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New Brighton Golf Club

Report for Rezoning Studies

Flood and Water Sensitive Urban Design Report

June 2011

INFRASTRUCTURE | MINING & INDUSTRY | DEFENCE | PROPERTY & BUILDINGS | ENVIRONMENT

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1. Introduction

1.1 The Site (see Appendix A)

New Brighton Golf Club (NBGC) is proposing to lodge a Planning Proposal for the redevelopment of around 16 ha (approx 300 dwellings) of surplus golf course lands for residential purposes, redesign of the existing golf holes, and construction of a new club house.

The site is located 4.5 km from Liverpool with existing access off Nurwarra Road. It is located adjacent to the M5 Motorway. The land currently consists of the existing golf course including grassed fairway and green areas, as well as vegetated areas.

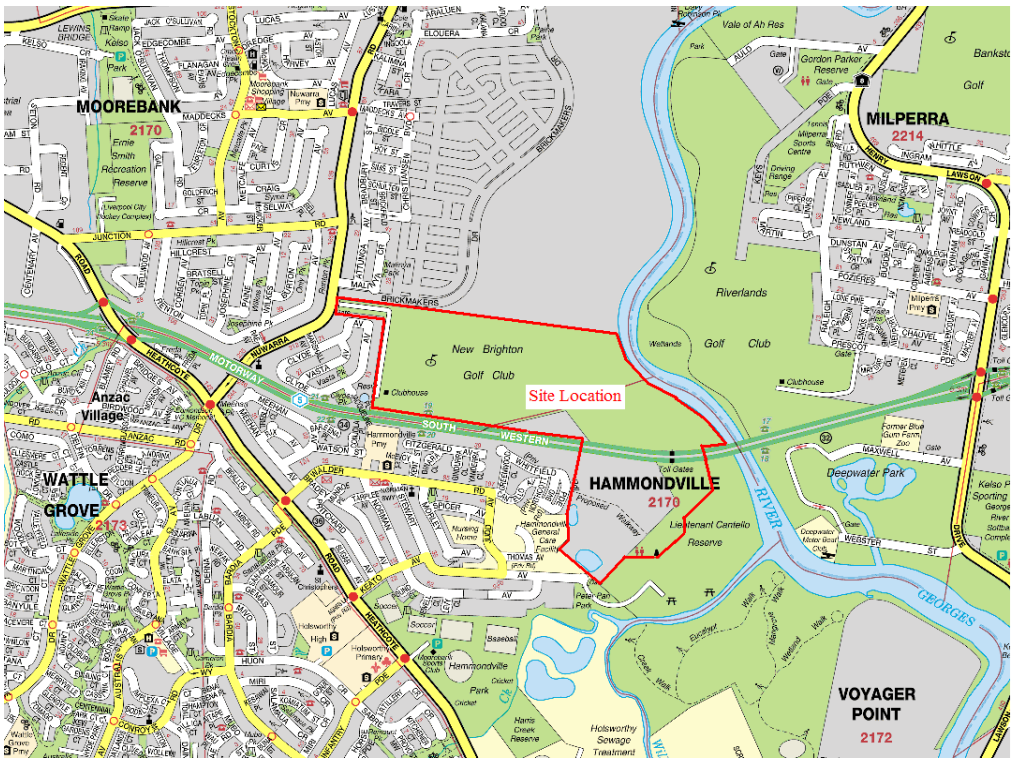


Figure 1 Site Location

1.2 Indicative Layout Plan (ILP)

This report is based on the site Masterplan dated 22/11/2010, which is included in Appendix A.

1.3 Water Sensitive Urban Design (WSUD)

WSUD encompasses all aspects of urban water cycle management including water supply, wastewater and stormwater management. WSUD is a multi-disciplinary approach that promotes opportunities for linking water infrastructure, landscape design and the urban built form to minimize the impacts of development upon the water cycle and achieve more sustainable forms of urban development.

The principles of WSUD are incorporated in the Liverpool City Council Development Control Plan. The intent of Councils' requirements in relation to stormwater management is to ensure systems are carefully planned, designed and located to prevent the disturbance, redirection, reshaping or modification of watercourses and associated vegetation and to protect the quality of receiving waters. If adequate WSUD measures are not adopted, the proposed development may have the following impacts:

- Increased stormwater runoff, which could impact sensitive downstream habitats in terms of flushing regimes (frequency, volume and rate), water quality and wetting cycles;
- Reduction in rainfall infiltration and decreased groundwater recharge; and
- Disturbance of groundwater flow due to site compaction, fill, landform reshaping and underground structures.

The suitability of WSUD solutions to any proposed development depends upon a number of factors, including climate and rainfall, site topography, geology and available land.

2. Existing Conditions and Opportunities

2.1 Climate and Rainfall

The New Brighton Golf Club experiences Sydney's sub-tropical climate with rainfall predominantly occurring in late summer and autumn. A number of Bureau of Meteorology (BOM) daily rainfall stations have been in operation in the area.

For the purposes of climate averages, BOM provides data for Liverpool (Station 067035), which has an annual rainfall of 870 mm. The figures below show the mean monthly rainfall and number of rain days recorded, which is considered representative of climate conditions at the site. The figures show elevated monthly rainfalls in the months of January to April, with the least rainfall being recorded in July to September. The mean number of rain days varies between approximately 4 and 8 days of rain days per month. Furthermore, the mild seasonal variability would indicate that rainwater collection via rainwater tanks might be viable, however this would depend on roof areas and demands for the captured water.

Figure 2 Monthly Mean Rainfall

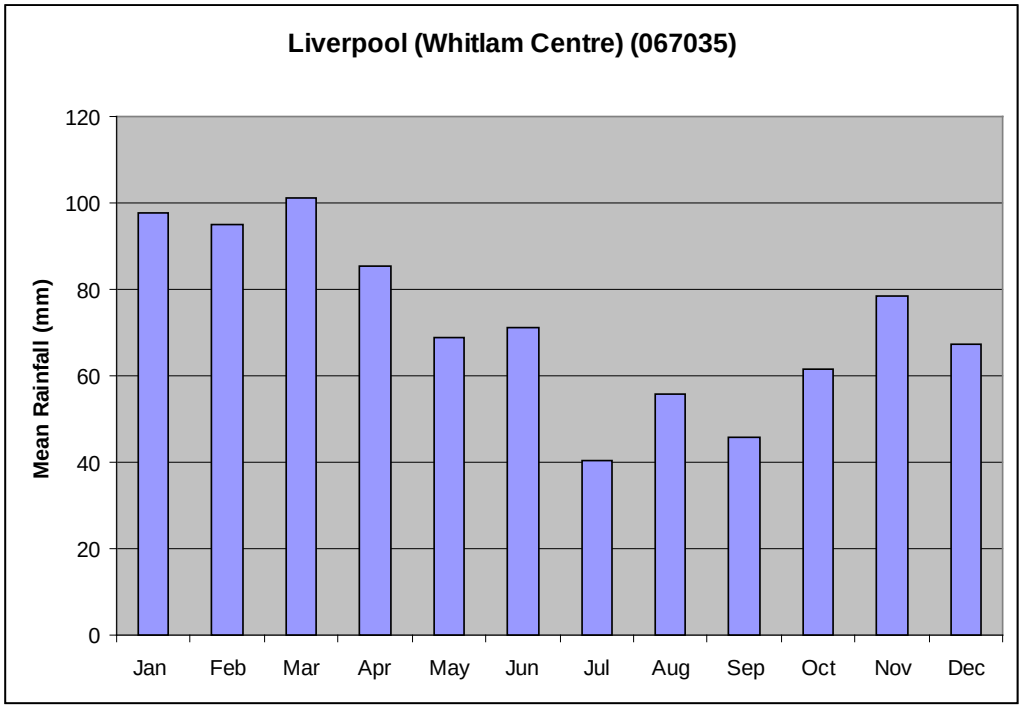
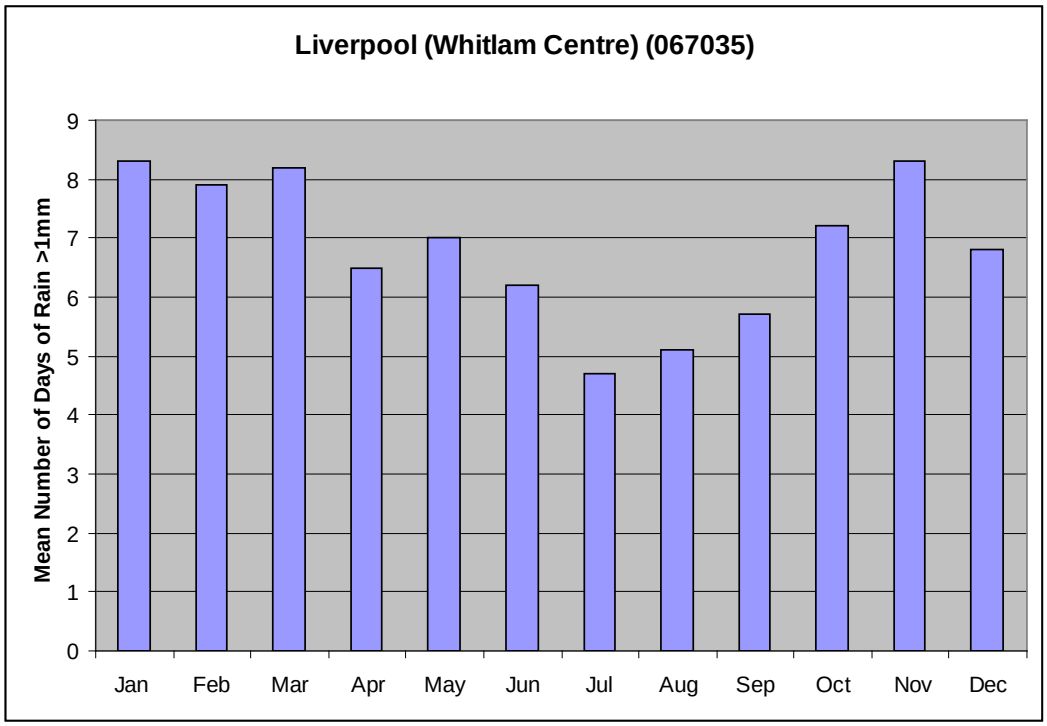


Figure 3 Mean Number of Rain Days



2.2 Topography and Slopes

The site topography ranges from approximately 2m AHD to 32m AHD. The majority of the site is a flat, located adjacent to the Georges River floodplain. The site experiences slopes of up to 10% and is located at the top of the catchment. Minimal uncontrolled runoff enters the site from upstream catchments flowing through the redevelopment area, with exception of a cross-catchment transfer of stormwater from the adjacent Boral site as described below.

2.3 Water Courses and Receiving Water

All runoff from the site discharges to the Georges River, without passing through any adjacent developed areas. During times of low flow, ponds throughout the golf course collect runoff. During times of higher flow these ponds would overflow or be submerged by backwater flooding from the Georges River. Only the large pond adjacent to the proposed 18th fairway is located outside the 100-year ARI event flood extents.

2.4 Cross-Catchment Transfers

From a brief site visit and discussions with Mirvac, it is understood that a portion (17.2 ha) of the adjacent Boral subdivision discharges stormwater to the large pond adjacent to the proposed 18th fairway, via a small basin, two 525mm diameter pipes and a smaller 225mm diameter pipe. The purpose of this discharge is to provide stormwater for reuse on the golf course. It is understood, that this stormwater is not treated before discharge from the Boral site and the works have not been complete to date. The

current arrangement of the diversion, would result in storms greater than the 5-year ARI event overflowing the small basin spillway, and discharging to the Georges River, thus bypassing the Golf Club lands.

While a catchment plan exists that shows a Boral catchment area of approximately 17.2ha draining to the diversion, it will be necessary to confirm the exact catchment area, and the arrangements for the treatment of stormwater for this diversion and in particular the conditions of consent relating to the treatment and discharge from stormwater prior to discharge from the Boral site. The implications of this diversion are:

- If the diverted stormwater is untreated, it will be necessary to determine what treatment is required and who will be responsible for the treatment before discharge to the receiving environment. In this regard it must be noted that during times of rainfall and diversion, it is unlikely that the stormwater will be reused for irrigation; and
- The New Brighton Golf Club should be aware of the risks associated with receiving untreated stormwater. This stormwater is likely to contain pollution related to residential sub-division. In addition other risks such as accidental spills would need to be considered. These matters, if not adequately considered could affect the functioning of the onsite dams.

2.5 Design Criteria and Environmental Objectives

The Liverpool City Council Development Control Plan 2008, the NSW Floodplain Development Manual (2005) and the Australian Rainfall and Runoff 2001 define the requirements for management of stormwater quantity, quality and flooding at the site. Specific advice was also received from Stephen Monte of Liverpool City Council. The following Liverpool City Council Documents were referenced in the DCP and were considered accordingly:

- Liverpool City Council ,Handbook for Drainage Design Criteria, 2003;
- Liverpool City Council , On-Site Stormwater Detention Technical Specification, 2003;
- Liverpool City Council , Development Design Specification D5 – Stormwater Drainage Design, 2003; and
- Liverpool City Council DCP 2008, Part 1.1: General Controls for All Development , Section 9: Flooding (With particular reference to the Georges River Floodplain Flood Planning Matrix).

2.5.1 Stormwater Quality

In the Liverpool City Council Development Control Plan 2008 pollution removal targets are nominated in Section 6.4. These targets are shown in Table 1.

Table 1 Adopted Retention Criteria

Pollutant	Retention Criteria (%)
Total Suspended Solids	80
Total Phosphorus	45
Total Nitrogen	45

2.5.2 Stormwater Quantity and Flood Risk

While Council's 2008 DCP requires developments to consider the cumulative effect of developments on downstream flood levels and velocities, Liverpool City Council has indicated to GHD that stormwater quantity detention may not be required for the site as there is no Council stormwater network downstream of the site. In accordance with Council's advice, the proposed WSUD strategy thus does not propose stormwater detention at this stage, but confirmation with Council should be sought at a later stage of design.

The Development Control Plan also states that any filling within the 100-year ARI event flood will normally be considered unacceptable unless compensatory excavation is provided.

The impervious fractions for the existing and developed conditions were adopted from Liverpool City Council's Handbook for Drainage Design Criteria, except for pervious golf course areas which were modelled with an impervious fraction of 5%.

The selection of storms modelled was adopted from the Liverpool City Council On-Site Stormwater Detention Technical Specification which specifies that calculations must be performed for the 5-year ARI event, a medium recurrence interval event, and the 100-year ARI event. The 20-year ARI event was selected as the medium recurrence event. The requirement for other storm events can generally be met by considering the outlet configuration in more detail.

Development and land-use in flood prone areas should be in accordance with the Liverpool City Council Development Control Plan 2008 and the NSW Floodplain Development Manual, 2005. In assessing the flood risk, consideration needs to be given to the full range of risks to people and property, for a full range of flood events up to and including the PMF. Development guidelines specify, amongst others:

- Habitable floor levels, together with normally occupied floors of special use developments should either be at or above the Flood Planning Level or be flood proofed to this level with flood compatible building components a specified in Councils Georges River Floodplain Management Matrix. The flood planning level is defined as being a freeboard of 500 mm above the 100-year ARI flood level for residential, commercial and industrial developments.
- For development in flood prone land, development must not lead to adverse off site impacts in flood levels, flood damages, flood behaviour or flood hazard. Provision of adequate and acceptable compensating works to offset must be provided; and
- Effective evacuation procedures must be provided for the full extent of the flood plain in accordance with the Liverpool City Council Georges River Floodplain Management Matrix, specifically:
  - Reliable access for pedestrians or vehicles during the 100-year ARI event to a publically accessible location above the PMF will be provided; and
  - Adequate flood warning to allow safe and orderly evacuation without increased reliance upon the SES or other authorised emergency services personnel will be provided.

2.6 Supporting Simulations

Numerical modelling was used to assess the flood and stormwater management, which included simulating:

- Existing conditions flood peaks for the 5-year and 100-year ARI events (using RAFTS) for all onsite local catchments where residential development is proposed;

- While Liverpool City Council has indicated to GHD that stormwater quantity detention may not be required for the site , we have nevertheless simulated increases in peak flows from the site due to the proposed residential footprint;
- Stormwater runoff quantity and quality for the developed scenario (using MUSIC) for all onsite local catchments where residential development is proposed; and
- Appropriate strategies for stormwater quality management throughout the site, which responded as best as possible to the Master Plan and which achieved the pollution load export requirements set by the design criteria (using MUSIC).

All modelling should be considered as preliminary and would need to be updated at later stages with more detailed studies, when better information on landform and the development footprint are known.

2.6.1 Existing Flood Risk

Local Flood Peaks

Flood peaks in response to the residential portion of the site were simulated according to Australian Rainfall and Runoff using the RAFTS hydrological model. Compilation of the model included:

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

An existing conditions model was developed, with catchments delineated to the site. A developed conditions model was compiled to simulate the increased flows due to an increase in impervious areas due the development for the 5-year and 100-year ARI events.

The RAFTS model was simulated for a range of durations ranging from 25 minutes to 12 hours. For each event the critical duration was reported. Lag times were based on average slopes and surface roughness, ranging between 1 m/s and 2 m/s. Percentage impervious areas, used in the hydrology model, were configured as follows, as per Council's Handbook for Drainage Design Criteria and specific advice from Stephen Monte of Council:

- Golf Course = 5%;
- Residential = 75%; and
- Maintenance Area = 90%.

The RAFTS modelling flood peak results are provided in Table 2, for the onsite catchments and the diversion from the adjacent Boral lands, under the assumption that the entire 17.2 ha catchment drains to the site for storms up to the 5-year ARI event.

Table 2 RAFTS modelling flood peak results

Catchment	Flood Peak (5-year ARI event)	Flood Peak (100-year ARI event)
New Brighton Golf Course	6.2 m^3/s	9.7 m^3/s
Boral (assuming 17.2 ha)	5.4 m^3/s	5.4 m^3/s (assuming overflow at diversion)

Georges River Flood Levels

The 100-yr ARI event Georges River flood extents for the site were obtained from Council, as levels provided in an email. The PMF flood level for the site was obtained in an email from Council dated 9th October 2009. Using 2 metre contour data this flood level was applied to the site topography to determine the PMF flooding extents. The 100-year and PMF flood extents are shown in Appendix B. From the flood maps, the existing site experiences the following flooding conditions:

- Approximately two-thirds of the current golf course site is inundated in the 100-year ARI event. The site is above the 100-year ARI event flooding by approximately 2 m; and
- Approximately three-quarters of the current golf course is inundated by the PMF, including approximately five percent of the proposed site area.

2.6.2 Stormwater Quality Management

Stormwater quality was assessed using the MUSIC model. The model was configured and simulated for post-development conditions in response to the Master Plan. In undertaking the MUSIC modelling, the following approach was used:

- The target pollution reduction parameters were obtained from the Liverpool City Council Development Control Plan 2008. Event mean concentrations and standard deviations were adopted for both base and storm flows;
- The large pond adjacent to the proposed 18th fairway was modelled, removing nutrients and fine particles from the runoff via settlement and removal of water from the system;
- Treatment efficiencies and guidance as recommended in the MUSIC User Guide (April 2005) and the Fletcher Technical Report 04/8 (December 2004) were adopted;
- Simulations were undertaken using the Liverpool (Whitlam Centre) (BOM Stn 0607035) 6 mm rainfall data for the period between 1989 and 1994 including a wet period; and
- Simulations were undertaken using the MUSIC model default Sydney evapo-transpiration monthly data. All simulations were performed using the stochastic simulation method.

2.7 Climate Change Sensitivity Assessment

Climate change impacts in relation to flooding and stormwater management have not been considered in this report. We recommend that this be investigated in ensuing stages of the development. Key impact to be considered relate to:

- Increased rainfall intensities; and
- Sea level rise.

3. The Master Plan and Potential Stormwater Impacts

If not managed appropriately, the 'hardening' of surface associated with development (roofs, driveways, roads, pavements etc.) 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);
- Impact groundwater flow due to site compaction, fill, landform reshaping and underground structures; and
- If the ground surface is filled in flood prone land a loss of flood storage results, which can increase flood levels and velocities, posing a hazard for areas within or adjacent to the flood plain.

The above are the long-term potential impacts. During construction there exist the potential for 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.

4. WSUD Management Strategy (See Appendix B)

4.1 General

4.1.1 Principles

Water usage and water conservation along with maintaining the health of the surrounding environment are important considerations of any proposed development.

A number of design principles are listed in the Liverpool City Council Development Control Plan 2008, which will help assist development in meeting the objectives of the DCP. This criterion 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 which will treat stormwater pollutants. WSUD elements implemented should not contribute to increased flooding risk.

In general, the principles for stormwater management at the site should aim to retain as much stormwater as possible, treat pollutant entrained in the stormwater, 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.

4.1.2 Objectives

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

- To protect and enhance natural water systems in urban developments;
- To manage water quality draining from the development;
- To reduce runoff and peak flows from developments by minimising impervious areas and maximising re-use; and
- To add value while minimising drainage infrastructure development costs.

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

4.1.3 Site Opportunities

General opportunities for WSUD at the site, within the Liverpool City Council requirements include:

- Maximise source control measures in preference to end of line treatment measures. Manage the quality of stormwater at or near the source, which will involve a significant component of education;
- Utilisation of the large pond adjacent to the proposed 18th fairway for treating stormwater; and
- Utilisation of on-lot treatment of stormwater quality where appropriate.

4.2 Stormwater Quality Management

4.2.1 The Water Quality Management Strategy

The water quality management strategy will consist of the following elements:

- Runoff from the proposed development area will be directed towards the large pond (the Stormwater Pond) adjacent to the proposed 18th fairway via the road network and drainage channels traversing the fairway. Gross Pollutant Traps would be provided before discharge to the drainage channels. While these channels are for conveyance, they may provide some benefit in treating water quality. The pond would provide significant treatment of water quality through settlement of suspended particles as well as removal of water from the system through evaporation and irrigation;
- The Maintenance Area runoff will be treated with on-lot facilities, such as gross-pollutant traps, oil water separation pits. These facilities can be supplemented with on-lot bio-retention systems in road ways or a rain garden. Provision of rainwater tanks on all lots should be maximised in accordance with Council's requirements; and
- The runoff from the Boral site has been assessed and directed towards the large pond (the Stormwater Pond) adjacent to the proposed 18th fairway via the diversion structure, for treatment.

4.2.2 Testing the Strategy Effectiveness

To test the effectiveness of the strategy, the MUSIC model was used to simulate the quality of runoff from the development footprint in accordance with Section 2.5.1.

The Stormwater Pond was modelled to test the feasibility of using the pond as the treatment facility. The evaporative losses from the pond were modelled but irrigation reuse was not considered. The pond is already used for irrigation and will continue to be utilised. This will have a beneficial effect on the treatment achieved in the pond. Treatment in the drainage channels traversing the proposed 18th fairway as well as the proposed Gross Pollutant Traps were not modelled, although they would achieve further water quality treatment.

For the treatment associated with the Maintenance Area representative single bio-retention nodes were used to test the scale and feasibility of the treatment required. The precise nature of the treatment facilities for these areas will be confirmed at a later stage.

Simulations have been undertaken for two scenarios as follows:

- Option 1: Runoff from the Boral site (at 17.2 ha) does not drain to the site and is not treated by the stormwater pond; and
- Option 2: Runoff from the Boral site (at 17.2 ha) is treated by the stormwater pond, via the diversion.

The percentage impervious parameters were the same as used in the RAFTS models. The treatment train effectiveness at critical locations are listed in Table 5.The table shows that the design criteria in Section 2.5.1 for total suspended solids, total phosphorous, total nitrogen are met, if runoff from the Boral site is not conveyed to the Stormwater Pond.

If the runoff from the Boral site is conveyed to the stormwater pond, then the treatment train efficiency for Total Nitrogen is slightly less than the target requirement, and all other targets are met. It may thus be possible to provide stormwater treatment for the stormwater from the Boral subdivision within the Golf Course Stormwater Pond. This may require an increase in the stormwater pond size and can be investigated during future stages of the development, once the exact catchment areas draining to the Golf Course lands have been determined.

Table 3 Stormwater Pond: Estimated Parameters

Wetted Surface Area (m^2)	Permanent Pool Volume (m^3) (estimate)	Extended Detention Depth (m)	Seepage Loss (mm/hr)
18,000	27,000	0.2	0

Table 4 Indicative Bio-Retention Areas

	Representative Bio-retention Filter Area (m^2) [A]	Treatment area (ha) [B]	[A] / [B] (m^2/ha)
Maintenance Area	130	0.6	220

Table 5 Pollutant removal rates at various outlets

	Option 1 Outlet of Golf Course Pond	Option 2 Outlet of Golf Course Pond with Boral inflows from 17.2ha	Outlet of Maintenance Area	Target (see Section 2.5.1)
Total Suspended Solids	88.4%	80.3	92.0%	80%
Total Phosphorus	71.5%	61.5	74.0%	45%
Total Nitrogen	55.0%	41.2	49.6%	45%
Gross Pollutants	~100%	~100%	~100%	Not Specified

4.2.3 Managing Construction Phase Stormwater Quality Impacts

Construction phase water quality impacts will be managed through the implementation of a Soil and Water Management Plan detailing stormwater management strategies in accordance with 'Soils and Construction, Managing Urban Stormwater' (Landcom 2006). Specific strategies include:

- Material management practices;
- Stockpile practices;
- Topsoil practices; and
- Erosion control practices (earth sediment basins, straw bales, sediment fences, turbidity barriers, stabilised site accesses, diversions and catch drains).

Monitoring, including inspections and water quality sampling, will be required as part of any development consent to ensure that management strategies are working effectively.

4.3 Stormwater Quantity Management

4.3.1 An Important Note

While Council's 2008 DCP requires developments to consider the cumulative effect of developments on downstream flood levels and velocities, Liverpool City Council has indicated to GHD that stormwater quantity detention may not be required for the site as there is no Council stormwater network downstream of the site. In accordance with Council's advice, the proposed WSUD strategy thus does not propose stormwater detention at this stage, but confirmation with Council should be sought at a later stage of design.

4.3.2 The Water Quantity Management Strategy

On advice of Council, we have not proposed a water quantity management strategy at this stage. However should it become necessary to detain peak flows:

- The large pond adjacent to the proposed 18th fairway could accommodate approximately 210 mm of flood storage on top of the permanent pool volume. The outlet from the pond would be configured such that during regular rainfall events the storage level remains at the bottom of the flood storage. However, during larger events the outflow is restricted to the existing peak flow rate, resulting in water being stored in the flood storage. The configuration of the outlet would require detailed consideration at a later stage due to the 100-year ARI event flooding backing up against the downstream bank of the pond; and
- Runoff from the site could be directed to the pond via the proposed road network and drainage channels traversing the proposed 18th fairway.

4.4 Flooding

4.4.1 Flood Management Strategy

All habitable floor levels would be located above the Flood Planning Level associated with flooding in the Georges River. Based on Part 1, Section 9 of the Liverpool City Council Development Control Plan 2008 it is proposed that Flood Planning Levels be adopted that locate habitable floor levels of buildings with a freeboard of 500 mm above 100-year ARI flood levels. For the site existing ground levels are such that filling will not be required to locate floor levels at or above the flood planning level.

Areas that are inundated by the PMF, including the Maintenance Area and parts of the site, would be provided with a flood evacuation strategy. Elevated areas would provide suitable evacuation muster areas.

Development and land-use in flood prone areas will be in accordance with Liverpool City Council's Development Control Plan 2008 and the NSW Floodplain Development Manual.

For flooding associated with discharges on internal roads and other areas of concentrated flow, it is proposed to limit the overland flows and lowering flow velocities and depths to reduce the flood hazard. This could be achieved through a detailed design of the subsurface stormwater infrastructure. In addition,

areas of high velocity may require energy dissipation using environmentally acceptable strategies (for example rock protection).

4.5 Water Demand Management and Re-use

Demand management should be maximised and could include water savings fittings, low flow showerheads, water efficient appliances, and low water demand toilets. Demand management should be implemented in order to meet the requirements of and/or similar to BASIX.

It is proposed that all buildings that have sufficient roof areas be provided with roof rainwater harvesting tanks. The rainwater tanks would overflow to the site stormwater system and the road stormwater drainage system.

Regional recycled water provision should be explored and maximised. The right combination between rainwater tanks and recycle water would need to be assessed further.

Stormwater harvesting should be promoted, in particular where the demands are located close to the storage location. In areas where open space areas are located close to water bodies, this may prove viable.

4.6 Ongoing Monitoring

Monitoring can be undertaken to ensure that stormwater quality management measures are working effectively. Monitoring would rely primarily on visual inspections and potentially sampling. Visual inspections should be undertaken of sediment traps, pits, diversion, GPTs, catch drains and all stormwater conveyance structures.

5. Conclusions

- A number of opportunities for management of stormwater quality, quantity and flooding exist at the New Brighton Golf Course. This management would benefit from the implementation of Water Sensitive Urban Design (WSUD) practices. WSUD encompasses all aspects of urban water cycle management including water supply, wastewater and stormwater management, that promotes opportunities for linking water infrastructure, landscape design and the urban built form to minimize the impacts of development upon the water cycle and achieve sustainable outcomes;
- The strategy for management of stormwater at the site nominates:
  - As Liverpool City Council has indicated to GHD that stormwater quantity detention may not be required for the site the proposed WSUD strategy thus does not propose stormwater detention at this stage, but confirmation with Council should be sought at a later stage of design.
  - Runoff from the proposed development area will be directed towards the large pond (the Stormwater Pond) adjacent to the proposed 18th fairway via the road network and drainage channels traversing the fairway. Gross Pollutant Traps would be provided before discharge to the drainage channels. The pond would provide significant treatment of water quality through settlement of suspended particles as well as removal of water from the system through evaporation and irrigation;
  - The Maintenance Area runoff quality and quantity from this area will be treated with on-lot measures;
  - For flood management, habitable floor levels of new residences will be above the flood planning level (100-yr ARI flood level plus 500 mm). A flood evacuation strategy would be provided for all areas inundated by the PMF.
  - Rainwater tanks throughout and water re-use will be maximised throughout the development, as required and as appropriate.
- It is understood that a portion (17.2 ha) of the adjacent Boral subdivision discharges stormwater to the large pond adjacent to the proposed 18th fairway. The purpose of this discharge is to provide stormwater for reuse on the golf course. It is understood, that this stormwater is not treated before discharge from the Boral site and the works have not been complete to date. The exact catchment area discharging to the Golf Course and conditions under which they occur will need to be determined. If necessary, the risk associated with receiving untreated stormwater need to be considered, as will any condition of the consent for that development requiring treatment prior to discharge.

Development and land-use in flood prone areas must be in accordance with Liverpool City Council's Development Control Plan 2008 and the NSW Floodplain Development Manual.

To test the effectiveness of the WSUD strategy, a MUSIC model was developed to demonstrate that the proposed treatment achieves target reductions. The results show that the treatment targets for total suspended solids, total phosphorous, total nitrogen are met, if runoff from the Boral subdivision is not conveyed to the Stormwater Pond. If the runoff from the Boral site is conveyed to the stormwater pond, then the treatment train efficiency for Total Nitrogen is slightly less than the target requirement, and all other targets are met. It may thus be possible to provide stormwater treatment of the Boral subdivision

stormwater within the Golf Course Stormwater Pond. This can be investigated during future stages of the development, once the exact catchment areas have been determined.

The results of the numerical modelling have shown that the proposed WSUD strategy together with the flood plain management adequately satisfies the requirements of the Liverpool City Council Development Control Plan 2008 and the NSW Floodplain Development Manual for management of stormwater quantity, quality and flooding at the site.

6. References

- Liverpool City Council Development Control Plan 2008;
- Liverpool City Council Handbook for Drainage Design Criteria, 2003;
- Liverpool City Council On-Site Stormwater Detention Technical Specification, 2003;
- Liverpool City Council Development Design Specification D5 – Stormwater Drainage Design, 2003.;
- 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.
- XP Software, XP-RAFTS User's Manual;
- NSW Government, Floodplain Development Manual, 2005;
- Landcom 2004, Soils and Construction, Managing Urban Stormwater, March 2004; and
- Australian Rainfall and Runoff , 2001

Appendix A

Proposed Site Plan

LOT WIDTH	TOTAL	
8.5 - 10	127	40%
12.5	110	35%
14 -15	76	25%
TOTAL	313	100%

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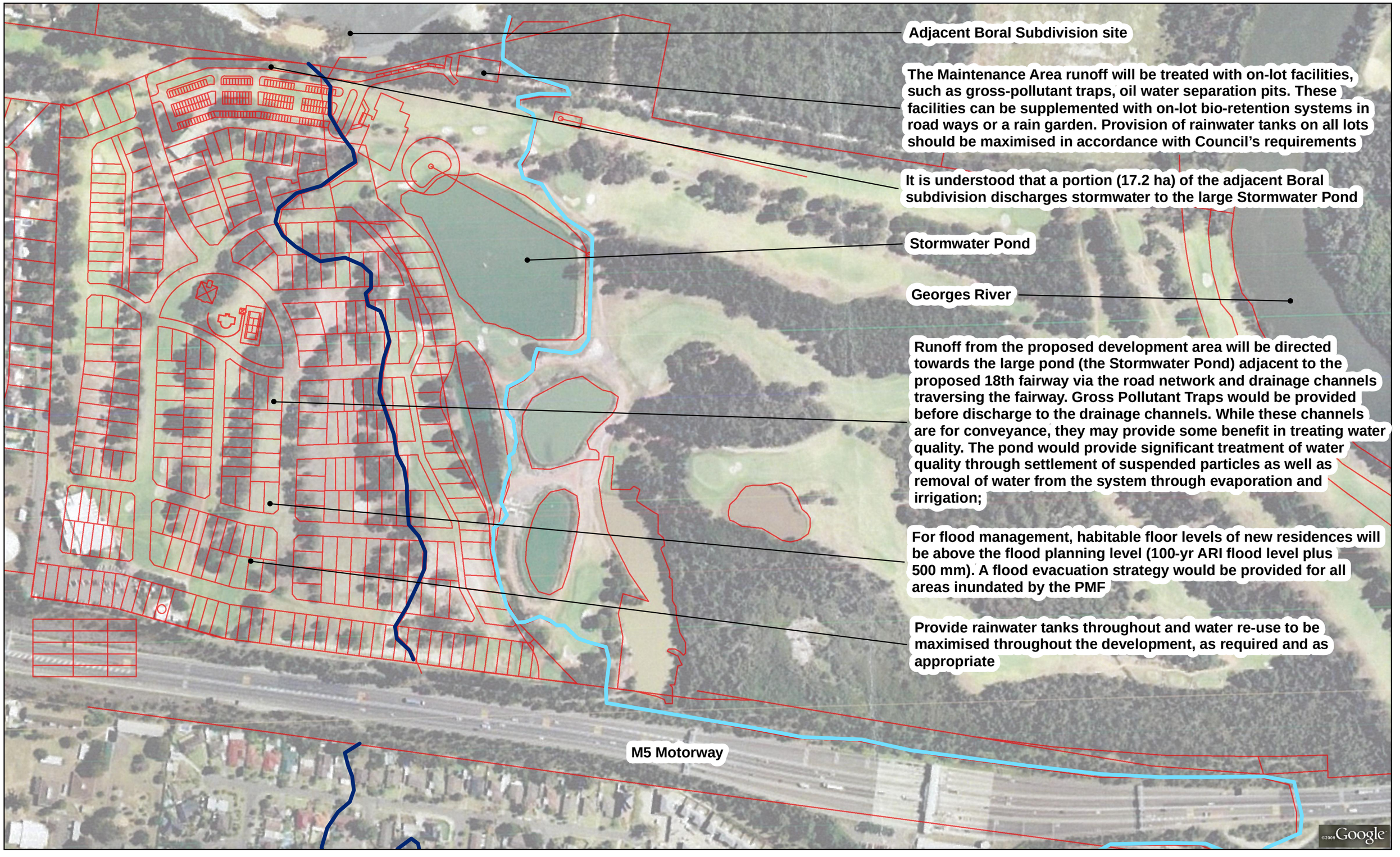
Appendix B

WSUD Strategy



1:3,000

0 25 50 100 150

Meters

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

LEGEND

- 100yr ARI Event Flood Extents
- PMF Flood Extents
- Proposed Development

GHD CLIENTS | PEOPLE | PERFORMANCE

New Brighton Golf Club
Rezoning Studies

Job Number	22-15545
Revision	A
Date	02/03/2011

Preliminary WSUD Strategy

"n:\AU\Coffs Harbour\Projects\22\15545\CADD\GIS\Maps\2011.02.25 New Brighton WSUD.mxd"

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

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