associated Sediment and Erosion control plan would need to be developed during the detail design phase of the project.

5. WSUD Management Strategy

5.1 General

5.1.1 Principles

Water usage and water conservation along with maintaining the health of the surrounding environment are important considerations of any proposed development. The Minmi Link Road development site is located in an area that is sparsely populated with significant aesthetic amenity and as such these considerations have been given a great deal of emphasis.

Local Councils are acutely aware of the need to maintain the health of the natural environment and have developed a comprehensive range of criteria for all new developments. Criteria includes, but is not limited to, the inclusion of stringent stormwater quantity and quality limits that require the adoption of a range of WSUD treatment measures to form a treatment train.

In general, the principles for stormwater management at the Minmi Link Road sites should aim to retain as much stormwater as possible on site, transport as little stormwater as possible to receiving waters, 'lose' as much stormwater as possible along the treatment train and slow the transmission of stormwater to receiving waters.

5.1.2 Objectives

In applying the above principles, the key planning and design objectives are generally:

- Protect and enhance natural water systems in urban developments;
- Integrate stormwater treatment into the landscape by incorporating multiple-use corridors that maximise the visual and recreational amenity of the development;
- Protect water quality draining from the development;
- Reduce runoff and peak flows from developments by employing local detention measures, minimising impervious areas and maximising re-use; and
- Add value while minimising drainage infrastructure development costs.

The development of a management plan to achieve the above will also consider flood management, flow management, water quality management and flow attenuation.

5.1.3 Opportunities

General opportunities for WSUD at the Minmi Link Road site include:

- Orientate roads to traverse contours, providing slopes with grades of 4% or less where possible to promote the provision of above ground conveyance mechanisms such as vegetated swales into the streetscape;
- Maintain and re-establish vegetation along waterways and provide public open space along drainage lines to develop multi-use corridors linking public and private areas;
- Preserve and restore existing valuable elements of the drainage system such as wetlands, natural channels and riparian vegetation;