City of Port Adelaide Enfield

North Arm East Catchment

Stormwater Management Plan

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1 Introduction

The North Arm East catchment lies predominantly within the City of Port Adelaide Enfield and partly within the Cities of Salisbury and Prospect. The catchment covers most of the inner northern suburbs of Adelaide and extends from the predominantly residential areas of Northfield, Greenacres and Sefton Park in the east to the industrialised areas of Cavan and Dry Creek in the west.

Stormwater runoff from the catchment is collected by a network of underground drains that feed into the North Arm East Outfall channel. This channel discharges into the Barker Inlet Wetlands at the downstream end of the catchment.

This Stormwater Management Plan for the catchment has been prepared in accordance with the Stormwater Management Authority's Stormwater Management Planning Guidelines (2007) and addresses issues of flood management, water quality, water harvesting and environmental enhancement associated with the management of stormwater.

2 Catchment Description

2.1 Catchment Boundary

The catchment boundary is shown in Figure 2.1. The catchment has an area of 2116 ha.

The catchment has been shown to include areas lying within the former Department of Agriculture land at Northfield that is currently being developed as a part of the Northgate development. While this area currently drains to the North Arm East outfall it has been proposed that the catchment be redirected to the Torrens (BC Tonkin & Associates, 1995). This will occur as a part of later stages of the proposed development. Detention basins that will be incorporated as part of the development will intercept both minor and major flows with the discharge from the basins limited such that they will not exceed the capacity of the drainage network that drains into the River Torrens.

The catchment was subdivided into smaller sub catchments based on the digital terrain model, available road grading information, drainage layout information and site inspections. These sub catchments are also shown in Figure 2.1.

2.2 Land Use

The existing land use in the catchment is shown in Figure 2.2 and was derived by analysis of Lands SA land use codes and field inspections.

Land within the catchment is predominantly used for residential purposes. The residential areas contain housing that was mostly developed between 1945 and 1960. The residential density in these older developed areas is generally low.

Industrial land use is concentrated in the north western portion of the catchment, generally to the north of Grand Junction Road. The industrial land in this area is almost fully developed.

East of Port Wakefield Road and north of Grand Junction Road, the land is primarily use for non-residential purposes of a much more 'open' character and includes the former abattoir and stock market, the Drive-In, the Woolworths Distribution Centre and the State Sports Park.

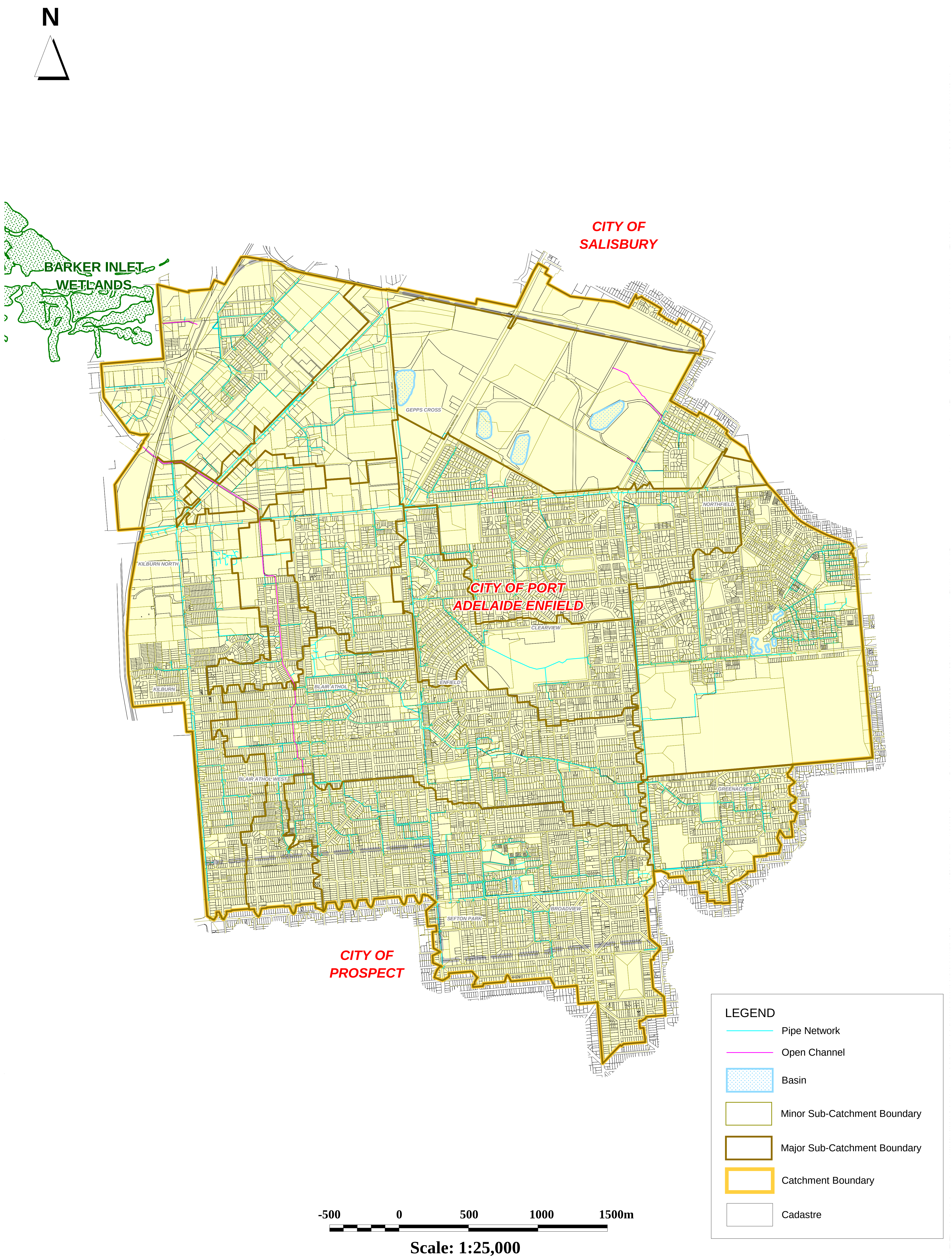
Commercial development within the catchment is primarily distributed along main roads, with the greatest concentrations occurring along Main North Road, Prospect Road, Grand Junction Road and Churchill Road.

Table 2.1 provides a breakdown of land use into various categories.

Table 2.1: Land Use Breakdown

Land Use Category	Proportion of Total Catchment Area
Residential	40%
Commercial	8%
Industrial	14%
Recreation	10%
Vacant Land	6%
Other (inc. Road Reserves)	22%

The relatively large area of 'Recreation' land use within the catchment is due to the area around the State Sports Park at Gepps Cross. Land uses within the 'Other' category include road reserves (almost 10% of the catchment, government institutions, schools and the Enfield Cemetery.



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City of Port Adelaide Enfield

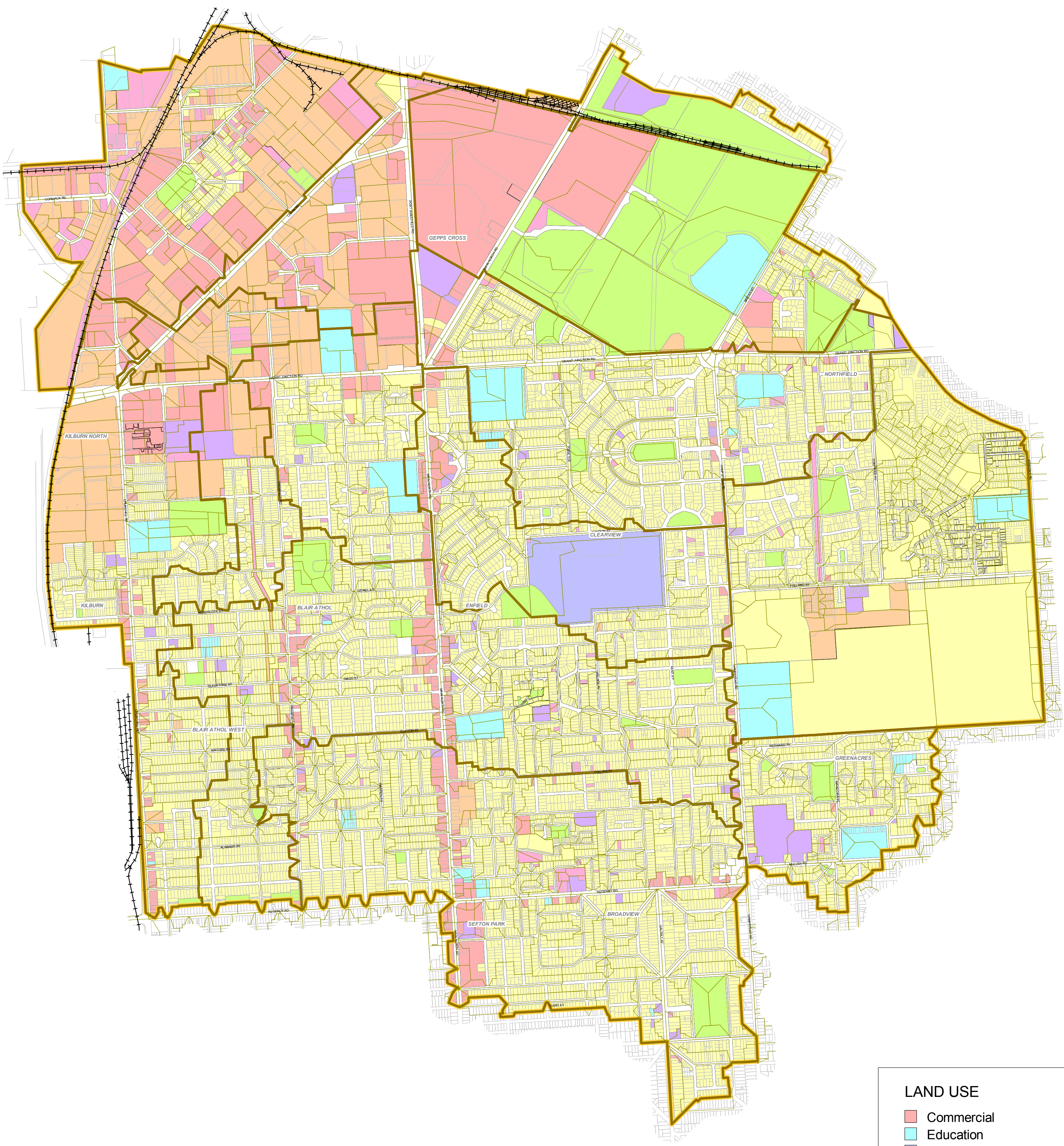
Urban Sotrmwater Master Plans

North Arm East Catchment

CATCHMENT PLAN

Figure 2.1

N



LAND USE

- Commercial
- Education
- Cemetery
- Government institution
- Recreation
- Residential
- Industry
- Vacant

Railway Alignment

Minor Sub-Catchment Boundary

Major Sub-Catchment Boundary

Catchment Boundary

Cadastre

-500 0 500 1000 1500m

Scale: 1:25,000

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North Arm East Catchment

CURRENT LAND USE

Figure 2.2

2.3 Existing Stormwater Infrastructure

Figure 2.3 shows the location of existing stormwater infrastructure in the catchment.

The following infrastructure elements are shown:

- Underground drainage systems (pipes and box culverts)
- Open channel systems
- Detention Basins
- Gross Pollutant Traps
- Wetlands
- Aquifer Recharge Sites

There are no existing pumping stations within the catchment.

Drainage within the catchment is provided by a system that is predominantly comprised of underground drains. This drainage network feeds into a number of underground trunk drains which form the main spines of the network. These trunk drains are shown in Figure 2.3 and include the:

- Clifton Street / Seaview Grove / Ragless Avenue System
- Lionel Avenue / Audrey Avenue / Prescott Street System
- Enfield Cemetery System
- Grand Junction Road System

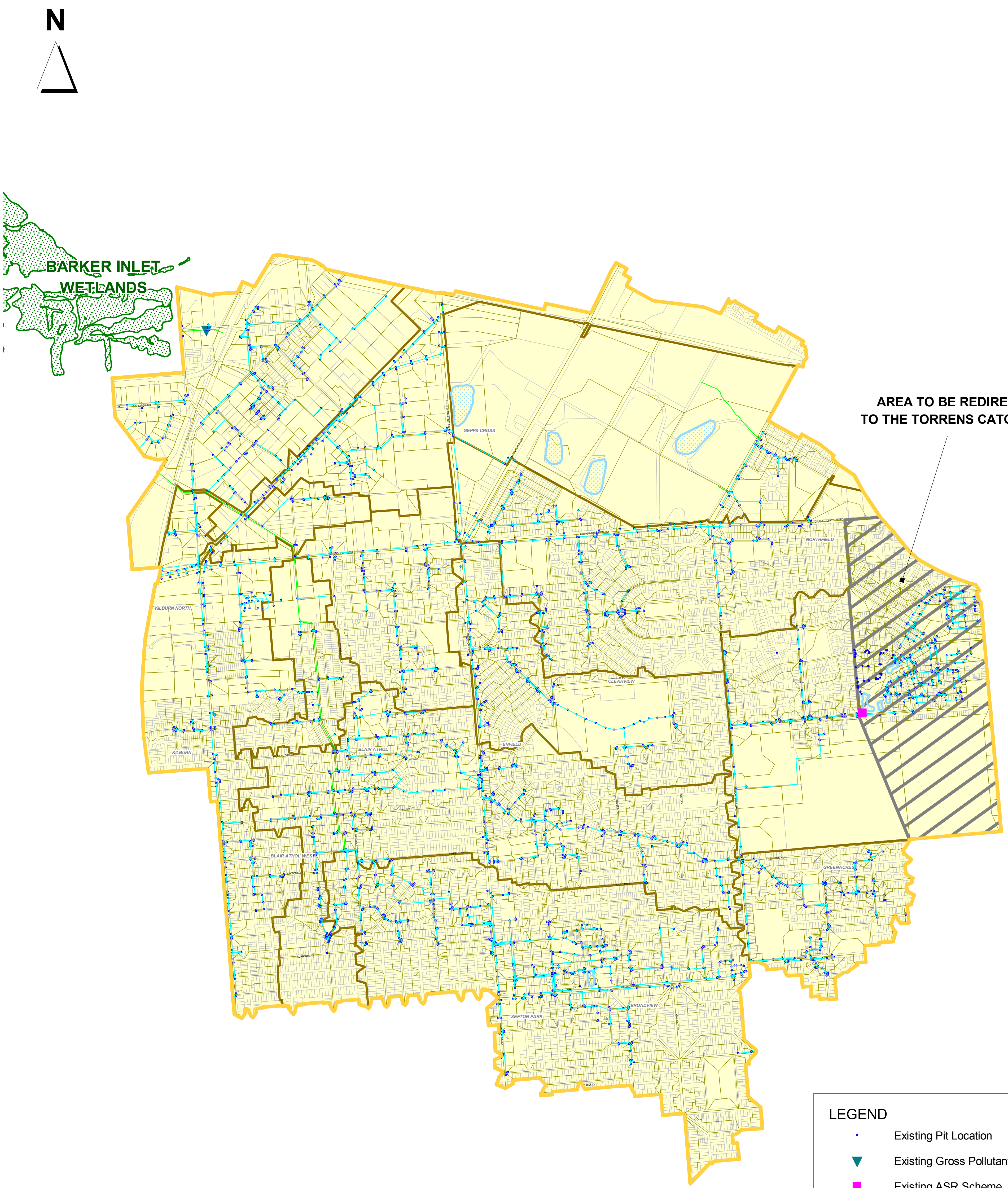
With the exception of the Grand Junction Road drain, all the remaining trunk drains are located within distinct valleys that run in a north westerly direction through the catchment. Council has over time upgraded a number of drains within the catchment, particularly along the well formed valleys. This has greatly reduced the flood risk in these areas.

The trunk drains discharge into a concrete lined outfall channel that extends from Kilburn to the Barker Inlet Wetlands. The trunk drain passes under a trunk SA Water sewer in Wingfield via a large siphon.

The Barker Inlet Wetlands provide an important function in improving the quality of stormwater discharged to the Barker Inlet. However, the wetlands also provide storage (during periods of high tide) for floodwaters from the North Arm East catchment and other adjacent catchments to the west.

2.4 Previous Studies

A number of previous investigations have been undertaken that are of relevance to stormwater management planning in the North Arm East Catchment. These are summarised below and formed part of Stage 1 of the SMP (ref # 20070212RA2B, dated October 2009).



LEGEND

- Existing Pit Location
- Existing Gross Pollutant Trap
- Existing ASR Scheme
- Existing Pipe Network
- Existing Open Channel
- Basin
- Minor Sub-Catchment Boundary
- Major Sub-Catchment Boundary
- Catchment Boundary
- Cadastre

-500 0 500 1000 1500m

Scale: 1:25,000

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City of Port Adelaide Enfield

Urban Sotrmwater Master Plans

North Arm East Catchment

EXISTING INFRASTRUCTURE

Figure 2.3

Initial Urban Stormwater Master Plan (Tonkin Consulting, 2003)

The Initial Urban Stormwater Master Plan collated the available information and prepared a series of plans in a GIS format. Plans were developed to show sub-catchment boundaries, land use, existing and proposed drainage infrastructure, drainage standards, soil types and groundwater zones.

The study also assessed the impact on runoff rates based on likely future development scenarios.

The study developed a series of catchment specific objectives and management strategies which covered the areas of:

- Flood Management
- Water Quality Improvement
- Water Use
- Environmental Protection and Enhancement

It also outlined areas of future work to develop the strategies identified within the Plan.

NAE Floodplain Modelling (Tonkin Consulting, 2006)

Hydrodynamic floodplain modelling of the NAE catchment was undertaken in 2006 by Tonkin Consulting. This study required the digitisation of the subcatchments draining to every inlet within the catchment. It modelled both the capacity of the underground pipe network and surface flood flow paths. It included analysis of both existing and future development scenarios.

Based on an analysis of the maps produced and knowledge of key staff, a number of flooding 'hot spots' within the NAE catchment were identified. The 'hot spots' in order of importance were:

1. Baker Street Area, Enfield.
2. Prescott Street / Fitzgerald Avenue, Enfield.
3. Glenview Avenue through to the Parade, Blair Athol.
4. Rosedale Street / Grand Junction Road, Blair Athol.
5. Dover Street, Blair Athol.

The peak flow rates calculated from this modelling within the outfall channel were considerably lower than the previous analysis undertaken in 1995. This was assessed to be due to flood storage throughout the catchment and the large lag time for surface flood flows to pass through the catchment towards the outfall channel.

For all ARI events the difference in flooding between existing and long-term development conditions was relatively minimal. The extent and magnitude of flooding did increase when the long-term development conditions were modelled but the increases were not dramatic. When comparing the results from the existing and long-term development conditions, it was evident that the increase in extent and magnitude of flooding was less for the 100 year ARI event than for the 5 and 20 year ARI events. This was due to the future development producing proportionally more runoff during the smaller ARI events.

North Arm East Drainage Study (Tonkin Consulting, 1995)

The North Arm East Drainage Study involved the development of a detailed hydrological model of the catchment to determine the capacity and standard of drainage systems in the area and to identify potential flooding locations.

The investigation identified a number of areas in which the capacity of the existing drainage system was deficient. A series of works were identified including:

- Upgrading of key lateral drainage systems
- Construction of new outfall drains
- Construction of a detention basin in the former Enfield Depot site

Council has completed construction of the majority of the upgrading works identified for lateral drainage systems in the catchment. In addition, one of the key trunk outfall drains (the Audrey Avenue Diversion Drain) has also been completed.

Some work was carried out to determine the possibility of constructing a detention basin within the Enfield Cemetery. However, no agreement could be reached with the Enfield Cemetery Trust at the time.

The only major works proposed in this Study that are yet to be carried out are the outfall channel upgrade, the Milton Avenue and Marmion Avenue drains and a detention basin within the Enfield Cemetery.

Enfield Depot Dam Review (Tonkin Consulting, 2000)

One of the key infrastructure items identified in the 1995 North Arm East Drainage Study was the construction of a stormwater detention basin in the former Enfield Council Depot site at Kilburn. This detention basin was proposed to reduce flows in the outfall downstream of Grand Junction Road and as a result would obviate the need to carry out upgrading works on the outfall which were determined to be costlier than construction of the detention basin.

The North Arm East outfall channel is concrete lined and in certain sections is in relatively poor condition. As a result, replacement of these sections of channel will be required in the medium term. In view of this, the costs associated with upgrading the outfall were reviewed, taking into account the fact that the channel would need to be replaced regardless of whether the Enfield Depot Dam was constructed.

The outcome of the investigation was that it would be more cost effective to upgrade the outfall than construct the detention basin. As yet, no funds have been allocated to proceed with these works.

Based on the reduction in peak flows as part of the floodplain modelling, the priority to upgrade the outfall channel has reduced.

Stormwater on Reserves (Square Holes, 2008)

This report interviewed residents who lived in the vicinity of dual purpose areas of open space (recreation and stormwater management). The outcomes of the study indicated that residents were generally happy that the area of open space served a dual purpose and there was only a fairly limited reduction in the useability of the site following rainfall events. Therefore, it appears that the additional creation of dual purpose open space will generally receive the support of residents and that it can continue to be considered as a stormwater management option.

State of Environment Report (City of Port Adelaide Enfield, 2007)

The State of the Environment Report covered a wide range of areas which included a section on Inland Waters. It discussed a number of stormwater related priorities including:

- Additional water quality monitoring of the Barker Inlet Wetland
- Undertaking full Stormwater Master Plans of all catchments within the City of Port Adelaide Enfield
- An increase in water harvesting through rainwater tanks and regional facilities
- Attempting to quantify the amount of groundwater extraction
- The management of groundwater supplies

Port Waterways Water Quality Improvement Plan (EPA, 2008)

This Plan investigated the impact of the surrounding catchments on the Port Waterways. It documented a series of actions and areas of future monitoring and research to improve the long term health of the Port Waterways.

While pollutant loadings were quantified within the report, it did not isolate the NAE catchment and the period of modelling was only for just over 1 year.

Port Adelaide Enfield Open Space Plan (Hassell, 2006)

This Plan reviewed the areas of open space within the Council area and provided opportunities to review management practices and strategically determine priorities for the future. Reference was made to the potential dual purpose of open space combining recreation and stormwater management with an emphasis on minimising impacts during storm events.

Barker Inlet, Magazine Creek and Range Wetlands Monitoring and Research Programme Report on Study Findings (Eco Management Services, 1999)

This report predominantly focussed on the Barker Inlet Wetland. It covered a number of areas including:

- Water quality monitoring and pollutant reduction performance
- Sediment heavy metal chemistry, toxicology and faunal diversity
- Groundwater interaction with pond water/soils and the establishment success of terrestrial and aquatic flora
- Water harvesting and reuse potential.

The report indicates that the programme was based on a relatively short data set and that the wetland performance may be likely to improve as the ecosystem continues to develop (as the wetland was constructed less than 4 years prior to the study).

Barker Inlet, Magazine Creek and Range Wetlands, Management and Maintenance Plans, Spill Contingency Plans, Existing Vegetation Condition and Supplementary Planting (Eco Management Services, 2011)

This report prepared a detailed management plan for three wetlands, including the wetlands that the North Arm East catchment discharges into. It covered a number of areas including water quality monitoring, spill management and management of existing infrastructure to ensure the continued long term sustainability of the wetlands.

North Arm East Wetland Condition Assessment (DesignFlow, 2012)

This report was based on a number of inspections and field tests of the North Arm East wetland. It identified a number of issues, that are predominantly related to high turbidity due to a lack of aquatic plants and the presence of carp within the wetlands. It recommended a number of measures to reduce the turbidity by installing carp bunds and creating shallow areas that could be planted with banks of aquatic plants.

North Arm East Catchment Development Trends (PAE, 2011)

This report undertook an update on the work undertaken by Jensen Planning and Design in 2003 to assess the development potential in the catchment. It indicated that the development over the most recent period had been similar to the levels of development projected in the original 2003 study. The report stated that allowances should be made for 100% of all development occurring in the 50-year long-term horizon as opposed to 60% as outlined in the Jensen study. It also showed that the short term projections in the Jensen study were fairly accurate based on actual development that has been undertaken since the report was written.

Inner Northern Adelaide Growth Precinct Framework (Jensen Planning and Design, 2009)

A large section of the NAE catchment was contained within the Study Area for this report. The report developed a high level strategic planning framework for the Inner Northern Metropolitan Adelaide area. It recommended development strategies for a number of precincts throughout the Study Area based on the assessed constraints and opportunities available. It also looked at potential major changes of land use in some areas and the development of existing areas of open space.

Urban Stormwater Master Plan Water Quality Report North Arm East Catchment (City of Port Adelaide Enfield, 2005)

This GIS based study investigated the water quality hazard potential throughout the catchment based on current land use. It assessed the impact of various components on overall stormwater quality which included stormwater runoff, solid and liquid waste generation, hazardous materials, short term development potential and septic tanks.

Urban Stormwater Harvesting Options Study (Wallbridge & Gilbert, 2009)

This study, which was undertaken for SA Water developed a number of stormwater harvesting options at sites where over 250ML per year can be reused. Barker Inlet Wetlands was one of the sites discussed within the report. The study indicated that approximately 1,240ML of water could be harvested from the Barker Inlet wetlands based on inflows from the NAE catchment.

2.4.1 Data Gaps

Based on the review of existing reports a number of data gaps were identified. These were as follows:

1. A damages assessment based on the floodplain modelling has not been undertaken. This would be required to support benefit cost ratios for flood mitigation options.
2. There is no supported hydrological model of the catchment as the most recent model used software that is discontinued (GENDRAIN).
3. There is no water quality model of the catchment.
4. There is no water harvesting model of the catchment.
5. The monitoring of the wetland performance has only been reported on in 1999 when the wetland was still establishing. Therefore, there is no data to determine the pollutant removal efficiency of the established wetlands. Pollutant loadings (nutrients and suspended solids) generated by the NAE catchment have only been monitored for a couple of years in the late 1990s. The short period of record makes it of limited use.
6. The viability and likely acceptance of a detention basin, wetland and harvesting facility within the Enfield Cemetery should be reviewed.

Items 2 and 3 have been developed as part of the SMP project with the construction of an ILSAX model (item 2) and a MUSIC model (item 3) while the Enfield Cemetery management have been contacted and have indicated support of item 6 provided they can harvest water to reduce their requirement for mains water.

2.5 Flood Modelling

TUFLOW modelling of the NAE catchment was undertaken in 2006 by Tonkin Consulting.

Based on a careful analysis of the maps combined with our knowledge of the study area, a number of flood prone areas within the NAE catchment have been identified. The locations in order of importance are;

1. Baker Street Area, Enfield.
2. Prescott Street/Fitzgerald Avenue, Enfield.
3. Glenview Avenue through to the Parade, Blair Athol.
4. Rosedale Street/Grand Junction Road, Blair Athol.
5. Dover Street, Blair Athol.

Baker Street

This area was affected by flooding on New Year's Eve 1995, and is a known flood prone location. For a rainfall event of 5 year ARI, flood waters are contained within the street network at depths of up to and in excess of 300mm. Significant flooding of housing in the area is likely for a rainfall event of 100 year ARI, between Grand

Junction Road and Whittington Street, with flood depths in excess of 500mm highlighted within many allotments resulting in extensive flood damages.

Prescott Street

As noted above this area is located in a localised valley. In a rainfall event of 5 year ARI flood depths in excess of 400mm are found within the street network. At this point disruption to traffic is likely as many passenger vehicles are unable to travel through such depths. Housing located at the corner of Calvert Street and Harewood Avenue is likely to experience significant flooding for a similar rainfall event. For rainfall events of greater ARI both flood depth and extent increase with more housing at risk of flooding.

Glenview Avenue

This is another area located in a localised valley. Flood depths in excess of 200mm are found within the street network for a rainfall event of 5 year ARI. Housing is at risk of flooding between Kings Avenue and Bent Street, and between Enfield and Glenview Avenue. During rainfall events of greater ARI flood depths and extent increase significantly with a large number of houses at risk of significant flooding.

Rosedale Street

Flood depths in excess of 500mm are likely to be experienced at the intersection of Rosedale Street and Grand Junction Road for rainfall events of 20 years ARI or greater. This is likely to lead to the closure of Grand Junction Road, a major arterial road, causing disruption to many services.

Dover Street

Between Grand Junction Road and Anson Street flood depths in excess of 400mm are likely to be experienced within the street network for rainfall events of 5 years ARI or greater. Flooding of allotments is likely to occur for events of 5 years ARI, with a significant number affected during events of 100 years ARI. The result will be extensive flood damages as well as road closures.

2.6 Soils

The distribution of soils across the catchment was derived from information contained in Bulletin 46 (Dept Mines, 1974) and is shown in Figure 2.4.

The following soil types are distributed across the catchment:

- Estuarine Muds and Sands (EMS)
- Red Brown Earths (RB5, RB6-RB7 and RB8)
- Black Earths (BE)
- Brown Solonised (BS)

The Estuarine Muds and Sands generally appear to occur in the area north of Grand Junction Road and west of the Adelaide - Gawler railway. These soils are grey, dark grey or mottled silt and sand deposits that contain some accumulations of organic material. They are generally not subject to shrinkage or swelling movements in response to wetting and drying. Drainage through the soil profile is generally relatively rapid. Red Brown Earths run in a band across the western portion of the catchment, with the exception of the RB8 profiles, which occur within Northfield. The Red Brown Earth soils are characterised by brown sandy topsoil overlying red brown sandy clay of indefinite thickness. The RB6-7 soils have a low potential for shrinkage or swelling movement in response to changes in soil moisture, RB5 has a moderate potential and RB8 has a high potential. Calcareous horizons within the RB8 soils have a potential to soften and collapse on wetting.

The Brown Solonised soils lie within the central and upper portions of the catchment. These soils are characterised by brown sandy topsoil overlying red brown clay that becomes more calcareous with depth. These soils have a low potential for shrinking and swelling movements, but are liable to collapse on wetting.

Black Earth soils are confined to the area within Northfield and Greenacres. These soils are highly expansive and subject to large movements due to changes in soil moisture.

Disposal of stormwater by infiltration is likely to be possible in areas where RB6-7, RB5 and EMS profiles are present. In other areas, the potential for large soil movements (or the collapse of soils) is likely to render systems relying on infiltration to be unsuitable, unless significant clearances to adjacent structures are able to be achieved.

2.6.1 Acid Sulphate Soils

There is a medium to high likelihood of acid sulphate soils (ASS) in the section of Estuarine Muds and Sands as shown on Figure 2.4. These soils have the potential to detrimentally impact stormwater assets such as concrete pipes, culverts and pits. New infrastructure in this area would need to be designed to protect it from ASS while existing assets would need regular inspections to ensure they are functional.

When disturbed Acid Sulfate Soils (ASS) have potential to release acidity and toxic contaminants to waterways which can cause damage to stormwater infrastructure and the environment. Erosion of bottom sediments containing monosulfidic material (MBO) during high stormwater flows can deoxygenate waterways and mobilise contaminants. Prolonged exposure of potential ASS to air may also cause irreversible loss of soil physical properties, further impacting stormwater assets.

There is a low likelihood of encountering ASS west of Cavan Road within the area of Red Brown Earths. Site specific testing would be required to determine if they are present.

ASS is unlikely to be encountered throughout the remainder of the catchment.

2.7 Groundwater

An assessment of groundwater issues relevant to the preparation of the Initial Urban Stormwater Master Plan for the North Arm East Catchment was prepared by Australian Water Environments. A summary of the key findings of the assessment is provided below.

2.7.1 Groundwater Zones

Groundwater zones beneath the North Arm East catchment are shown in Figure 2.5. The zones have been adapted from those defined by Gerges (Gerges, 1997) and are based on the hydrogeological characteristics and the nature of groundwater use. They have not changed significantly over recent times. The Natural Resources Management Board is planning to implement a water allocation plan that will cover the extents of the NAE catchment. Its focus will be on managing aquifer usage by commercial and industrial users.

Zone 1 represents an area of predominantly industrial groundwater extraction from the first Tertiary aquifer. The other major use of groundwater in this zone is for irrigation of open space and greened areas.

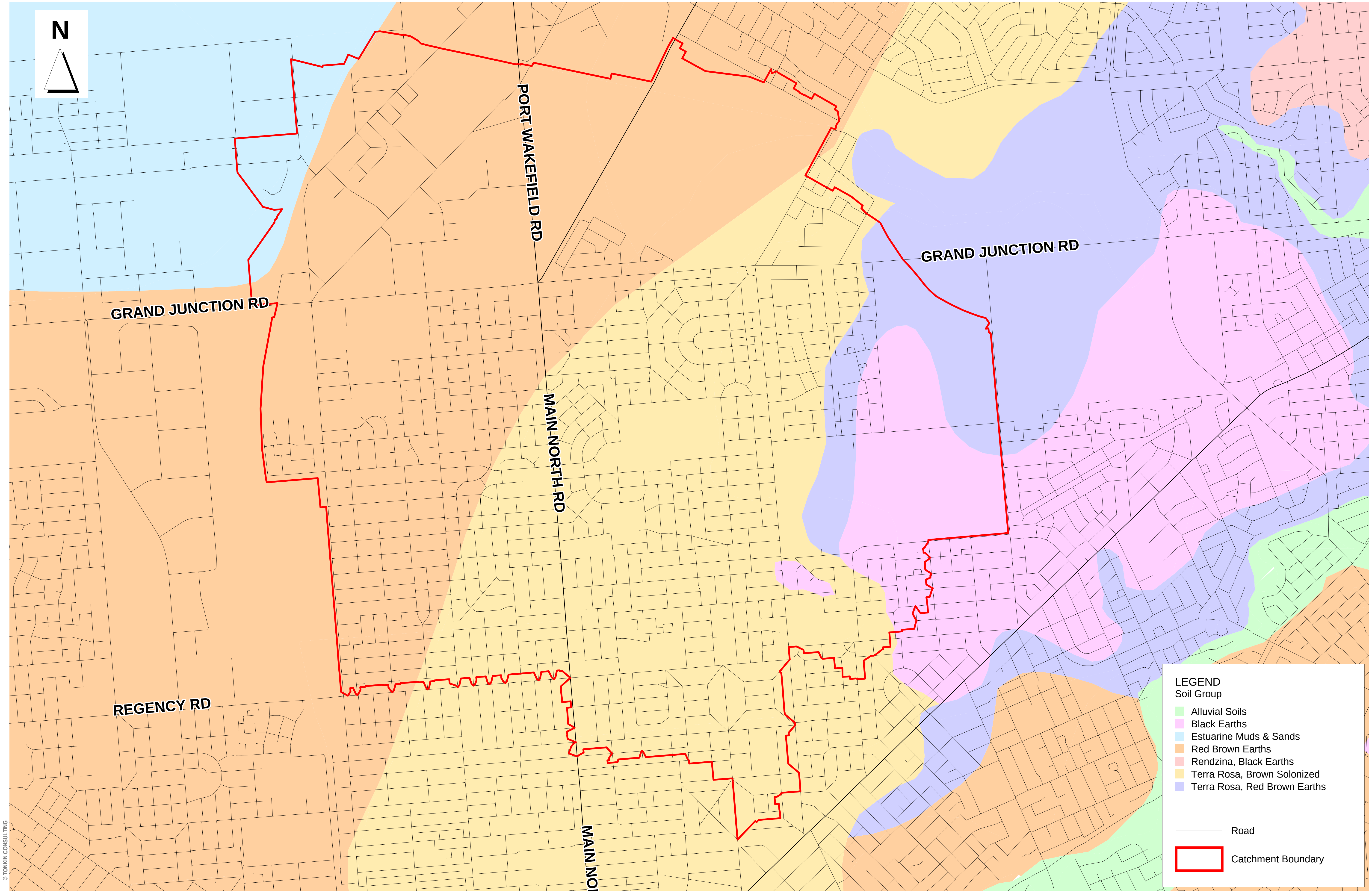
Zones 4 and 5 contain domestic bores that mostly access the shallow Quaternary aquifers for garden watering.

Each of the zones contains the Quaternary Aquifers (Q1 to Q6) and the Tertiary Aquifers (T1 to T4). The nature of each of these aquifer systems is described below.

2.7.2 Quaternary Aquifer System

The Quaternary Aquifers are a shallow system of thin aquifers lying within sand and gravel layers in the Quaternary sediments. The salinity of the Quaternary aquifers is highly variable both within and between the various aquifers and ranges from less than 1000 mg/L to more than 5000 mg/L. Yields are typically less than 4 L/s and are highly variable.

The Quaternary aquifer system appears to have downward leakage between all aquifers. The average depth to water in the lower lying areas of the catchment is approximately 2 to 4m. There are no observation bores in the upper portions of the catchment.



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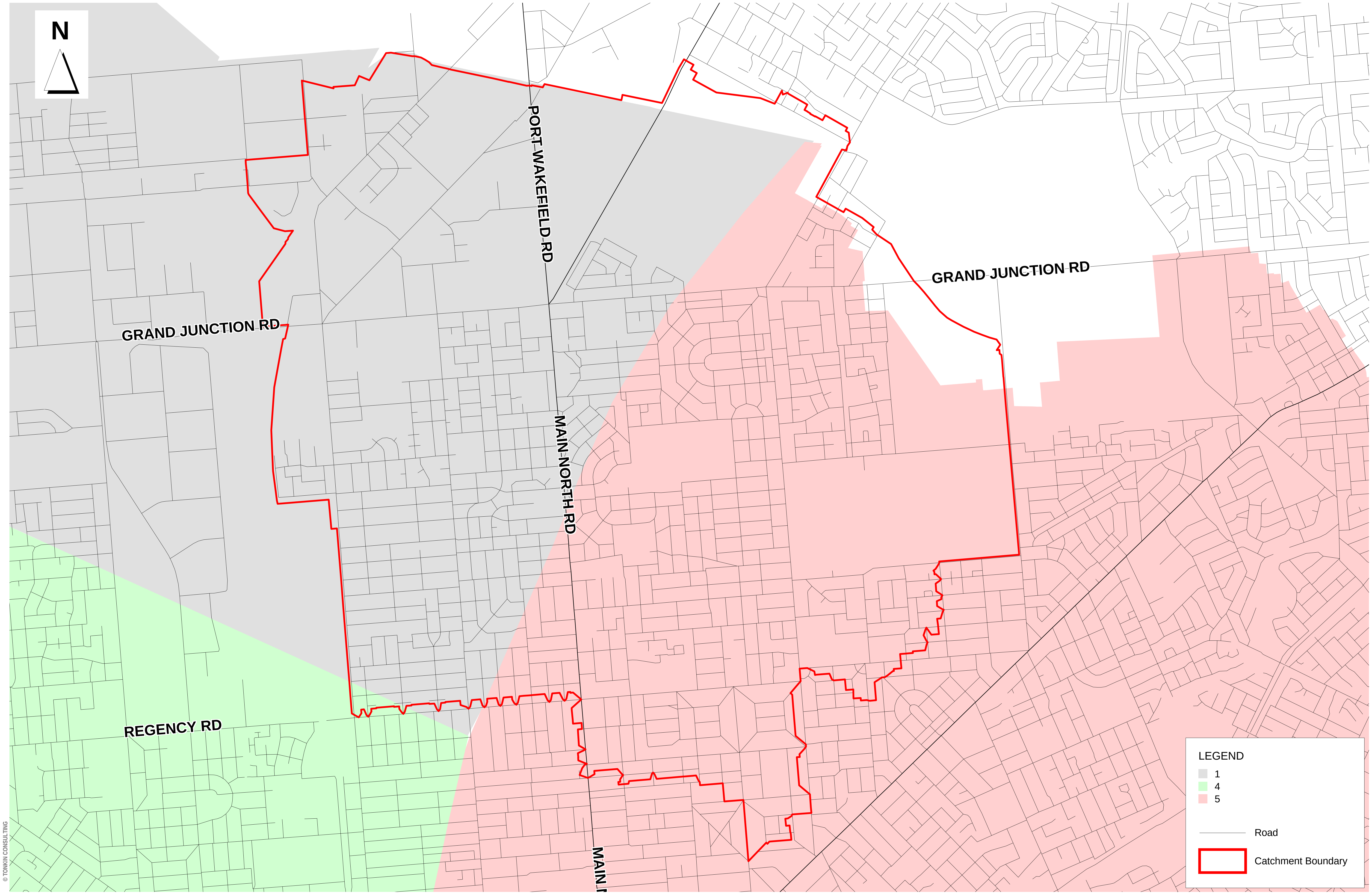
City of Port Adelaide Enfield

Urban Stormwater Management Plans

North Arm East Catchment

SOIL TYPES

Figure 2.4



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Scale: 1:25,000

City of Port Adelaide Enfield

Urban Stormwater Management Plans

North Arm East Catchment

GROUNDWATER ZONES

Figure 2.5

The implication of shallow depths to the water table in the lower portions of the catchment is that excavations for stormwater basins or wetlands may intersect groundwater. Under such conditions, the storage will be less effective with leakage likely to occur. Significant leakage into the underlying Q1 aquifer may induce rising water tables in the immediate vicinity of the basin that could affect adjacent properties. Groundwater quality may also be compromised by pollutants within the stormwater.

The depth to groundwater also gives an indication of the ability of the aquifer to store additional water. Artificial recharge in areas of less than 2 m depth to water may induce salinity, salt damp and flooding or foundation movement.

The Quaternary aquifers are for the most part fairly thin and do not have storage capacity for large scale Aquifer Storage and Recovery (ASR) schemes. A previous study (Pavelic et al, 1992) has assessed the capability of the upper Quaternary aquifer system for ASR, identifying feasible areas for various size schemes.

Whilst it is limited in areas suitable for industrial sized schemes, small scale residential developments could access the Quaternary system for onsite detention either using a bore for recovering the water, or simply recharging the aquifer with on-site retention systems. However, these schemes would be subject to a range of regulatory and technical constraints before any schemes could be implemented.

2.7.3 Tertiary Aquifer System

The Tertiary aquifers lie at a greater depth than the Quaternary aquifer systems. The first Tertiary aquifer contains the best quality groundwater being generally suitable for most purposes. In some areas the salinity in this aquifer is less than 1000 mg/L. Only a few users access the second Tertiary aquifer which has a salinity that varies from 1000 to 10000 mg/L.

Yields from the first Tertiary aquifer are typically in the range 5 to 15 L/s.

The depth to groundwater in the Tertiary aquifer system varies depending on the level of groundwater extraction. In areas of high groundwater extraction, levels within the T1 aquifer are generally seasonal and vary by as much as 15 m between summer and winter.

The Tertiary aquifer system has the potential to store large amounts of water.

2.8 Development Potential and Impact on Runoff

Assessment of the likely extent and nature of future development (redevelopment) within the catchment was initially undertaken by Jensen Planning and Design in conjunction with Tonkin Consulting, in 2003 (Jensen Planning and Design, 2003). The analysis utilised data gained from a number of sources as follows:

- Planning SA's (now the Department of Planning, Transport and Infrastructure) Site Value to Capital Value property data
- Discussions with the SA Housing Trust regarding future development proposals for Trust owned land
- Discussions with the Land Management Corporation (Renewal SA) regarding future development proposals for Government owned land
- Analysis of the development policy outlined in the Port Adelaide Enfield (City) Development Plan

The key findings of these investigations are set out below.

2.8.1 Development Projections

The analysis undertaken by Jensen Planning and Design to identify residential allotments within the City of Port Adelaide Enfield that have the potential to be subdivided were based on the requirements contained in the Development Plan, current at that time. As a part of the analysis, the concept of the ratio between capital value and site (land) value was proposed as an indicator of the likelihood of allotments being redeveloped. Those allotments having a capital value close to the site value were considered to be more attractive to developers and therefore more likely to be redeveloped.

In undertaking this analysis, it was assumed that a planning horizon of greater than 50 years was appropriate due to the long life of stormwater assets. However, a shorter term planning horizon (approximately 5 years) was also considered to assist in setting priorities for various investigations and implementation of works in the catchment.

The analysis predicted 3080 new dwellings to be built in the short-term with 6866 predicted in the long-term (50 years). However, a development scenario that realised only 60% of the maximum long-term development potential was considered more likely, being 4120 dwellings.

It should be noted that the analysis is based on the development potential provided within the policy framework of the Development Plan. This development potential may not ever be realised and future changes in zoning or changes in land use will affect the runoff characteristics over time. The results of the analysis should therefore be treated as being indicative rather than definitive.

The aforementioned work undertaken by Jensen Planning and Design was reassessed by the City of Port Adelaide Enfield in 2011. This work indicated that the initial short term development assumptions made in the Jensen study were approximately correct but took the view that for the purposes of long term stormwater planning that the maximum development potential scenario should occur. However, this is considered to be too conservative and would be likely to over predict future runoff generated by the catchment and that the 60% figure, as recommended by the Jensen study, is more appropriate. The 40% of allotments that weren't likely to be developed had a high capital value to site value ratio (the top 40% of values), which meant that the dwellings were relatively new or were well maintained or heavily renovated. It is not considered likely that these higher value dwellings would be knocked down and replaced in the long term development scenario (50 years).

In considering the likely difference in imperviousness between the two approaches it should be noted that all dwellings that weren't deemed likely to be subdivided still had their runoff coefficient increased to allow for extensions and new garages etc.

The increased application of Water Sensitive Urban Design (WSUD) elements in design and the compulsory use of rainwater tanks for new developments may partly mitigate the increase in runoff from future development. However, WSUD is generally only viable within large-scale developments and the cumulative ad-hoc residential infill will continue to be a threat to the capacity of the NAE Catchment’s drainage system.

2.8.2 Land Management Corporation (Renewal SA)

Some Government owned land within the catchment has been identified by the LMC as having the potential for development. The potential impact associated with an increase in runoff from these areas has been included in the analysis of potential increases in runoff.

2.8.3 Other Potential Development Sites

A number of developments have been built or are proposed within the State Sports Park including a new super school and a number of new sporting facilities. These will increase impervious coverage in the area.

Large amounts of development are also occurring as part of the Northgate development. However, stormwater will be managed on site and therefore the Northgate development will have minimal impact on the NAE Catchment’s drainage system.

The Enfield High School, Gepps Cross Girls High and Ross Smith Secondary have closed due to the new Gepps Cross Super School. The Kilburn Primary School has been consolidated into the Gepps Cross Primary School. Development of these sites has the potential to result in a significant change in their runoff characteristics. Given the relatively large amount of open space at these sites there is the potential that they could be converted into regional scale stormwater facilities.

2.8.4 Impact on Runoff

An analysis of existing impervious area within the catchment (expressed as a runoff coefficient) and changes in impervious area likely to be brought about under various scenarios of redevelopment was undertaken as part of the original 2003 analysis. Some manual amendments have been made based on known future development in the Sport Park area and in Gepps Cross. The following summary is presented in relation to the findings of the analysis for the North Arm East catchment.

Figure 2.6 shows the existing runoff coefficient for various sub-areas within the catchment based on an assessment of existing land use.

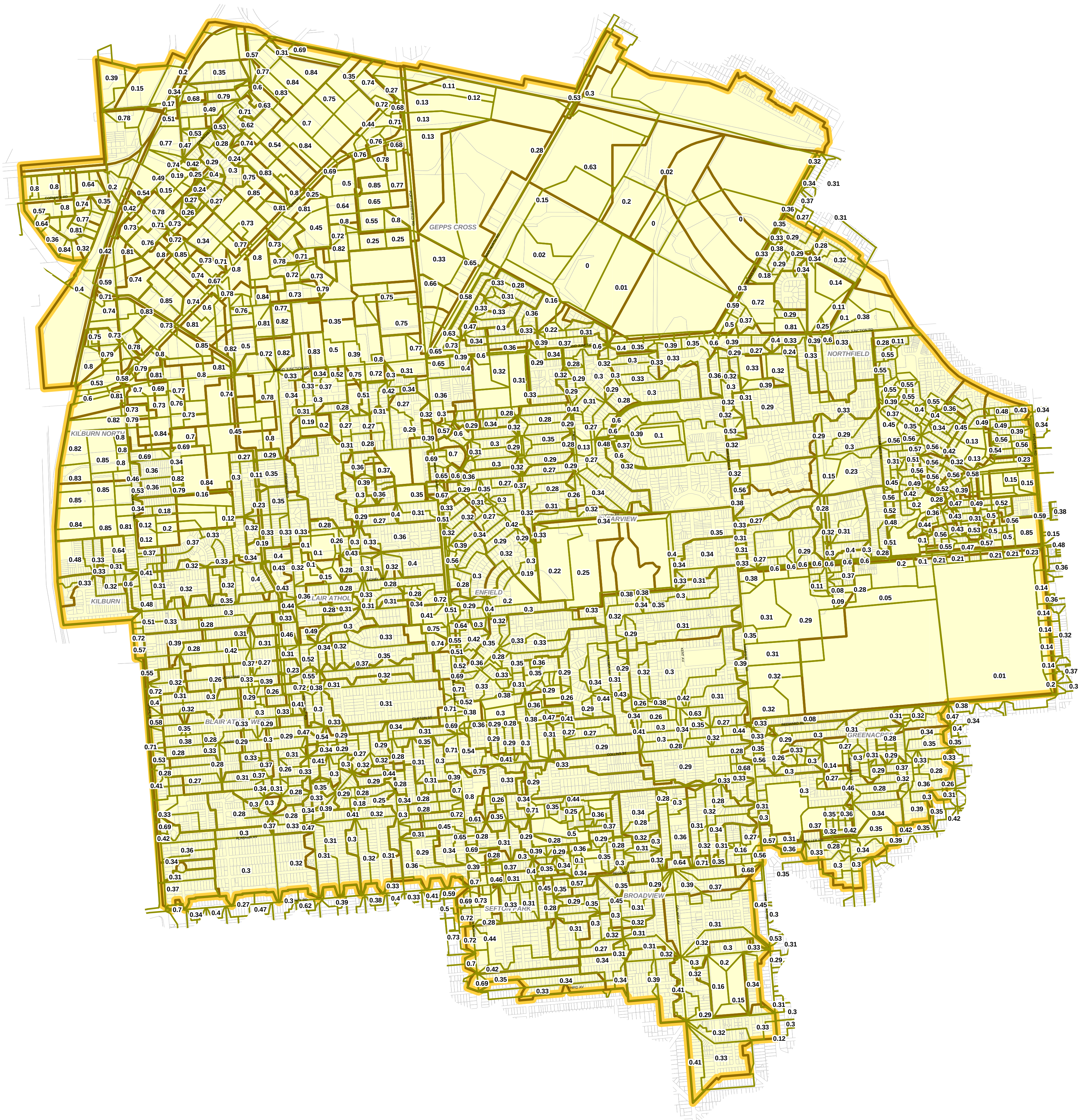
The impact of redevelopment as described above was determined by assessing the likely changes in impervious area within each sub catchment due to:

- Subdivision and redevelopment of residential allotments
- Demolition of existing houses on single allotments and replacement with new residences
- Extension and upgrading of existing residences.

The change in impervious area within each sub catchment was calculated and the results are presented in Figure 2.7 based on a long term planning horizon (estimated to be 50 years) which allows for development of 60% of the ultimate development potential (as outlined in Section 2.8.1). This assessment is based on a projection of current rates of development within the catchment. The runoff coefficients shown in Figure 2.7 are used as inputs into the long term development scenario flood plain maps which are included in Appendix C. No allowance has been made for any allotment scale retention or detention systems that may help to reduce peak flows and runoff volumes. Therefore, the results can be considered to be conservative.

As peak flows are directly related to impervious area, the figures provide an indication of the likely increases in flow brought about by uncontrolled redevelopment in various areas of the catchment. As can be seen from Figure 2.7, quite substantial changes in runoff are expected throughout the catchment unless measures are put in place to mitigate the impact, particularly for small ARI events. In larger events the change will be proportionally less as there is typically a large contribution from both pervious and impervious areas in these events. Therefore, an increase in impervious area has less impact during large events, which cause the most significant flooding.

N



-500 0 500 1000 1500m

Scale: 1:25,000

LEGEND

- Minor Sub-Catchment Boundary
- Major Sub-Catchment Boundary
- Catchment Boundary
- Cadastre

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MAP DETAILS

Cadastral Data:	PBBI Australia
Catchment Data:	Tonkin Consulting
Land Use Data:	City of Port Adelaide Enfield
Job Number:	2007.0212
Filename:	NAE_Figure28_ROC_exist.WOR
Drawn:	TJF/SC
Date:	19/01/2010

City of Port Adelaide Enfield

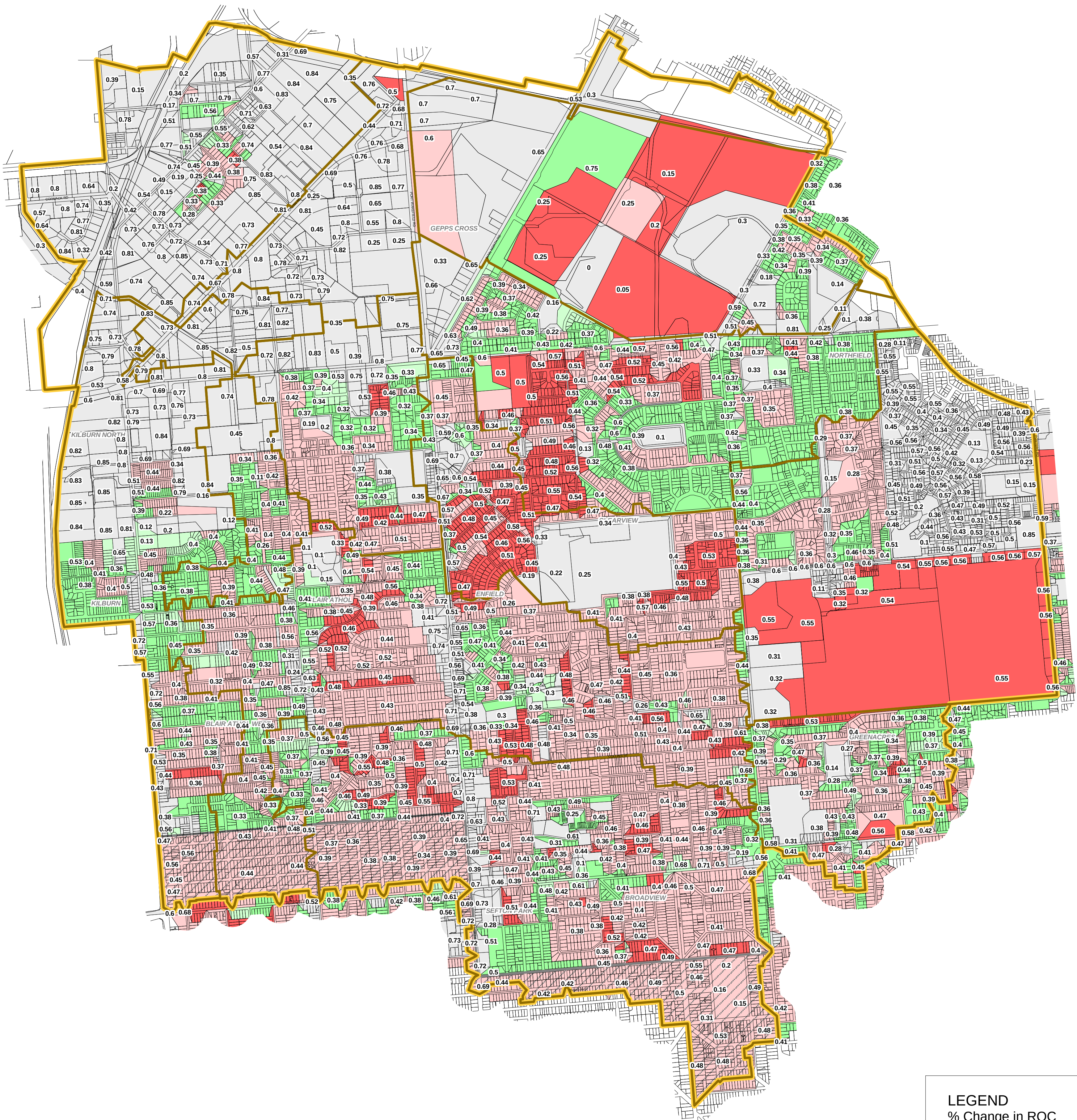
Urban Sotrmwater Master Plans

North Arm East Catchment

EXISTING RUNOFF COEFFICIENTS

Figure 2.6

N



LEGEND
% Change in ROC

- Less than 5
- 5 to 10
- 10 to 20
- 20 to 50
- Greater than 50

Major Sub-Catchment Boundary

Catchment Boundary

Cadastre

-500 0 500 1000 1500m

Scale: 1:25,000

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MAP DETAILS

Cadastral Data:	PBBI Australia
Catchment Data:	Tonkin Consulting
Land Use Data:	City of Port Adelaide Enfield
Job Number:	2007.0212
Filename:	NAE_Figure210.WOR
Drawn:	TJF/SC
Date:	30/05/2011

City of Port Adelaide Enfield

Urban Sotrmwater Master Plans

North Arm East Catchment

RUNOFF COEFFICIENT INCREASE (Long Term)

Figure 2.7

3 Optimised Decision Making Methodology

3.1 Background

"Optimised Decision Making Guidelines (ODMG): A sustainable approach to managing infrastructure" was developed by the New Zealand National Asset Management Steering Group in 2004. The guidelines were developed to "allow the application of the very best management techniques and practices to ensure that the decisions made on maintaining, renewing and investing in new assets are both optimal and sustainable".

The ODMG are particularly suited to the solving of a single problem or opportunity with a number of worked examples given within the guidelines such as:

- Footpath renewal
- Wastewater treatment plant upgrade
- Road realignment
- Stormwater flooding at a particular location

The development of this Stormwater Management Plan has required the selection of solution(s) to identified problem(s) from a range of available solutions. The ODMG process has been applied as a tool to support the decision making process, taking into account a range of objectives, in the preparation of this Stormwater Management Plan.

3.2 Process Overview

The process to implement the ODMG is flexible, and in the application to the preparation of this Stormwater Management Plan has been implemented according to a four step process as described below.

Step 1 - define the problem or opportunity

The definitions are generally concise, well defined and typically relate to a particular problem (such as a flooding hotspot) or desire to achieve a particular objective (such as a catchment water harvesting target).

Step 2 - identify potential options to manage the problem or opportunity

This step requires the broad identification of all possible solutions. Alongside these, a list of non-negotiable criteria ('deal breakers' such as performance standards and use of valuable open space) would apply, some of which may emerge in response to the nature of the solutions put forward. The options list is then subsequently cut down to a shortlist of potential options according to these criteria.

Step 3 - multi-criteria analysis of the potential options

The options are evaluated against a range of criteria that may include economic, environmental and social considerations. Each option is scored against each of the criteria which are given a weighting based on their relative importance.

Step 4 - identify the optimal solution

This step generally involves selecting a solution that obtains the highest score in the evaluation process.

3.3 Evaluation Criteria

Six main evaluation criteria have been developed. A number of sub-criteria within each area have also been established. Each of these is described in more detail below.

3.3.1 Flood Protection of Development

Improved Flood Protection

A number of areas have been identified as being flood prone throughout the NAE catchment. This weighting is related to a likely improvement in flood risk in at least one of the known flood prone areas.

3.3.2 Runoff Quality and Impact on Receiving Environment

This criterion has been further subdivided into four sub-criteria. These criteria can be modelled within MUSIC.

Reduction in Gross Pollutants

The reduction in gross pollutants is compared against acceptable quantities entering the Barker Inlet wetlands. A desirable target would be to improve the amenity of the wetlands.

Reduction in Suspended Solids

The reduction in suspended solids is compared against acceptable quantities entering the Barker Inlet wetlands. A desirable target would be to limit suspended solids to the current design loading for the wetlands.

Reduction in Nitrogen

The reduction in nitrogen is compared against acceptable quantities entering the Barker Inlet wetlands. A desirable target would be to limit nitrogen to the current design loading for the wetlands.

Reduction in Phosphorus

The reduction in phosphorus is compared against acceptable quantities entering the Barker Inlet wetlands. A desirable target would be to limit phosphorus to the current design loading for the wetlands.

3.3.3 Beneficial Use of Stormwater

Direct Infiltration

The passive infiltration of surface water into the underlying shallow aquifer and the irrigation of vegetated areas.

Storage and Reuse

This involves aquifer storage and recovery (ASR) into deep aquifers. A target for reuse would be for the ASR to provide a noticeable reduction in mains water usage.

3.3.4 Social Values

Improved Visual Amenity

This criterion would include removal of concrete and paved areas and replacement with landscaped areas and the general improvement of amenity by constructing landscaped drainage elements (wetlands, WSUD etc.)

Improved Public Safety

This would be related to issues such as reducing fast flowing waters and reducing dangerous flood risk

Additional Useful Open Space

This could include improving the functionality and the services available within an area of open space that is currently unavailable for public use.

Disruption During Construction

The implementation of some items of new infrastructure may result in disruption to the public. This could range from physical displacement and traffic disruptions during construction.

3.3.5 Environmental Benefit

Habitat Creation

Some stormwater related works have the potential to create new areas of habitat. This would predominantly be within regional scale facilities such as wetlands and basins.

Increased Biodiversity

Regional scale stormwater facilities may also provide increased biodiversity in the area by providing new areas of habitat.

3.3.6 Capital and Maintenance Cost

Capital Cost

The capital cost criteria relates to the upfront capital cost of the proposed works. This would be compared against what could reasonably be afforded by Council and the sources of financial support that may be available.

Economic Viability

The economic viability compares the capital cost of the works to the benefits derived from less flood damages to enable the derivation of a benefit to cost ratio.

Recurring / Maintenance Cost

Once established most new infrastructure will require some form of maintenance. Wetlands, GPTs and pump stations would all require regular maintenance.

3.4 Criteria

Following consultation with the Steering Committee the following weightings were applied to the main assessment criteria.

Table 3.1: Weighting of Main Criteria

Criteria	Weighting
Flood Protection of Development	30
Runoff Quality and impact on receiving environment	10
Beneficial Use of Stormwater	10
Social values	15
Environmental Benefit	10
Capital Cost, Maintenance Cost and Economic Viability	25
TOTAL	100

Table 3.2 shows the agreed weightings that have been applied to each of the sub-criteria.

Table 3.2: Weighting of Sub-Criteria

Criteria	Sub-Weighting
Flood Protection of Development	
Improved Flood Protection	100
Runoff Quality and impact on receiving environment	
Reduction in Gross Pollutants	40
Reduction in Suspended Solids	40
Reduction in Nitrogen	10
Reduction in Phosphorus	10
Beneficial Use of Stormwater	
Storage and Reuse	85
Direct Infiltration	15
Social values	
Improved Visual Amenity	50
Improved Public Safety	20
Additional Useful Open Space	20
Disruption during Construction	10
Environmental Benefit	
Habitat Creation	70
Increased Biodiversity	30
Capital and Maintenance Cost	
Capital Cost	45
Economic Viability	45
Maintenance Cost	10

Each option was given a rating against each criterion. These ranged from 0 through to 4. As a general guide the relative weightings are discussed in Table 3.3.

Table 3.3: Criterion Weighting Guide

Rating	Capital, Economic Viability and Maintenance Cost
0	Significant costs incurred. Major Council expenditure. Would require significant forward financial planning. Benefit / cost ratio significantly lower than other options and below 1.0.
1	Large costs incurred. Large Council expenditure. Likely to require changes to Council financial planning. Benefit / cost ratio moderately lower than other options
2	Moderate cost option. Likely to be accommodated based on existing Council budgets. Benefit / cost ratio similar to other options
3	Low cost option. Benefit / cost ratio moderately higher than other options
4	Insignificant cost option. Benefit / cost ratio significantly higher than other options and above 1.0.

Rating	Flood Protection of Development
0	No improvement to existing flood risk
1	Low level of improvement to flood risk
2	Moderate improvement to flood risk
3	Large improvement to flood risk. 10-50-year ARI flood protection
4	Large improvement to flood risk. 100-year ARI flood protection, the maximum level that can reasonably be expected.

Rating	Runoff Quality and impact on receiving environment
0	No improvement in water quality
1	Low level of improvement in downstream water quality
2	Moderate improvement in downstream water quality
3	Large improvement in downstream water quality
4	Significant improvement in downstream water quality. Maximum level of improvement that could reasonably be achieved.

Rating	Environmental Benefit
0	No environmental benefit
1	Low level of environmental benefit
2	Moderate environmental benefit
3	Large environmental benefit
4	Significant environmental benefit. Maximum level of improvement that could reasonably be achieved.

Rating	Social values
0	No improvement in social values
1	Low level of improvement in social values
2	Moderate improvement in social values
3	Large improvement in social values
4	Significant improvement in social values. Maximum level of improvement that could reasonably be achieved.

Rating	Beneficial Use of Stormwater
0	No beneficial use of stormwater
1	Low level of beneficial use of stormwater
2	Moderate beneficial use of stormwater
3	Large beneficial use of stormwater
4	Significant beneficial use of stormwater. Maximum level of improvement that could reasonably be achieved.

4 Problems and Opportunities

Based on discussions with the Steering Committee as well of results of past modelling the main problems and opportunities within the catchment have been collated. These are described below.

4.1 Grand Junction Road Flooding

A number of areas along Grand Junction Road in the broad area between Dover Street (to the west) and Coles Street (to the east) have been identified as flood prone. The worst area is in the vicinity of Baker Street to the east of Main North Road. The area in general is relatively flat while the trunk drainage capacity is of a relatively low standard. Unlike in other steeper areas of the catchment floodwaters tend to pond in the area due to no readily available overland flood flow path. The 100-year ARI existing floodplain mapping in the area is shown in Figure 4.1.

4.2 State Sports Park

Previous work has identified that one of the worst flood affected areas within the catchment is in the vicinity of Baker Street (refer Figure 4.1) which is located to the south-west of the State Sports Park. The most effective solution to this problem is considered to be a combination of flood detention storage and main drain upgrades. Provided that suitable land can be identified, a solution that is more biased towards flood storage will be the most cost-effective solution.

The State Sports Park is currently largely undeveloped and hence contains large areas of open space. However, most areas of the park have been nominated for a variety of future developments. Notwithstanding these future developments, there may be opportunities for the investigation of stormwater management elements within the site that not only assist Council in mitigating against flooding in adjoining areas, but compliment efforts within the site to mitigate, treat, capture and reuse site runoff.

4.3 Enfield Cemetery

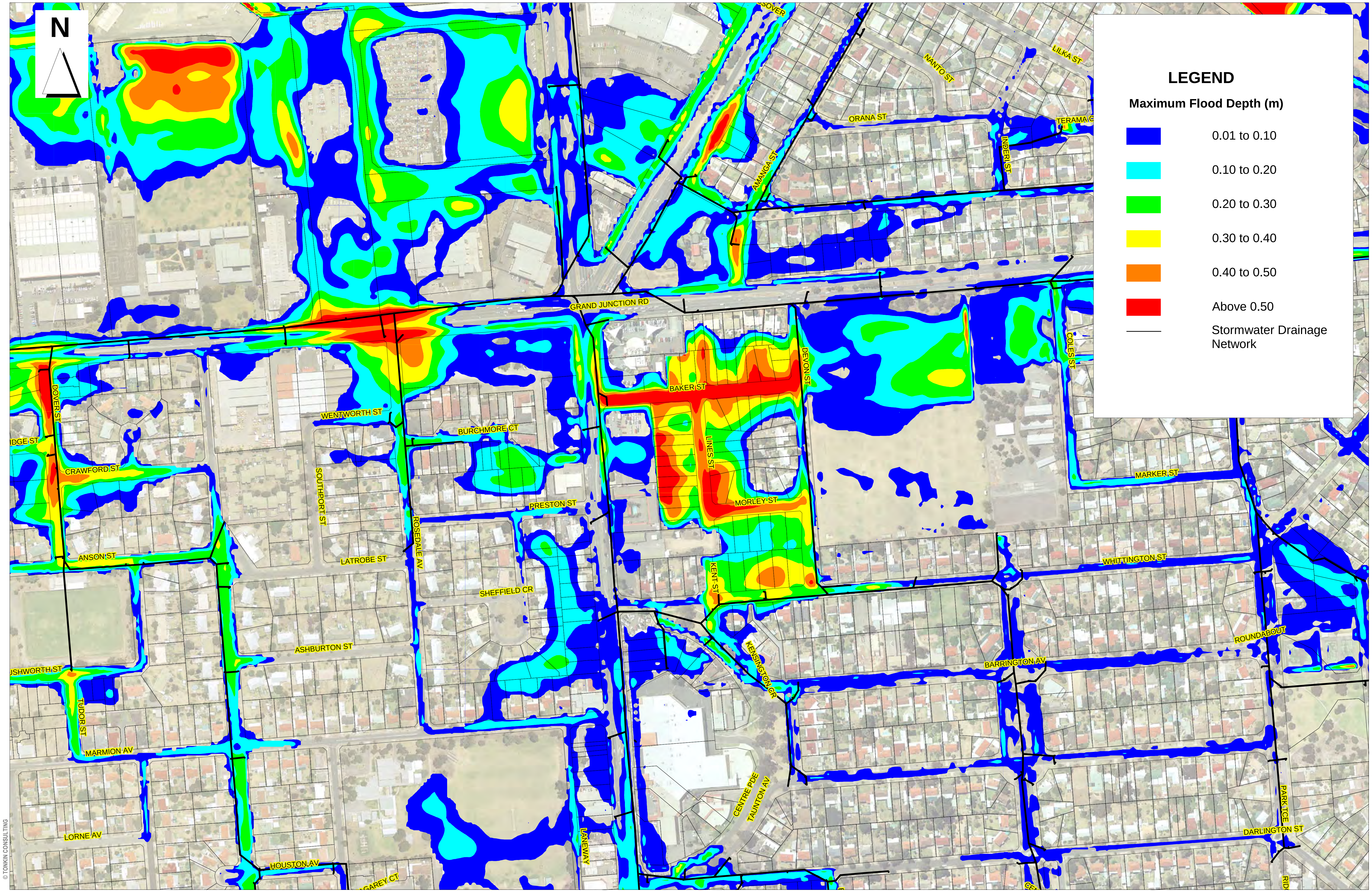
The Enfield Cemetery is within a natural valley. It is located within a catchment which ultimately contributes to the flood problems associated with the flooding in the vicinity of Grand Junction Road (refer Section 4.1). The western, downstream portion of the cemetery is currently undeveloped. There is the possibility of constructing a flood mitigation dam within the natural valley.

4.4 Enfield High School

The Enfield High School has closed due to the new Gepps Cross Super School. The eight hectare site is of strategic importance in relation to the flooding issues associated with Grand Junction Road. While land acquisition costs would be high a portion of the land could potentially be utilised for a flood mitigation basin by diverting pipe and surface flows into the site from Grand Junction Road.

4.5 Outfall Channel

The main concrete outfall channel is in poor structural condition with sections of concrete breaking away from the base and walls of the channel. There are large areas of silt build up and vegetation growing within the channel base. Sections of the channel have also been identified as having a capacity less than the previously recommended 20-year ARI standard. However, the results of the recent TUFLOW modelling have shown that currently large flood flows are unable to reach the main channel due to limitations within the drainage network and surface flood storage within the catchment. The outfall channel also passes under a large SA Water sewer in Wingfield. Large amount of gross pollutants gets trapped on the upstream side of the siphon as shown in Figure 4.2. The siphon also acts as an informal sediment trap. The location of the siphon is shown in Figure 8 within Appendix B.



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MAP DETAILS

Cadastral Data:	PBBI Australia
Drainage Data:	Tonkin Consulting
Job Number:	2007.0212
Filename:	NAE_Figure41.wor
Drawn:	Todd Rundle
Date:	30/05/2011

City of Port Adelaide Enfield

100 year ARI Flood Mapping

Grand Junction Road area

North Arm East Catchment

Figure 4.1

Figure 4.2: Build-up of debris behind the sewer siphon along the main outfall channel

The outfall channel is bounded by residential, commercial or industrial development along its full length. There are some areas that abut properties owned by Housing SA or large industrial allotments with the potential to widen the channel, as negotiations would only be with relatively few property owners. In some locations it may even be possible to replace the concrete channel with sections of grass lined channel which would allow for an improvement in water quality.

4.6 Marmion Avenue Drain

The opportunity to construct a drain along Marmion Avenue was identified in the North Arm East Drainage Study (Tonkin Consulting, 1995). Its function was to intercept flows within Main North Road and divert them into the main outfall channel prior to the flows reaching the main drain in Grand Junction Road. This option was therefore able to provide an improvement to the drainage capacity of the trunk drain in Grand Junction Road.

4.7 Increase in Runoff from Infill Development

An increase in runoff from infill development has the potential to increase peak flow rates and runoff volumes within the catchment, particularly during smaller ARI events where runoff is typically only from impervious areas.

In larger events the increase in runoff is less significant as in these events pervious areas generate a larger proportion of the runoff. Therefore, there isn't as large a difference between peak flows produced by pervious and impervious areas in these events.

4.8 NAE Portion of the Barker Inlet Wetlands

The catchment discharges into the NAE portion of the Barker Inlet Wetlands. The wetlands have a number of issues including a lack of aquatic vegetation, high turbidity and large numbers of carp. These issues mean that the wetlands are not as effective as they could be in improving the quality of water that passes through them. Opportunities to tackle these issues should be considered such that the quality of discharge from the catchment is improved.

4.9 Floor Level Controls

Council has good flood plain mapping information of the catchment and is in a position to ensure that new development is set with floor levels high enough that they are protected from flooding during a 100-yr ARI event.

4.10 Public Awareness about Flooding

As Council has good information about flood prone areas within the catchment they would be able to inform the community of this information such that people can be in a better position to react to a potential flood event. This can help to reduce the amount of flood damages that may occur.

4.11 Economic Assessment

Based on the mapping that has been undertaken, Council are able to undertake an economic assessment to determine the value in implementing various flood control measures. This can be used to justify and prioritise capital works within the catchment.

5 Stormwater Management Objectives

5.1 Stormwater Management Goals

The key issues to be addressed in the development of any plan for the management of stormwater runoff from an urban catchment include:

- Flooding
- Water Quality
- Water Use
- Environmental Protection and Enhancement

Arising from these issues, broad goals for management of urban stormwater runoff can be developed and are commonly identified as follows:

Goal 1: Flood Management

- Provide and maintain an adequate degree of flood protection to existing and future development.

Goal 2: Water Quality Improvement

- Improve water quality to meet the requirements for protection of the receiving environment and downstream water users.

Goal 3: Water Use

- Maximise the economic use of stormwater runoff for beneficial purposes while ensuring sufficient water is maintained in creeks and rivers for environmental purposes.

Goal 4: Environmental Protection and Enhancement

- Manage stormwater runoff in a manner that protects and enhances biodiversity and the natural environment. In association with this goal, land used for stormwater management purposes should be developed, where possible, to facilitate recreation use and to enhance amenity.

The development of an Initial Urban Stormwater Master Plan for the North Arm East Catchment has required that these broad goals be further refined to identify catchment specific management objectives. These specific objectives have enabled targeted management strategies to be identified and assessed.

5.2 Guidelines for Urban Stormwater Management

Development of catchment specific objectives for management of runoff from the North Arm East catchment have been carried out with reference to the principles contained in the document 'Stormwater Management Planning Guidelines' prepared by the Stormwater Management Authority (2007).

The catchment specific objectives that have been developed are consistent with the directions for management of stormwater promoted by the guidelines.

5.3 Catchment Specific Objectives

5.3.1 Flood Management

Existing Drainage Standard

Drainage within the North Arm East Catchment is currently provided by a system predominantly composed of underground drains. These drains discharge into the North Arm East outfall channel which is a man-made concrete lined open channel that runs through the suburbs of Kilburn, Gepps Cross and Wingfield. The outfall channel discharges into the Barker Inlet Wetland.

Components making up the existing drainage system can be broadly categorised into three components:

- Lateral or Feeder Drains

  These drains collect runoff from streets within the catchment and have the primary function of preventing nuisance flooding of roadways.

- Main or Trunk Drains

  These drains form the main spines of the underground drainage system and act as the discharge point for the lateral drainage systems. The main drains can carry substantial flows and have the primary purpose of preventing property damage due to concentrated flood flows.

- Outfall Channel

  The outfall channel collects flows from the main drains and has the primary purpose of transferring floodwaters to the catchment outlet without damage to property.

The existing standard of these components varies across the catchment and recommendations for upgrading the system were made in the North Arm East Drainage Study (BC Tonkin & Associates, 1995). This investigation also provided recommendations on appropriate design standards for various components of the system as follows:

- Lateral Drains : 5 year ARI
- Main Drains : 20 year ARI
- Outfall Channel : 20 year ARI

Selection of the desirable design standard for the feeder drain system was based on commonly accepted practice by finding a balance between capital expenditure and the management of localised flooding and drainage issues. Selection of the design standard for the main drains and outfall channel was based on an assessment of the costs associated with upgrading these systems and the likely consequences of flooding if the capacity of these systems was to be exceeded.

As a part of the Stormwater Management Plan, it is appropriate that these design standards be reviewed to ensure that they are consistent with current practice and that they take account of likely changes to the nature of development within the catchment.

Currently Accepted Design Standards

Australian Rainfall and Runoff (IE Aust, 1987) provides some guidance on design standards for urban stormwater drainage. The design standard is embodied in the major-minor principle, which aims to ensure that development is protected from inundation in a 100 year ARI event. Under the major-minor principle, the drainage system is considered to be comprised of a minor (generally underground) component that prevents nuisance flooding of roadways resulting from relatively frequent storm events, and a major component (generally along surface flow paths such as roads and reserves) that carries excess runoff during more substantial storm events. The combined capacity of the minor and major system components should be sufficient to carry the peak flow produced by a 100 year ARI event. A design standard of between 2 and 5 years is generally adopted for the minor system.

The major-minor philosophy is generally applied to the design of drainage systems serving areas of new development and as a result is appropriate for such areas as the Northgate development within the North Arm East Catchment.

Within areas that are already developed, the ability to provide the same level of protection from flooding as in an area of new development is generally limited by the layout of existing roads and reserves and by the topography. Within the North Arm East catchment, the situation is even more complex due to the fact that the main drainage outfalls have been established and have a fixed capacity. The cost associated with upgrading these outfalls would be prohibitive and would present a number of practical difficulties.

In these existing developed areas, the selection of an appropriate design standard to protect property that is at risk of inundation therefore requires the exercise of engineering judgement to balance the cost of the works against the benefits obtained.

Proposed Underground Drainage Design Standard

Lateral and Feeder Drainage Systems

A 5 year ARI design standard was recommended in the North Arm East Study for street drainage systems feeding the main trunk drains in the catchment. This standard is considered to be appropriate as it is in accordance with generally accepted practice for the design of minor drainage systems where the focus is to eliminate nuisance flooding and ensure surface flows through the road network are kept at manageable levels. However, for existing systems in roads that are not used as main transport routes, a design standard as low as 2 year ARI may be acceptable, provided that adequate surface flow paths are available for major flows.

Where property is likely to be inundated as a result of overflow of the underground drainage system (for example at a trapped low point), a higher design standard (up to a 100 year ARI) is appropriate. However, in most locations within the North Arm East catchment, physical constraints, the capacity of the downstream drainage system or the cost of carrying out works is likely to limit the design standard that is able to be achieved. In these circumstances, any works carried out to improve the degree of flood protection provided to property should provide the highest design standard (up to a 100 year ARI) that can be practically achieved within the given constraints.

Trunk Drains and Outfall Channel

Investigations undertaken as a part of the North Arm East Drainage Study included a detailed consideration of the costs associated with upgrading trunk drains and the outfall channel, the benefits associated with upgrading these systems to various standards and the physical constraints involved. Based on these investigations, selection of a 20 year ARI design standard for the main drains and outfall channel was recommended. Works have proceeded in the catchment based on these standards.

Given the above background, the nominated standards are considered to be appropriate. However, it should be noted that these are minimum standards that should not be reduced by future development.

Flood Storage in Barker Inlet Wetland

The Barker Inlet Wetland provides temporary storage for flows generated from the upstream catchment which may be unable to be discharged to sea during periods of high tide. Design of the wetland was undertaken on the basis that flood levels in the storage would not impact upstream development during a 100 year ARI event.

The behaviour of the storage during various combinations of flood inflow and tide level is the subject of a separate Study undertaken for the City of Port Adelaide Enfield (Tonkin Consulting, 2005). The original design criterion, that the 100 year ARI flood level in the storage does not impact upstream development, is still considered to be appropriate.

The report predicted peak 100-yr ARI flood levels at the inlet into the Barker Inlet Wetlands of between 2.11 (existing) and 2.34mAHD (future development and increased rainfall intensity) based on a predicted 0.5m of sea level rise and 100 years of projected land subsidence as per Scenario 3 conditions (Tonkin Consulting, 2005). This is higher than the predicted peak hydraulic level at the outlet of the channel (1.8mAHD) indicating that under some circumstances peak levels within the wetlands will increase the level of the hydraulic grade line within the downstream sections of the outfall channel. These impacts are likely to be limited to the section of channel between the outlet and a relatively short distance upstream of Cormack Road.

Flood Management Objectives

Based on the above, the following catchment specific objectives for management of flooding in the North Arm East Catchment have been set. Due to the different constraints that are present in new and existing areas of development, different objectives have been set for each of these areas.

For new development undertaken within the catchment (typically Greenfield development or the broad scale revitalisation of an area) the following flood management objectives will apply:

Objective 1.1

- Protect all properties from inundation in a 100 year ARI event.

Objective 1.2

- Provide an underground drainage system having a minimum capacity sufficient to carry a 5 year ARI flow.

Objective 1.3

- Ensure that gutter flow widths within any local street are limited to a maximum width of 2.5 m during a 5 year ARI rainfall event. Gutter flow widths on major transport routes should be limited in accordance with the design requirements set out by Department of Planning, Transport and Infrastructure for these roads.

Objective 1.4

- Ensure that runoff from any new development does not increase the degree of flood risk to other properties for all events up to a 100 year ARI.

Within areas of existing development within the catchment, the following flood management objectives will apply:

Objective 1.5

- Where economically and practically viable, protect existing development from inundation in a 100 year ARI event. A lower standard of flood protection may be adopted where physical and economic constraints limit the ability to achieve a 100 year ARI level of protection. Where a lower standard is adopted, this should be justified based on an assessment of the saving in construction costs relative to the increase in both direct (e.g. physical damage) and indirect (e.g. disruption) flood damage costs.

Objective 1.6

- Where economically and practically viable, provide an underground street drainage system having sufficient capacity to carry a 5 year ARI event. A lower underground drainage standard (as low as 2 year ARI) may be adopted in existing developed areas provided that adequate surface flow paths are available to carry major flows and the consequences of nuisance flooding of roadways are not significant.

Objective 1.7

- Provide and maintain a network of trunk drains and an outfall channel having sufficient capacity to carry a 20 year ARI event.

Objective 1.8

- Provide and maintain flood storage at the downstream end of the catchment to provide for high tide levels in the Barker Inlet and ensure that upstream development is not affected by the stored floodwaters in a 100-year event making allowances for predicted sea level rise.

Objective 1.9

- Increase the public awareness of flood risk such that they are better able to respond to a flood event and reduce flood damages.

5.3.2 Water Quality Improvement

Runoff from the North Arm East catchment discharges into the Port River - Barker Inlet system. The importance of this system is well documented because of its extensive mangroves and seagrass communities and its role as a spawning, breeding and shelter zone for many aquatic species. Pollutants of particular significance to this system include nutrients, heavy metals, organic compounds and litter.

Currently, all runoff from the North Arm East catchment is intercepted by the NAE portion of the Barker Inlet Wetland prior to discharge to the Barker Inlet. This wetland was designed to adequately treat stormwater runoff from the entire catchment to a level that will protect the downstream receiving waters. A review of the performance of these wetlands (EMS, 1999), which was based on data for the period between 1995 and 1998, showed that they are achieving pollutant removal efficiencies at the level envisaged in their design. These levels are similar to those outlined in the recently prepared wetland management plans (EMS, 2011).

Table 5.1: Reduction in Pollutants in Barker Inlet Wetland

Parameter	% Reduction
Total Phosphorus	~70%
Total Nitrogen	~60%
Heavy Metals	45 – 90%
Suspended Solids	~85%

Note: The reductions shown are up to the point of discharge into the inter-tidal section of the wetland for the period 1995 to 1998.

There are no natural watercourses or other natural water bodies of significance within the catchment. The protection of aquatic ecosystems other than the Barker Inlet from the adverse impacts of runoff from the North Arm East catchment is therefore not required.

While the quality of runoff from the catchment is currently improved by the NAE portion of the Barker Inlet Wetland system, there are some issues associated with the management and performance of the wetland (and the quality of water discharged from the wetland) that would benefit from implementation of further stormwater quality improvement strategies in the catchment. These issues include:

- Gross Pollutant Management

  It has been estimated that the catchment would produce approximately 850 m^3 of gross pollutants in an average year based on a generation rate of 0.4 m^3/ha/yr. There are currently only limited facilities to trap and remove these gross pollutants, which includes the informal arrangement upstream of the sewer syphon along the main outfall, as discussed in Section 4.5, and the trash racks within the main outfall channel upstream of the NAE Wetlands. The existing trash racks have sufficient capacity to store approximately 10 m^3 of gross pollutants. Materials that are not captured by the existing trash rack, or upstream of the syphon will either accumulate within the Barker Inlet wetland, or be transported through the wetland into the Barker Inlet itself.

  The floating material trapped in the wetland or discharged to the Barker Inlet can cause unsightly conditions immediately after a major stormwater event. Certain types of debris can also be a hazard to marine life in the Barker Inlet. Significant inputs of organic material into the wetland could also lead to depletion of oxygen in the water column during decay of the material (although this is less likely to be an issue due to the size of the wetland).

  It is therefore desirable that inputs of gross pollutants to the wetland be reduced.

- Sediment Export

  There is currently only limited facility to trap and remove coarse sediment at the inlet to the wetland. Under present conditions, this material is likely to accumulate in the most upstream ponds of the system. At some point, dredging and removal of this material will be necessary as outline in the management plan for the wetlands (EMS, 2011).

  In order to minimise the frequency of these dredging operations, good catchment management usually employs a 'treatment train' approach where sediment export is minimised at source and facilities are provided at key locations in the catchment to trap sediment where it is able to be more easily and economically removed. Export of sediment, particularly from construction sites, is likely to be a significant issue in the catchment given the extent of development and redevelopment that has been identified.

The control of sediment export from the catchment is therefore a priority.

- Pollutant Point Sources

  While most pollutant sources within urban catchments are diffuse, some activities produce higher sources of pollutants. These activities may include construction and certain types of industrial and commercial land uses. The catchment contains significant areas of industrial and commercial land use and as a result, these activities are likely to have a substantial impact on water quality.

  In order to reduce the impacts of these activities on the performance of the wetland, good catchment management usually employs an approach of providing additional measures at source to capture these pollutants.

- Major Transport Routes

  The catchment includes a number of major road transport corridors. Due to the traffic volumes, runoff from these roads is likely to contain higher levels of pollutants than from other less heavily trafficked corridors. In addition, there is a higher potential for chemical spills on these roads.

  The former Transport SA has prepared a plan for management of runoff from roads under their care and control within metropolitan Adelaide (Tonkin, 2000). For the major catchments in the north western sector of Adelaide, the existing protection provided by the Barker Inlet wetlands against the effects of poor quality runoff from roadways and from chemical spills was identified. However, due to the high traffic volumes and the potential for accidents in the area, it was recommended that water quality improvement and spill capture facilities be provided in association with any upgrading work on major roads in the area.

- Increased Flows Due to Redevelopment

  Design of the Barker Inlet wetland was undertaken using estimations of runoff from the catchment based on the current level of development. Increased impervious area within the catchment will result in an increase in the quantity of runoff to be treated and may result in a reduced effectiveness of the wetland.

  In order to address these issues, the following catchment specific objectives for management of water quality from the North Arm East Catchment have been set:

Objective 2.1

- Manage the quantity of gross pollutants entering the NAE portion of the Barker Inlet wetland such that the quantities are less than that those currently produced by the catchment. Actual reduction targets will be set once additional monitoring is undertaken to quantify the amount of gross pollutants generated by the catchment.

Objective 2.2

- Minimise the quantities of sediment exported from the catchment such that the quantifies are less than those currently produced by the catchment and increase capture of coarse sediment upstream of the NAE portion of the Barker Inlet wetland where it is economic to do so. Actual reduction targets will be set once additional monitoring is undertaken to quantify the amount of sediment generated by the catchment.

Objective 2.3

- Intercept pollutants at source from land uses and activities having a high potential for pollutant generation.

Objective 2.4

- Minimise the increase in flows from redevelopment such that the existing performance of the NAE portion of the Barker Inlet wetland is maintained and that the volume of water discharged into the Port River - Barker Inlet system is maintained to current levels.

Objective 2.5

- Optimise and improve the current water quality treatment performance of the NAE portion of the Barker Inlet wetlands

5.3.3 Water Use

There is currently only one location within the catchment at which a scheme for harvesting stormwater is operational. This is the aquifer storage and recovery scheme at the Folland Avenue Wetland within the Northgate Development. A scheme to harvest stormwater from the Barker Inlet wetland has been outlined as part of a recent study (Wallbridge & Gilbert, 2009) and is currently under construction. Aquifer storage and recovery is a key component of the Government's Water for Good plan which aims to harvest 60GL/annum of recycled stormwater in the greater Adelaide area by 2050. It will also assist in meeting the objectives of SA Water's regional supply and demand plans which aim to provide adequate water for sustainable growth over the next 40 years.

There is no requirement to maintain environmental flows within catchment watercourses as these comprise highly modified channels. It is also unlikely that the quantities of stormwater harvested from the catchment, either in on-site systems or catchment scale facilities, would ever be significant enough to affect the viability of the downstream wetlands or the harvesting facility proposed within these wetlands. Indeed, with ongoing redevelopment, there may be some advantage in minimising inflows to the wetlands to ensure that their effectiveness in improving runoff quality is maintained.

The ability to harvest stormwater in larger catchment scale facilities is limited by the availability of open space to construct the harvesting schemes and the economic viability of these schemes. As the catchment is heavily developed there are only limited opportunities for water harvesting.

Based on the above the following catchment specific objectives for water use have been adopted:

Objective 3.1

Encourage on-site use of stormwater runoff to minimise discharges to the downstream stormwater system.

Objective 3.2

Where economically viable, utilise stormwater runoff for beneficial purposes in catchment scale facilities where large amounts of open space exist, such as within the State Sports Park, the NAE portion of the Barker Inlet Wetlands or within the former Enfield High School site.

Objective 3.3

Across the catchment maximise the capture and re-use of stormwater runoff based on the constraints of a fully developed urban catchment.

5.3.4 Environmental Protection and Enhancement

There are no existing natural watercourses or water bodies of significance within the catchment. As a result, opportunities for environmental enhancement in association with management of urban stormwater will be limited to those that may be associated with construction of new stormwater management facilities on areas of open space.

Development of multiple use drainage open space requires a careful consideration of the interaction between drainage provision, environmental enhancement, water quality and recreation provision. By application of appropriate principles and implementation of suitable guidelines it is possible to serve a range of needs while at the same time providing a suitable drainage system. In doing so, advantages can be compounded beyond those which may be achieved if each component were considered in isolation.

The following catchment specific objectives have therefore been adopted:

Objective 4.1

Within new developments, encourage the use of open space provided for drainage infrastructure for other purposes such as amenity enhancement, passive or active recreation and environmental enhancement.

Objective 4.2

Where new stormwater management facilities are constructed on existing open space maximise the community use and benefit derived from the facility and ensure that opportunities for biodiversity, amenity and environmental enhancement are realised.

5.3.5 Asset Management

Stormwater drainage forms a considerable financial asset for the City of Port Adelaide Enfield. Considering that a large portion of the existing drainage infrastructure was constructed over 30 years ago, some degree of structural degradation is likely. Degraded infrastructure will reduce the ability of the drainage system to act as per its original design intent.

Without careful planning, structural failure of existing infrastructure may necessitate immediate and expensive rectification. Careful asset management will allow for future planning to determine the timeline for replacement of assets.

The following general objectives have therefore been set:

Objective 5.1

Maintain up to date information on the age and condition of existing drainage infrastructure by undertaking;

- CCTV inspections of drains, with a particular focus on box culverts
- Visual inspection of basins and other water sensitive urban design infrastructure

Objective 5.2

Plan for the strategic replacement of infrastructure nearing the end of its design life, with a particular focus on major assets such as trunk drainage systems.

Objective 5.3

All stormwater infrastructure including WSUD schemes are to be maintained in accordance with cost-effective maintenance management plans.

Objective 5.4

Stormwater infrastructure is to be managed sustainably.

6 Management Strategies

6.1 Flood Management

Council is typically looking to implement catchment scale schemes to manage both existing flooding problems and those that may be posed by future infill development within the catchment (as discussed in Section 2.8.4 and 4.7). New or enlarged drains will be able to provide additional capacity to the existing drainage network which will assist in managing the increase in peak flow rates generated by infill development. New basins will be able to temporarily detain the additional volume of flows that would be produced by infill development and release it at a rate that doesn't overload the downstream drainage system.

A number of catchment scale facilities are discussed in this section (to meet Objective 1.5) as well as options for allotment scale works (Objective 1.1 and 1.4).

6.1.1 Minor Flood Management

Other than the areas described in Section 4.1, the fairly dispersed and relatively minor nature of flooding within the catchment makes it difficult to economically provide a desirable level of flood protection to all properties (to meet Objective 1.5).

It is assessed that the only viable solution in many areas would require significant infrastructure upgrades, which could not be economically viable, given the small number of properties that would be protected at each location. Furthermore, there are many physical constraints within the catchment which limit the ability to provide a desirable level of flood protection. These constraints include flat grades towards the downstream end of the catchment, limited available open space that is in a suitable location for flood mitigation and limited space between existing major services or existing development (such as along the outfall channel).

For example there are currently about three properties assessed to be flood prone in a 100-yr ARI event at Hillsdale Street in Prospect and seven properties near Garland Avenue in Kilburn (based on 200mm of water depth at the property centroid).

The Prospect properties are at the upstream end of a drainage network that would require an 800m section of upgrade between the site and the outfall channel. An upgrade of the entire 800m length of the network, such that the three properties were no longer flood prone, would cost in the vicinity of $1.2m based on a rate of $1,500/m. The likely flood damages in a 100-yr ARI event would be in the vicinity of $120,000, which is considerably less than the value of the upgrade works and is therefore an upgrade in not warranted on economic terms.

The Kilburn properties drain against the grade into the trunk drain within Churchill Road. The only way to improve the capacity of the local drainage system would be to reduce the hydraulic grade line within the Churchill Road trunk drain. This drain continues for 1,500m before it discharges into the outfall channel. While an upgrade of the entire drain would reduce flood risk to more than just the seven properties in Kilburn, there are only approximately ten flood prone properties that drain into the Churchill Road trunk drain downstream of Garland Avenue. The upgrade cost of the Churchill Road outfall drain would be in the vicinity of $4.5m based on a rate of $3,000/m, given the size of the existing trunk drain and that the works would be within an arterial road. This is considerably higher than the likely 100-yr ARI flood damages of $400,000.

6.1.2 State Sports Park

6.1.2.1 Catchment Description

The State Sports Park is relatively undeveloped with less than 15% covered by development in the form of buildings, car parks or roads. The site also receives inflows from a 28-hectare residential catchment to the east of Briens Road. The site grades relatively steadily from east to west with ground levels ranging from 55mAHD to 11mAHD.

6.1.2.2 Site Stormwater Management

Stormwater within the State Sports Park is managed by a series of detention basins and open channels. The largest of the basins is located in the south-western corner of the site (corner of Kara Street and Main North Road). A small basin is located to the north between the basin and a large commercial development. Two other large basins are located further to the east. The first is to the south-east of the Hockey Stadium (in the Foresters Forest area), while the furthest upstream basin is located towards the east of the site mid way between the Velodrome and Briens Road.

A report by Wallbridge & Gilbert (State Sports Park, Gepps Cross Stormwater Management Scheme, Infrastructure Requirements, 1996) provided a range of allowable levels of impervious site coverage for each of the 17 allotments on the site. They provided an "allowable" value and a lower "alternative" value. It appears that based on the works done on the site so far (in regards to flood storage volumes) the lower "alternative" levels of development have been adopted. The lower level allowed for approximately 40 hectares of development within the site. Based on inspection of recent aerial photography there is only 19 hectares of impervious area which would indicate that the existing infrastructure is adequately sized for the current level of development. However, it is understood that additional development is planned for the Woolworths site to the north, a new super school site has been completed to the east of the site and a number of sporting related developments are planned for the future.

The only stormwater discharge from the site is via a 300mm diameter pipe from the existing detention basin within the south-western corner of the site.

6.1.2.3 State Sports Park Opportunities

Grand Junction Road Flow Diversions

The only feasible opportunity identified in relation to the State Sports Park, in the context of the North Arm East catchment, is to divert stormwater into the site from Grand Junction Road. This will assist in meeting the goals of reduced flood risk, increased water harvesting and water quality improvement as discussed in more detail below.

Grand Junction Road runs along portions of the southern boundary of the State Sports Park site. A stormwater drain (675mm diameter) runs under the road and services residential catchments to the south. Based on existing site levels it would be possible to divert flows into the State Sports Park from the Grand Junction Road drain from anywhere upstream of Amber Avenue where site levels are close to 10m or more above the natural ground levels within the south western and Foresters Forest detention basins within the State Sports Park.

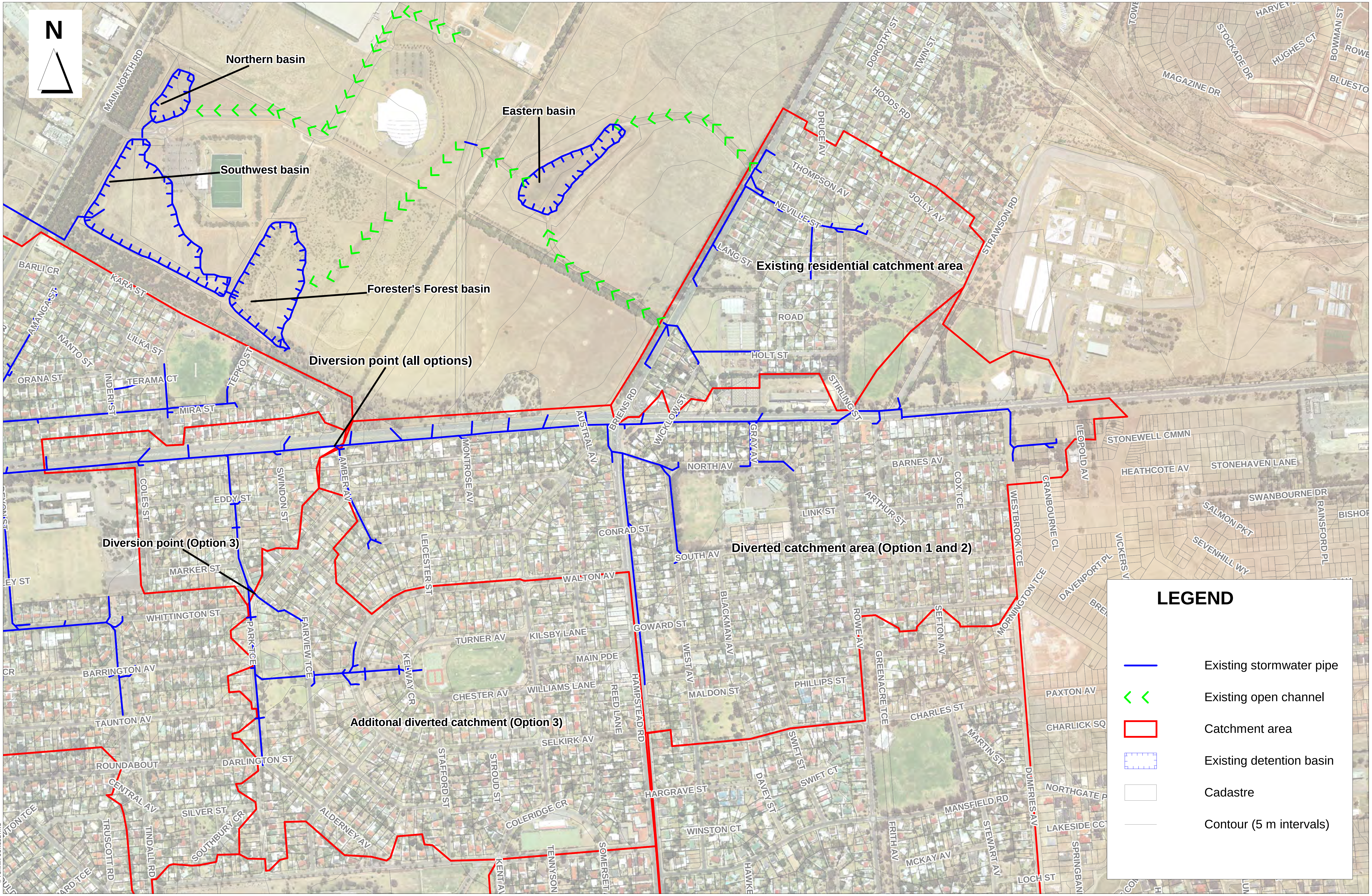
Three options have been investigated. The first is to intercept base flows from the Grand Junction Road drain to divert the majority of the annual volume of flow into the State Sports Park. This flow could then be directed into a wetland system, in combination with runoff from the existing catchment to maximise the volume of water that could be harvested.

The second and third options involve full interception and redirection of flows into the site. The first of these options is to intercept flows at Amber Avenue, while the second would also involve the interception of flows along Park Terrace. The Park Terrace option would maximise the reduction in flood risk further downstream in the vicinity of Baker Street with interception of approximately 40% of the catchment upstream of the Main North Road, Grand Junction Road intersection.

Figure 6.1 provides an overview of the existing drainage system within the State Sports Park. It also shows the extent of the Grand Junction catchment that could be diverted into the State Sports Park for the various options. These options are discussed in further detail below.

Option 1: Partial Diversion at Amber Avenue

The partial diversion option would involve diversion of base flows from the Grand Junction Road drain into the State Sports Park. The benefit of only diverting part of the flow would mean that the amount of upgrade works required within the State Sports Park to manage the increase in flows would be reduced. Diversion of the 3-month



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MAP DETAILS

Cadastral Data:	PBBI Australia
Drainage Data:	Tonkin Consulting
Job Number:	2007.0212
Filename:	NAE_Figure61.wor
Drawn:	Todd Rundle
Date:	30/05/2011

-150 0 150 300 450
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Scale: 1:7,500

City of Port Adelaide Enfield

State Sports Park
Stormwater Opportunities

Catchment areas

Figure 6.1

flow rate would result in approximately 95% of the annual flow volume within the Grand Junction Road drain being diverted. Therefore, the majority of annual flow would be diverted for water harvesting purposes. The 3-month flow rate is estimated to be approximately 700L/s.

This option would require an increase in the detention storage requirement within the SPP as it still results in a large increase in volume of flow entering the State Sports Park drainage system. As this option only diverts a moderate proportion of the total flow volume in the 100-year ARI event, there would only be a minor reduction in flood risk at Baker Street.

The partial diversion option is contained within Appendix B (Figure 1).

Option 2: Full Diversion at Amber Avenue

This option would involve diverting the full flow within Grand Junction Road. Diversion of the flow at Amber Avenue will increase the impervious area draining into the State Sports Park by approximately 25-30 hectares. This is a significant increase on the current level (~27 hectares) and the "alternative" option in the Wallbridge & Gilbert report (48 hectares). Full diversion will require a significant increase in the amount of detention storage within the State Sports Park. However, it appears that a large increase is possible (refer Section 6.1.2.4 below).

In the 100-year ARI event large surface flood flows are likely to pass along Grand Junction Road due to the capacity of the underground drains being exceeded. These surface flood flows could be intercepted with the construction of a series of inlet pits along Grand Junction Road to increase the proportion of flow diverted into the State Sports Park during large ARI events (e.g. 100-year), thereby maximising the reduction in flood risk within the Baker Street area.

This option would divert approximately 25% of the catchment that drains towards the Baker Street flood prone area.

This option is shown as Figure 2 in Appendix B.

Option 3: Full Diversion at Amber Avenue and Park Terrace

The option is similar to Option 2. However, it also includes full diversion of flows at the Park Terrace and Amber Avenue intersection. This will intercept an additional 20 hectares of impervious area. The interception pipe would run along Amber Avenue and then run along the alignment of the drain proposed for Options 1 and 2. The section of drain along Amber Avenue would run against the natural grade and would require deep excavation (up to 5.5m deep) in the vicinity of Melrose Avenue.

Similarly to Option 2 the interception of surface flows at Park Terrace would require a series of additional inlet pits to collect surface flood flows. The grade of the interception pipe along Amber Avenue will need to be relatively flat (as it goes against the grade) and will therefore need to be large in size (~1,350mm diameter) to divert the 100-yera ARI flow.

This option would divert approximately 40% of the catchment that drains towards the Baker Street flood prone area.

This option is shown as Figure 3 in Appendix B.

6.1.2.4 Basin Upgrades

A number of detention basin upgrades would be required to safely manage the additional volume of inflows into the State Sports Park based on the diversion of flows from Grand Junction Road. The two basins that would require upgrading are the south-western basin which is located within the lowest part of the State Sports Park and the Foresters Forest basin further to the east.

South Western Basin

Based on an assessment of the existing levels of the adjacent hockey stadium car park, the maximum height that the embankment could be increase to would be 14.5mAHD (currently at 14.0mAHD). Raising the embankment height to 14.5mAHD would increase the detention storage volume by 12ML from 38ML to 50ML.

The discharge capacity from the basin is very limited and passes through a 300mm pipe on a flat grade. The capacity of this drain has been estimated to be 70L/s. This forms the only outlet point for the State Sports Park.

Additional discharge from the site may be possible if the water is pumped into a proposed water harvesting scheme to the north of the State Sports Park (refer Section 6.3.1.1) and/or by constructing a new outfall drain for the Sports Park. The most likely outfall point for a new outfall drain would be the existing 2.4m wide by 0.9m high box culvert in Main North Road adjacent to southern end of Barli Crescent which is approximately 400m south of the site. This area is close to 5m lower than the invert levels of the south west basin and could therefore operate on gravity. A balance is needed between a higher discharge rate, which will reduce the amount of detention storage required, capital cost, and the need to reduce flows within the Grand Junction Road drain. A discharge rate of approximately 250L/s is considered appropriate and is a significant reduction on the peak rate of 2-3m^3/s (depending on the diversion option) that is being diverted into the site from Grand Junction Road.

The alignment of the proposed outfall drain is shown as Figure 4 in Appendix B.

Foresters Forest Basin

There is the potential to increase the peak storage height of this basin significantly without impacting on any upstream development (existing or planned). The works would involve increasing both the length and height of the existing embankment. Due to the natural topography of the site the increase in storage is relatively inexpensive as the extension of the embankment will naturally generate detention storage behind it (i.e. excavation is not required to provide the detention storage). However, some trees are likely to require removal. The impact on trees will be relatively minor provided the extension of the banks is on the backward face of the existing embankment as the majority of this land is currently not vegetated. A new hockey pitch is proposed immediately to the west of the existing embankment. This potentially limits how far the embankment can be extended to the west.

The amount of additional detention capacity required for the Foresters Forest basin depends on how much additional catchment is diverted into it and if an additional outfall drain is constructed downstream of the south-western basin as this would also allow an increase in the discharge rate from the Foresters Forest basin. The outlet from of the basin needs to be restricted to a level similar to the capacity of the south-western basin's outlet capacity to prevent it from overtopping in the 100-year ARI event. This is currently 70L/s, but could potentially be increased to 250L/s as outlined above. Table 6.1 provides a summary of options for the Foresters Forest basin. The embankment heights include an allowance of 300mm for freeboard.

The current basin has been built to a height of 16.8mAHD (at its lowest point) with a capacity of 28ML. A more extensive embankment if required for the low flow options than for the higher discharge option to create the required amount of detention storage.

A new hockey pitch is proposed immediately to the west of the existing embankment. This potentially limits how far the embankment can be extended to the west.

Table 6.1: Summary of Foresters Forest Basin Enlargement Options

Option Description	Embankment Height	Detention Volume	Discharge Rate
Option 1, Partial diversion, low discharge	18.5mAHD	105ML	50L/s
Option 2, Full diversion, low discharge	18.8mAHD	125ML	50L/s
Option 3, Maximum diversion, low discharge	19.0mAHD	135ML	50L/s
Option 2b, Full diversion, higher discharge	17.8mAHD	62ML	250-300L/s
Option 3b, Maximum diversion, higher discharge	18.8mAHD	95ML	250-300L/s

Based on the 50L/s outflow rate, the lower parts of the basin would regularly be inundated following rainfall (for approximately 1 day per 10mm of rainfall). This is likely to impact on the vegetation in this area. However, the basin will remain dry for the majority of the drier months. For the higher discharge rate, the basin will typically only be wet for a day or two following heavy rainfall.

6.1.3 Enfield Cemetery

The Enfield Cemetery is located within a natural gully. The western portion of the site is currently undeveloped. A relatively small (35 hectare) residential catchment drains through the site. There is the opportunity to construct an embankment within the base of the gully. This would form a detention basin behind the embankment within the western portion of the gully. There is no development within the gully that would be impacted by inundation.

There is the opportunity to divert additional flows through the site by intercepting flows within the Folland Avenue Drain which is fed by a 61-hectare catchment. This would require the construction of a new drain between Hampstead Road and the cemetery and an upgrade of the existing underground drain through the cemetery. The pipe would intercept the 600mm diameter pipe running south along Hampstead Road and the 675mm diameter pipe running west along Folland Avenue. An 825mm would have an equivalent capacity to the existing drainage pipes.

By diverting flows at Folland Avenue a proportion of the flows that pass down the Fitzgerald Avenue / Prescott Street valley will be diverted away from the valley which has been shown to be moderately flood prone as part of the TUFLOW flood mapping. This valley will also receive additional flows as part of development in the Northgate area.

The basin will require 37ML of detention storage if discharge is limited to 1.2m^3/s for the 100-year ARI event. This will require an embankment close to 5 metres above existing natural surface levels.

These works are summarised in Figure 6 in Appendix B.

6.1.4 Marmion Avenue Diversion Drain

The section of the main Grand Junction Road drain to the west of Main North Road is very flat and due to the large inflow at Main North Road is under capacity which is partly responsible for the flooding that the TUFLOW modelling has shown to occur in the area. The opportunity to divert a large portion of the flows within Main North Road is available along Marmion Avenue and help to meet Objective 1.7. The drain would run the full length of the road (970m) and discharge directly into the main outfall channel. A 1200mm diameter pipe is required to enable interception of the majority of the flow within the Main North Road drain (~3m^3/s). The section between Florence Avenue and the outfall channel is very flat and will require twin 1200mm diameter pipes to provide an equivalent capacity to the steeper section of drain east of Florence Avenue.

These works are summarised in Figure 7 in Appendix B.

6.1.5 Outfall Channel Upgrades

The outfall channel has been modelled in HEC-RAS. Various options to modify the channel have been investigated.

The TUFLOW modelling has shown that significantly less flow reaches the channel than indicated by the ILSAX and GENDRAIN modelling due to flood storage within the catchment and restrictions within the drainage network. While both the TUFLOW and ILSAX models have essentially the same inflow hydrographs the TUFLOW model is more accurately able to route the flows through the catchment, in particular surface flood flow paths through the road network and through properties. It is also able to more accurately model the flood storage that is available throughout the catchment as it utilises the digital terrain model of the catchment.

The outfall channel has been divided into three different sections based on the level of works required to give the channel an adequate standard and meet Objective 1.7. The level of works for each section ranges from 'minor upgrades to 'major upgrades'. The only section to remain unchanged is the sewer siphon.

The outfall capacity is to be increased by:

- Levee banks on either side of the channel
- Culvert crossing upgrades
- Channel widening / upgrades

The amount of space available towards the lower reaches of the channel (in the vicinity of Grand Junction Road and Churchill Road) is the overriding restriction which will limit the standard of the outfall channel.

In the upper reaches of the channel (upstream of Marmion Avenue) there is adequate space available to allow upgrades to be made to provide a significant increase in the capacity of the channel.

In some locations the channel is in poor condition (typically downstream of Grand Junction Road) and upgrades would involve replacing the entire channel. In areas upstream of Grand Junction Road the works would typically only involve widening the channel and retaining as much of the existing channel as possible.

A recommended channel widening regime is shown in Table 6.2. It will not require any additional land acquisition but will utilise the full extent of the existing drainage reserve in a number of areas. Some additional design development and accurate field survey would be required to confirm the channel and culvert sizes outlined below.

Table 6.2: Channel Upgrade Summary

Location	Channel Size	Culvert Size
Start of channel to downstream of Northcote Street	4m wide base width, 1.4m deep, 1 in 1 side slopes	5.5m wide by 1.8m high box culverts
Downstream of Northcote Street to downstream of Grand Junction Road	9m wide base width, 1.4m deep, 1 in 1 side slopes	3 x 3.0m wide by 1.5m high box culverts
Downstream of Grand Junction Road to downstream of Railway Reserve	13m wide base width, 1.4m deep, 1 in 1 side slopes	5 x 3.0m wide by 1.45m high box culverts
Downstream of Railway Reserve to end of channel	18m wide base width, 1.4m deep, 1 in 1 side slopes	4 x 5.0m wide by 1.3m high box culverts

These works are summarised in Figure 8 in Appendix B.

Grass Lined Channel

The option to remove the concrete and replace it with a grassed earth lined channel is not considered to be viable in most areas due to the large reduction in channel capacity this would create and the limited space available.

However, between Way Street and Marmion Avenue the majority (30 of 40 properties) of the channel is against a series of properties owned by Housing SA on the western side. There is also a section of channel south of Cormack Road where the area to the west of the channel is currently underutilised. In these areas there is the potential to widen the channel significantly by acquisition of adjacent land or using adjacent undeveloped land.

In general terms the channel will need to be approximately 3 times wider (from top of bank to top of bank) for a grass lined channel, with 1 in 5 side slopes to have an equivalent hydraulic capacity as the existing concrete channel (with the current 1 in 1 side slopes). Therefore, the total channel width would need to be between 30 and 35m. Given the existing channel reserve width is between 15-17m wide an additional 15-20m of land is required along the western edge of the channel. In addition to widening the channel the culverts would also need to be widened significantly to reduce the large contraction and expansion loss that would be generated if the existing culverts were retained. At some locations it may be possible to close off roads that cross the channel to enhance the linear nature of the works, to improve the channel hydraulics and to reduce the capital costs.

The 15-20m strip of land includes a number of duplexes where only half of the site is required. In these instances a single dwelling could be reconstructed on the portion of the site that is not required. In other areas a portion of the yard area would be removed. However, redevelopment of the front portion of the blocks would still be possible. It is estimated that there would be a net loss of approximately 13 dwellings after redevelopment (assuming a 300m^2 minimum lot size for new allotments).

A grass lined channel could include a number of landscaped features to improve the amenity of the area including shared paths, riparian vegetation and deeper pools to create aquatic habitat along the channel.

6.1.6 Outfall Channel Detention Basin

Two locations have been investigated for the potential construction of a detention basin along the main Outfall Channel. The main purpose of the basin is to detain flows to reduce the peak passing further downstream, thereby improving the standard of the channel. The two locations are the Council Depot site in the vicinity of Marmion Avenue and the Canine Association land south of Cromwell Road.

6.1.6.1 Council Depot Site

A basin at this site would be directly “on-line” with the main outfall channel. The basin is able to reduce peak flows by approximately 15% (4m^3/s) with a detention storage volume of approximately 26,000m^3.

While the basin is on Council land the site was originally used as a landfill. The level of contamination of the site is unknown, but is likely to be underlain by waste material that was dumped on the site. There is also a large amount of overburden on the site that would need to be removed before any effective detention storage was created. An estimated 67,000m^3 of material would need to be excavated to provide the basin. Current disposal costs of this material are estimated to be \$170/m^3 making excavation and disposal costs over \$11 million. Based on this high cost the construction of a basin at this site is not considered viable unless a large proportion of the material at the site was free from contamination.

6.1.6.2 Canine Association

A large amount of open space is located within the Canine Association land south of Cromwell Road. Approximately 3 hectares of land would be required to provide a similar impact on flood flows to the proposed Council Depot basin. The basin is not directly on line with the outfall channel and would require a large interconnection culvert between the basin and the outfall channel. It is likely that a culvert in the vicinity of 3.0m wide by 1.2m high would be required to pass enough flow into the basin to ensure it works effectively. The likely interception point for the culvert would be at Solent Avenue. A small pipe (375mm diameter) would be required to drain the basin after it had filled. The outlet drain would pass along Cromwell Road to the outfall channel. The outfall channel is lower at this point (in comparison to Solent Avenue) and therefore allows for a deeper basin invert level increasing the available storage depth. This therefore reduces the amount of land required. A relatively minor bund would be required around the perimeter of the site up to a level of 5.8mAHD to prevent water spilling to the north-west of the basin.

Scenario modelling for a detention basin within the land owned by Dogs SA (referred to as the Canine Association within this document) was undertaken and the results were included in the draft consultation document. However, the land is under the private ownership of Dogs SA, who are not supportive of the implementation of this option (Comm. per meeting with Dogs SA Board in April 2013). If potential benefit emerges in the future due to development pressures in the catchment, implementation of this option will require the agreement of the landowner.

For information purposes a plan showing the above option is shown in Figure 9 in Appendix B.

6.1.7 Enfield High School

The site is located at a strategic location within the North Arm East catchment and is upstream of the flood prone Baker Street area.

As the site is currently flood prone, the proposed works will involve the construction of an open channel around a portion of the site's eastern and northern boundaries which would direct surface flows from Grand Junction Road into a depressed area (or basin) at the western end of the site.

In addition to surface flows, pipe flows could also be diverted into the basin. However, if all flows were to be diverted into the site, inundation of the basin is likely to occur virtually every time it rains. This could limit the value of the area as useable open space.

The system could be configured such that base flows are able to bypass the site using the existing drain in Grand Junction Road and only have larger flows enter the site. With this configuration in the majority of rainfall events, no water would enter the basin. This would improve the usability of the site for other purposes such as open space (for recreation) with inundation of the area due to floodwaters only occurring when the flows exceed the base flow rate. The bypass could be configured within a flow splitter box to be equivalent to the 1 in 3 month flow rate such that the site is only inundated on average four times per year. A mound placed around the perimeter of the basin would maximise the amount of flood storage that could be incorporated into the site by increasing the effective depth of the basin. The basin would drain via a small diameter pipe into the existing Council drain within Grand Junction Road (or possibly Devon Street).

TUFLOW modelling indicates that during a 100-yr ARI, 9-hour event, approximately 65ML of flow passes the site, comprised of 50ML of piped flows and 15ML of surface flood flows. Bypass of the 1 in 3 month flow (approximately 900L/s) results in approximately 18ML of flow by passing the basin. Therefore, a basin volume of approximately 45-50ML is required to fully intercept the remaining piped and surface flood flows. Approximately 3.0 hectares of the site will be required to hold this water, depending on a number of factors including:

- Whether the system is to be able to fully drain via gravity into the Devon Street or Grand Junction Road drainage system (as this would limit the invert level of the basin)
- The maximum flood storage level in the basin to permit development on the remainder of the site to drain via gravity into the basin during an extreme flood event
- Limitations on the maximum embankment height to ensure the aesthetics of the basin are appropriate for its location
- How much of the site is set at a higher level to reduce the frequency that it is inundated which would improve its usability as open space but reduce the volume of detention storage
- Whether the basin can be set hard up against the Grand Junction Road boundary or if a buffer strip is required
- The grade batters that can be incorporated into the embankments that surround the basin
- Whether shallow groundwater or rock would impact on the depth of the basin.

Reducing the flow in the Grand Junction Road trunk drain to a 1 in 3 month flow creates additional capacity in the drain. This has a benefit in allowing additional flow into the drain from the 900mm drain along Devon Street and also allows for additional flow into the drain from drainage systems further downstream. Therefore, the benefits of the diversion works extend well beyond the immediate area of the Enfield High School site by improving the standard of the downstream drainage systems.

A portion of the site could also be dedicated to a permanent water body. This would potentially allow for the interception of minor base flows that drain past the site in Grand Junction Road to enable the harvesting of this water. This is discussed in more detail in Section 6.3.1.2.

The works are shown in Figure 10 and 11 in Appendix B which also show the incorporation of a permanent water body into the detention basin.

As the Enfield High School site is located only a short distance downstream of the proposed location where water could be diverted into the State Sports Park, construction of a diversion (into the State Sports Park) would not be recommended if the Enfield High School scheme was implemented. In addition to interception of the majority of the pipe flows (similar to the Sports Park Interception option) the Enfield High School option also intercepts surface flood flows, making this option superior to the Sports Parks option in mitigating flooding. It is also further downstream in the catchment and is therefore able to divert a larger proportion of the catchment.

6.1.8 Floor Level Control

Implementation of this strategy involves the assessment and specification of minimum floor levels for new development as an essential component of the Development Assessment Process. Floor levels for new development should be set with appropriate freeboard above the 100 year ARI flood level.

In general, this is currently achieved within the catchment by requiring that the floor level of new developments be at a minimum level (usually 200 mm) above the top of the adjacent kerb. This approach is based on the assumption that the street system has adequate capacity to carry the 100 year ARI flood flows.

In general, this approach is appropriate for most areas within the catchment. However, where development is located adjacent to a road sags or localised topographic depressions, or where the street system carries major flows from a larger than normal subcatchment, higher floor levels may be required. This information can be derived from the TUFLOW flood mapping that has been undertaken for the catchment. The flood mapping results can be used to provide guidance for floor levels for new development in areas deemed to potentially be flood prone in the 100-year ARI event

In coastal areas of the catchment the floor levels will need to be in accordance with both Council's and the Coastal Protection Board requirements.

6.1.9 Barker Inlet Wetlands

The Barker Inlet Wetlands provide a significant volume of flood storage. Any major works proposed within the wetlands would need to be critically assessed to ensure that there is no increase in upstream flood risk within the North Arm East catchment.

6.1.10 On-site Retention

An option considered in the investigations for the SMP has been the potential to amend or update planning regulations to require a greater level of retention of stormwater in the design of new developments, as an additional management tool. The use of planning policy to improve stormwater management outcomes, complementary to engineering strategies, can provide benefits in some scenarios and at some scales.

The State Government has amended all Council Development Plans recently (2012), to incorporate the requirement for all new developments to incorporate Water Sensitive Urban Design (WSUD) elements wherever practical, including the re-use of stormwater on-site where the proposed design doesn't increase flooding risk. The implementation of WSUD techniques is now a standard part of the assessment of new developments, and has highlighted the potential water management opportunities available to developers (a report undertaken by the City of Port Adelaide Enfield that provides a detailed discussion in relation to the development and planning policy elements relevant to the NAE catchment is contained within Appendix F).

For new commercial or industrial properties, Council's current Development Plan requires stormwater detention or retention (harvesting) to be incorporated into the site design, where appropriate to the nature and practical use of the site.

The planning provisions also require that for any major land division stormwater is to be managed in such a way that the volume of stormwater coming from the site is no greater than the original (pre-development) volume. This has meant that the majority of larger 'greenfield' residential land divisions in the last decade have incorporated significant new neighbourhood scale public stormwater management strategies, including rain gardens, swale and infiltration areas, bio-filtration schemes, lakes, formation of creeks in reserves, wetlands, and in some cases, aquifer recharge (where the site conditions and space permit). These techniques often also serve to improve the quality of water entering the receiving waterways.

The City of Port Adelaide Enfield works closely with developers of large land divisions to identify and implement significant stormwater retention strategies at the neighbourhood and sub-catchment scale, and this will remain a core beneficial use of planning and development policy and practice to complement engineering solutions.

Several factors, however, constrain the capacity for individual, small scale, new residential developments to achieve a consistent level of retention that would result in quantifiable benefits to runoff rates and volumes. These constraints include:

- The SA Government's recent changes to urban planning policy (which have flowed through to Council Development Plans via the 2012 BDP amendments) now encourage (and in some areas mandate) a significantly higher level of medium and high density housing in the metropolitan area. This has resulted in greater 'infill' development occurring where two or more dwellings replace one original dwelling on the same land parcel (refer figure on page 5 of Appendix F). New developments of this type result in extensive coverage of the allotment's land, and therefore allows little space or opportunity for on-site stormwater detention.
    - This has been a significant development type in the North Arm East Catchment in the last decade. It is predicted that in the short term (5-10 years) as many as 1483 allotments could be subdivided to provide for an additional dwelling. In the long-term (50 years) as many as 5921 allotments (maximum development scenario) could be developed in a similar way (refer NAE Catchment Development Trends 2011 in Appendix F).
    - Infill development may exceed the predicted totals if the State Government pursues higher densities along identified transit corridors within the Catchment (e.g. Prospect Road, Main North Road and Hampstead Road), as envisaged in the 30 Year Plan for Greater Adelaide. However, this would require a change to the minimum allotment sizes currently specified within the Residential Zone's Residential East and Comprehensive Development policy areas. Additionally, these corridors are not priority corridors so it remains to be seen if they will be targeted for higher densities within the next 30 years.
    - The trend for larger houses on smaller blocks increases the level of stormwater generated from the site, but reduces the capacity of each site to incorporate any reliable element of on-site retention to accommodate that increased generation.
- There is a known risk that individual site retention schemes on private property may not be managed or maintained reliably into the longer term which could increase the risk of flooding if the site schemes were relied upon as part of the wider public system. Council's preferred approach wherever possible is to ensure the neighbourhood and catchment level public stormwater systems and infrastructure is able to accommodate a worst case scenario. Any smaller scale on-site retention or detention undertaken by individual developers will be a valuable additional buffer in a large event, but Council considers that the application of the planning provisions for single allotments should not be fully relied on to prevent flooding of the individual property, or more widely.
    - The existing provisions allow for developers to install underground tanks if the soil conditions and related circumstances allow, and if the cost is not prohibitive. The installation of a 1kL rainwater tank (plumbed to the house) is also now a mandatory requirement for all new residential developments. This has a minor

benefit to stormwater flows from the site (i.e. may slow down the initial 'first flush' in a rain event, if the tank is empty), but is mostly beneficial from the water conservation perspective in providing an alternative source of water. A system that is plumbed into the house places a greater demand on water from the tank (as opposed to a system purely used for irrigation) and will result in water levels in the tank being lower on average, providing greater storage to mitigate flows.

  - Additional research still needs to be undertaken to assess the effectiveness of rainwater tanks in reducing flood peaks using a system where water is drawn from the tank for in-house use. This research may show an improved effectiveness of tanks in flood management. However, it is likely that the 1kL minimum tank size would need to be increased to make a measureable impact during significant rainfall events.

- Given that these policies can only apply to new developments (not existing properties), there is limited stormwater management benefit to be gained at a catchment or sub-catchment level from the application of additional planning provisions to single site and 'infill' developments, over and above the existing WSUD and related requirements in the Development Plan.

The option to amend the planning provisions to mandate significant stormwater retention on individual residential sites may become a more valued option in the future as the catchment reaches its full development potential (based on the predictions), and all other options have been investigated and implemented. At this stage, it has not been included as a key recommendation in the NAE SMP, however an action is recommended to monitor the ongoing upstream development and creation of new impermeable areas so as to assess the value of implementing this option in the future.

6.1.11 Monitor the Impact of Infill Development

To better understand the potential impacts of infill development and to determine the most effective way of managing the potential risks, Council should continue to be committed towards monitoring the impact of infill development within the catchment. Council have already committed to the University of SA's study "Understanding the impact of infill on Stormwater Infrastructure Flood Management Capacity" and will consider implementing the report's recommendations once they are considered within the context of the NAE catchment.

6.1.12 Local Area Drainage

A number of areas throughout the catchment have limited underground drainage infrastructure. This typically results in large gutter flows and potential localised flooding issues where the gutter flows exceed the capacity of the road network. Infill development will exacerbate this problem. Additional drains extended into these areas would mitigate the flood risk caused by large gutter flows and reduce the reliance on existing inlet pits to manage large approach flow rates and therefore help to meet objective 1.3. Works at each site would typically involve the construction of 300-500m of relatively small diameter drainage pipes. The following areas have been identified as having a limited local drainage network:

- Maud Street and Livingstone Street, Prospect
- Park Street and Third Avenue, Prospect
- Manuel Avenue, Blair Athol.

6.1.13 Non-Structural Flood Mitigation Measures

Three key non-structural flood mitigation measures are considered appropriate for the NAE Catchment. These are outlined below.

Planning and Land Use Zoning

The City of Port Adelaide Enfield has good flood plain mapping information for the entire catchment. This information should be utilised in the planning of new developments to ensure that they are provided with adequate flood protection (Objective 1.1). This would include ensuring existing overland flood flow paths are retained and floor levels are set above the predicted level of the 100-yr ARI flood with appropriate freeboard (as outlined in Section 6.1.8).

Development controls such as on-site retention, site coverage limits or minimum block sizes may also be considered upstream of areas which currently experience flooding problems to limit the increase in flows generated by the higher density developments (Objective 1.4).

Education and Awareness

Detailed flood plain mapping of the catchment is available. To meet Objective 1.9, this information should be made widely available to the community so that they understand where flooding is likely to occur. Awareness of flood risk can allow them to better manage the risk and reduce flood damages. This awareness could be in the form of mail outs, making the maps publically available (e.g. online) and having information available at public places such as libraries and Council offices. Businesses and residents can be encouraged to develop flood action plans to reduce damages in the event of a flood and change the way in which valuable items are stored.

Flood Warning and Flood Forecasting

Whilst the response time for the catchment is relatively short, if the community is given some warning of the potential for a flood the magnitude of the social and economic damages can be reduced significantly. People and emergency services would have more time to sand bag flood prone areas and valuable portable property could be moved away from areas that may have otherwise suffered flood damages. The potential reduction in flood damages when more than 12 hours of warning is provided, as opposed to less than two hours, can range from 20% up to 50%, depending on the relative experience of the community in dealing with flooding (State Government of Victoria, 2000). Similar to education and awareness, these potential reductions are significant compared to the structural measures.

Given the relatively short response time for the catchment (typically 1-2 hours) the only opportunity to provide a significant warning time would be to issue a flood warning before the rainfall event reaches the catchment. The reliability of this information may result in complacency if the warnings are issued too frequently without actual flood events occurring.

6.2 Water Quality

A MUSIC model of the catchment was developed. The catchment was divided into 22 sub-catchments. The catchments were all approximately evenly sized and were based on changes in land use and the existing catchment boundaries.

Each catchment was divided into two sections. A relatively small section (typically 3%) has been modelled to be intercepted by tanks for reuse. The remainder of the catchment drains directly to the outlet node of the catchment.

The annual modelled pollutant loads are shown in Table 6.3.

Table 6.3: Modelled Annual Pollutant Loads – Current Catchment

Pollutant	Annual Load*	Load (kg/ha/yr)
Total Suspended Solids	550,000kg	230
Total Nitrogen	7,750kg	3.6
Total Phosphorus	1,100kg	0.51
Gross Pollutants	117,000kg	54

*Based on default parameters within the MUSIC software (CRC for Catchment Hydrology, 2005).

6.2.1 Gross Pollutant Traps Located at Strategic Locations

This option would involve the construction of proprietary GPTs along all major trunk drains throughout the catchment. This analysis indicated that approximately 17 sites would be required to treat the majority of the network. The strategic location for the position of GPTs is at the downstream end of a section of the catchment prior to them discharging into any major outfall drain or channel. Once flows have reached the main outfall drain or channels the flow rates and drain sizes are typically too large to be able to install a GPT.

The MUSIC model of the catchment was modified to include the installation of the GPTs such that the model was able to estimate the pollutant reduction levels. These results are shown in Table 6.4 and show that such a scheme would be relatively effective at reducing both gross pollutants (80% reduction) and suspended solids (65%).

Table 6.4: Pollutant Reduction based on widespread implementation of GPTs

Pollutant	Residual Pollutant Load (kg/yr)	Pollutant Reduction (%)
Total Suspended Solids	190,000	65
Total Phosphorus	862	22
Total Nitrogen	6,840	12
Gross Pollutants	23,900	80

While the reductions are relatively significant, the GPTs are only able to remove a small proportion of phosphorus and nitrogen. In addition, the wetlands have been reported as satisfactorily treating nutrient loads as discussed in Section 5.3.2 and therefore additional expenditure to further decrease nutrients is not a high priority within the catchment.

The existing sewer siphon at Wingfield acts as a large gross pollutant trap and captures large amounts of floating material within the upstream section of the siphon structure (refer Figure 4.2). Periodic maintenance of this build-up of material will ensure the channel's capacity is not impacted by this material or pushed further downstream during large flow events.

Cost estimates to implement this option are shown in Section 7.1.2.

6.2.2 Street Sweeping

An increase in the current level of street sweeping was considered as a possible method to reduce pollutant loads within stormwater runoff to improve water quality. Most studies, however show that current street sweeping practices in Australia are generally ineffective as an at source stormwater quality improvement measure. Street sweeper inefficiencies at reducing pollutants are due to the small size of many street sediments, frequency of rainfall, timing of sweeping practices with pollutant build up, unfavourable conditions, such as parked cars blocking the streets and windy conditions (T.A Walker and T.H.F Wong, 1999). The incremental improvement in water quality by increasing street sweeping frequencies beyond what is required for aesthetic purposes is likely to be low. Therefore, this option has not been considered further. However existing levels of street sweeping should be retained as it will help to reduce the amount of gross pollutants (>5mm) being mobilised and washed into the stormwater system.

6.2.3 State Sport Park Opportunities

There is the option to either construct a wetland within the State Sports Park or divert the water into a stormwater harvesting scheme proposed by the City of Salisbury to the north of the State Sports Park.

This will potentially either treat or divert runoff generated by approximately 10-13% (220-270ha) of the overall North Arm East catchment depending on how much of the catchment is diverted into the Sports Park. If the water is diverted out of the catchment (into the potential scheme operated by the City of Salisbury) it will reduce the loading on the existing Barker Inlet wetlands and assist in meeting Objective 2.4.

6.2.4 Enfield High School Opportunities

There is the option to divert base flows into the Enfield High School site where it could then be pumped into a stormwater harvesting scheme proposed by the City of Salisbury to the north of the State Sports Park.

This will divert runoff generated by approximately 7% (145ha) of the overall North Arm East catchment. Water diverted out of the catchment (into the potential scheme operated by the City of Salisbury) would reduce the loading on the existing Barker Inlet wetlands and assist in meeting Objective 2.4.

6.2.5 Pollutant Treatment Devices

In accordance with Council's Development Guide #18 pollutant treatment devices are required for new car parking areas exceeding six parking spaces or which exceed 250m^2 in area. The devices need to capable of removing oils, silts, greases and coarse sediments prior to discharge from the site. Water sensitive urban design elements such as bio-retention swales could potentially be substituted for a proprietary device. These measure will assist in meeting Objective 2.3.

6.2.6 Outfall Channel

The potential to replace the section of outfall channel between Way Street and Marmion Avenue and south of Cormack Road with a grassed earth lined channel has been identified elsewhere in this Plan. Vegetation within these sections of channel will filter the water and provide some sediment control. The section near Cormack Road is immediately upstream of the NAE portion of the Barker Inlet wetlands and would allow for some pre-treatment of water prior to discharge into the wetlands. There is also the potential to create localised ponds within the sections of earth lined channels. These ponds can create a section of habitat by incorporating aquatic plantings and would encourage infiltration and result in sediment (Objective 2.2) and nutrient removal.

Compared to the existing section of concrete lined open channel a section of earth lined channel will require additional maintenance to ensure that weed infestations are managed, any silt build up is removed and that planned vegetation is able to establish and is maintained. Responsibility for maintenance is likely to fall upon Council.

6.2.7 Sewer Siphon

As outlined in Section 4.5 the sewer siphon traps a large quantity of floating gross pollutants and also acts as an informal sediment trap. The viability of regular maintenance to remove the gross pollutants and sediment from the siphon is to be investigated. This has the potential to reduce the pollutant loading on the Barker Inlet Wetlands.

6.2.8 Acid Sulfate Soils (ASS)

An ASS hazard assessment should be conducted within the planning stages of any projects within the high risk areas identified in Section 2.6.1, in accordance with the strategies outlined in the Coastline Bulletin No 33 (2003), the Metropolitan Adelaide and Northern Coastal Action Plan (2009) and the South Australian Environmental Protection Authority (SA) 2007, Site Contamination – Acid Sulfate Soil Materials Guideline.

6.2.9 Impact on Receiving Environment

The Barker Inlet Wetlands contribute approximately 10% of the nitrogen and phosphorus load into the Port River and Barker Inlet system (EPA, 2008). Of this the North Arm East catchment contributes approximately 30% of the flow into the wetlands. Therefore, the NAE catchment produces approximately 3% of the load of nitrogen and phosphorus into the receiving waters.

Based on a 23% catchment yield (Wallbridge & Gilbert, 2009) the existing catchment is estimated to produce approximately 2,700ML/year of runoff. The future predicted long term impervious area is predicted to increase by 22% (based on analysis between the results shown in Figure 2.6 and Figure 2.7). This would indicate that future yields from the catchment will potentially increase to 3,300ML/year. However approximately 6% of the catchment's impervious area is proposed to be diverted and harvested (150ML/yr) into the State Sports Park (refer Section 6.3.1.1). In addition, up to 250ML/year will be harvested from domestic systems in the long term (refer Section 6.3.1.5) and 1,240ML/year is planned to be harvested from the Barker Inlet Wetlands (refer Section 6.3.1.4). Therefore, annual discharge from the outlet of the Barker Inlet Wetlands is predicted to drop from 2,700ML currently to 1,650ML in the long term based on the above assumptions. The actual volume of discharge into the wetlands will increase slightly from 2,700 to 2,900ML/year. This is unlikely to result in any significant reduction in the long term performance of the wetlands provided regular maintenance of the wetlands is undertaken as recommended within the Barker Inlet Management Plan (EMS, 2011).

Based on the above assessment it is likely that total nutrient loads in the receiving waters from the catchment are likely to reduce over time, particularly if the major harvesting scheme within the Barker Inlet Wetlands commences operation. This will meet the requirements of the Port Waterways Water Quality Improvement Plan.

6.2.10 North Arm East Wetland Functionality Improvement

The North Arm East wetland condition assessment report (DesignFlow, 2012) identified a number of measures to improve the functionality of the wetlands. The works, as outlined below, would assist in meeting Objective 2.5.

- Create carp exclusion bunds at strategic locations throughout the wetland to enable the ability to reduce carp numbers by isolating sections of the wetlands
- Planting the bunds with dense aquatic plants such that they will help to cleanse flows through filtration
- Increase the extents of aquatic plantings (it is acknowledged that this would be challenging due to the deep nature of the wetland and would require additional bunds or filling).

6.2.11 Water Quality Monitoring

Anecdotal evidence indicates that the NAE portion of the Barker Inlet Wetlands is not performing as well as the HEP section. The North Arm East wetland condition assessment report (DesignFlow, 2012) also indicated that there was high turbidity and limited water plants within the wetland. As a strategy to help support Objectives 2.1 through to 2.5 it is recommended that Council, in collaboration with the EPA and the AMLR NRM Board monitors the performance of the wetlands to ensure that the overall water quality design objectives are being achieved, to assess how they are performing over time and to ensure that the wetlands are not being impacted by upstream activities. Monitoring of the wetlands was a recommendations contained within the “Barker Inlet, Magazine Creek and Range Wetlands, Management and Maintenance Plans, Spill Contingency Plans, Existing Vegetation Condition and Supplementary Planting” (EMS, 2011). If the monitoring results indicate that the wetlands are not performing as well as expected it may trigger additional investigation work to determine how its performance can be improved, such as the works recommended in the 2012 DesignFlow report.

Monitoring should also be established to monitor the quantities of flow, gross pollutants and sediment entering the wetland to assess the effectiveness of upstream management measures and the impact of additional infill development and changes in land use.

The results from the monitoring would allow calibration of the MUSIC model of the catchment. The model could then be modified to assess changes in pollutant loadings based on different strategies within the catchment and also to assess how proposed improvements to the wetland could improve water quality.

6.2.12 North Arm East Wetland Future Management

The North Arm East Wetlands are not exclusively the responsibility of Council and are the responsibility of a number of agencies. It is therefore recommended to undertake an inter-agency review of the management and monitoring arrangements for the entire Barker Inlet wetlands, so as to establish clear management roles, responsibilities, resourcing, partnering and governance arrangements into the future.

6.2.13 Water Sensitive Urban Design

Council can opportunistically identify water sensitive urban design elements that could be incorporated into other projects that are undertaken within the catchment. This could include projects such as:

- Providing rain gardens as part of road reconstruction projects
- Directing stormwater runoff into reserve areas as part of open space upgrades to allow for passive irrigation and water quality improvement

- Retrofitting tanks for on-site reuse within Council owned properties to reduce mains demand and minimise clean roof runoff mixing with dirty water from other areas
- Incorporating gross pollutant traps into underground drainage upgrades

6.3 Water Use

Runoff from the catchment will form a large part of the runoff volume that is proposed to be harvested from the Barker Inlet wetlands as part of a recent large scale water harvesting scheme proposed for the wetlands. However, there are a number of other opportunities within the catchment. The main focus of harvesting would be centred on the opportunities associated with the proposed basin within the State Sports Park.

6.3.1.1 State Sports Park

A well designed wetland that is able to provide an average of three days residence time is generally considered large enough to provide adequate water quality improvement as part of an ASR scheme. The approximate size of wetland required for the various options are outlined in Table 6.5.

Table 6.5: Wetland Sizing

Option	Impervious Catchment Area (ha)	Retention Volume Required (m^3)	Area required (average depth 0.4m) (m^2)
1 & 2	55	3,500	9,000
3	80	5,000	12,500

The wetland can be accommodated within the south-western basin, provided the wetland does not result in any significant reduction to the amount of detention storage available. Due the slope of the land the wetland is likely to be in the form of a series of stepped basins at different levels.

Harvestable Yield

A well designed and appropriately sized wetland has the potential to harvest approximately 40-50% of the catchment yield. Table 6.6 provides an indication of the estimated harvestable yield based on the various options discussed above. Additional work would be required to confirm the viability of ASR on the site. All options would result in harvesting more water than would be required by the State Sports Park. Therefore, additional customers for ASR water should be investigated further.

Table 6.6: Harvestable Yields

Option	Harvestable Yield (ML/year)	Irrigation Potential
1 & 2	80-120	20 hectares
3	120-180	30 hectares

Pumped Water Harvesting Option

An alternative to the construction of a wetland within the State Sports Park would be to temporarily retain water and then pump it (at a rate of approximately 30L/s) into a wetland based water harvesting scheme proposed by the City of Salisbury directly to the north of the State Sports Park. This option would reduce the upfront capital cost and reduce the amount of ongoing maintenance that would be required (compared to a wetland and ASR scheme). It also has the potential to increase the overall volume of water harvested by approximately 50% compared to the values shown in Table 6.6 as any inflows could be harvested immediately (rather than waiting for water quality to improve as it passes through the wetland) and the pump rate could potentially be higher than the rate that the underground aquifers are able to accept recharge.

The increase in discharge rate from the south west basin would only allow a marginal reduction in the size (~5%) of the detention storage that would be required. Commercial aspects associated with the costs of transfer, treatment, storage and supply require further discussion with the relevant parties.

This option is shown as Figure 5 within Appendix B and would assist in meeting Objective 3.2

6.3.1.2 Enfield High School

A permanent water body could be incorporated into a portion of the Enfield High School basin (as outlined in Section 6.1.7). This would then allow for base flows from the Grand Junction Road trunk drain to be diverted into the site. To ensure that the majority of the site can still be useable open space, only a portion of the basin should be used as a dedicated permanent water body. An extended detention depth of up to 0.3m could be used to capture stormwater without significantly impacting on the aesthetics and integrity of the banks.

Given the size of the upstream catchment (145ha) it is likely that it would not be viable to construct a standalone water treatment and harvesting scheme at the site. However, the water could still be diverted into the City of Salisbury harvesting scheme as outlined in the above section as an option for harvesting water from the State Sports Park. This would require a rising main approximately 2.6km long. The majority of this length would be through the State Sports Park. Harvesting water from the site would help to meet Objective 3.2.

If a permanent water body was to take up approximately one quarter of the base of the basin (as it would not be considered useable open space) there would be approximately 1,500kL of storage within the top 0.3m of the permanent water body that could be used to temporarily capture and harvest stormwater. This is sufficient to capture up to 3-4mm of runoff on the catchment. To maximise the amount of water captured it will be necessary to harvest the full volume (1,500kL) within a few hours such that the extended detention depth can be turned over a few times per day during periods of moderate rainfall (~10mm/day or above). This would then potentially allow up to 10-15mm or so of rainfall to be captured each day, which is equivalent to approximately 80% of the annual runoff or 120ML/year. To achieve this objective, the pumped extraction rate (to the City of Salisbury scheme) would need to be in the order of 100L/s as this would enable transfer of 1,500kL of water in about 4 hours.

The permanent water body is incorporated into the concept plan for the basin which is shown in Figures 10 and 11 within Appendix B.

6.3.1.3 Enfield Cemetery

There is an opportunity to harvest water from the basin that would be formed by the construction of the embankment within the valley within the Enfield Cemetery. Consultation with the Adelaide Cemeteries Authority has indicated that they are interested in the opportunity to harvest water from the basin. ASR has been ruled out based on a report by Australian Groundwater Technologies. However, direct harvesting from an irrigation lake at the base on the basin could be possible. The volume that could be harvested would be relatively small as the majority of the basin would be required for flood storage (as opposed to retention) and the main irrigation demand in summer would not coincide with the main inflows into the basin during winter.

6.3.1.4 NAE Portion of the Barker Inlet Wetlands

The Urban Stormwater Harvesting Options Study (Wallbridge & Gilbert, 2009) provided an overview of harvesting opportunities from the Barker Inlet Wetlands. Their report indicated that approximately 1,240ML/year of water could be treated from the NAE catchment based on 19 injection wells operating at 13-15L/s each. The existence of native vegetation was flagged as a possible restriction to what would be possible on the site.

6.3.1.5 On-site Reuse

As outlined in Section 6.1.10, all new dwellings and some extensions and alterations will typically require a rainwater tank to be plumbed into the house to reduce mains water demand. While there are diminishing returns for installing larger tanks in terms of the annual volume of water harvested, they would have the potential to provide some benefit in flood mitigation. Council could pursue the option of supporting or requiring tanks larger than the legislated minimum to assist in both reduced mains demand (Objective 3.1) and improved flood mitigation.

A typical tank with 150m^2 of connected roof area plumbed into the laundry, hot water, toilet and outdoor areas is likely to reduce mains water demand in the range of 20-50kL/year. Based on 4,000 to 7,000 new houses in the catchment in the next 50 years or so (refer Section 2.8) this is likely to reduce mains demand by up to 250ML/year.

6.4 Environmental Protection and Enhancement

6.4.1 Utilisation of Open Space

The establishment of wetland or detention systems provide an opportunity to increase biodiversity, improved amenity, education and recreation facilities as well as provision of habitat for fauna. These opportunities should be considered when implementing the wetlands and basins identified within this report.

The strategic use of open space for stormwater management has the potential to secure the long-term use of an area as useable open space. This is particularly relevant to opportunities within the Enfield High School and the Canine Association site as both these sites have the potential to become fully developed in the future. The replacement of the section of concrete outfall channel between Way Street and Marmion Avenue also has the potential to create additional usable open space within the catchment.

6.5 Asset Management

6.5.1 Assess Condition of Existing Infrastructure

Detailed site inspections involving CCTV and physical inspection by structural engineers will enable an estimation of the residual design life for various section of the drainage system to be made (Objective 5.1). Priority should be given to inspecting drains that have at least two or three of the characteristics described in Table 6.7.

Table 6.7: CCTV Inspection Priority

Drain Characteristic	Discussion
Large drain size (larger than 750mm diameter)	Large drains comprise the highest value component of Council's drainage assets and the unplanned replacement of a section of large drain would have a large impact on Council's financial resources.
Old drain (more than 30 years old)	The older the drain the more likely that it will be nearing the end of its design life.
Prominent location	Some drains are located in prominent locations such as the centre of a commercial area or within an arterial road. Should these drains fail it would result in major traffic disruptions (if the area was no longer trafficable) and the potential for flood damages is highest.
Box culvert	Historically, box culverts have failed well before their expected design life which increases the need to understand their current condition.

Based on the outcomes of these investigations, future works can be prioritised to ensure that the drainage system is replaced prior to the end of its design life (Objective 5.2). If replacement works are deemed necessary, a hydrological and hydraulic assessment of the system should be made to determine if the replacement system should be enlarged to meet the drainage standard objectives outlined within Section 5.3.1.

Money should be set aside to initially prioritise which drains should be inspected and then recurring funding should be made available to undertake CCTV inspections of the drainage assets.

6.5.2 Develop an Asset Maintenance Plan

A number of recommendations of this plan include infrastructure that will require regular maintenance to ensure that it will continue to function as intended. It is recommended to develop a maintenance plan (Objective 5.3) to cover the long term management of the Council's drainage assets, particularly the assets that have a relatively high maintenance frequency. It would need to include the following key areas:

- The location and description of the asset
- The likely frequency (or event trigger such as a heavy rainfall event) that maintenance will be required
- The type of maintenance that will be required (e.g. removal of silt, weeding, etc.)

Council will also need to allow for adequate resourcing and budgets to maintain the additional infrastructure that may be constructed as part of the implementation of the recommendations of this SMP.

7 Costs and Funding Opportunities

7.1 Costings

This section provides a summary of the costs required to implement a number of the strategies that have been outlined within Section 6 of the report. A more detailed breakdown of costs is provided in Appendix A. The detailed breakdowns identify the time that the estimates were made, which range between 2010 and 2014. Some of the rates, particularly those used for the older estimates, are now likely to be higher due to inflation. While this would increase the cost estimates, it is not considered to be by a significant amount and would not impact on the economic assessment, as outlined in Section 8.4.

7.1.1 State Sports Park

The costings for the diversion of water into the State Sports Park have included the following:

- Diversion pipes between Grand Junction Road and the State Sports Park
- Increase in the embankment height to the Foresters Forest basin embankment
- Increase in the embankment height to the south-western basin embankment to 14.5mAHD (all options)
- A wetland within the base of the south west basin
- A new diversion pipe between Park Terrace and Grand Junction Road (Option 3 only)
- An ASR scheme (pumps, bores, controls etc.)
- Engineering design and survey

Based on the above the cost of each option is shown in Table 7.1. These costs are indicative only. Further design development is required to provide greater confidence with these estimates.

The cost for the wetland component has been separated from the works required for flood mitigation. The wetland component makes up a considerable component of the total cost. It is considered to be an optional extra provided the viability of an ASR scheme can be confirmed. The wetland component could also be constructed after the completion of the flood mitigation component.

The wetland and ASR component could be replaced by construction a retention basin, pump station and rising main with the water directed into the system controlled by the City of Salisbury for a cost of approximately $0.7m, as discussed in Section 6.3.1.1.

Table 7.1: Construction Cost Estimates

Option	Flood mitigation component	Wetland and ASR component*
Partial Diversion (Option 1)	$0.85m	$1.05m
Full Diversion at Amber Avenue, low discharge rate (Option 2)	$1.25m	$1.05m
Full Diversion at Park Terrace and Amber Avenue, low discharge rate (Option 3)	$2.8m	$1.3m
Full Diversion at Amber Avenue, higher discharge rate (Option 2b)	$1.35	$1.05

*$0.7m if pumped to the City of Salisbury

The costings assume that the material for the embankment can be sourced from the site. They do not allow for any infrastructure required to deliver the water between the wetland and any customers.

Due to the potential for multiple benefits derived from the diversion of stormwater into the State Sports Park and the size of the contribution catchment, the project is likely to be eligible for Stormwater Management Authority funding.

7.1.2 Gross Pollutant Traps at Strategic Locations throughout the Catchment

Costing information for the GPTs have been derived from Appendix H of the MUSIC software manual (version 3). It has been imperially derived based on the catchment area being treated by each GPT.

An estimate of pollutant loadings removed from each GPT has been estimated based on a loading rate of 0.16m^3/ha/year. This has been used to derive the annual maintenance cost.

Table 7.2: Construction Cost Estimates for GPTs

Item	Cost
Supply and install GPTs at 17 sites throughout the catchment	$4.0-$4.5 million
Annual maintenance	$80,000/year

7.1.3 Marmion Avenue Diversion Drain

The cost of this project is essentially related to the cost of laying new pipes down Marmion Avenue and some costs associated with connection to existing systems. The cost estimate makes an allowance of $240,000 for service relocation costs and would need to be refined as part of further design development. There is the potential for a large variance in the cost to alter services depending on the type of services that will require alteration.

Table 7.3: Construction Cost Estimates for GPTs

Item	Cost
Main drain and pits	$2.45 million
Miscellaneous	$0.60 million
TOTAL	**$3.05 million**

7.1.4 Enfield Cemetery Diversion and Detention Basin

The two main cost components relating to the construction of this element are the diversion pipe and the construction of the embankment. No allowance has been made for land acquisition.

A summary of construction costs is provided in Table 7.4.

Table 7.4: Construction Cost Estimates for Enfield Cemetery Diversion and Detention Basin

Item	Cost
Diversion drain	$1,080,000
Basin embankment	$360,000
Miscellaneous	$560,000
TOTAL	**$2,000,000**

7.1.5 Canine Association Detention Basin

The Canine Association basin does not require significant excavation and the material on the site is unlikely to be contaminated based on previous land uses. However, the land is under private ownership (Canine Association) and at this stage the owners are not willing to facilitate the option of utilising a portion of their site for stormwater management purposes. If required in the future, implementation of this option will require the agreement of the landowner. Construction costs were estimated as part of the pre-consultation process, and are provided in Table 7.5 for information only.

Table 7.5: Construction Cost Estimates for Canine Association Detention Basin

Item	Cost
Diversion pipe between channel and basin	$760,000
Land acquisition	Not included
Basin excavation	$1,600,000
Miscellaneous	$940,000
TOTAL	**$3,300,000**

7.1.6 Depot Dam Detention Basin

The major expense associated with constructing a basin at the depot dam site is due to the high cost of disposing of the material which is likely to be contaminated, as the site has historically been used as a landfill. The costs are exacerbated due to the large amount of overburden that would need to be removed. The costings have been based on a $170/m^3 rate to remove the contaminated material. Extensive sampling would be required to confirm if all of the material is contaminated.

Table 7.6: Construction Cost Estimates for Depot Site Detention Basin

Item	Cost
Basin excavation	$13,700,000
Miscellaneous	$900,000
TOTAL	**$14,600,000**

7.1.7 Enfield High School Detention Basin

7.1.7.1 Surface Water Interception Option

The Enfield High School basin does not require significant excavation and the material on the site is unlikely to be contaminated based on previous land uses. A portion of the excavated material may also be suitable to use for the construction of the embankment. To ensure the aesthetics of the area a relatively large amount will need to be spent on landscaping the area.

Table 7.7: Construction Cost Estimates for Enfield High School Detention Basin

Item	Cost
Land acquisition	Not included
Basin excavation, diversion channel and embankment	$350,000
Landscaping	$400,000
Miscellaneous	$150,000
TOTAL	**$900,000**

7.1.7.2 Surface and Piped Water Interception Option

This basin has much more significant excavation that the above option and also includes the incorporation of a permanent water body within the basin and for a pump and rising main to transfer the water into the City of Salisbury harvesting scheme north of the State Sports Park.

Table 7.8: Construction Cost Estimates for Enfield High School Detention Basin

Item	Cost
Land acquisition	Not included
Basin excavation, diversion channel and embankment	$970,000
Permanent water basin	$320,000
Pump station and rising main	$900,000
Landscaping	$420,000
Miscellaneous	$420,000
TOTAL	**$3,000,000**

7.1.8 Outfall Channel Upgrades

The costs associated with the upgrade to the outfall channel have been split into a number of stages as set out below. The downstream sections are significantly more expensive than the upstream sections as the costing has been based on a full demolition and widening of the channel as opposed to just a partial widening of the upstream sections with the retention of as much of the existing channel as possible. The costs have been broken down further into the cost for a like for like replacement of the channel and the incremental increase in cost to upgrade the channel. As there is no requirement to replace the existing channel upstream of Grand Junction Road (as it is in reasonable condition) the replacement costs for these sections is not included.

Table 7.9: Construction Cost Estimates for Outfall Channel Upgrades

Channel Section	Item	Replace exist ($ million)	Extra Upgrade Cost ($ million)	Total Cost ($ million)
Start of channel to d/s of Northcote Street	Widening existing channel	n/a	1.36	1.36
	Culvert road crossings - Jersey Avenue to Northcote Street (5.5 m wide x 1.8 m high)	n/a	1.72	1.72
D/s Northcote Street to d/s of Grand Junction Road	Widening existing channel	n/a	3.12	3.12
	Culvert road crossings - Brunswick Street to Grand Junction Road (3 x 3 m wide x 1.5 m high)	n/a	2.50	2.50
D/s Grand Junction Road to d/s of Railway reserve	Total channel demolition and widening	5.58	1.23	6.81
	Culvert road crossings - Cavan Road to Railway crossing (5 x 3 m wide x 1.45 m high)	2.45	0.61	3.06
D/s Railway reserve to end of channel	Total channel demolition and widening	5.76	1.63	7.39
	Culvert road crossings - Cormack Road to Railway crossing (5 x 3 m wide x 1.45 m high)	1.78	0.44	2.22
All sections	Miscellaneous works	1.02	1.02	1.02
	TOTAL	**16.6**	**12.6**	**29.2**

The cost to construct a 900m long section of earth lined channel between Way Street and Marmion Avenue (as described in Section 6.1.5) is likely to double the cost of culverts (an additional $1.7 million), while saving about $1.1 million on channel construction works (as a landscaped earth lined channel will be cheaper than an extended concrete channel). However, the required land value is potentially close to $9.2 million. Therefore, the estimated cost to earth line the channel between Way Street and Marmion Avenue is $13.8 million or $9.8 million more than the $3.9 million cost for the concrete option outlined in Table 7.9 that requires no land acquisition. Based on the above costings the work to earth line a section of channel could not viably be done in isolation and would need to be incorporated into a broader revitalisation of the surrounding area. Annual maintenance is estimated to be $20,000 a year (eWater, 2009).

7.1.9 Local Area Drainage

The costs of the local area drainage items outlined in Section 6.1.12 are relatively minor and are likely to range between $150,000 and $300,000. Refinement of cost estimates would be possible upon further design development at each site with a large variable being service relocation costs.

7.1.10 Wetland Monitoring

The costs to undertake a yearlong monitoring program to determine the current water quality improvement performance of the NAE portion of the Barker Inlet Wetlands based on a series of grab samples and field measurements would cost in the order of $20,000.

7.1.11 Wetland Functionality Improvement

The construction of additional carp bunds and an increase in the amount of shallow aquatic plantings is estimated to cost in the order of $250,000.

7.1.12 Education and Awareness

A program to educate the community about flood risk through mail outs, webpages and local media, such as the Messenger newspaper, is estimated to cost $10,000 as a one off expense.

7.1.13 Asset Condition Assessment

A budget of $20,000 per year would allow for periodic CCTV inspection of key drainage assets within the catchment that would allow for a good ongoing understanding of the condition of the underground drainage assets.

7.1.14 Asset Maintenance

An ongoing budget allowance of $300,000 per year should be set aside for the maintenance of drainage assets within the catchment, which includes pipe cleaning and the relatively expensive maintenance associated with proposed water sensitive urban design elements (such as wetlands).

7.1.15 Sewer Siphon Trash Removal Study

A $10,000 budget would cover a feasibility study to see how easy it would be for the regular removal of gross pollutants that are trapped behind the sewer siphon.

7.1.16 Water Sensitive Urban Design

Council has currently committed $100,000 per year council wide to undertake WSUD measures, as part of larger projects. This amount is proposed to increase in Council's 10 year Capital Works Program to $150,000 in 2020/21 financial year and to $200,000 in the 2023/24 financial year. Approximately 20% of this budget has been allocated to the NAE catchment.

7.2 Funding Opportunities

7.2.1 Stormwater Management Authority (SMA)

The main stormwater related funding opportunity is with the Stormwater Management Authority (SMA). They typically prioritise funding towards schemes that provide a wide range of benefits including water quality and re use. Given their relatively large scale the majority of the project outlined above would be eligible for SMA funding. The project that may be deemed the most likely to obtain funding is the State Sports Park project, particularly if the elements relating to water harvesting and water quality improvement are incorporated into the design.

8 Modelling Results and Assessment

Floodplain mapping of the North Arm East (NAE) catchment was undertaken using TUFLOW software in 2006 (Tonkin Consulting, 2006). To determine the effectiveness of the various management options outlined above a number of scenarios have been modelled by modifying the original TUFLOW model and comparing the results with the existing floodplain maps. A qualitative assessment has been made (by visual inspection of the maps) as well as a quantitative assessment by determining the reduction in the number of flood prone properties. This has subsequently allowed input to be made in formulating ratings for each option as part of the optimised decision making process as outlined in Table 8.11.

Seven different elements have been modelled in various combinations. The various elements are:

- Element A: Enfield Cemetery Diversion Drain
- Element B: State Sports Park Diversion
- Element C: Marmion Avenue Diversion Drain
- Element D: Canine Association Detention Basin (consultation has indicated that at this stage this element will not proceed, however modelling results are still discussed below)
- Element E: Outfall Channel Widening.
- Element F1: Enfield High School Detention Basin (diversion of surface flows only)
- Element F2 Enfield High School Detention Basin (diversion of surface and pipes flows)

Some minor changes have also been made to the existing scenario. The scenarios that have been selected for modelling are described below. The number of scenarios has been rationalised to only consider logical combinations of elements.

8.1 Modelled Scenarios

8.1.1 Existing Conditions

The existing condition was modelled using the long-term development runoff coefficient and the 100-year ARI rainfall event. The output varies from the mapping produced for the NAE flood mapping study (Tonkin Consulting, 2006) as it includes refinements based on more recent information and advances in software modelling techniques. The recent review of future development levels (Port Adelaide Enfield Council, 2011) has indicated that the original long-term development assessment work was potentially on the conservative side. However, no changes have been made to the existing model scenario as the increased application of WSUD is likely to partly mitigate the increase in runoff from future development.

The existing condition forms the basis for comparison with the various scenarios described below.

8.1.2 Scenario 1: Enfield Cemetery Diversion Drain (Element A)

This option involves the construction of an interception drain from the intersection of Hampstead Road and Folland Avenue. The new 825mm diameter drain passes down Milton Avenue and through the Enfield Cemetery. It increased to a 900mm diameter drain part way through the cemetery where a lateral drain joins into the system from the south. A new embankment, to a height of 42.0mAHD was modelled within the natural valley along the western boundary of the cemetery. The outfall from the basin was modelled as 450mm diameter pipe which results in a significant reduction in the peak flow downstream of the basin.

8.1.3 Scenario 2: State Sports Park Diversion (Element B)

This is Option 2b (refer Table 6.1) and involves the redirection of flows into the State Sports Park from Grand Junction Road at Amber Terrace via a 1200mm diameter pipe. The height of the Foresters Forest basin embankment has been increased to 17.8mAHD to manage the increase in flow volumes. The south western basin has been increased in height to 14.5mAHD, as per the original design intent of the basin. Water leaves the downstream basin via a new 450mm diameter outfall and via a pump (at 40L/s) into the proposed Salisbury water harvesting scheme to the north of the State Sports Park.

8.1.4 Scenario 3: Enfield Cemetery Diversion and State Sports Park Diversion (Elements A and B)

This option is a combination of Scenarios 1 and 2 shown above.

8.1.5 Scenario 4: Enfield Cemetery Diversion, State Sports Park Diversion and Marmion Avenue Drain Elements (Elements A, B and C)

This option is the same as Scenario 3 but also includes the construction of the Marmion Avenue drain (Element C). The drain will intercept the majority of flows within Main North Road at Marmion Avenue. The scenario involves the construction of a new 1200mm diameter pipe between Main North Road and Florence Avenue and two 1200mm diameter pipes between Florence Avenue and the main outfall channel.

8.1.6 Scenario 5: Enfield Cemetery Diversion, State Sports Park Diversion, Marmion Avenue Drain and Canine Association Basin Element (Elements A through to D)

This scenario is the same as Scenario 4 but also includes the construction of a detention basin within the Canine Association land (Element D). The basin is 3 hectares in size and includes a 3.0m wide by 1.2m high interconnection culvert with the main outfall channel at Solent Avenue. A 375mm pipe will drain the basin and links between the culvert and the outfall channel at Cromwell Road. A bund has been placed around the perimeter of the site up to a level of 5.8mAHD.

8.1.7 Scenario 6: Channel Widening and Box Culvert Enlargements (Element E)

This scenario is as per the original model but includes increases in the size of the outfall channel and culvert crossings (Element E). The channel has been upgraded in four distinct zones as shown in Table 8.1. All sections are concrete lined.

Table 8.1: Channel Upgrade Summary

Location	Channel Size	Culvert Size
Start of channel to downstream of Northcote Street	4m wide base width, 1.4m deep, 1 in 1 side slopes	5.5m wide by 1.8m high box culverts
Downstream of Northcote Street to downstream of Grand Junction Road	9m wide base width, 1.4m deep, 1 in 1 side slopes	3 x 3.0m wide by 1.5m high box culverts
Downstream of Grand Junction Road to downstream of Railway Reserve	13m wide base width, 1.4m deep, 1 in 1 side slopes	5 x 3.0m wide by 1.45m high box culverts
Downstream of Railway Reserve to end of channel	18m wide base width, 1.4m deep, 1 in 1 side slopes	4 x 5.0m wide by 1.3m high box culverts

8.1.8 Scenario 7: Enfield Cemetery Diversion, State Sports Park Diversion, Marmion Avenue Drain and Channel Widening and Box Culvert Enlargements (Elements A, B, C and E).

This scenario is the same as Scenario 4 but also includes the channel and culvert upgrades (Element E) as detailed in Scenario 6.

8.1.9 Scenario 8A: Enfield High School Detention Basin (Element F1)

This option involves the construction of a detention basin within the former Enfield High School site to intercept surface flood waters that currently spill through the site from areas to the east of the site. The basin has a small outlet that connects into the existing Council drain in Devon Street.

8.1.10 Scenario: 8B: Enfield High School Detention Basin and State Sports Park Diversion (Elements F1 and B)

This is the same as Scenario 8A but also includes the diversion of water into the State Sports Park (Element B).

8.1.11 Scenario 8C: Enfield High School Detention Basin (Element F2)

This option is the same as Scenario 8A but also includes the interception of pipe flow from the Grand Junction trunk drain (as well as surface flood waters that currently spill through the site). However base flows (up to the 1 in 3 month flow) within the Grand Junction Road trunk drain are diverted to by-pass the basin (other than potential flows diverted for harvesting purposes).

8.1.12 Scenario 9: Enfield High School Detention Basin and Enfield Cemetery Diversion Drain (Elements A and F2)

This is the same as Scenario 8C but also includes the Enfield Cemetery Diversion Drain (Element A).

8.1.13 Scenario 10: Enfield High School Detention Basin, Enfield Cemetery Diversion Drain and Marmion Avenue Drain (Elements A, C and F2)

This scenario is the same as Scenario 9 but also includes the Marmion Avenue diversion drain (Element C).

8.1.14 Scenario 11: Marmion Avenue Diversion Drain

This scenario involves the construction of the Marmion Avenue diversion drain (Element C) between Main North Road and the main outfall channel.

8.2 Model Results

The results for each scenario have been compared to the existing results. Both a qualitative (descriptive) and quantitative (mm reduction in flood level compared to the existing situation) description of the flooding has been provided. A further quantitative description of the reduction in flood risk has been made in Section 8.2.15 by comparing the number of blocks that are considered to be flood prone. Flood damages have also been assessed along with an economic assessment of a number of scenarios. The methodology used for the calculation of flood damages is described in Section 8.3. The output from the 10 scenarios is shown in Appendix C. Each map indicates which scenario is shown. The various elements that are incorporated into each scenario is described in Section 8.1. All results are for the long term development scenario as discussed in Section 2.8.

8.2.1 Scenario 1: Enfield Cemetery Diversion Drain

This scenario resulted in the following improvements in flood risk:

- Minor reduction in flooding in the vicinity of the main outfall channel between Northcote Street and Marmion Avenue (~100mm reduction)
- Minor reduction in flooding west of Main North Road between Stanley Avenue and Grand Junction Road (up to 100mm reduction)
- Minor to moderate reduction in flooding along Gove Road, Essex Street and Darlington Street, Enfield (100-200mm reduction)
- Marginal reduction in flooding north of Grand Junction Road (0-50mm reduction)
- Marginal reduction in flooding in the vicinity of Baker Street, Enfield (0-50mm reduction)

8.2.2 Scenario 2: State Sports Park Diversion

This scenario resulted in the following improvements in flood risk:

- Minor reduction in flooding in the vicinity of Baker Street, Enfield (50-100mm reduction)
- Minor reduction in flood risk in the vicinity of Grand Junction Road and Rosedale Avenue, Blair Athol (~50mm reduction)
- Marginal reduction in flooding north of Grand Junction Road (slight improvement compared to Scenario 1) (0-50mm reduction)

8.2.3 Scenario 3: Enfield Cemetery Diversion and State Sports Park Diversion

In addition to benefits derives from the above two scenarios the combination of both options provides the following additional improvements

- Minor to moderate reduction in flooding in the vicinity of Baker Street, Enfield (100-200mm reduction)
- Minor reduction in flooding north of Grand Junction Road (~50mm reduction)

8.2.4 Scenario 4: Enfield Cemetery Diversion, State Sports Park Diversion and Marmion Avenue Drain

In addition to the improvements derived from Scenario 3 the construction of the Marmion Avenue Drain provides the following benefits:

- Moderate reduction in flood risk in the vicinity of Baker Street, Enfield (~250mm reduction)
- Minor to moderate reduction in flood risk in the vicinity of Grand Junction Road and Rosedale Avenue, Blair Athol (~100mm reduction)
- Minor reduction in flooding north of Grand Junction Road (50-100mm reduction). Large reduction in the extent of shallow flooding west of Port Wakefield Road.

As the drain discharges additional flow into the outfall channel there is a minor increase in flood risk (typically 30-50mm) in the vicinity of Nelson Street and Solent Avenue, Blair Athol.

8.2.5 Scenario 5: Enfield Cemetery Diversion, State Sports Park Diversion, Marmion Avenue Drain and Canine Association Basin

In addition to the improvements derived from Scenario 4 the construction of a detention basin within the Canine Association land provides the following benefits:

- Moderate reduction in flooding in the vicinity of the main outfall channel between Northcote Street and Marmion Avenue (~200mm reduction)
- Minor reduction in flooding north of Grand Junction Road (~100mm reduction). Large reduction in the extent of shallow flooding west of Port Wakefield Road.
- A reduction of approximately 4m^3/s (15%) in the peak flows within the outfall channel downstream of the basin

8.2.6 Scenario 6: Channel Widening and Box Culvert Enlargements

This scenario resulted in the following improvements in flood risk:

- Moderate reduction in flooding in the vicinity of the main outfall channel between Le Hunte Street and Marmion Avenue (~200mm reduction).
- Minor reduction in flooding north of Grand Junction Road, between the northward projection of Churchill and Prospect Roads (~100mm reduction). Large reduction in the extent of shallow flooding.

8.2.7 Scenario 7: Enfield Cemetery Diversion, State Sports Park Diversion, Marmion Avenue Drain, Channel Widening and Box Culvert Enlargements

In addition to the improvements derived from Scenario 4 the enlargement of the outfall channel provides the following benefits:

- Moderate reduction in flooding in the vicinity of the main outfall channel between Le Hunte Street and Marmion Avenue (~250mm reduction) (slight improvement on Scenario 6)

- An increase in the reduction in flooding north of Grand Junction Road, between the northward projection of Churchill and Prospect Roads (~100-150mm reduction). Large reduction in the extent of shallow flooding.
- Moderate to significant reduction in flood risk upstream of Cavan Road directly north of the outfall channel (~400mm reduction).

8.2.8 Scenario 8A: Enfield High School Detention Basin Surface Interception Only

This scenario resulted in the following improvements in flood risk:

- Minor reduction in flooding in the vicinity of Baker Street, Enfield (~100mm reduction)
- Minor reduction in flood risk in the vicinity of Grand Junction Road and Rosedale Avenue, Blair Athol (~50mm reduction)
- Marginal reduction in flooding north of Grand Junction Road (0-50mm reduction)

8.2.9 Scenario 8B: Enfield High School Detention Basin and State Sports Park Diversion

This scenario resulted in the following improvements in flood risk:

- Minor reduction in flooding in the vicinity of Baker Street, Enfield (~100mm reduction)
- Minor reduction in flood risk in the vicinity of Grand Junction Road and Rosedale Avenue, Blair Athol (~50mm reduction)
- Marginal reduction in flooding north of Grand Junction Road (0-50mm reduction)

8.2.10 Scenario 8C: Enfield High School Detention Basin Pipe and Surface Flow Interception

This scenario resulted in the following improvements in flood risk:

- Moderate reduction in flooding in the vicinity of Baker Street, Enfield (~150-200mm reduction)
- Minor reduction in flood risk in the vicinity of Grand Junction Road and Rosedale Avenue, Blair Athol (~50-100mm reduction)
- Minor reduction in flooding north of Grand Junction Road (100mm reduction)

8.2.11 Scenario 9: Enfield High School Detention Basin and Enfield Cemetery Diversion

In addition to the benefits derived from Scenario 8C the diversion of water into the Enfield Cemetery provides the following benefits:

- Moderate to significant reduction in flooding in the vicinity of Baker Street, Enfield (~300mm reduction)
- Minor reduction in flood risk in the vicinity of Grand Junction Road and Rosedale Avenue, Blair Athol (~100-150mm reduction)
- Minor reduction in flooding north of Grand Junction Road (100-150mm reduction)

8.2.12 Scenario 10: Enfield High School Detention Basin, Enfield Cemetery Diversion Drain and Marmion Avenue Drain

In addition to the benefits derived from Scenario 9 the construction of the Marmion Avenue drain provides the following benefits:

- Significant reduction in flood risk in the vicinity of Baker Street, Enfield (~500mm reduction)
- Moderate reduction in flood risk in the vicinity of Grand Junction Road and Rosedale Avenue, Blair Athol (~200mm reduction)
- Minor to moderate reduction in flooding north of Grand Junction Road (~150-200mm reduction). Large reduction in the extent of shallow flooding west of Port Wakefield Road.

As the Marmion Avenue drain discharges additional flow into the outfall channel there is a marginal increase in flood risk (typically 5-20mm) along the outfall channel in the vicinity of Nelson Street and Solent Avenue, Blair Athol.

8.2.13 Scenario 11: Marmion Avenue Diversion Drain

This scenario resulted in the following improvements in flood risk:

- Minor reduction in flooding in the vicinity of Baker Street, Enfield (50-100mm reduction)
- Minor reduction in flooding north of Grand Junction Road (~50mm reduction)
- Minor reduction in flood risk in the vicinity of Grand Junction Road and Rosedale Avenue, Blair Athol (~50-100mm reduction)

As the drain discharges additional flow into the outfall channel there is a minor increase in flood risk (typically 40-80mm) in the area along the outfall channel between Brunswick Street and Marmion Avenue, Kilburn.

8.2.14 Alternative Scenarios

Due to the extensive modelling time that would have been involved, not all combinations of the proposed elements were modelled in TUFLOW. This section provides a qualitative assessment of some other possible scenarios.

A number of the proposed elements including the work within the State Sport Park, Enfield High School and within the Enfield Cemetery require work within property owned by the State Government. There is no guarantee that these elements will be constructed as they are subject to successful negotiation with the various parties.

The outfall channel may, through necessity, require replacement irrespective of the construction of the other elements outlined above. The combination of these works with elements A and B are also discussed qualitatively below as well as the combination of the channel works combined with work at the Canine Association (Element D).

No Enfield Cemetery Basin (Element A)

If the Enfield Cemetery Basin does not form part of the overall scheme the following implications would result:

- The flow heading towards the Baker Street area from the valley that the cemetery is located on would increase with a minor to moderate increase in flooding in the area
- As the water would not be diverted at Hampstead Road there would be a slight increase in flooding along the Fitzgerald Avenue / Prescott Street valley
- The importance of diverting water into either the Enfield High School (preferred) or the State Sports Park would increase
- The importance of the Marmion Avenue drain is increased as it will assist in freeing up capacity within the Main North Road drain providing relief to the Baker Street area and providing additional capacity to the main drain in Grand Junction Road

No Enfield High School Diversion (Element F2)

If the diversion of water from Grand Junction Road into the former Enfield High School site does not form part of the overall scheme the following implications would result:

- The importance of being able to divert water into the States Sports Park would increase
- The flow heading towards the Baker Street area from Grand Junction Road would increase with a minor to moderate increase in flooding in the area if the diversion of flows into the State Sports Park also wasn't able to be implemented

No State Sports Park Diversion (Element B)

If the diversion of water from Grand Junction Road into the State Sports Park site does not form part of the overall scheme the following implications would result:

- The importance of being able to divert water into the former Enfield High School site would increase
- The flow heading towards the Baker Street area from Grand Junction Road would increase with a minor to moderate increase in flooding in the area if the diversion of flows into the State Sports Park also wasn't able to be implemented

Outfall Channel Upgrade (Element E) in conjunction with the Enfield Cemetery Basin (Element A) or Sports Park Diversion (Element B)

The outfall channel is located a long distance away from the Baker Street flooding area which is the main focus of the Enfield Cemetery basin and Sports Park Diversion. The peak flow rates reaching the outfall channel are predominantly limited by the capacity of the inlet pipes, as due to the flat nature of the catchment, overland flood flows do not naturally drain towards and spill directly into the channel. Therefore, the channel upgrade will not be effected significantly if Elements A and B are not constructed.

Canine Association Basin (Element D) in conjunction with Outfall Channel Upgrade (Element E)

The main goal of both the Canine Association Basin and the outfall channel upgrade is to reduce the amount of flooding along the outfall channel by either reducing the peaks flow rates along the channel (Element D) or by increasing the capacity of the channel (Element E). To some extent as both elements set out to meet the same goal there is a diminishing return in undertaking both elements. If the detention basin is constructed there is less need to upgrade the channel. Conversely if the channel is upgraded there is less need to reduce the peak flow rates. However, given that the outfall channel upgrade is likely to occur (at least in the lower reaches where the quality of the existing drain is poor) the detention basin is potentially the only other option available to Council to manage the standard of the outfall channel (other than dealing with a significant amount of contaminated material at the Council depot site). This option could become worth pursuing in the long term if future development rates increase beyond what has been predicted and if sea level rise starts to impact on the downstream end of the outfall channel. However, the land for the basin is under private ownership of Dogs SA, who are not supportive of this option.

8.2.15 Summary of Properties Flooded

The following table provides a summary of the number of properties flooded based on the various scenarios for the long-term development 100-year ARI event. The properties have been split into residential and non-residential. Properties have been considered flood prone if the flood depth is more than 200mm above the centroid of the block for residential and 100mm for non-residential properties. Typically damages to non-residential areas will be higher than residential areas as they are predominantly related to the large commercial and industrial areas towards the downstream end of the catchment.

Table 8.2: Summary of Properties Flooded

Scenario	Elements	Capital Cost* ($ millions)	Residential	% Reduction compared to existing	Non-Residential	% Reduction compared to existing
Existing	-	-	136	n/a	70	n/a
1	A	2.0	110	19%	64	9%
2	B	2.1	121	11%	68	3%
3	A, B	4.1	101	26%	61	13%
4	A, B, C	7.1	84	38%	59	16%
5	A, B, C, D	10.5	68	50%	54	23%
6	E	12.6#	111	18%	58	17%
7	A, B, C, E	19.8#	63	54%	47	33%
8A	F1	0.9	124	11%	68	3%
8B	F1, B	3.0	120	12%	68	3%
8C	F2	3.0	112	18%	65	7%
9	A,F2	5.0	84	38%	59	16%
10	A,C,F2	8.1	81	40%	54	23%
11	C	3.1	129	5%	67	4%

*Excludes any allowance for land acquisition

The capital cost that includes channel widening is only for the total cost minus the cost of asset replacement

As a single project Element F2 (Scenario 8C) has the largest impact in reducing flood risk in the key trouble spot in the catchment near Baker Street and in the areas north of Grand Junction Road. It diverts both pipe and surface flood flows into the site unlike the State Sports Park option (Element B) which only diverts pipe flows. The school site is also located further downstream than the point where flows would be diverted into the State Sports Park making it clearly superior to the State Sports Park option. However, the proposed works at the school site are more expensive that the State Sports Park option and also requires fairly significant land acquisition. The single element that has the smallest impact is Element C (Scenario 11) which is the Marmion Avenue diversion drain.

Element A, the Enfield Cemetery diversion drain and basin, has a relatively large impact in reducing flood damages based on the reduction in flooded properties with the majority of these being along the main outfall channel between Le Hunte Street and Marmion Avenue.

Scenario 9 shows that the Enfield Cemetery diversion drain (Element A) works well in combination with the Enfield High School (Element F2) as they both manage separate portions of the catchment. There is a further moderate reduction in flood risk due to the inclusion of the Marmion Avenue diversion drain (Element C) which is shown in Scenario 10. Inspection of the flood maps for Scenario 10 show that virtually all flooding within the Baker Street area is removed.

Element B (State Sports Park Diversion) is about half as effective as Element A in terms of the number of properties considered to be flood prone. There are further moderate reductions based on Scenario 3 (the combination of Elements A and B) and Scenario 4 which combines the Marmion Avenue diversion drain with elements A and B. However, these reductions are not as significant as Scenarios 9 and 10 which include the Enfield High School diversion in place of the State Sports Parks diversion.

A further improvement comes about through the construction of a detention basin within the Canine Association land (Scenario 5) with close to 50% less residential and 25% less non-residential properties considered flood prone in the 100-year ARI long-term development rainfall event. However, the results indicate that channel widening will be more effective at reducing flood risk than the construction of the detention basin if combined with the Elements A through to C (Scenario 7).

Scenario 6 (channel widening) only has a moderate improvement in reducing the number of residential flood prone properties as the majority of them are not in a close vicinity to the channel. It has a similar impact to reducing flood risk within the downstream section of the catchment as Scenario 3.

Element F1 (Enfield High School basin) is not as effective as Element B (State Sports Park Diversion) and provides minimal incremental benefit if it is combined with Element B (Scenario 8B). This is because element F1 is only a short distance downstream of where flows are diverted out of the catchment as part of Element B. Therefore, it would not be very beneficial to implement both elements.

8.2.16 Total Damages

Total flood damages for the unmitigated long term development scenario are shown in Table 8.3 for various ARIs.

Table 8.3: Flood Damages

ARI	Flood Damages (million)
5 year	\$11.4
20 year	\$29.0
100 year	\$81.1

A breakup of flood damages for the key 100-yr ARI event is shown in Table 8.4. The largest proportion (81.8%) of damages is from high value large (above 1,000m^2) non-residential properties with 414,000m^2 of land inundated (deeper than 0.1m) across a total of 264 properties. This is evident from the flood maps contained in Appendix C which show large amounts of flooding within the predominantly industrial areas to the north of Grand Junction Road. Flood damages to residential properties comprise of 5.8% of the total with 136 properties considered to be flood prone.

The various different land use categories are discussed in more detail in Section 8.3.

Table 8.4: 100-yr ARI Flood Damages Break-up

Land Use Category	Flood Damages (million)	% of total	Comments
Residential properties	$4.7	5.8	136 properties
Low value non-residential small properties	$0.05	0.1	11 properties
Medium value non-residential small properties	$0.46	0.6	9 properties
High value non-residential small properties	$2.3	2.8	18 properties
Low value non-residential large properties	$0.84	1.0	147,000 m^2 inundated across 69 properties
Medium value non-residential large properties	$6.4	7.9	100,000 m^2 inundated across 44 properties
High value non-residential large properties	$66.3	81.8	414,000 m^2 inundated across 264 properties
TOTAL	**$81.1**	**100**	

8.2.17 Annual Average Damage (Long Term Base Scenario)

The annual average damage (AAD) is an estimate of the average annual cost of flood damages over a long period of time. It balances frequent, small flood damage against rare, but significant flood damage and provides a convenient way to compare different floodplain management measures. AAD is the probability-weighted mean of the actual flood damages; it is equivalent to the area beneath the damage–probability curve.

The damage–probability curve for this long term development scenario is shown in Figure 8.1. For events with an annual exceedance probability (AEP) equal to or greater than 50% minimal flood damages were assumed. This assumption was adopted based on the typical average 2 year ARI standard of the underground drainage network in the Study Area and the ability of the road network to convey minor surface flows if the capacity of the underground drainage system is exceeded.

The AAD for the study area was calculated to be $6.93 million based on the results shown in Table 8.3.

8.3 Flood Damages Methodology

The flood damages assessment has applied the Rapid Appraisal Method (RAM) developed by the Victorian Department of Natural Resources and Environment (DNRE, 2000). The RAM allows for a rapid and consistent evaluation of floodplain management measures in a cost–benefit analysis framework. By keeping the assessment process simple (compared to other methods) it enables the method to be easily documented and repeated.

8.3.1 Data pre-processing

The RAM relies primarily on geographic datasets which require pre-processing before the damages assessment can be undertaken. In particular, the cadastral boundaries, the land use types, and property valuations allocated by the State Valuation Office are used.

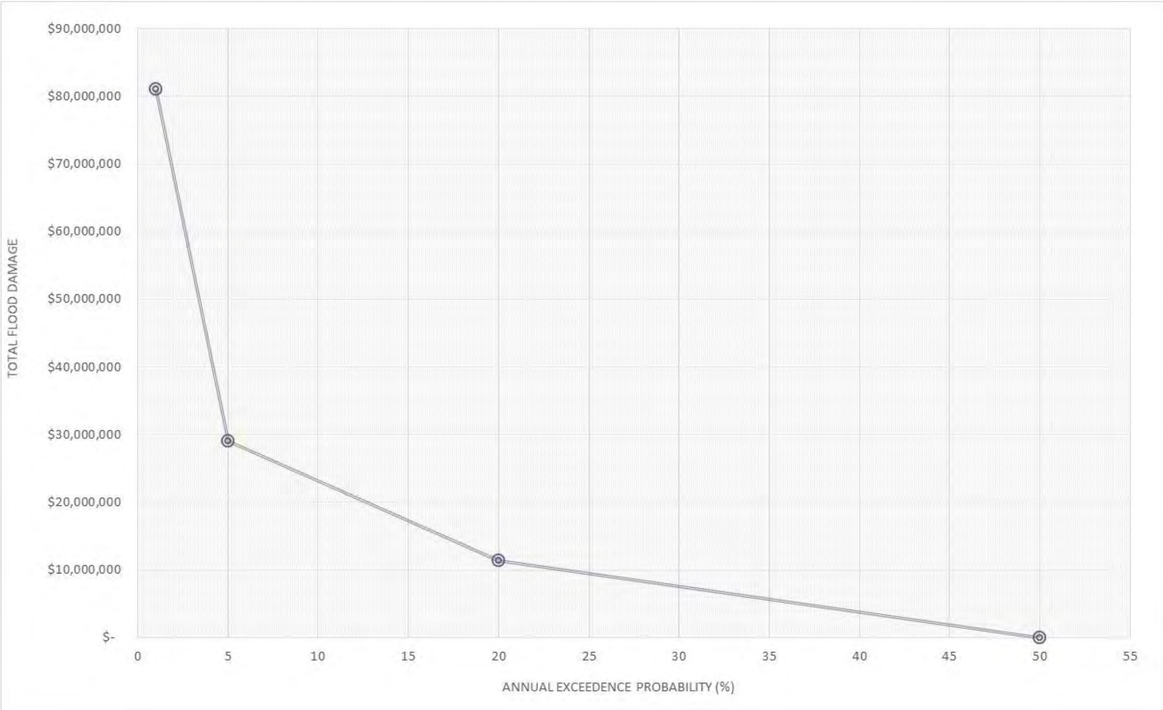
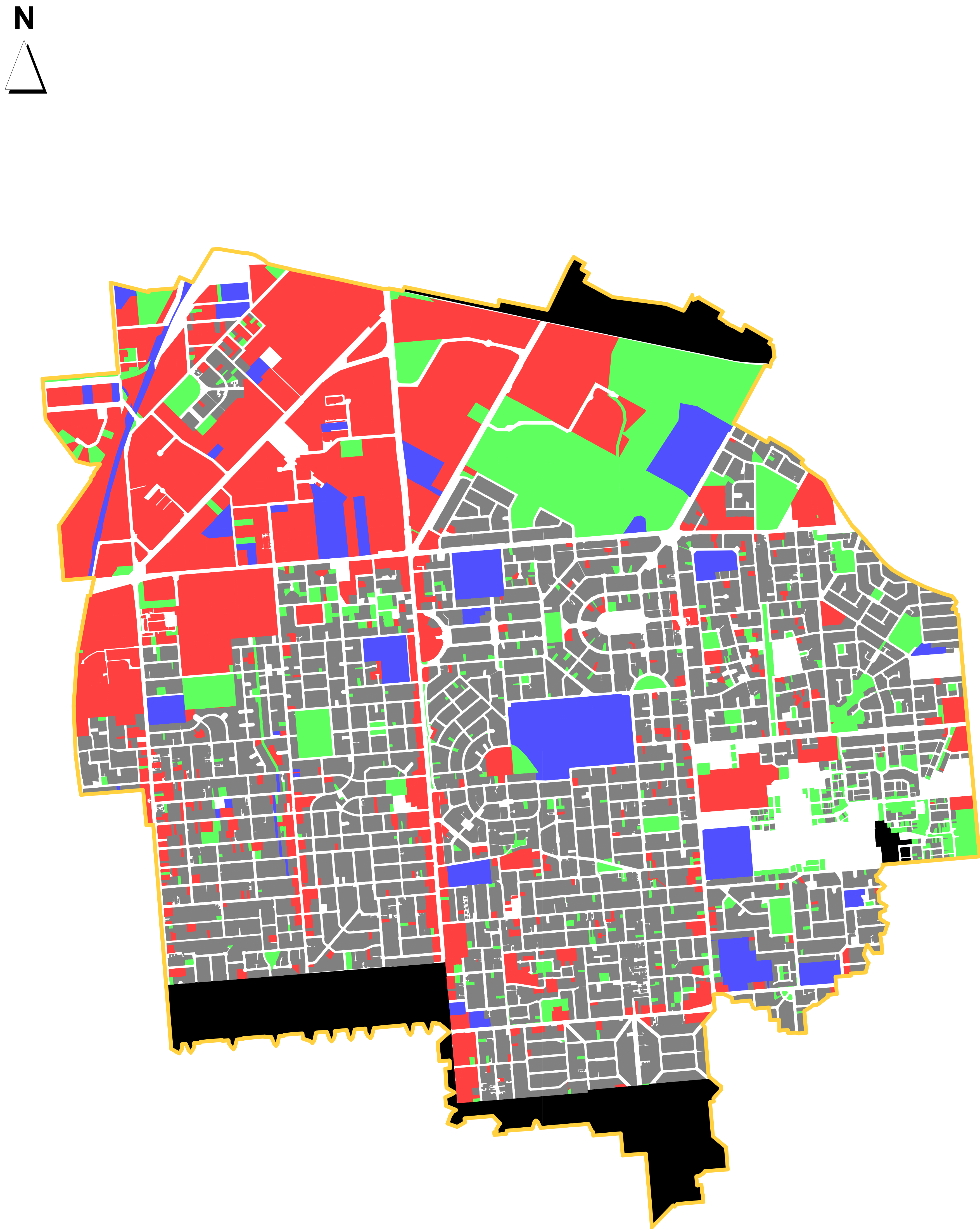


Figure 8.1: Damage Probability Curve

8.3.1.1 Potential damage category and property valuation

A potential damage category was assigned to each allotment based on land use type. The potential damage categories describe the relative damage potential of a property and reduces the number of land use types that require assessment to a more manageable number. The adopted methodology treats residential properties separately to other land use types. Four damage categories were used: low, medium, high and residential. Table 8.5 summarises how the different damage categories were assigned. Manual checking and refinement was necessary to produce the final dataset. The final break up of valuation areas is shown in Figure 8.2.

Residential property valuations were obtained for the residential allotments and were associated with each property in the GIS database. Residential allotments were the only damage category where valuation data was used to determine flood damages.



Legend

- High
- Medium
- Low
- Residential
- Excluded

-500 0 500 1000 1500m

Scale: 1:25,000

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MAP DETAILS

Cadastral Data:	City of Port Adelaide Enfield
Job Number:	2007.0212
Filename:	NAE_Figure82.wor
Drawn:	JCM
Date:	02/11/2015

City of Port Adelaide Enfield

Urban Stormwater Master Plans

North Arm East Catchment

DAMAGE CATEGORIES

Figure 8.2

Table 8.5: Damage Categories

General description of land use	Damage potential category
Residential	Residential
Retail	High
Industrial	High
Public reserves	Low
Education institutions	Medium
Public utilities	Medium
Recreation areas	Low
Agricultural	Low

8.3.1.2 Exclusion of small allotments

Allotments with an area less than 50 m^2 were removed to reduce the affect these had on the final calculated damages. These allotments predominantly included car parks assigned to strata titles, which, if left in the dataset, would have contributed large residential damages to the calculation when, in reality, no property damage would have occurred.

8.3.1.3 Removal of multi-storey dwellings

Only the first floor of multi-storey buildings were included in the damages assessment. As such, cadastral allotments representing the upper levels of these buildings were removed from the dataset.

8.3.2 Direct potential damage

The direct flood damages were calculated for three different groups: residential allotments, all other allotments with area less than 1,000 m^2, all other allotments with an area greater than 1,000 m^2. The following sections describe the calculation undertaken for each group.

8.3.2.1 Residential damages

Residential allotments were only considered damaged if the flood depth at the centroid of the allotment was greater than 0.2 m. The 0.2 m threshold was used based on the assumption that the finished floor level of dwellings is typically 0.2m above ground level.

The flood damages for residential allotments were determined based on the individual property value relative to the average property value, the depth of flooding above finished floor level, and a base flood damage amount. Equation 8.1 shows the function used to calculate the flood damages.

$$Damage = \$30{,}000 + \$30{,}000 \times above\_floor\_flood\_depth \times \frac{value\_of\_property}{average\_property\_value}$$

Equation 8.1 Residential flood damages function

The base flood damage amount ($30,000) and the factor used for the property value component of damage are based on work conducted by Tonkin Consulting in 2008 adjusted for inflation to 2015 values. The previous work reviewed several flood damage assessments undertaken in Adelaide.

8.3.2.2 Small non-residential allotment potential damages

Non-residential allotments with area less than 1,000 m^2 were considered flooded if the depth of flooding at the centroid was greater than 0.1 m. The 0.1 m threshold was based on the assumption that the finished floor level of non-residential properties is typically lower than residential dwellings.

A flat rate was used to determine damages for this group of allotments (Table 8.6). The damage is based on 2008 figures adjusted for inflation to 2015 values.

Table 8.6: Damages Multipliers for Small Blocks (less than 1,000m^2)

Damage potential category	Damage per allotment
Low	$4,000
Medium	$32,000
High	$80,000

8.3.2.3 Large allotment potential damages

Large allotments (with area greater than 1,000 m^2) were considered flooded if any portion of the allotment was inundated to a depth above 0.1 m. For each damage potential category, the total flooded area for each allotment was determined and multiplied by the appropriate unit rate (Table 8.7).

Table 8.7: Damages Multipliers for Large Blocks (larger than 1,000m^2)

Damage potential category	Damage multiplier per m^2
Low	$5
Medium	$40
High	$100

Normally, potential damage for large allotments is determined by the flooded area of buildings. However, building footprints were not available in this study and an attempt to produce this dataset was considered too costly. Instead the damage multipliers have been reduced to account for the fact that only some large allotments are fully covered by buildings. The reduced unit rates were developed based on visual inspection of the aerial photograph.

8.3.3 Indirect potential damages

Indirect damages have been determined using the factors listed in Table 8.8. Indirect damages were estimated to be 60% of direct damages for medium and high damage potential categories (due to the higher disruption to services, transport, and commerce) and 15% for residential and low damage potential (Kate 1965, and URS, 2005).

Table 8.8: Indirect damage factors

Damage potential category	Indirect damage factor (%)
Residential	15
Low	15
Medium	60
High	60

8.3.4 Potential to actual damages reduction

The potential direct and indirect damages are not equivalent to realised damages due to mitigating factors such as the community's flood preparedness. Given the rapid response time of the catchment and the low frequency of significant flooding, an actual to potential conversion ratio of 0.9 has been adopted. This value is based on Table 3.5 of the Rapid Appraisal Method for Floodplain Management report (DNRE, 2000).

8.3.5 Exclusions

The following damages have not been collated as part of the damages assessment:

- Damage to vehicles
- Damage to roads, railways or other linear infrastructure
- Economic costs due to injury or loss of life

These damages cannot be easily assessed as part of a cadastral based flood assessment and therefore have not been quantified.

8.4 Economic Assessment

An economic assessment has been undertaken for a number of the scenarios that are described in Section 8.1. The benefit has been derived based on a reduction in the annual average damage (AAD). These values have been calculated by applying the methodology outlined in Section 8.3 to each of the modelled scenarios and then determining the net reduction in annual average damage. The reduction in AAD for each scenario is shown in Table 8.9. In the context of a total AAD of $6.93 million the various scenarios represent a significant reduction in damages in the range of 5-17%. As a standalone option, the Enfield High school works (Element F2) result in the largest reduction in AAD other than channel widening (which has a significantly larger capital cost).

Costs for each scenario have been taken from Section 7.1. The reduction in damages has been partly offset by a likely increase in maintenance costs of the new infrastructure. The maintenance costs have been determined based on the size of the infrastructure and the costing information that is available within the appendices of the MUSIC User Manual (eWater, 2009).

Table 8.9: Summary of Costs

Scenario	Elements	Capital Cost ($ millions)	Annual Maintenance Cost ($)	Reduction in AAD ($)	Reduction in AAD (%)
1	A	2.0	29,000	549,000	7.9
2	B	2.1	28,000	520,000	7.5
4	A, B, C	7.1	57,000	1,110,000	16.0
6	E	12.6*	0	900,000	13.0
8C	F2	6.0	28,000	690,000	10.0
9	A,F2	8.0	57,000	1,090,000	15.8
10	A,C,F2	11.1	57,000	1,150,000	16.6
11	C	3.1	0	390,000	5.6

* The capital cost is for the total cost minus the cost of asset replacement of the open channel

The economic assessment, which is shown in Table 8.10 has been based on a 4.4% discount rate that has been provided by Council and has included the derivation of an internal rate of return, a net present value and a benefit cost ratio. The assessment has been based on a 50-year time horizon. Schemes having the highest benefit / cost ratio provide the best value on investment while those having the highest net present value would have the best long term benefit. The internal rate of return is the rate that the benefits would need to be discounted at to create a net present value of $0. The higher the value the more attractive the project.

Table 8.10: Economic Assessment

Scenario	Elements	Internal Rate of Return (%)	Net Present Value ($ million)	Benefit / Cost Ratio
1	A	26	8.1	5.2
2	B	24	7.5	4.8
4	A, B, C	15	13.4	3.0
6	E	7	5.2	1.4
8C	F2	11	7.0	2.2
9	A,F2	13	12.2	2.6
10	A,C,F2	10	10.4	2.0
11	C	13	4.5	2.5

All options could be recommended on economic terms as there is a positive net present value and a benefit cost ratio of well above 1.0. The scenarios that present the highest benefit / cost ratios are 1 and 2 which comprised of the Enfield Cemetery basin (Element A) and the State Sports Park Diversion (Element B). They have a relatively low cost, partly due to no need for land acquisition, and provide for a relatively large reduction in AAD.

As more options are included there is not always an increase in net present value and the benefit / cost ratio typically reduces (e.g. by comparing scenario 9 with 10). This is due to there being diminishing returns as multiple options are included as they are all generally focussed on reducing flooding in the Baker Street area and in areas north of Grand Junction Road and west of Main North Road.

The assessment is highly dependent on the initial capital costs, which have been taken directly from Section 7.1. Some refinement of these costs by further developing some of the concept designs may be warranted and may alter the economic assessment.

The large upfront capital cost of upgrading the outfall channel means that as an upgrade, it is not warranted on economic terms. However, if the channel were to fail completely there would be major damages. The analysis is only showing the reduction in damages based on the current channel, not a channel that has failed.

A sensitivity analysis was undertaken by altering the 4.4% discount rate used for the assessment by plus and minus 30%. The sensitivity analysis of the discount rate showed that changes to the rate didn't have a big impact as scenarios that had a positive benefit cost ratio were still positive and net present values were also still positive. Therefore, variations in the discount rate will not significantly change the viability of any scenarios shown in Table 8.10.

8.5 Assessment of Benefits for each option through implementation of the Optimised Decision Making Methodology

The six elements outlined above have been analysed using the optimised decision making methodology as outlined in Section 3. In addition to the assessed flood protection component that has been discussed in Section 0 ratings have also been given to the following broad categories (as discussed in Section 3):

- Runoff quality and impact on receiving environment
- Beneficial use of stormwater
- Environmental benefit
- Social values
- Capital and maintenance cost

A summary of these ratings are shown in Table 8.11 while the full breakdown in contained within Appendix D.

Table 8.11: Optimised Decision Making Rating of Options

Criteria	Maximum score	Stage Sports Park diversion with harvesting	Cemetery diversion and basin	Marmion Avenue drain	Enfield High School Basin with harvesting*	Outfall channel upgrade**
Flood protection of development	30	15	15	15	15	15
Runoff quality and effects on Barker Inlet Wetlands	15	7.5	2.3	0	3.8	0
Beneficial use of stormwater	15	11.3	4.3	0	7.5	0
Social values	10	2.6	1.3	0.8	6.9	1.1
Environmental	5	2.1	0	0	2.1	0
Capital and maintenance cost	25	11.9	12.5	10.3	9.1	1.9
TOTAL	**100**	**50.4**	**35.3**	**26.6**	**44.3**	**18.0**

* Element F2 which includes diversion of both pipe and surface flows

** This does not include the option to grass line a section of channel

The analysis has clearly shown that the options that score well across a range of criteria have received the highest overall total score (Enfield High and Sports Park). The options that purely focus on reducing flood risk (Marmion drain and outfall channel upgrade) do not score as highly.

The majority of the options shown in the table will complement each other in terms of reducing flood risk. However, the outfall channel upgrade and the Canine basin are both focused on improving the capacity of the outfall channel such that one of these options would reduce the need to implement the other option. Also as the Enfield High School Basin is only a short distance downstream of the Sport Park diversion point there is little incremental benefit in both options being implemented. Additional discussion of the various options and the recommended priorities is shown in Section 9.2.

9 Priorities, Timeframes and Responsibilities

9.1 Responsibilities

The Stormwater Management Plan provides the roadmap for the mitigation of flooding for the North Arm East Catchment. The Steering Group which has overseen the development of the Stormwater Management Plan comprises representatives of key stakeholder organizations that have responsibility for implementing the Stormwater Management Plan. However, the primary organisation that will be required to push for the implementation of the recommendations contained within the plan will be the City of Port Adelaide Enfield.

9.2 Priorities for major flood mitigation works

The optimised decision making methodology has been applied to assess the various major flood mitigation options against a wide range of benefits including reduction in flood risk, water reuse and water quality improvements (refer Sections 3 and 8.5).

The modelling has shown that the Enfield Cemetery diversion in conjunction with the Enfield High School diversion work well together in reducing flood risk within the catchment. The Marmion Avenue diversion drain only provides a localised improvement in flood risk in the Baker Street area. The diversion of water into a basin at the Canine Association land further improves the situation but at significant additional cost. However, it is not as effective as widening the outfall channel.

It is unrealistic to expect that any of the scenarios would completely remove all flooding throughout the catchment as they have not reduced the extent of flooding in some of the more minor flood prone areas. However, the main improvement in flood risk is focused on the main flood prone areas.

Some options provide a wide range of benefits (such as the Enfield High School diversion) and therefore score well across a number of items within the optimised decision making methodology where as some options have a narrower focus (such as the Marmion Avenue diversion drain) and are therefore considered to be a lower priority.

Based on the flood modelling results and the implementation of the optimised decision making methodology the proposed works have been prioritised as follows.

Priority 1: State Sports Park Diversion – Element B (high priority)

The recommended work within the State Sports Park is Option 2b from Table 6.1. It involves the full diversion of flows within the Grand Junction Road drain at Amber Avenue and an increase in the size of the outlet pipe from the south-western basin. It provides a wide range of benefits including a reduction in flood risk, opportunity for water reuse and water quality improvements as outlined below.

This option will only require minimal additional land as it will predominantly utilise existing open space and will not limit proposed future development options within the State Sports Park. Therefore, it is a relatively cost effective option and does not require negotiation with many third parties which will simplify implementation of the proposed works.

Flood Reduction Benefits

While not as effective in reducing flood risk as Priority 2 (Enfield cemetery diversion) or 5 (Enfield High School Basin) it still provides a moderate reduction in flood risk predominantly in the Baker Street flood prone area (approximately 15 less flood prone residential properties). The works will also improve upon an existing problem due to the very small diameter outlet to the downstream basin within the south-western corner of the State Sports Park which has on occasion blocked and resulted in flooding over the top of the basin embankment.

The works will essentially divert flow from 80 hectares of catchment away from the flooding problems along Baker Street and improve the drainage standard for the remainder of the trunk drain in Grand Junction Road between Amber Avenue and the outfall channel.

Water Reuse Benefits

Preliminary yield modelling has indicated that if the water is pumped from the site into the nearby Dry Creek harvesting scheme operated by the City of Salisbury approximately 120-180ML of water could be harvested from the south-western basin of the State Sports Park. To facilitate this, additional retention storage would need to be incorporated into the base on the basin. Supplementing the supply to an existing scheme is likely to be more cost effective than establishing a new stand-alone harvesting scheme on site.

Water Quality Benefits

This diversion and harvesting of water within the State Sports Park will assist in reducing the load imposed on the Barker Inlet Wetlands which is likely to increase over time due to increased development within the catchment. The proposed harvesting basin will also act as a sedimentation basin which will provide some preliminary water quality improvement for all water draining into it.

Priority 2: Enfield Cemetery Diversion – Element A (medium-high priority)

This option involves the diversion of additional catchment through the cemetery with the construction of an embankment across the existing valley at the western end of the site to create detention storage within the valley.

Consultation with the Adelaide Cemeteries Authority has indicated that the formation of a basin on the western boundary of the site is part of one option they are considering as part of their master plan for the site and that they are open to further consultation should the concept need to be firmed up in the future.

Flood Reduction Benefits

The Cemetery Diversion works in parallel with the State Sports Park Diversion or Enfield High School Diversion to reduce downstream flood risk. The works will divert 61 hectares of flow that currently drains through the Fitzgerald Avenue / Prescott Street which will reduce the pressure placed onto this system. The basin within the cemetery will reduce the peak flows that pass down the drain along Gove Road which will reduce peak flow rates passing along the existing Main North Road and Grand Junction Road trunk drains.

Water Reuse Benefits

There may be the opportunity to opportunistically harvest water directly from the basin for irrigation of the Enfield Cemetery. However, the annual yields would be relatively low as the peak demand will coincide with periods of low rainfall.

Water Quality Benefits

This option will provide some minor improvement in water quality if a body of permanent water is incorporated into the base of the basin. Such a basin will enable coarse sediments to drop out of the flow before discharging from the basin.

Priority 3: Marmion Avenue Diversion Drain – Element C (medium priority)

This option involves the construction of a new diversion drain along Marmion Avenue between Main North Road and the outfall channel. In combination with works associated with Priorities 1 and 2 above this drain significantly reduces the flood risk in the Baker Street area. The diversion drain frees up capacity within the Main North Road drain which is subsequently able to accept more flows from the Whittington Street drain which reduces the volume of spill into the Baker Street area.

There is a small increase in flood risk in the vicinity of Nelson Street and Solent Avenue due to the additional water that is drained into the main outfall channel. This increased flood risk is removed if either Priority 4 or 6 are constructed.

Compared to Priority 4 (channel widening) the benefits derived from this option will be borne much earlier due to the very large amount of expenditure that would be required to implement the channel widening. The reduction in peak flows arriving at the outfall channel based on the more recent TUFLOW modelling are also lower than previously predicted, reducing the urgency to upgrade the outfall channel.

There are no water quality or harvesting benefits associated with this option.

Priority 4: Channel widening – Element E (medium priority)

This option involves the widening of the existing outfall channel and installing larger culverts at the road crossings along the majority of the length of the outfall channel.

Flood Reduction Benefits

The channel is in poor condition downstream of Grand Junction Road and water spills out of the channel in a number of locations. Widening the channel does result in a reduction in the extent of flooding in a number of locations along the channel but does not have much impact in the main flood prone areas in Baker Street or north of Grand Junction Road east of Prospect Road. It is recommended that the widening works are done in conjunction with the channel replacement works. Therefore, the additional cost required to increase the channel capacity will only form a moderate proportion of the overall project cost. The outfall channel is a major Council asset and will require significant expenditure which is likely to require construction in a number of stages. The stages should be constructed from downstream to upstream. The logical breakdown of stages would be:

- Stage 1: Outlet up to railway reserve (800m, full channel replacement)
- Stage 2: Railway reserve to downstream of Grand Junction Road (930m, full channel replacement)
- Stage 3: Downstream of Grand Junction Road to downstream of Northcote Street (1300m, channel widening only)
- Stage 4: Downstream of Northcote Street to upstream end of channel (670m, channel widening only)

Due to the very long time before upgrade works are likely to provide an improvement in flood risk the early stages of the work may need to commence prior to the completion of the higher priority works in the catchment.

Other Benefits

This option has no water quality unless a portion of the open channel is converted into a section of earth lined channel (as outlined in Section 6.2.6). This would provide some improvement in water quality, particularly for smaller events. The channel would also provide additional useful open space if the reserve is converted into a pedestrian corridor. It would also improve local amenity.

Priority 5: Enfield High School Basin – Element F2 (Low)

This option involves the interception of pipe flow (other than the 1 in 3 month flow) and surface flood flows into a 50ML detention basin within the former Enfield High School site. It provides a wide range of benefits including a large reduction in flood risk, opportunity for water reuse and water quality improvements as outlined below. It also provides an opportunity to provide more useful open space within the catchment. However, if the State Sports Park works proceed (Priority 1) there would be little need to implement the works at the Enfield High School as the works are located a short distance downstream of where flows would be diverted into the State Sports Park and would therefore provide only a moderate incremental benefit. It also has a lower cost benefit ratio than the State Sports Park basin which is predominantly due to the large land acquisition costs that are associated with this option.

The benefits discussed below are on the assumption that this is a stand-alone option and that the State Sports Park option did not proceed.

Flood Reduction Benefits

Of all the potential capital works projects within the catchment, this project results in the highest reduction in flood risk (if undertaken as a stand-alone project). The works will essentially intercept and detain all pipe (except for base flows) and surface flood flows from a 145 ha portion of the catchment and prevent them from reaching the major flooding spot at Baker Street. It will also improve the drainage standard for the remainder of the trunk drain in Grand Junction Road between Devon Street and the outfall channel.

As the works free up capacity within the Grand Junction Road trunk main it allows for a large increase in flow within the Devon Street drain which provides a further reduction in the volume of surface flood flows arriving at the Baker Street low spot from the south.

Water Reuse Benefits

Preliminary yield modelling has indicated that if the water is pumped from the site into the nearby Dry Creek harvesting scheme operated by the City of Salisbury, approximately 120ML of water could be harvested from the basin, provided that base flows are diverted into the site. To facilitate this a permanent water storage component would need to be incorporated into the base on the basin. Based on the volume of water that could be harvested, supplementing the supply to an existing scheme is likely to be more cost effective than establishing a new stand-alone harvesting scheme on site.

Water Quality Benefits

This diversion and harvesting of base flows into the Enfield High School site will assist in reducing the load imposed on the Barker Inlet Wetlands which is likely to increase over time due to increased development within the catchment. The proposed harvesting basin will also act as a sedimentation basin which will provide some preliminary water quality improvement for all water draining into it.

Other benefits

Separately from flood risk management the conversion of a portion of the former school site into a predominantly dry detention basin would have a number of social benefits including the creation of additional useful open space and the potential for improved visual amenity (as opposed to a residential development of the site).

Priority 6: Canine Association Basin – Element D (Nil)

The works associated with this site involve the interception of peak flows within the outfall channel into a dry detention basin that would be excavated on the site. Flows would subsequently drain back into the outfall channel via a small outlet pipe.

Consultation with the Canine Association has indicated that they are not willing to negotiate at this stage for any potential works on their site. Therefore, this report does not recommend any works be undertaken on the site. However, as part of the consultation process the benefits of a basin at the site were summarised and are outlined below.

Flood Reduction Benefits

The poor condition of the outfall channel is likely to require that it be replaced in the next 10 or so years before it is no longer able to function effectively. If the channel is also upgraded as part of these works it is unlikely that the cost to construct the Canine Association basin would be warranted as channel upgrades would reduce the need to reduce peak flows within the main outfall channel.

The upper limit to the overall standard of the outfall channel is the lack of space within the drainage reserve at the downstream end (as discussed in Section 6.1.5). A basin located towards the downstream end of the main outfall channel has the potential to partly reduce this limitation. Retention of the area as open space would ensure that this possible opportunity is not lost.

Similarly to the channel widening works the basin only has a limited impact on reducing flood risk in the major flood prone areas of the catchment.

Other benefits

The site is of strategic importance in creating a potential buffer between industrial and residential areas and is one of the only large areas of open space along the alignment of the main outfall channel (other than the contaminated Depot site). A basin at the site will potentially guarantee the long term use of the area as open space.

9.3 Other Recommended Works

9.3.1 Flood Mitigation

A flood awareness progress should be commissioned to potentially reduce flood damages, in the event of a significant flood event (refer Section 6.1.13).

9.3.2 Asset Management

Existing stormwater infrastructure is a major Council asset and continued maintenance of existing assets will be required which would include CCTV inspections, removal of pollutants from capture devices, maintenance of wetlands and open channels and removing pit and pipe blockages. The replacement of infrastructure that has reached the end of its design life will also be required, such as the main outfall channel as mentioned as Priority 4 of Section 9.2.

9.3.3 Water Quality

A number of strategies should be recommended to improve water quality in the catchment. These are listed below in descending order of priority.

- Establish a monitoring program to assess pollutants entering the wetlands which will enable the effectiveness of proposed water quality improvement measures to be assessed (refer Section 6.2.11) and to better quantify the performance of the wetlands. If the monitoring results indicate that the wetlands are not performing as well as expected additional investigation work should be undertaken to determine how its performance can be improved. The monitoring would also enable the MUSIC model to be calibrated to the pollutant loads being generated by the catchment. The model could subsequently be used to assess how various catchment measures will improve water quality and may also potentially be used as a tool to model proposed changes to the wetlands.
- The scope of the flood awareness program should be extended to make people aware that their actions have the potential to impact on downstream water quality and that changes in their actions (littering, car washing) can improve downstream water quality.
- Undertake capital works to improve the functionality of the wetlands to remove pollutants as this is likely to be the best value for money option to improve the quality of water that is discharged into Gulf St Vincent (refer Section 6.2.10).
- Commission a study to determine the viability of removing gross pollutants and sediment from the sewer siphon. The study would also need to estimate the quantity of pollutants that it would prevent from reaching the Barker Inlet Wetlands such that it can be compared to the expense of undertaking the maintenance (refer Section 6.2.7).
- Opportunistically construct WSUD projects as part of other projects within the catchment.

The installation of GPTs at strategic locations throughout the catchment (refer Section 6.2.1) is a low priority due to the large initial capital expense and ongoing maintenance costs. Council's expenditure to improve water quality in the catchment should preferentially be spent on improving the functionality of the wetlands which would also be able to treat a wider range of pollutants than can be removed by GPTs.

9.3.4 Other Projects Likely to Proceed

A number of other schemes are already underway in the catchment including:

- Harvesting of water from the Barker Inlet Wetland (as outlined in Section 6.3.1.4) which has the benefit of significantly reducing mains demand (provided adequate demand for the water can be found) and reducing pollutant loads entering Gulf St Vincent.
- On-site domestic scale capture and reuse of stormwater as part of the compulsory rainwater tank legislation. Council could promote the use of tanks larger than the minimum size as mentioned in Section 6.3.1.5 to further reduce mains demand and may have some impact on flood risk by retaining a relatively large proportion of the hydrograph on site during some flood events.

9.4 Timeframes

All of the components outlined above require considerable expenditure and will need to be staged over a number of years to enable budgeting for the works to fit in with other Council priorities. Based on an expenditure of approximately $1.3m per year implementing the recommendations within this report a 10-year capital works plan is presented in Table 9.1.

Potential SMA funding for the major capital works or additional Council expenditure would allow for an accelerated program of works as shown in Table 9.2 ($2.3m per year). Costs do not include any allowance for land acquisition. Some level of compensation would be required for the construction of a basin within the Enfield Cemetery site. The Marmion Avenue and outfall channel upgrades would require little or no land acquisition.

Due to the significant expenditure required in relation to the outfall channel (estimated to be $29m) an additional 27 years of funding would be required beyond what is shown in Table 9.1 if Council only budgets for $1.3m a year or for an additional 8 years beyond what is shown in Table 9.2 if it can obtain SMA funding or increase annual expenditure within the catchment on drainage infrastructure to $2.3m per year.

Table 9.1: 10-year Capital Works Plan (values stated in millions) – no SMA funding

Priority	Task	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026
1	State Sports Park	1.0	1.1								
2	Wetland monitoring	0.02									
3	Flood education program	0.01									
4	Wetland upgrade			0.15	0.1						
5	Sewer siphon study			0.01							
6	CCTV	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
7	Asset maintenance	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
8	Enfield Cemetery			1.0	1.0						
9	WSUD projects	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.04	0.04	0.04
10	Marmion Avenue					1.0	1.0	1.0			
11	Outfall channel Stage 1								1.0	1.0	1.0*
TOTAL		1.37	1.44	1.50	1.44	1.35	1.35	1.35	1.36	1.36	1.36

* Funding required for an additional 27 years to complete all stages of the outfall channel if $1.2m is spent each year.

Table 9.2: 10-year Capital Works Plan (values stated in millions) –SMA funding

Priority	Task	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026
1	State Sports Park	1.05									
2	Wetland monitoring	0.02									
3	Flood education program	0.01									
4	Wetland upgrade		0.15	0.1							
5	Sewer siphon study		0.01								
6	CCTV	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
7	Asset maintenance	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
8	Enfield Cemetery		1.0								
9	WSUD projects	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.04	0.04	0.04
10	Marmion Avenue			1.0	0.5						
11	Outfall channel Stage 1				0.5	1.0	1.0	1.0	1.0	0.5	
12	Outfall channel Stage 2									0.5	1.0*
SMA subsidy#		1.05	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
TOTAL		2.47	2.50	2.44	2.34	2.35	2.35	2.35	2.36	2.36	2.36

Or increased Council expenditure to $2.3m per year

* Funding required for an additional 8 years to complete all stages of the outfall channel if $2.3m is spent each year.

10 References

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Appendix A

Cost Estimates

INDICATIVE CONSTRUCTION COST ESTIMATE FOR THE DEPOT DAM - NAE OUTFALL CHANNEL

Project: **NAE SMP - Depot Dam**

Job No: 2007.0212
Date: 16-Feb-10 Sheet No 1 of 1

Estimated by: T. Rundle
Review by: T. Kerby

Note: Cost estimates provided by Tonkin Consulting are based upon historic cost information and experience, and do not allow for latent conditions, changes in scope and market conditions (ie competition, escalation, changes to public and private utility policies in regards to relocation and augmentation of services).

Tonkin Consulting recommend that a professional Quantity Surveyor be engaged if assurance of cost is required and project budget estimates allowing for these factors are required.

Item No	Description	Unit	Qty	Rate	Cost
1	**Preliminaries**				
1.1	Establishment	item	1	$100,000	$100,000
1.2	Setting out	item	1	$30,000	$30,000
2	**Earthworks - contaminated soil**				
2.1	Depot dam - overburden	m^3	41,000	$170	$6,970,000
2.2	Depot dam - excavation	m^3	26,000	$170	$4,420,000
3	**Miscellaneous**				
3.1	Landscaping, planting	m^2	30,000	$14	$420,000
3.2	Engineering design and survey	item	1	$120,000	$120,000
3.3	Cleaning up	item	1	$20,000	$20,000
3.4	Testing	item	1	$60,000	$60,000

Sub-Total	**$12,140,000**
Contingencies (20%)	**$2,428,000**
TOTAL	$14,568,000

INDICATIVE CONSTRUCTION COST ESTIMATE FOR THE DOG PARK DAM - NAE OUTFALL CHANNEL

Project: **NAE SMP - Canine Association Basin**

Job No: 2007.0212
Date: 16-Feb-10

Sheet No 1 of 1

Estimated by: T. Rundle
Review by: T. Kerby

Note: Cost estimates provided by Tonkin Consulting are based upon historic cost information and experience, and do not allow for latent conditions, changes in scope and market conditions (ie competition, escalation, changes to public and private utility policies in regards to relocation and augmentation of services).

Tonkin Consulting recommend that a professional Quantity Surveyor be engaged if assurance of cost is required and project budget estimates allowing for these factors are required.

Item No	Description	Unit	Qty	Rate	Cost
1	**Preliminaries**				
1.1	Establishment	item	1	$100,000	$100,000
1.2	Setting out	item	1	$30,000	$30,000
2	**Stormwater Drainage**				
2.1	3.0m wide by 1.2m high Box Culvert diversion pipe	m	160	$3,500	$560,000
2.2	375mm Class 3 RCP	m	160	$300	$48,000
2.3	Outlet Headwall with scour protection	ea	2	$12,000	$24,000
3	**Earthworks**				
3.1	Dog park dam - overburden	m^3	20,400	$30	$612,000
3.2	Dog park dam - excavation	m^3	24,000	$30	$720,000
4	**Miscellaneous**				
4.1	Land Acquisition - not included	ha			
4.2	Traffic control	item	1	$15,000	$15,000
4.3	Landscaping, planting	m^2	30000	$14	$420,000
4.4	Engineering design and survey	item	1	$140,000	$140,000
4.5	Cleaning up	item	1	$10,000	$10,000
4.6	Testing	item	1	$30,000	$30,000

Sub-Total	**$2,709,000**
Contingencies (20%)	**$541,800**
TOTAL	$3,250,800

INDICATIVE CONSTRUCTION COST ESTIMATE FOR CEMETARY BASIN AND DIVERSION PIPE

Project: **NAE SMP - Cemetery basin and diversion pipe**

Job No: 2007.0212
Date: 16-Feb-10

Sheet No 1 of 1

Estimated by: T. Rundle
Review by: T. Kerby

Note: Cost estimates provided by Tonkin Consulting are based upon historic cost information and experience, and do not allow for latent conditions, changes in scope and market conditions (ie competition, escalation, changes to public and private utility policies in regards to relocation and augmentation of services).

Tonkin Consulting recommend that a professional Quantity Surveyor be engaged if assurance of cost is required and project budget estimates allowing for these factors are required.

Item No	Description	Unit	Qty	Rate	Cost
1	**Preliminaries**				
1.1	Establishment	item	1	$80,000	$80,000
1.2	Setting out	item	1	$30,000	$30,000
2	**Stormwater Drainage**				
2.1	900 dia class 2 RCP pipe	m	220	$850	$187,000
2.2	825 dia class 2 RCP pipe	m	750	$800	$600,000
2.3	Junction Box	ea	12	$8,000	$96,000
2.4	Outlet Headwall with scour protection	ea	1	$15,000	$15,000
3	**Earthworks**				
3.1	Cemetary detention basin embankment	m^3	16,500	$18	$297,000
4	**Miscellaneous**				
4.1	Traffic control	item	1	$25,000	$25,000
4.2	Landscaping, planting	m^2	6000	$14	$84,000
4.3	Engineering design and survey	item	1	$120,000	$120,000
4.4	Cleaning up	item	1	$15,000	$15,000
4.5	Testing	item	1	$20,000	$20,000
4.6	Service alterations	ea	5	$20,000	$100,000

Sub-Total	**$1,669,000**
Contingencies (20%)	**$333,800**
TOTAL	$2,002,800

INDICATIVE CONSTRUCTION COST ESTIMATE FOR
MARMION AVENUE DIVERSION DRAIN

Project: **NAE SMP - Marmion Avenue diversion drain**

Job No: 2007.0212
Date: 16-Feb-10

Sheet No 1 of 1

Estimated by: T. Rundle
Review by: T. Kerby

conditions, changes in scope and market conditions (ie competition, escalation, changes to public and private utility policies in regards to estimates allowing for these factors are required.

Item No	Description	Unit	Qty	Rate	Cost
1	**Preliminaries**				
1.1	Establishment	item	1	$80,000	$80,000
1.2	Setting out	item	1	$30,000	$30,000
2	**Stormwater Drainage**				
2.1	1200 dia class 2 RCP diversion pipe	m	1460	$1,300	$1,898,000
2.2	Interception Structure / splitter box	item	1	$25,000	$25,000
2.3	1500 square Junction Box	ea	12	$8,000	$96,000
2.4	Outlet Headwall	ea	1	$15,000	$15,000
3	**Miscellaneous**				
3.1	Traffic control	item	1	$25,000	$25,000
3.2	Engineering design and survey	item	1	$140,000	$140,000
3.3	Cleaning up	item	1	$15,000	$15,000
3.4	Testing	item	1	$20,000	$20,000
3.5	Service alterations	ea	10	$20,000	$200,000

Sub-Total	**$2,544,000**
Contingencies (20%)	**$508,800**
TOTAL	$3,052,800

INDICATIVE CONSTRUCTION COST ESTIMATE FOR
NAE OUTFALL CHANNEL UPGRADE

Project: **NAE SMP - Channel Upgrade**

Job No: 2007.0212
Date: 14-Sep-10

Sheet No 1 of 1

Estimated by: T. Rundle
Review by: T. Kerby

Note: Cost estimates provided by Tonkin Consulting are based upon historic cost information and experience, and do not allow for latent conditions, changes in scope and market conditions (ie competition, escalation, changes to public and private utility policies in regards to relocation and augmentation of services).

Tonkin Consulting recommend that a professional Quantity Surveyor be engaged if assurance of cost is required and project budget estimates allowing for these factors are required.

Item No	Description	Unit	Qty	Rate	Cost
1	**Preliminaries**				
1.1	Establishment	item	1	$ 150,000	$150,000
1.2	Setting out	item	1	$ 25,000	$25,000
2	**Earthworks and channel upgrades**				
2.1	Widening existing channel - Start of channel to d/s of Northcote Street	m	665	$ 1,700	$1,130,500
2.2	Widening existing channel - D/s Northcote Street to d/s of Grand Junction Road	m	1,300	$ 2,000	$2,600,000
2.3	Total channel demolition and widening - D/s Grand Junction Road to d/s of Railway reserve	m	930	$ 6,100	$5,673,000
2.4	Total channel demolition and widening - D/s Railway reserve to end of channel	m	800	$ 7,700	$6,160,000
3	**Stormwater drainage**				
3.1	Culvert road crossings - Jersey Avenue to Northcote Street (5.5 m wide x 1.8 m high)	m^2	715	$ 2,000	$1,430,000
3.2	Culvert road crossings - Brunswick Street to Grand Junction Road (3 x 3 m wide x 1.5 m high)	m^2	800	$ 2,600	$2,080,000
3.3	Culvert road crossings - Cavan Road to Railway crossing (5 x 3 m wide x 1.45 m high)	m^2	1,020	$ 2,500	$2,550,000
3.4	Culvert road crossings - Cormack Road to Railway crossing (5 x 3 m wide x 1.45 m high)	m^2	740	$ 2,500	$1,850,000
4	**Miscellaneous**				
4.1	Traffic control	item	1	$ 200,000	$200,000
4.2	Engineering design and survey	item	1	$ 400,000	$400,000
4.3	Cleaning up	item	1	$ 40,000	$40,000
4.4	Testing	item	1	$ 30,000	$30,000

Sub-Total	**$24,318,500**
Contingencies (20%)	**$4,863,700**
TOTAL	$29,182,200

INDICATIVE CONSTRUCTION COST ESTIMATE FOR
REPLACE CHANNEL, LIKE FOR LIKE (I.E ASSET RENEWAL ONLY)

Project: **NAE SMP**

Job No: 2007.0212
Date: 9-Sep-10

Sheet No 1 of 1

Estimated by: T. Rundle
Review by: T. Kerby

Note: Cost estimates provided by Tonkin Consulting are based upon historic cost information and experience, and do not allow for latent conditions, changes in scope and market conditions (ie competition, escalation, changes to public and private utility policies in regards to relocation and augmentation of services).

Tonkin Consulting recommend that a professional Quantity Surveyor be engaged if assurance of cost is required and project budget estimates allowing for these factors are required.

Item No	Description	Unit	Qty	Rate	Cost
1	**Preliminaries**				
1.1	Establishment	item	1	$ 150,000	$150,000
1.2	Setting out	item	1	$ 25,000	$25,000
2	**Earthworks and channel upgrades**				
2.1	Widening existing channel - Start of channel to d/s of Northcote Street	m	665	$ 1,500	$997,500
2.2	Widening existing channel - D/s Northcote Street to d/s of Grand Junction Road	m	1,300	$ 1,500	$1,950,000
2.3	Total channel demolition and widening - D/s Grand Junction Road to d/s of Railway reserve	m	930	$ 5,000	$4,650,000
2.4	Total channel demolition and widening - D/s Railway reserve to end of channel	m	800	$ 6,000	$4,800,000
3	**Stormwater drainage**				
3.1	Culvert road crossings - Jersey Avenue to Northcote Street (5.5 m wide x 1.8 m high)	m^2	715	$ 1,700	$1,215,500
3.2	Culvert road crossings - Brunswick Street to Grand Junction Road (3 x 3 m wide x 1.5 m high)	m^2	800	$ 1,700	$1,360,000
3.3	Culvert road crossings - Cavan Road to Railway crossing (5 x 3 m wide x 1.45 m high)	m^2	1,020	$ 2,000	$2,040,000
3.4	Culvert road crossings - Cormack Road to Railway crossing (5 x 3 m wide x 1.45 m high)	m^2	740	$ 2,000	$1,480,000
4	**Miscellaneous**				
4.1	Traffic control	item	1	$ 200,000	$200,000
4.2	Engineering design and survey	item	1	$ 400,000	$400,000
4.3	Cleaning up	item	1	$ 40,000	$40,000
4.4	Testing	item	1	$ 30,000	$30,000

Sub-Total	**$19,338,000**
Contingencies (20%)	**$3,867,600**
TOTAL	$23,205,600

INDICATIVE CONSTRUCTION COST ESTIMATE FOR
NAE OUTFALL CHANNEL UPGRADE

Project: **NAE SMP - Channel Upgrade - Grassed Lined - Way to Marmion**

Job No: 2007.0212
Date: 22-Jan-13 Sheet No 1 of 1

Estimated by: T. Rundle
Review by: T. Kerby

Note: Cost estimates provided by Tonkin Consulting are based upon historic cost information and experience, and do not allow for latent conditions, changes in scope and market conditions (ie competition, escalation, changes to public and private utility policies in regards to relocation and augmentation of services).

Tonkin Consulting recommend that a professional Quantity Surveyor be engaged if assurance of cost is required and project budget estimates allowing for these factors are required.

Item No	Description	Unit	Qty	Rate	Cost
1	**Preliminaries**				
1.1	Establishment	item	1	$ 40,000	$30,000
1.2	Setting out	item	1	$ 10,000	$10,000
2	**Earthworks and channel upgrades**				
2.1	Total Channel demolition and widening d/s Way to d/s Marmion Ave. 20m base width, 1.4m deep, 1 in 5 side slopes	m	880	$ 600	$528,000
2.2	Landscaping open channel	m	880	$ 350	$308,000
3	**Stormwater drainage**				
3.1	Culvert road crossings -Way Street to Marmion (6 x 3 m wide x 1.5 m high)	m^2	1,400	$ 2,000	$2,800,000
4	**Miscellaneous**				
4.1	Traffic control	item	1	$ 60,000	$40,000
4.2	Engineering design and survey	item	1	$ 80,000	$80,000
4.3	Cleaning up	item	1	$ 10,000	$10,000
4.4	Testing	item	1	$ 5,000	$5,000

Sub-Total	**$3,811,000**
Contingencies (20%)	**$762,200**
TOTAL	$4,573,200

INDICATIVE CONSTRUCTION COST ESTIMATE FOR
ENFIELD HIGH SCHOOL BASIN

Project: **NAE SMP - Enfield High School Basin Surface Interception only**

Job No: 2007.0212
Date: 19-Sep-12 Sheet No 1 of 1

Estimated by: T. Kerby
Review by: T. Cresswell

Note: Cost estimates provided by Tonkin Consulting are based upon historic cost information and experience, and do not allow for latent conditions, changes in scope and market conditions (ie competition, escalation, changes to public and private utility policies in regards to relocation and augmentation of services).

Tonkin Consulting recommend that a professional Quantity Surveyor be engaged if assurance of cost is required and project budget estimates allowing for these factors are required.

Item No	Description	Unit	Qty	Rate	Cost
1	**Preliminaries**				
1.1	Establishment	item	1	$15,000	$15,000
1.2	Setting out	item	1	$10,000	$10,000
2	**Stormwater Drainage**				
2.1	New 375mm RCP outlet pipe	m	30	$300	$9,000
2.2	Connection to existing drain	ea	1	$5,000	$5,000
3	**Earthworks**				
3.1	Diversion channel	m	250	$150	$37,500
3.2	Basin excavation	m^3	8,000	$25	$200,000
3.3	Perimeter embankment	m^3	1,500	$35	$52,500
4	**Miscellaneous**				
4.1	Land Acquisition - not included	ha			
4.2	Traffic control	item	1	$10,000	$10,000
4.3	Landscaping, planting	m^2	24000	$14	$336,000
4.4	Engineering design and survey	item	1	$60,000	$60,000
4.5	Cleaning up	item	1	$10,000	$10,000
4.6	Testing	item	1	$15,000	$15,000

Sub-Total	**$760,000**
Contingencies (20%)	**$152,000**
TOTAL	$912,000

INDICATIVE CONSTRUCTION COST ESTIMATE FOR
ENFIELD HIGH SCHOOL BASIN

Project: **NAE SMP - Enfield High School Basin Surface and Piped flow interception**

Job No: 2007.0212
Date: 27-Mar-14

Sheet No 1 of 1

Estimated by: T. Kerby
Review by: E. Johnson

Note: Cost estimates provided by Tonkin Consulting are based upon historic cost information and experience, and do not allow for latent conditions, changes in scope and market conditions (ie competition, escalation, changes to public and private utility policies in regards to relocation and augmentation of services). No allowance for existing site services to be modified. No allowances for dewatering of excavation or encountering groundwater.

Tonkin Consulting recommend that a professional Quantity Surveyor be engaged if assurance of cost is required and project budget estimates allowing for these factors are required.

Item No	Description	Unit	Qty	Rate	Cost
1	**Preliminaries**				
1.1	Establishment	item	1	$100,000	$100,000
1.2	Setting out	item	1	$25,000	$25,000
2	**Stormwater Drainage**				
2.1	New 300mm RCP outlet pipe	m	45	$270	$12,150
2.2	New 1050mm RCP inlet pipe	m	45	$950	$42,750
2.3	Flow split junction boxes	ea	2	$8,000	$16,000
2.4	Headwalls	ea	2	$5,000	$10,000
3	**Earthworks**				
3.1	Strip and stock topsoil (100mm)	m^3	3000	$7	$21,000
3.2	Diversion channel	m	250	$150	$37,500
3.3	Basin excavation	m^3	33,000	$20	$660,000
3.4	Permenant water basin	m^3	6,000	$20	$120,000
3.5	Clay lining permanent water basin	m^2	6,000	$25	$150,000
3.6	Perimeter embankment (reuse excavated material)	m^3	3,000	$30	$90,000
4	**Pump and Rising Main**				
4.1	100L/s capacity pump station and sump	item	1	$70,000	$70,000
4.2	300mm rising main	m	2600	$250	$650,000
4.3	Electrical supply	item	1	$30,000	$30,000
5	**Miscellaneous**				
5.1	Land Acquisition - not included	ha	1.6	$0	$0
5.2	Subsoil drainage systesm	m2	650	$40	$26,000
5.3	Traffic control	item	1	$10,000	$10,000
5.4	Landscaping, planting	m^2	29000	$12	$348,000
5.5	Engineering design and survey	item	1	$80,000	$80,000
5.6	Cleaning up	item	1	$10,000	$10,000
5.7	Testing	item	1	$15,000	$15,000

Sub-Total	**$2,523,400**
Contingencies (20%)	**$504,680**
TOTAL	$3,028,080

INDICATIVE CONSTRUCTION COST ESTIMATE FOR
OPTION 1: PARTIAL DIVERSION

Project: **NAE SMP - SPORTS PARK**

Job No: 2007.0212
Date: 29-May-11 Sheet No 1 of 1

Estimated by: T. Rundle
Review by: T. Kerby

Note: Cost estimates provided by Tonkin Consulting are based upon historic cost information and experience, and do not allow for latent conditions, changes in scope and market conditions (ie competition, escalation, changes to public and private utility policies in regards to relocation and augmentation of services).

Tonkin Consulting recommend that a professional Quantity Surveyor be engaged if assurance of cost is required and project budget estimates allowing for these factors are required.

Item No	Description	Unit	Qty	Rate	Cost
1	**Preliminaries**				
1.1	Establishment	item	1	$100,000	$100,000
1.2	Setting out	item	1	$30,000	$30,000
2	**Stormwater Drainage**				
2.1	450 dia class 2 RCP diversion pipe	m	400	$400	$160,000
2.2	Junction Box	ea	6	$2,500	$15,000
2.3	Outlet Headwall with scour protection	ea	1	$8,000	$8,000
3	**ASR Component**				
3.1	Aquifer injection pump and pump station	item	1	$60,000	$60,000
3.2	Control and monitoring system	item	1	$50,000	$50,000
3.3	Drilling new bores	each	2	$40,000	$80,000
3.4	Boreheads	each	2	$10,000	$20,000
4	**Earthworks**				
4.1	Forreseter Forrest detention basin embankment	m^3	20,000	$18	$360,000
4.2	South-west basin embankment enlargements	m^3	1,000	$22	$22,000
4.3	Silt basin excavation, cut to fill on site	m^3	2,500	$12	$30,000
4.4	Wetland body excavation, cut to fill on site	m^3	11,000	$12	$132,000
4.5	Wetland clay lining and placement of growing medium	m^2	9,000	$25	$225,000
5	**Miscellaneous**				
5.1	Traffic control	item	1	$15,000	$15,000
5.2	Landscaping, planting	m^2	9000	$14	$126,000
5.3	Engineering design and survey	item	1	$120,000	$120,000
5.4	Cleaning up	item	1	$10,000	$10,000
5.5	Testing	item	1	$15,000	$15,000

Sub-Total	**$1,578,000**
Contingencies (20%)	**$315,600**
TOTAL	$1,893,600

INDICATIVE CONSTRUCTION COST ESTIMATE FOR
OPTION 2: FULL DIVERSION AT AMBER AVE

Project: **NAE SMP - SPORTS PARK**

Job No: 2007.0212
Date: 29-May-11

Estimated by: T. Rundle
Review by: T. Kerby

Note: Cost estimates provided by Tonkin Consulting are based upon historic cost information and experience, and do not allow for latent conditions, changes in scope and market conditions (ie competition, escalation, changes to public and private utility policies in regards to relocation and augmentation of services).

Tonkin Consulting recommend that a professional Quantity Surveyor be engaged if assurance of cost is required and project budget estimates allowing for these factors are required.

Item No	Description	Unit	Qty	Rate	Cost
1	**Preliminaries**				
1.1	Establishment	item	1	$100,000	$100,000
1.2	Setting out	item	1	$30,000	$30,000
2	**Stormwater Drainage**				
2.1	1050 dia class 2 RCP diversion pipe	m	440	$950	$418,000
2.2	Double SEP	ea	8	$2,500	$20,000
2.3	Junction Box	ea	4	$6,000	$24,000
2.4	Outlet Headwall with scour protection	ea	1	$12,000	$12,000
3	**ASR Component**				
3.1	Aquifer injection pump and pump station	item	1	$60,000	$60,000
3.2	Control and monitoring system	item	1	$50,000	$50,000
3.3	Drilling new bores	each	2	$40,000	$80,000
3.4	Boreheads	each	2	$10,000	$20,000
4	**Earthworks**				
4.1	Forreseter Forrest detention basin embankment	m^3	24,000	$18	$432,000
4.2	South-west basin embankment enlargements	m^3	1,000	$22	$22,000
4.3	Silt basin excavation, cut to fill on site	m^3	2,500	$12	$30,000
4.4	Wetland body excavation, cut to fill on site	m^3	11,000	$12	$132,000
4.5	Wetland clay lining and placement of growing medium	m^2	9,000	$25	$225,000
5	**Miscellaneous**				
5.1	Traffic control	item	1	$15,000	$15,000
5.2	Landscaping, planting	m^2	9000	$14	$126,000
5.3	Engineering design and survey	item	1	$120,000	$120,000
5.4	Cleaning up	item	1	$10,000	$10,000
5.5	Testing	item	1	$15,000	$15,000

Sub-Total	**$1,941,000**
Contingencies (20%)	**$388,200**
TOTAL	$2,329,200

INDICATIVE CONSTRUCTION COST ESTIMATE FOR
OPTION 2B: FULL DIVERSION AT AMBER AVE, NEW OUTFALL PIPE

Project: **NAE SMP - SPORTS PARK**

Job No: 2007.0212
Date: 29-May-11

Sheet No 1 of 1

Estimated by: T. Rundle
Review by: T. Kerby

Note: Cost estimates provided by Tonkin Consulting are based upon historic cost information and experience, and do not allow for latent conditions, changes in scope and market conditions (ie competition, escalation, changes to public and private utility policies in regards to relocation and augmentation of services).

Tonkin Consulting recommend that a professional Quantity Surveyor be engaged if assurance of cost is required and project budget estimates allowing for these factors are required.

Item No	Description	Unit	Qty	Rate	Cost
1	**Preliminaries**				
1.1	Establishment	item	1	$100,000	$100,000
1.2	Setting out	item	1	$30,000	$30,000
2	**Stormwater Drainage**				
2.1	1050 dia class 2 RCP diversion pipe	m	440	$950	$418,000
2.2	450 dia class 2 RCP outfall pipe	m	580	$320	$185,600
2.3	375 dia class2 RCP	m	40	$280	$11,200
2.4	Double SEP	ea	9	$2,500	$22,500
2.5	Junction Box	ea	12	$6,000	$72,000
2.6	Outlet Headwall with scour protection	ea	1	$12,000	$12,000
3	**ASR Component**				
3.1	Aquifer injection pump and pump station	item	1	$60,000	$60,000
3.2	Control and monitoring system	item	1	$50,000	$50,000
3.3	Drilling new bores	each	2	$40,000	$80,000
3.4	Boreheads	each	2	$10,000	$20,000
4	**Earthworks**				
4.1	Forrester Forrest detention basin embankment	m^3	9,000	$18	$162,000
4.2	South-west basin embankment enlargements	m^3	1,000	$22	$22,000
4.3	Silt basin excavation, cut to fill on site	m^3	2,500	$12	$30,000
4.4	Wetland body excavation, cut to fill on site	m^3	11,000	$12	$132,000
4.5	Vegetated swale drains	m	300	$80	$24,000
4.6	Mini basins with rock spillways	each	3	$25,000	$75,000
4.7	Wetland clay lining and placement of growing medium	m^2	9,000	$25	$225,000
5	**Miscellaneous**				
5.1	Traffic control	item	1	$15,000	$15,000
5.2	Landscaping, planting	m^2	9000	$14	$126,000
5.3	Engineering design and survey	item	1	$120,000	$120,000
5.4	Cleaning up	item	1	$10,000	$10,000
5.5	Testing	item	1	$15,000	$15,000

Sub-Total	**$2,017,300**
Contingencies (20%)	**$403,460**
TOTAL	$2,420,760

INDICATIVE CONSTRUCTION COST ESTIMATE FOR
OPTION 3: FULL DIVERSION AT AMBER AVE AND PARK TCE

Project: **NAE SMP - SPORTS PARK**

Job No: 2007.0212
Date: 29-May-11 Sheet No 1 of 1

Estimated by: T. Rundle
Review by: T. Kerby

Note: Cost estimates provided by Tonkin Consulting are based upon historic cost information and experience, and do not allow for latent conditions, changes in scope and market conditions (ie competition, escalation, changes to public and private utility policies in regards to relocation and augmentation of services).

Tonkin Consulting recommend that a professional Quantity Surveyor be engaged if assurance of cost is required and project budget estimates allowing for these factors are required.

Item No	Description	Unit	Qty	Rate	Cost
1	**Preliminaries**				
1.1	Establishment	item	1	$120,000	$120,000
1.2	Setting out	item	1	$30,000	$30,000
2	**Stormwater Drainage**				
2.1	1350 dia class 2 RCP diversion pipe (deep excavation)	m	350	$2,100	$735,000
2.2	1500 dia class 2 RCP diversion pipe	m	450	$1,700	$765,000
2.3	Double SEP	ea	16	$2,500	$40,000
2.4	Junction Box	ea	8	$8,000	$64,000
2.5	Outlet Headwall with scour protection	ea	1	$15,000	$15,000
3	**ASR Component**				
3.1	Aquifer injection pump and pump station	item	1	$60,000	$60,000
3.2	Control and monitoring system	item	1	$50,000	$50,000
3.3	Drilling new bores	each	3	$40,000	$120,000
3.4	Boreheads	each	3	$10,000	$30,000
4	**Earthworks**				
4.1	Forreseter Forrest detention basin embankment	m^3	26,000	$18	$468,000
4.2	South-west basin embankment enlargements	m^3	1,000	$22	$22,000
4.3	Silt basin excavation, cut to fill on site	m^3	3,500	$12	$42,000
4.4	Wetland body excavation, cut to fill on site	m^3	15,000	$12	$180,000
4.5	Wetland clay lining and placement of growing medium	m^2	12,500	$25	$312,500
5	**Miscellaneous**				
5.1	Traffic control	item	1	$25,000	$25,000
5.2	Landscaping, planting	m^2	12500	$14	$175,000
5.3	Engineering design and survey	item	1	$140,000	$140,000
5.4	Cleaning up	item	1	$15,000	$15,000
5.5	Testing	item	1	$20,000	$20,000

Sub-Total	**$3,428,500**
Contingencies (20%)	**$685,700**
TOTAL	$4,114,200

INDICATIVE CONSTRUCTION COST ESTIMATE FOR
DIVERT WATER TO SALISBURY FOR TREATMENT AND HARVESTING

Project: **NAE SMP - SPORTS PARK**

Job No: 2007.0212
Date: 29-May-11

Sheet No 1 of 1

Estimated by: T. Rundle
Review by: T. Kerby

Note: Cost estimates provided by Tonkin Consulting are based upon historic cost information and experience, and do not allow for latent conditions, changes in scope and market conditions (ie competition, escalation, changes to public and private utility policies in regards to relocation and augmentation of services).

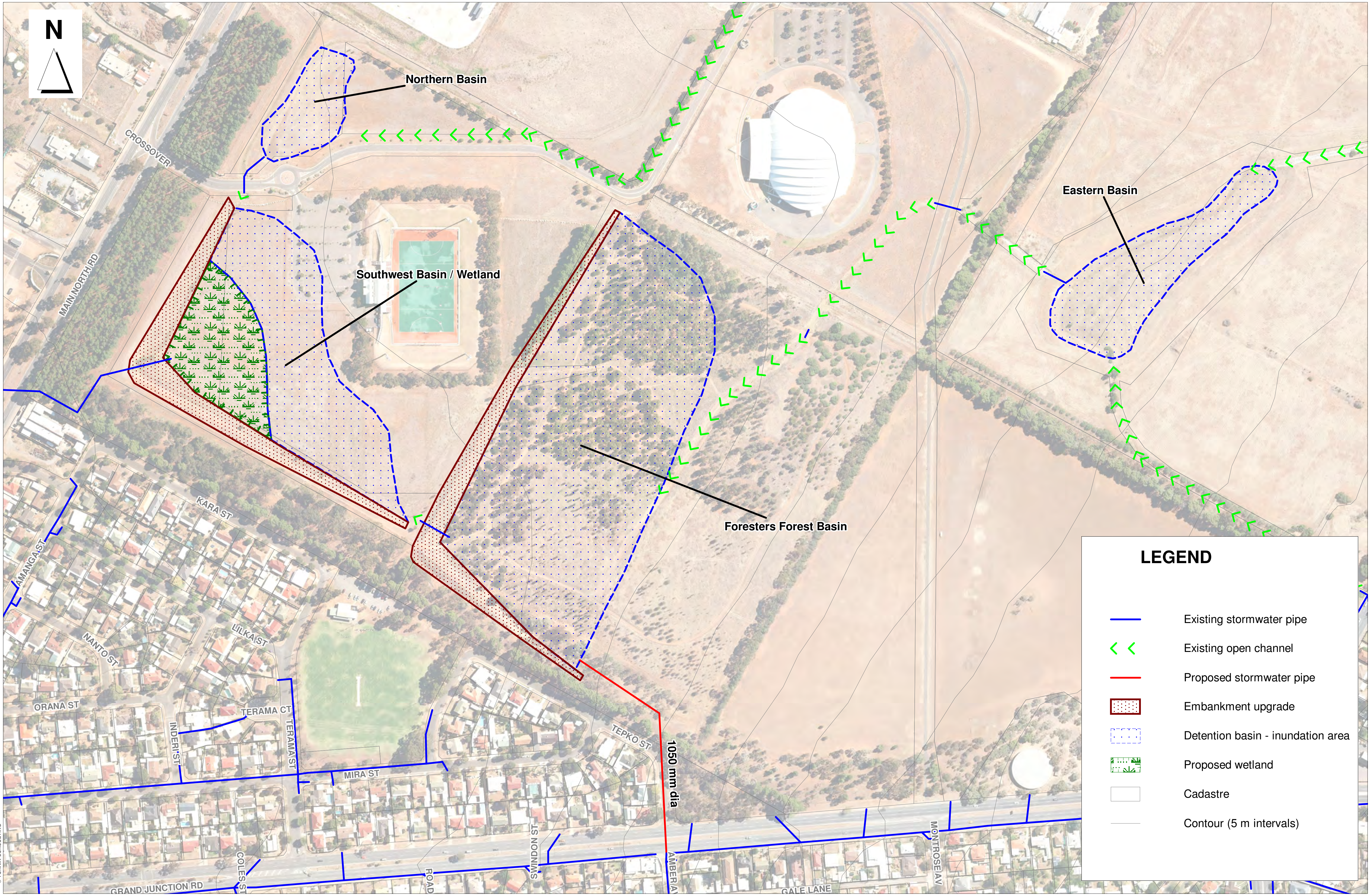
Tonkin Consulting recommend that a professional Quantity Surveyor be engaged if assurance of cost is required and project budget estimates allowing for these factors are required.

Item No	Description	Unit	Qty	Rate	Cost
1	**Preliminaries**				
1.1	Establishment	item	1	$50,000	$50,000
1.2	Setting out	item	1	$15,000	$15,000
2	**Pump and Rising Main**				
2.1	30L/s capacity pump station and sump	item	1	$40,000	$40,000
2.2	180mm rising main	m	1800	$140	$252,000
2.3	Electrical supply	item	1	$30,000	$30,000
3	**Earthworks**				
3.1	South-west basin retention storage cut to fill on site	m^3	6,000	$12	$72,000
3.2	Retention basin clay lining	m^2	2,500	$20	$50,000
4	**Miscellaneous**				
4.1	Traffic control	item	1	$5,000	$5,000
4.3	Engineering design and survey	item	1	$60,000	$60,000
4.4	Cleaning up	item	1	$5,000	$5,000
4.5	Testing	item	1	$8,000	$8,000

Sub-Total	**$587,000**
Contingencies (20%)	**$117,400**
TOTAL	$704,400

Appendix B

Stormwater Management Opportunities



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MAP DETAILS

Cadastral Data:	PBBI Australia
Drainage Data:	Tonkin Consulting
Job Number:	2007.0212
Filename:	SSP2.wor
Drawn:	Todd Rundle
Date:	16/11/2012

-70 0 70 140 210

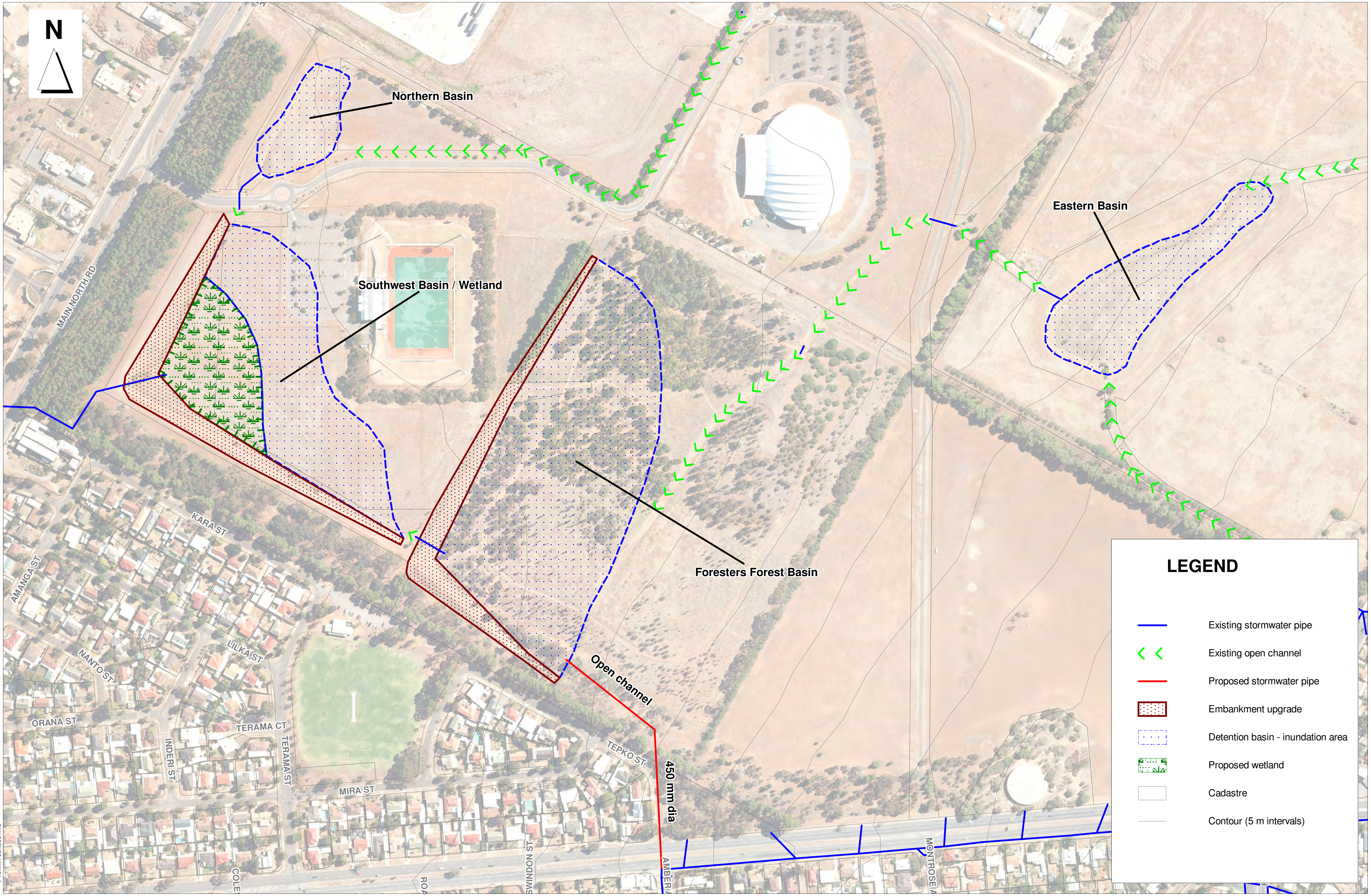
Meters

Scale: 1:3,500

City of Port Adelaide Enfield

State Sports Park
Stormwater Opportunities
Full Stormwater Diversion - Amber Tce

Figure 2



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MAP DETAILS

Cadastral Data:	PBBI Australia
Drainage Data:	Tonkin Consulting
Job Number:	2007.0212
Filename:	SSP1.wor
Drawn:	Todd Rundle
Date:	16/11/2012

-70 0 70 140 210

Meters

Scale: 1:3,500

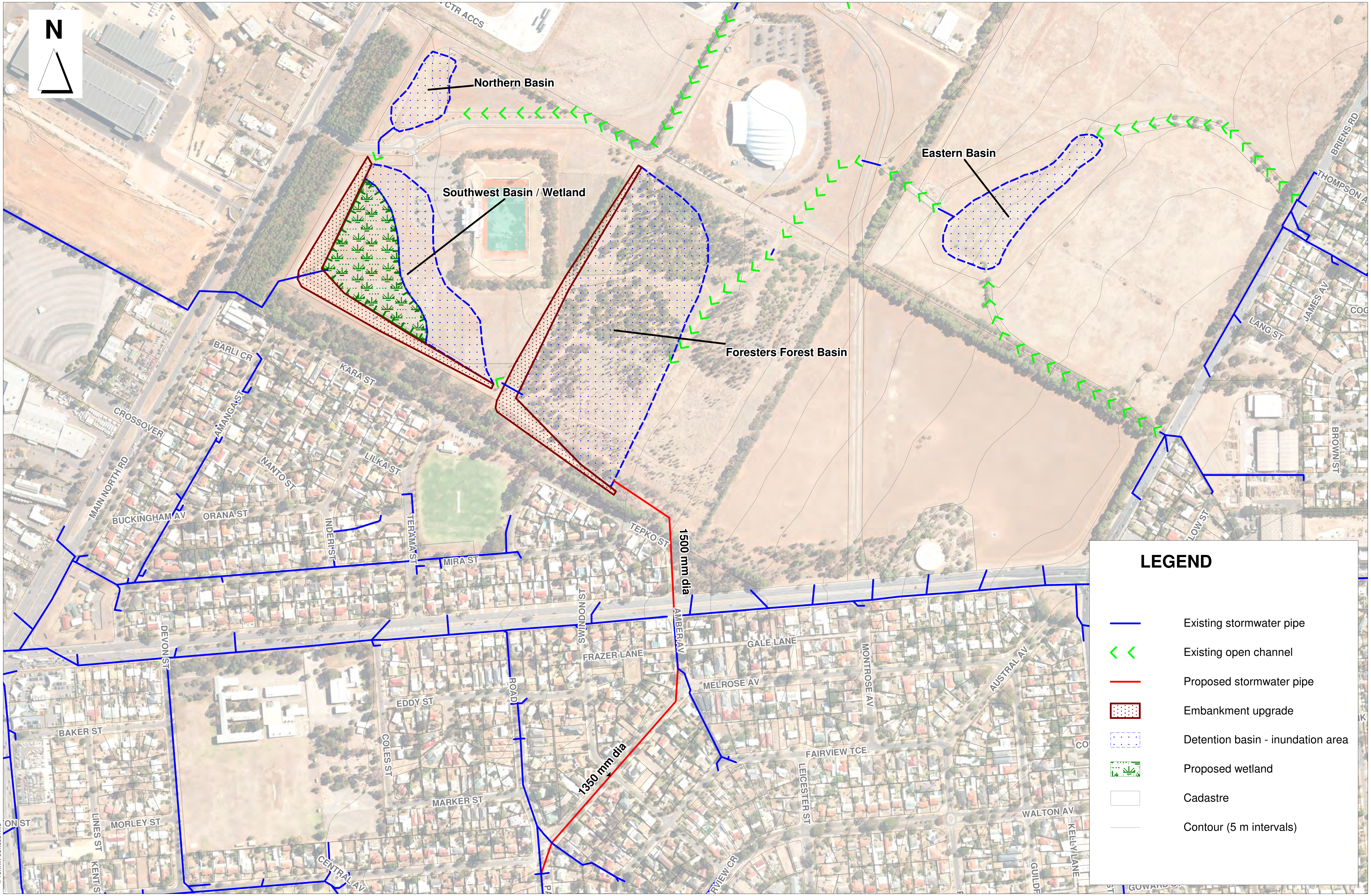
City of Port Adelaide Enfield

State Sports Park

Stormwater Opportunities

Partial Stormwater Diversion - Amber Tce

Figure 1



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MAP DETAILS

Cadastral Data:	PBBI Australia
Drainage Data:	Tonkin Consulting
Job Number:	2007.0212
Filename:	SSP3.wor
Drawn:	Todd Rundle
Date:	16/11/2012

-100 0 100 200 300
Meters

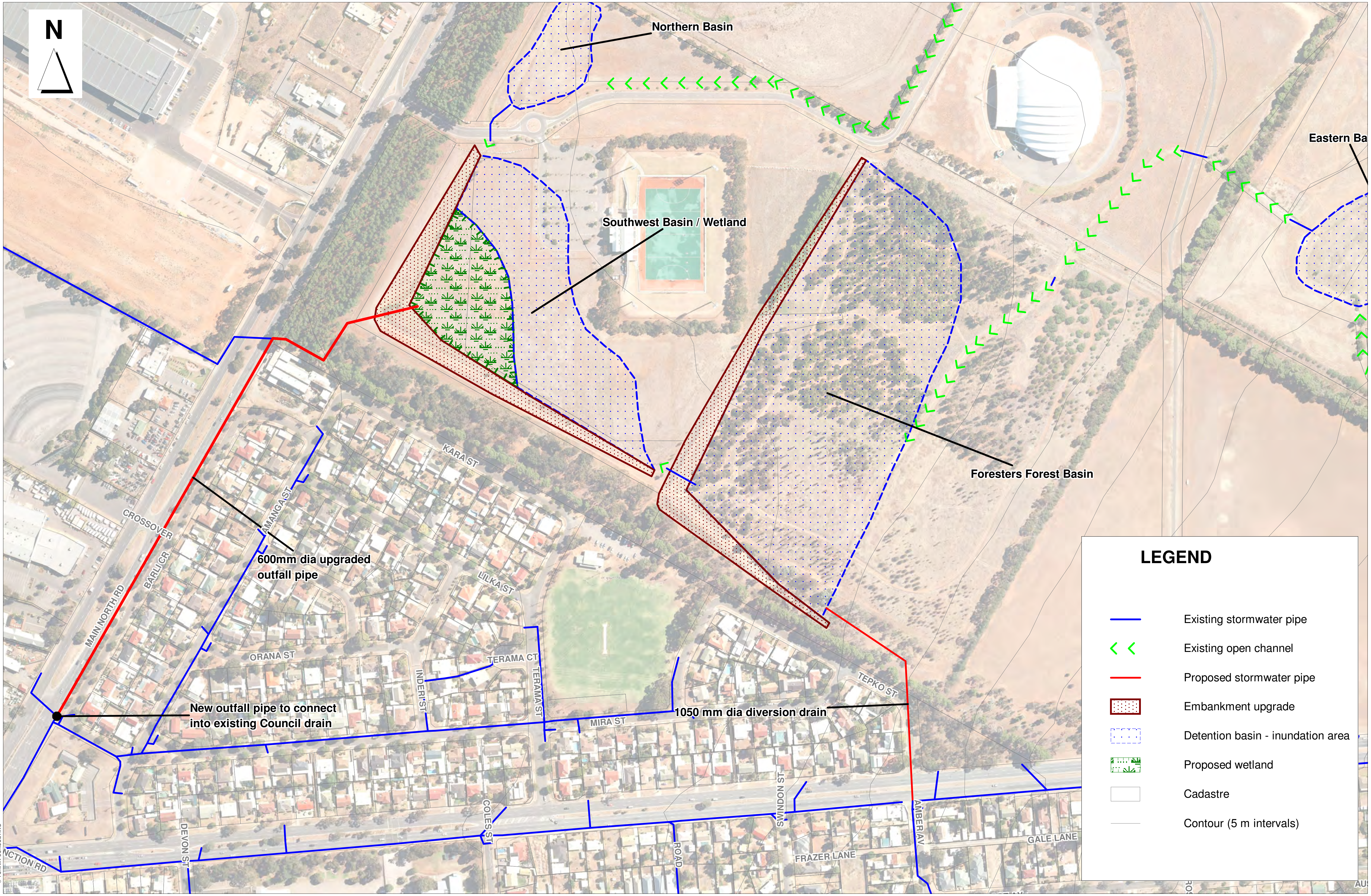
Scale: 1:5,000

City of Port Adelaide Enfield

State Sports Park
Stormwater Opportunities

Full Stormwater Diversion - Amber Ave and Park Tce

Figure 3



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Drainage Data:	Tonkin Consulting
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Filename:	SSP4-UO.wor
Drawn:	Todd Rundle
Date:	16/11/2012

-70 0 70 140 210

Meters

Scale: 1:3,500

City of Port Adelaide Enfield

State Sports Park

Stormwater Opportunities

Full Stormwater Diversion - Amber Tce with upgraded outfall pipe

Figure 4

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Filename:	SSP5.wor
Drawn:	Todd Rundle
Date:	16/11/2012

-100 0 100 200 300

Meters

Scale: 1:5,000

City of Port Adelaide Enfield

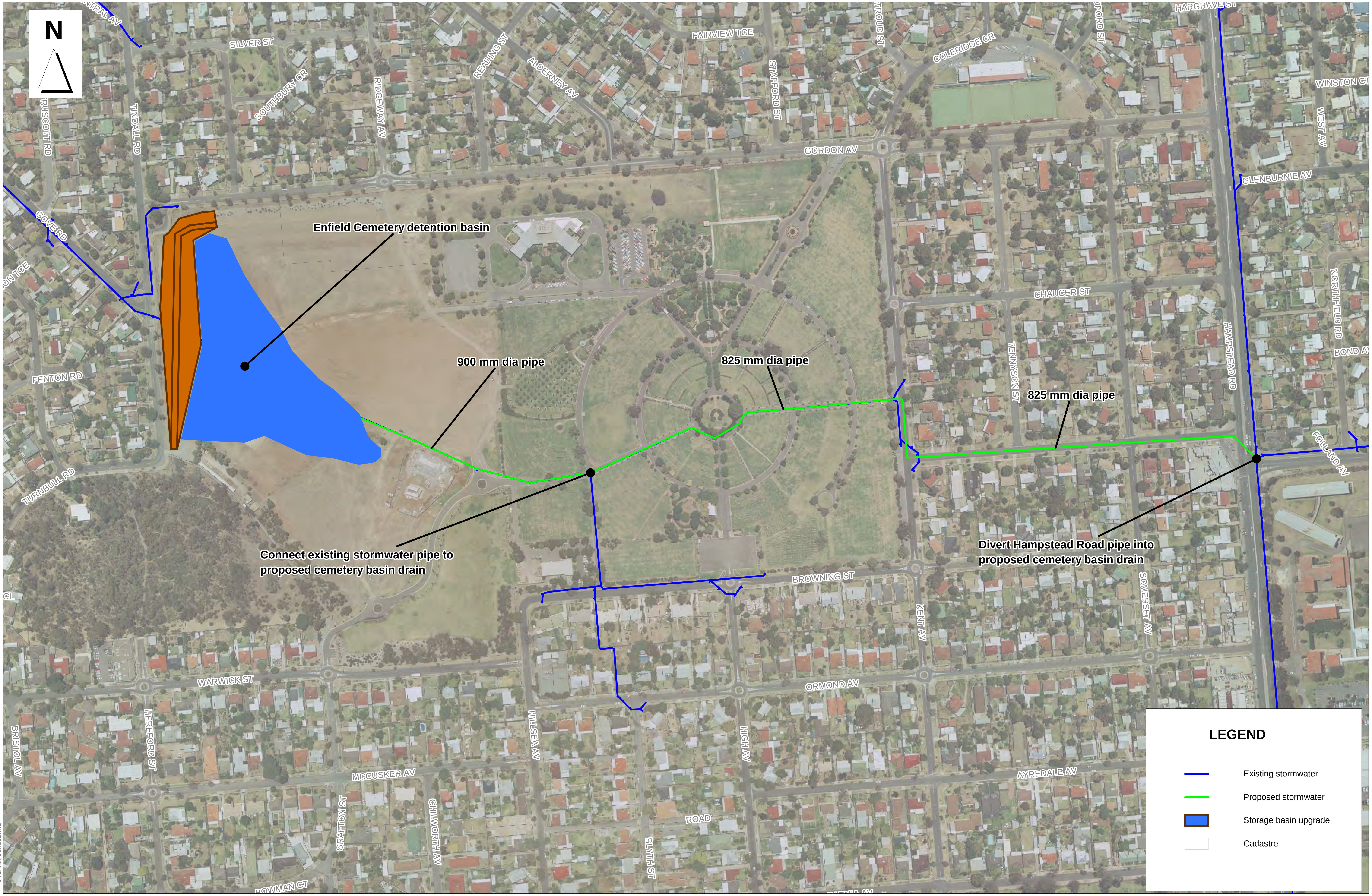
State Sports Park

Stormwater Opportunities

Pumped discharge to City of Salisbury stormwater harvesting scheme

Possible for all options

Figure 5



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MAP DETAILS

Cadastral Data:	PBBI Australia
Drainage Data:	Tonkin Consulting
Job Number:	2007.0212
Filename:	AppBFig6.wor
Drawn:	Todd Rundle
Date:	04/02/2011

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Meters

Scale: 1:3,500

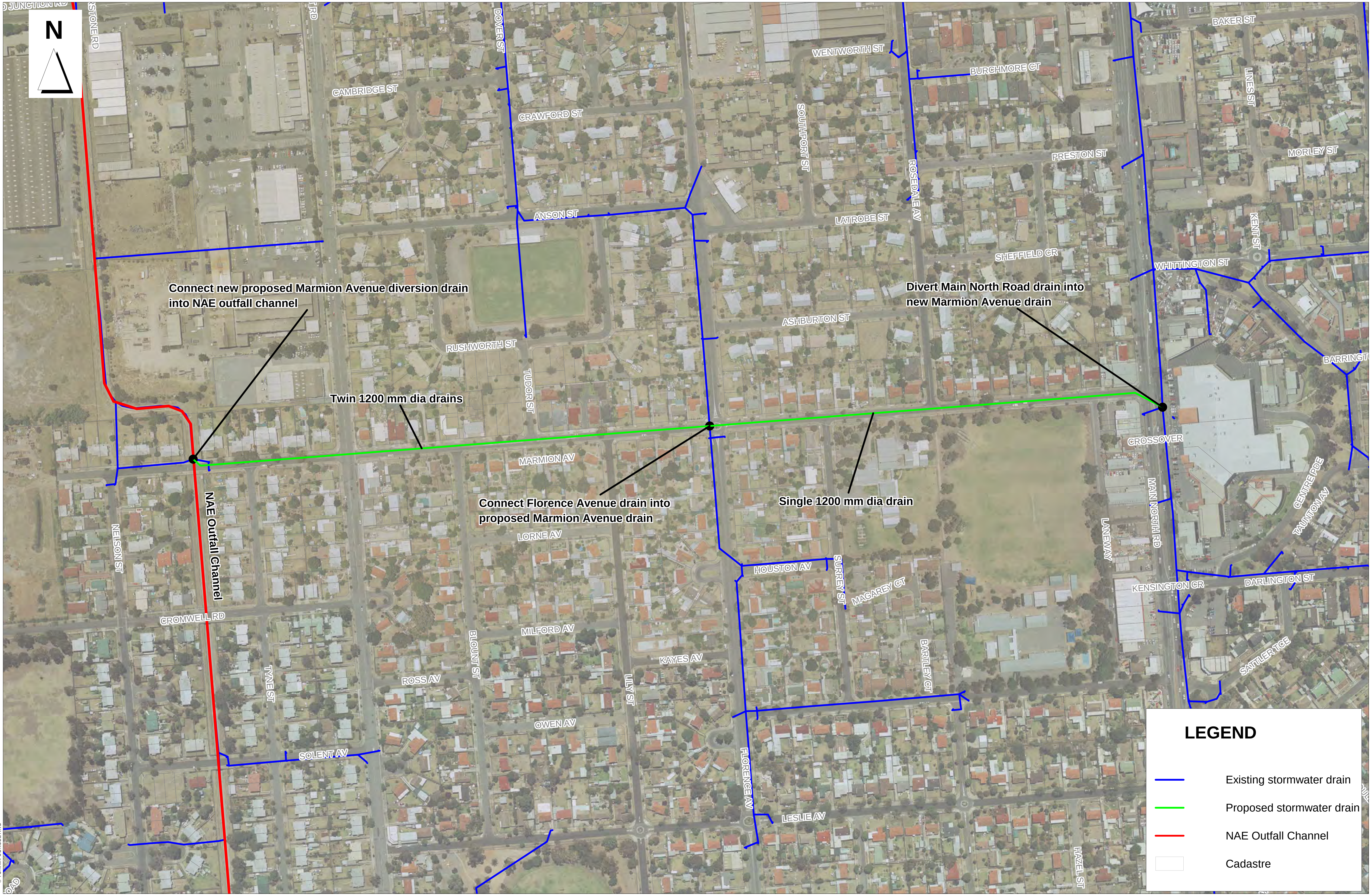
City of Port Adelaide Enfield

North Arm East

Stormwater Management Plan

Enfield Cemetery detention basin

Figure 6



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MAP DETAILS

Cadastral Data:	PBBI Australia
Drainage Data:	Tonkin Consulting
Job Number:	2007.0212
Filename:	AppBFig7.wor
Drawn:	Todd Rundle
Date:	04/02/2011

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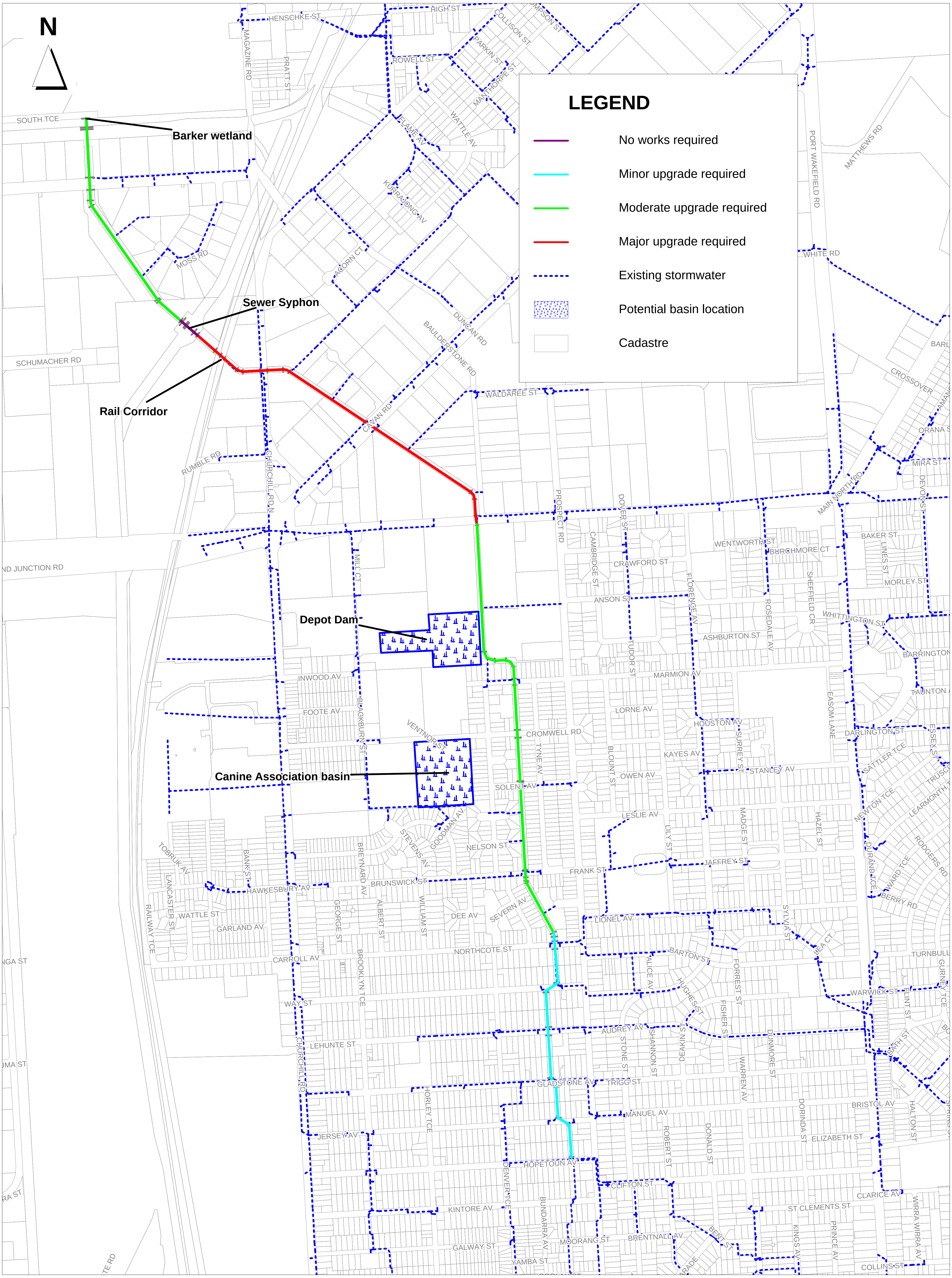
Meters
Scale: 1:3,500

City of Port Adelaide Enfield
North Arm East
Stormwater Management Plan
Marmion Avenue diversion drain
Figure 7



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MAP DETAILS

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Drainage Data:	Tonkin Consulting
Job Number:	2007.0212
Filename:	AppBFig8.wor
Drawn:	Tim Kerby
Date:	24/10/2012

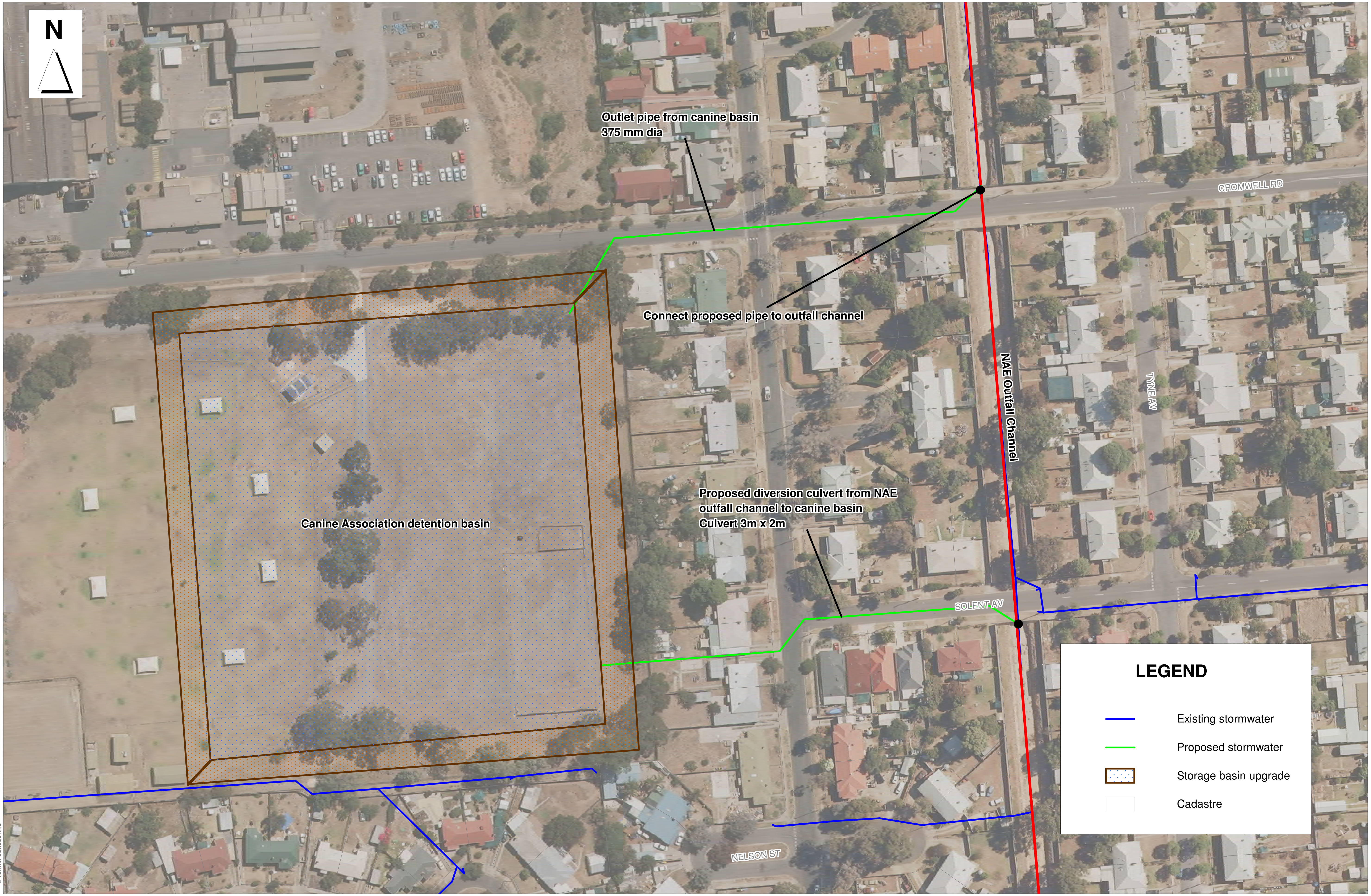
City of Port Adelaide Enfield

North Arm East

Stormwater Management Plan

Outfall Channel - Upgrade Works

Figure 8



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MAP DETAILS

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Drainage Data:	Tonkin Consulting
Job Number:	2007.0212
Filename:	AppBFig10.wor
Drawn:	Todd Rundle
Date:	16/11/2012

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Meters

Scale: 1:1,300

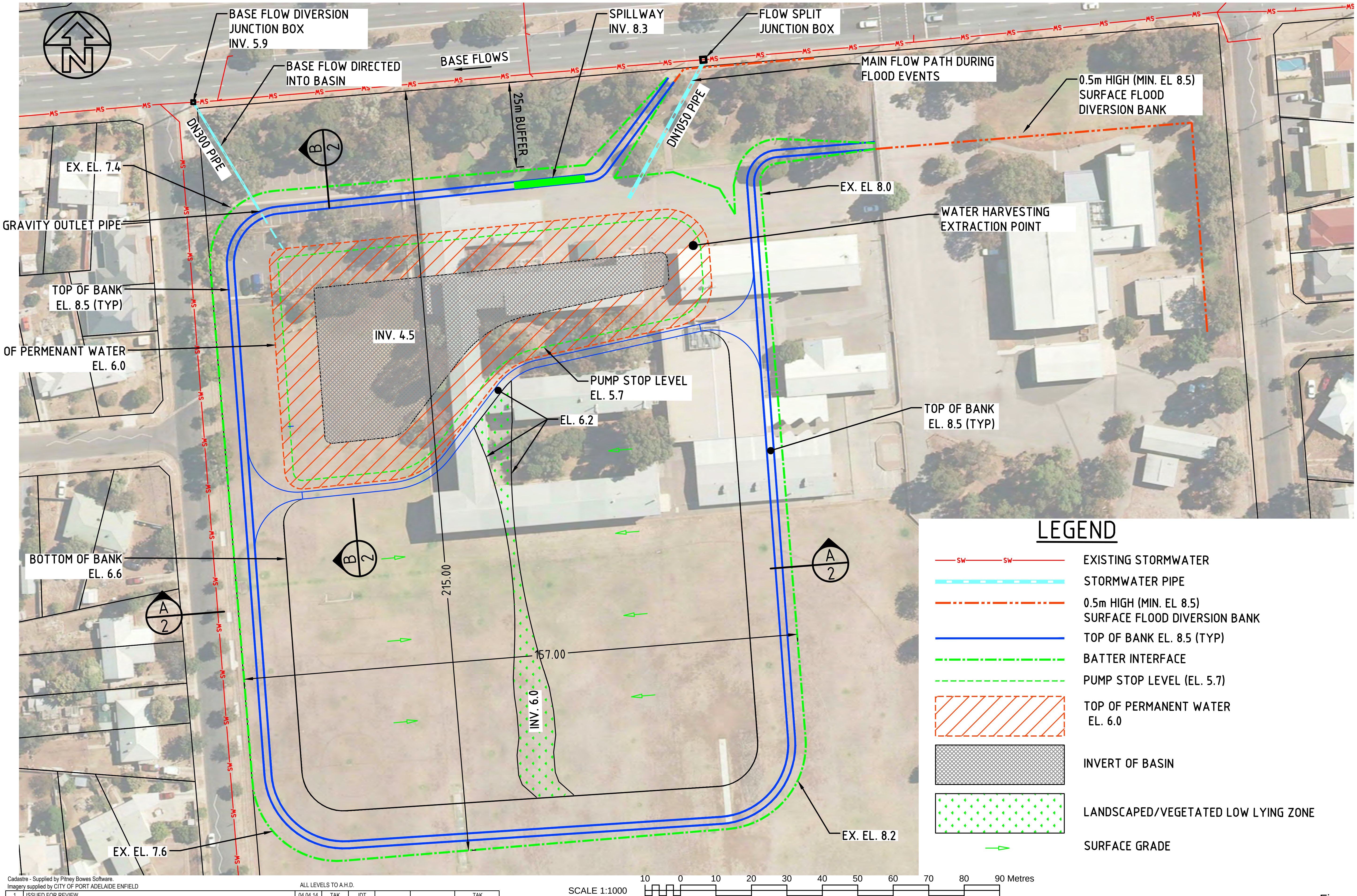
City of Port Adelaide Enfield

North Arm East Catchment

Stormwater Management Plan

Canine Association detention basin

Figure 9



Cadastre - Supplied by Pitney Bowes Software.
Imagery supplied by CITY OF PORT ADELAIDE ENFIELD

ALL LEVELS TO A.H.D.

REV	AMENDMENT / REASON FOR ISSUE	DATE	DES.	DWN.	DWGCHK.	VERIFIED	APPROVED
1	ISSUED FOR REVIEW	04.04.14	TAK	JDT			TAK

T:\2007\20070212 NAE SMP\ACAD\20070212_ENFIELD HIGH.DWG [FIG 10] 04-Apr-2014 - 1:47pm

© TONKIN CONSULTING TCA3LCEN.dwg

Figure 10

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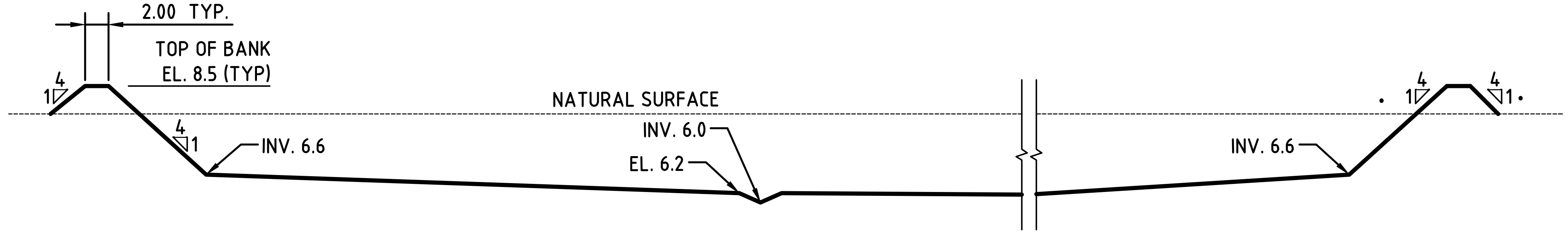
a better approach

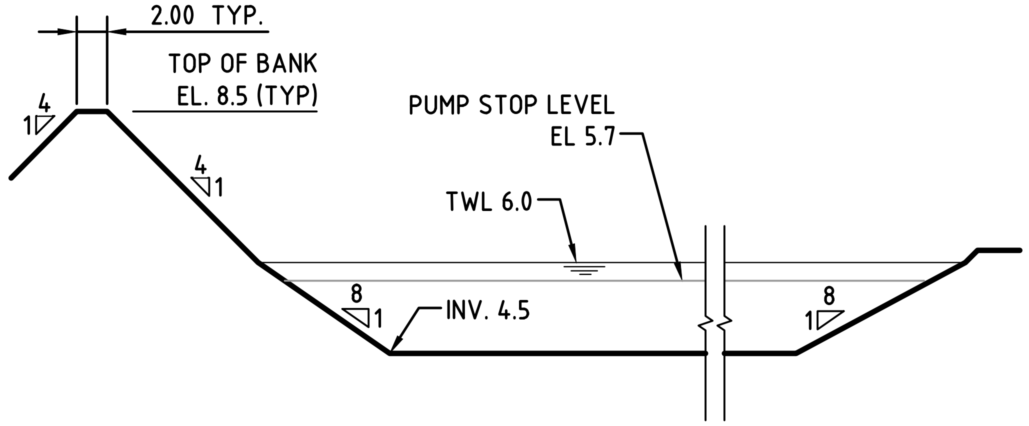
Job No:
Filename: 20070212_ENFIELD HIGH.DWG
Survey By:
Survey Date:
Scale: 1:1000
Sheet Size: A3

CITY OF PORT ADELAIDE ENFIELD
ENFIELD HIGH SCHOOL
DETENTION/ RETENTION BASIN
CONCEPT DESIGN - PLAN



SECTION A - A

NTS



SECTION B - B

NTS

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ALL LEVELS TO A.H.D.

REV	AMENDMENT / REASON FOR ISSUE	DATE	DES.	DWN.	DWGCHK.	VERIFIED	APPROVED
1	ISSUED FOR REVIEW	04.04.14	TAK	JDT			TAK

Figure 11

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a better approach

Job No:

Filename: 20070212_ENFIELD HIGH.DWG

Survey By:

Survey Date:

Scale: AS SHOWN

Sheet Size: A3

CITY OF PORT ADELAIDE ENFIELD

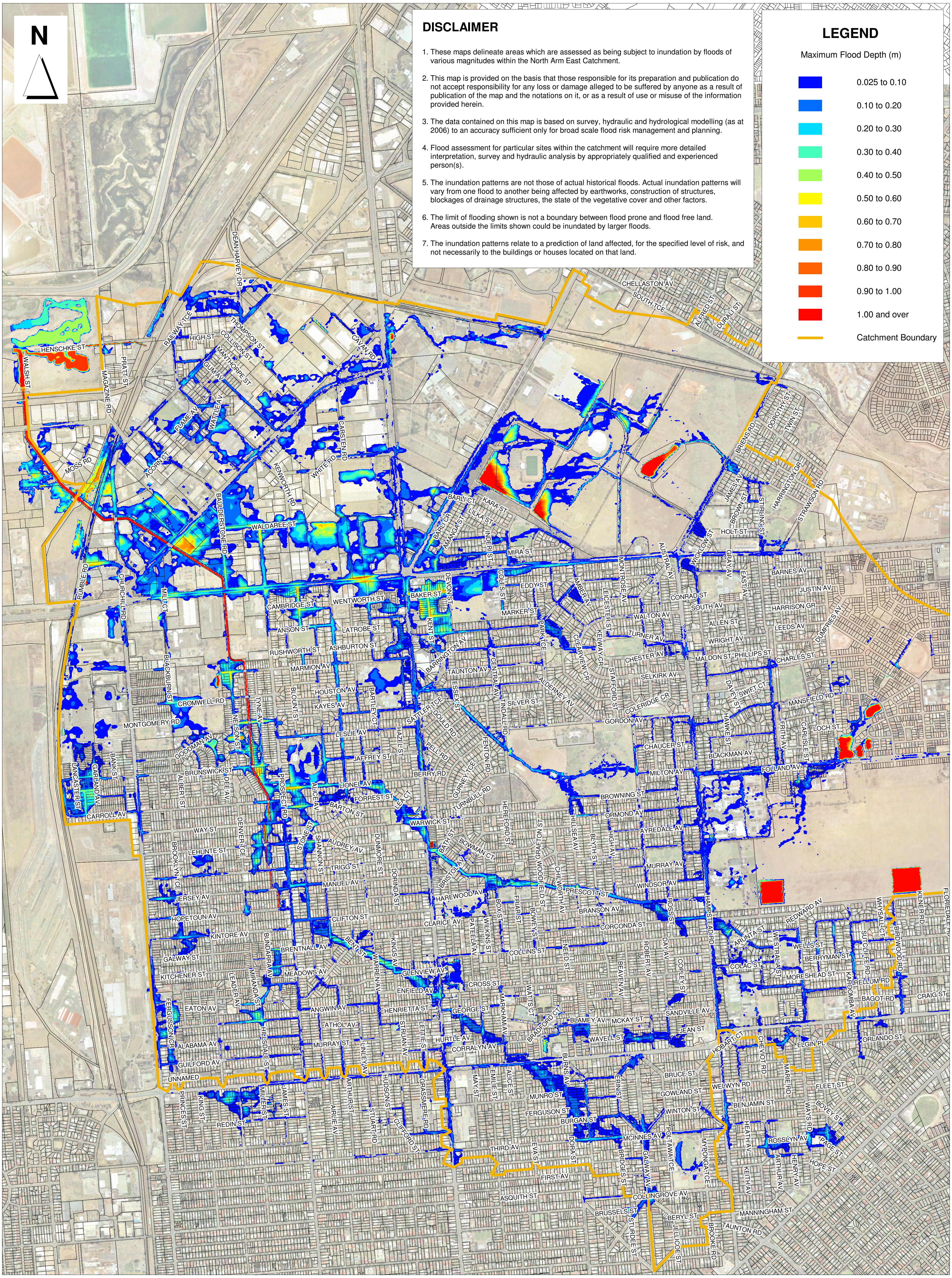
ENFIELD HIGH SCHOOL

DETENTION/ RETENTION BASIN

CONCEPT DESIGN - SECTIONS

Appendix C

TUFLOW Scenario Maps



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MAP DETAILS

Cadastral Data: DEH
Flood Mapping: Tonkin Consulting
Job Number: 2007.0212
Filename: 100yr_LT_Existing_A3.wor
Drawn: Tim Cresswell
Date: 03/05/2010

-0.25 0 0.25 0.5 0.75
Kilometres (Scale: 1:20,000)

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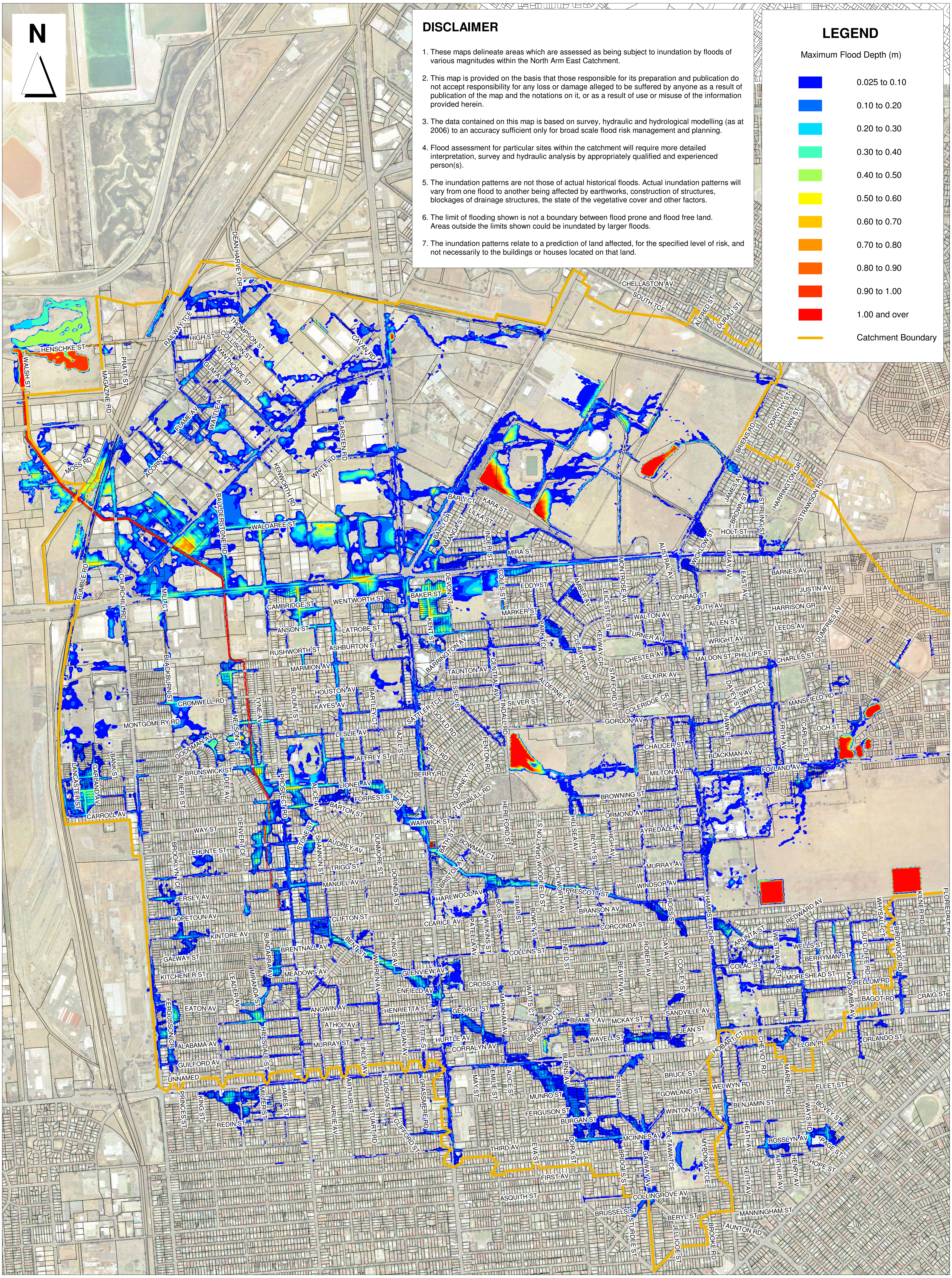
100yr ARI Long-term Flood Inundation Map
Existing Infrastructure

North Arm East Catchment

Figure A.1



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Cadastral Data: DEH
Flood Mapping: Tonkin Consulting
Job Number: 2007.0212
Filename: 100yr_LT_Scenario1_A3.wor
Drawn: Tim Cresswell
Date: 03/05/2010

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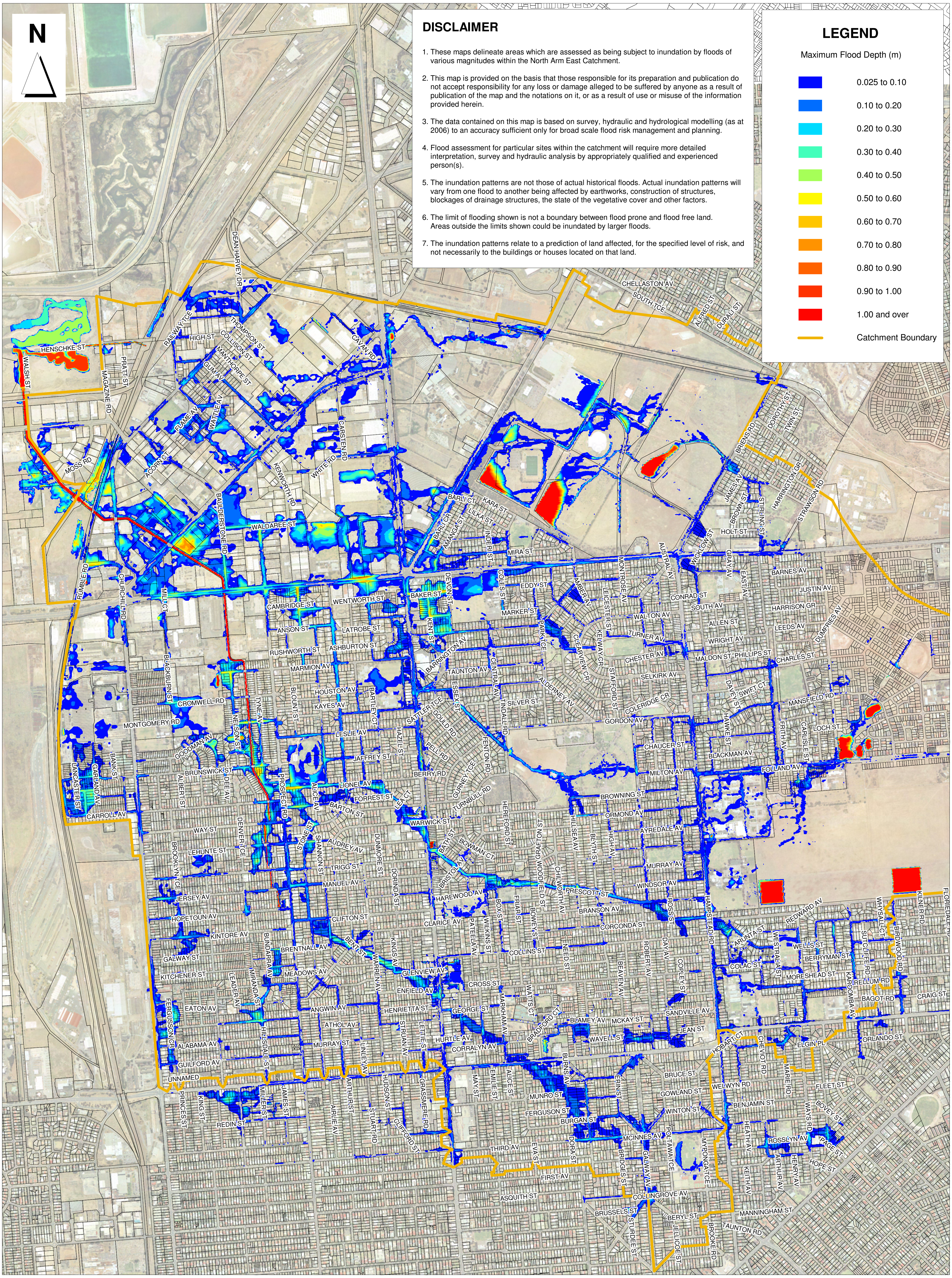
Kilometres (Scale: 1:20,000)

City of Port Adelaide Enfield

100yr ARI Long-term Flood Inundation Map Scenario 1

North Arm East Catchment

Figure A.2



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Flood Mapping: Tonkin Consulting
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Filename: 100yr_LT_Scenario2c_A3.wor
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Date: 09/05/2011

-0.25 0 0.25 0.5 0.75

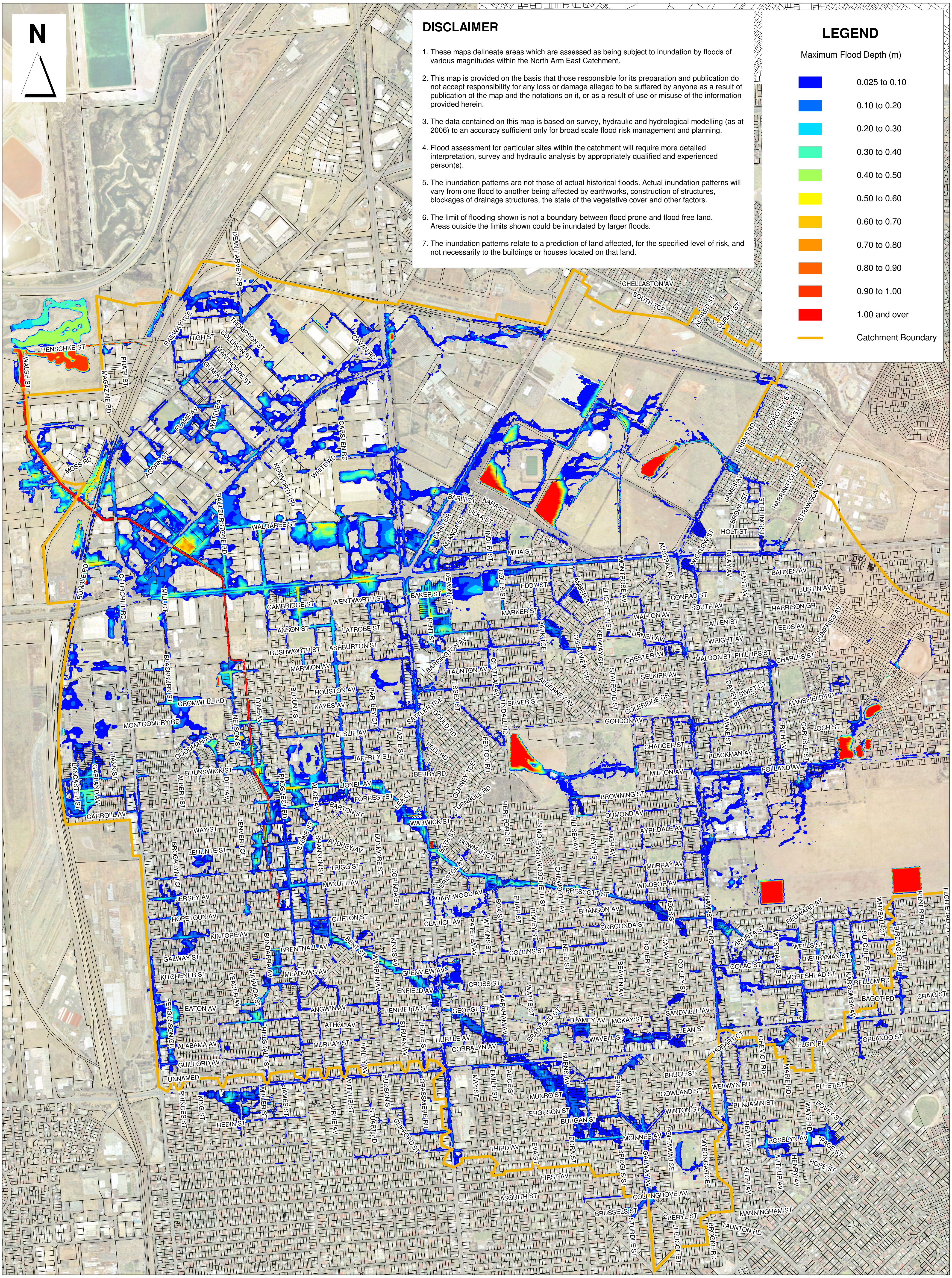
Kilometres (Scale: 1:20,000)

City of Port Adelaide Enfield

100yr ARI Long-term Flood Inundation Map Scenario 2c

North Arm East Catchment

Figure A.3



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Filename:	100yr_LT_Scenario3c_A3.wor
Drawn:	Tim Cresswell
Date:	09/05/2011

-0.25 0 0.25 0.5 0.75

Kilometres (Scale: 1:20,000)

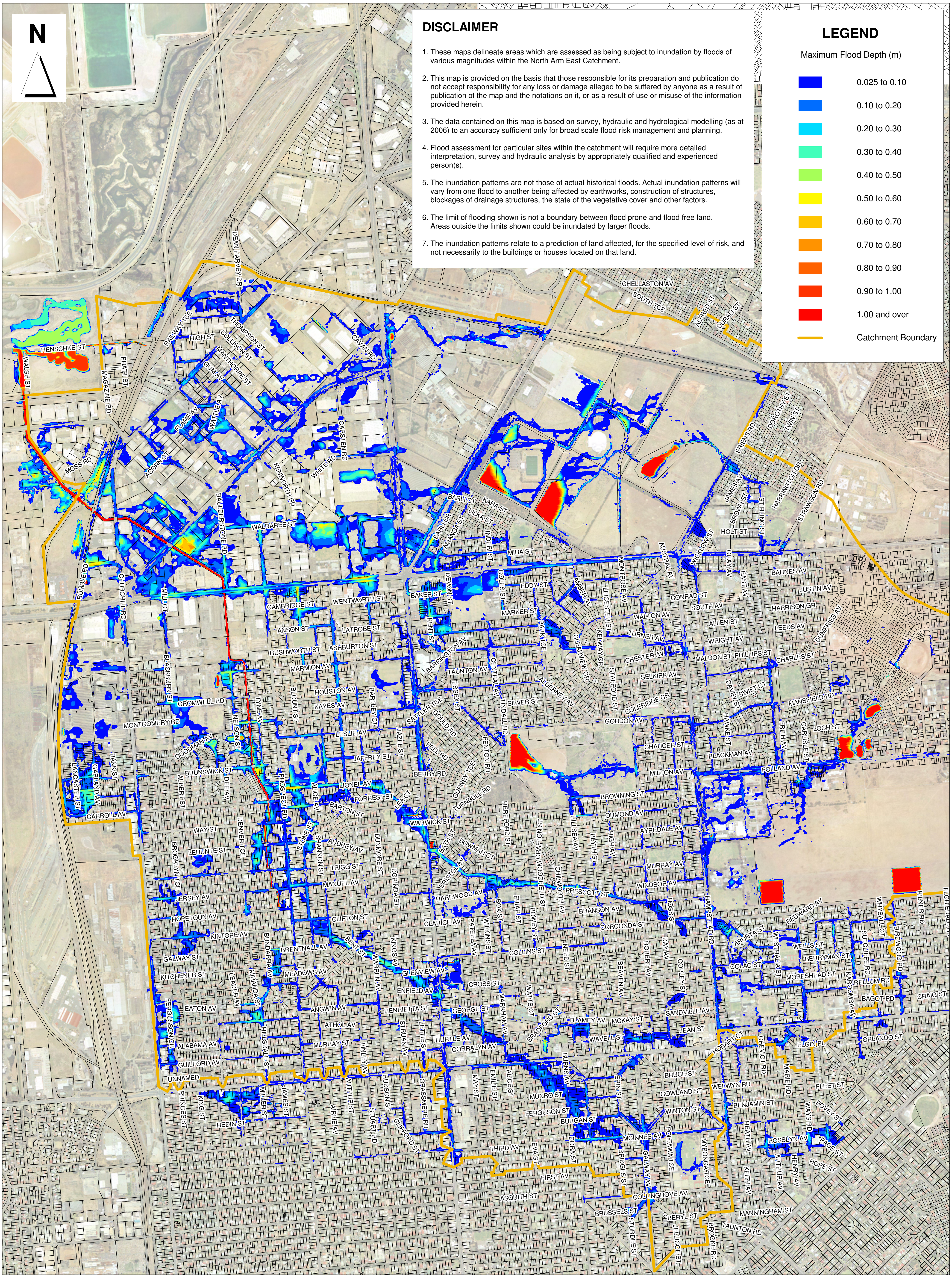
City of Port Adelaide Enfield

100yr ARI Long-term Flood Inundation Map

Scenario 3c

North Arm East Catchment

Figure A.4



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MAP DETAILS

Cadastral Data: DEH
Flood Mapping: Tonkin Consulting
Job Number: 2007.0212
Filename: 100yr_LT_Scenario4c_A3.wor
Drawn: Tim Cresswell
Date: 09/05/2011

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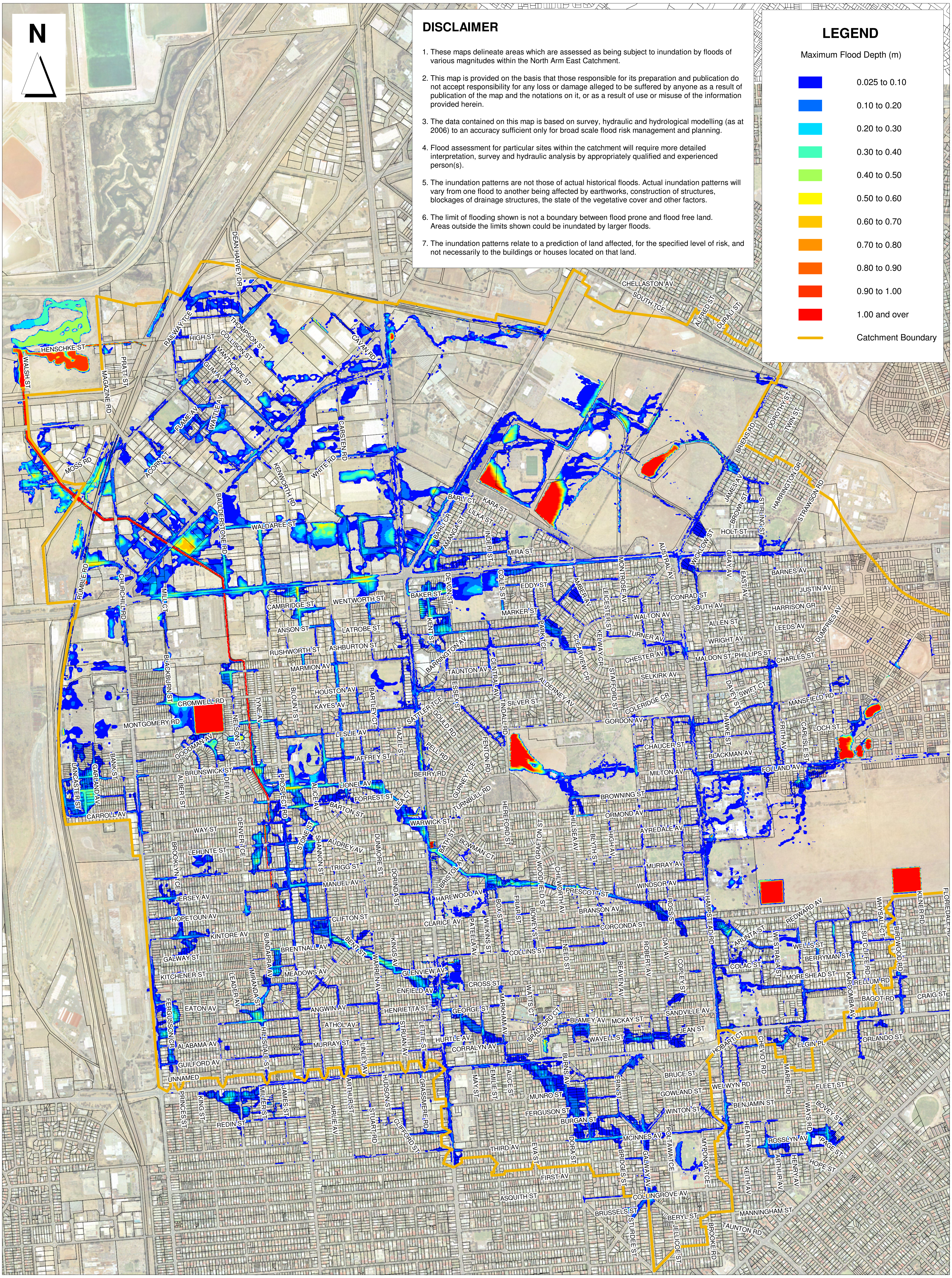
Kilometres (Scale: 1:20,000)

City of Port Adelaide Enfield

100yr ARI Long-term Flood Inundation Map
Scenario 4c

North Arm East Catchment

Figure A.5



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Flood Mapping: Tonkin Consulting
Job Number: 2007.0212
Filename: 100yr_LT_Scenario5c_A3.wor
Drawn: Tim Cresswell
Date: 09/05/2011

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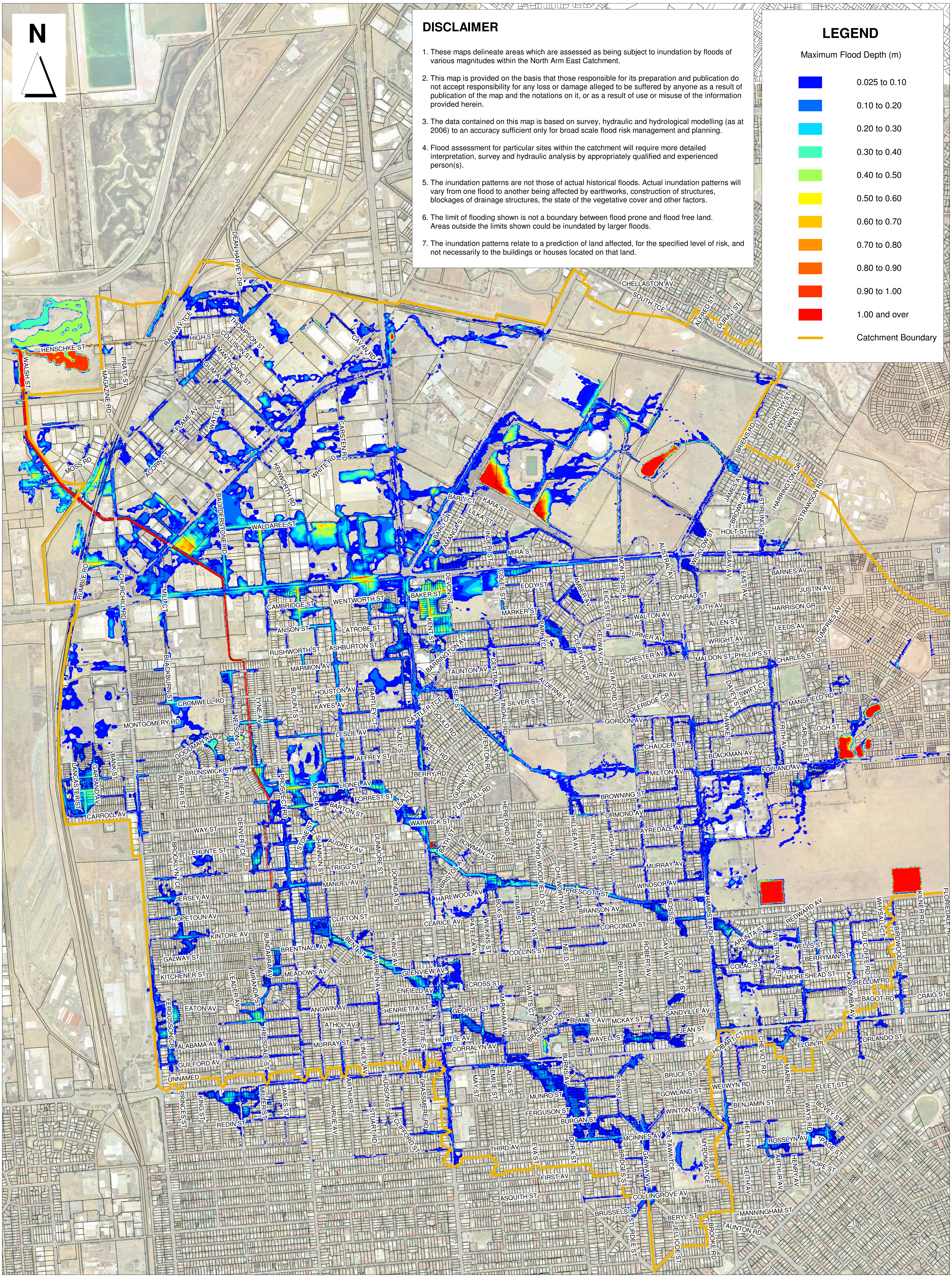
Kilometres (Scale: 1:20,000)

City of Port Adelaide Enfield

100yr ARI Long-term Flood Inundation Map
Scenario 5c

North Arm East Catchment

Figure A.6



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MAP DETAILS
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Flood Mapping: Tonkin Consulting
Job Number: 2007.0212
Filename: 100yr_LT_Scenario6_A3.wor
Drawn: Tim Cresswell
Date: 03/05/2010

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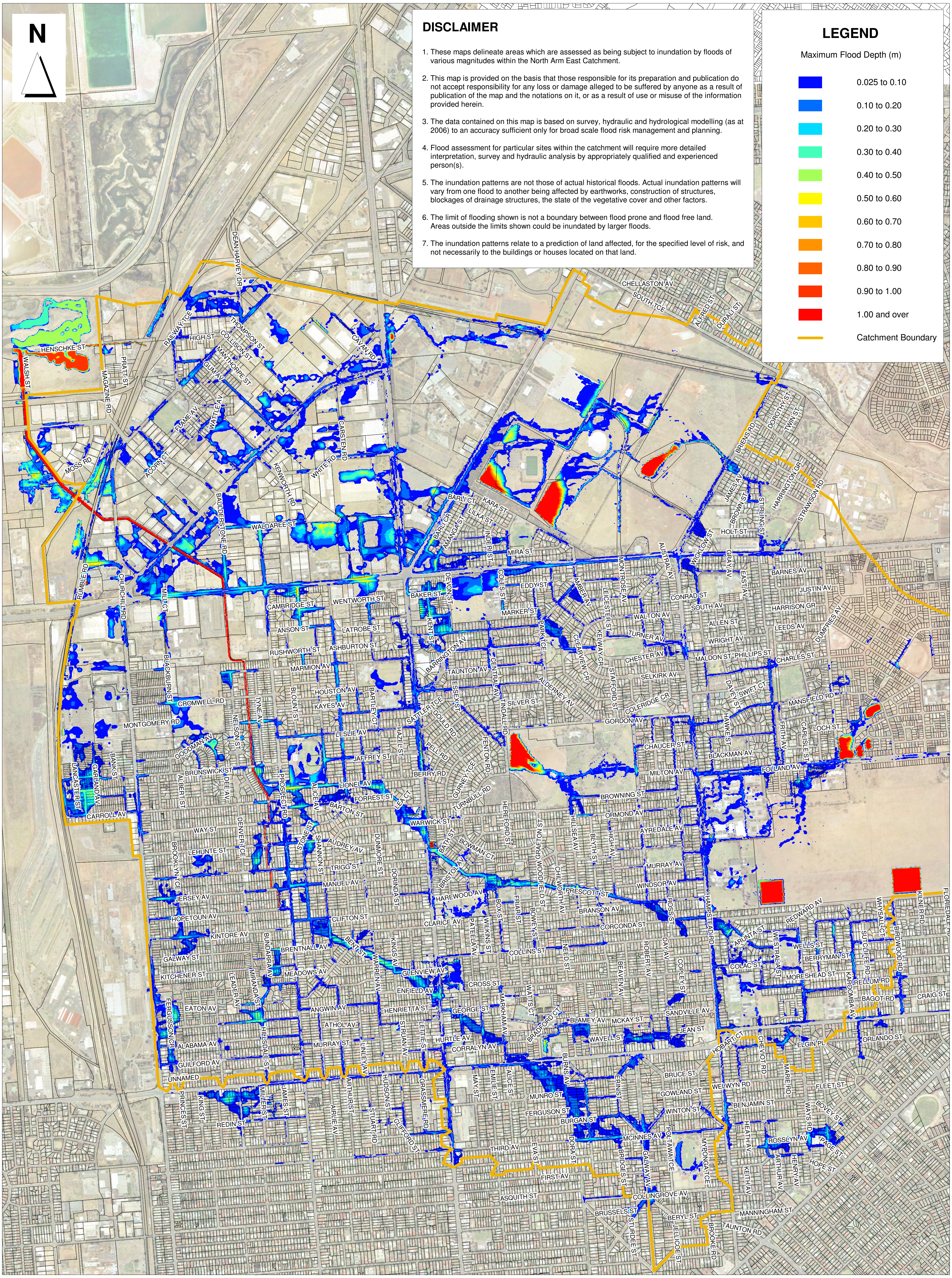
Kilometres (Scale: 1:20,000)

City of Port Adelaide Enfield
100yr ARI Long-term Flood Inundation Map
Scenario 6
North Arm East Catchment
Figure A.7



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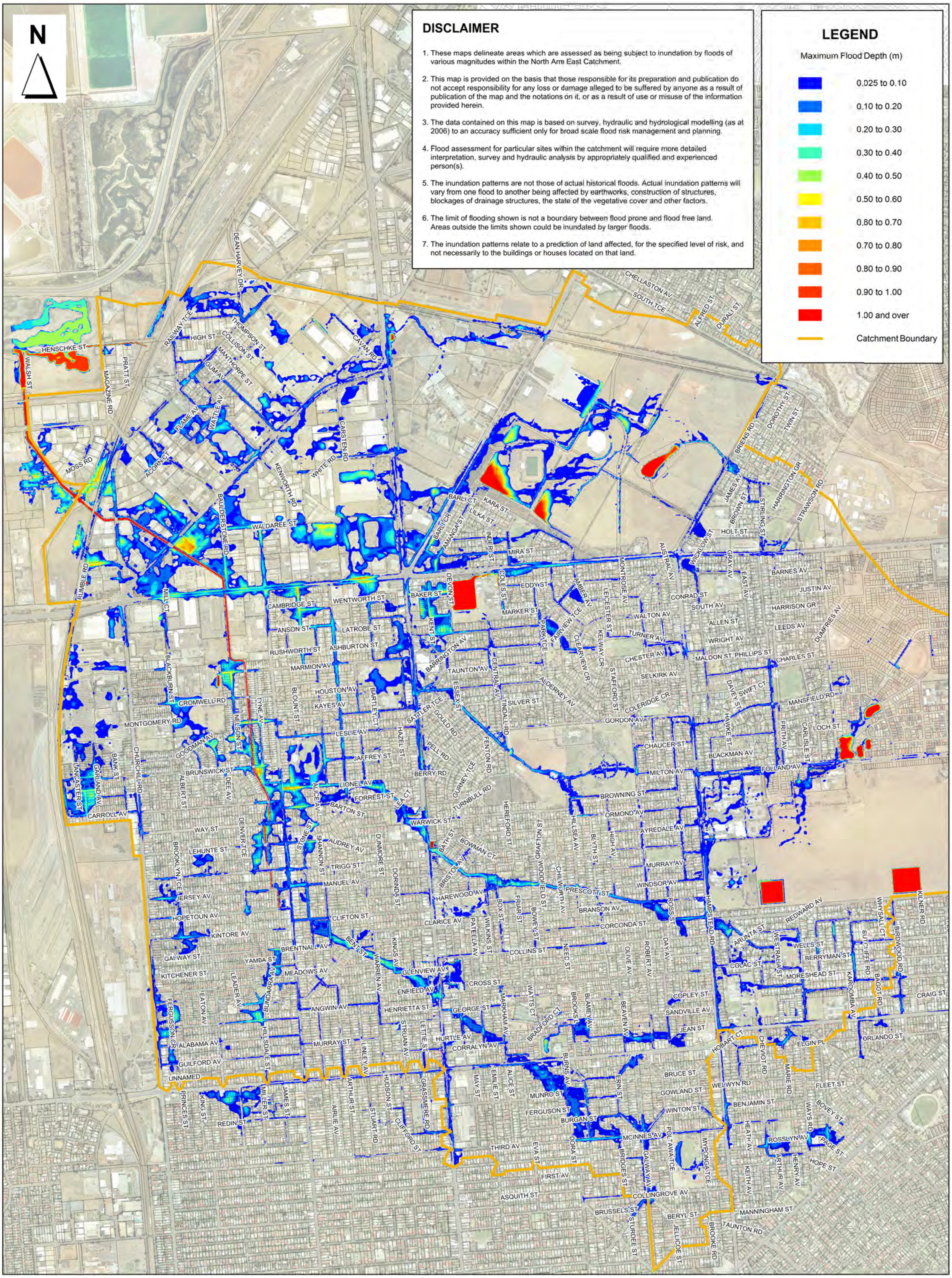
Flood Mapping: Tonkin Consulting
Job Number: 2007.0212
Filename: 100yr_LT_Scenario7c_A3.wor
Drawn: Tim Cresswell
Date: 09/05/2011

City of Port Adelaide Enfield

100yr ARI Long-term Flood Inundation Map
Scenario 7c

North Arm East Catchment

Figure A.8



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Job Number: 2007.0212
Filename: 100yr_LT_Scenario8c_A3.wor
Drawn: TDC
Date 10/04/2014

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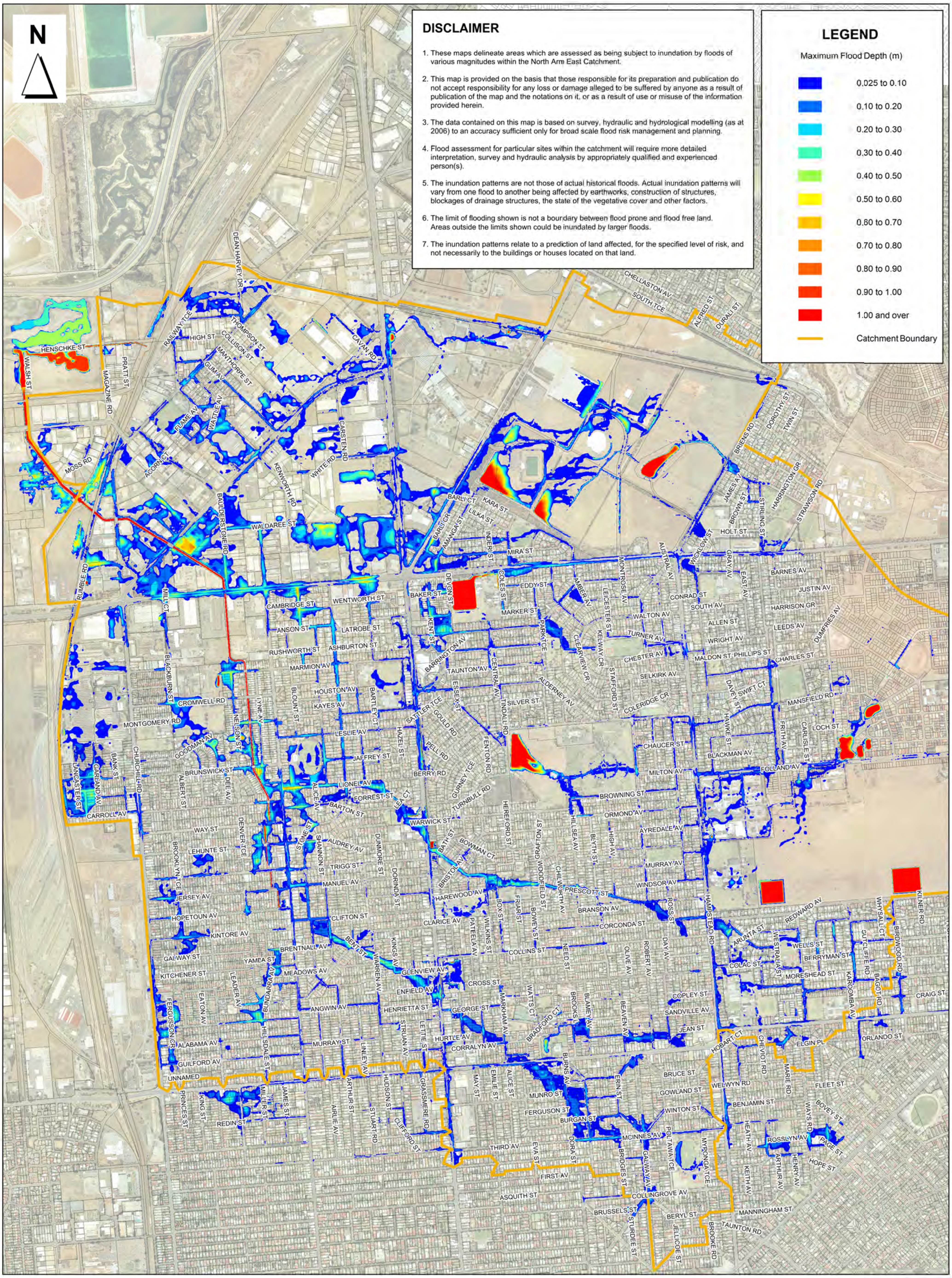
Kilometres (Scale: 1:20,000)

City of Port Adelaide Enfield

100yr ARI Long-term Flood Inundation Map
Scenario 8c

North Arm East Catchment

Figure A.9



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LEGEND

Maximum Flood Depth (m)

- 0.025 to 0.10
- 0.10 to 0.20
- 0.20 to 0.30
- 0.30 to 0.40
- 0.40 to 0.50
- 0.50 to 0.60
- 0.60 to 0.70
- 0.70 to 0.80
- 0.80 to 0.90
- 0.90 to 1.00
- 1.00 and over
- Catchment Boundary

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MAP DETAILS

Cadastral Data: DEH
Flood Mapping: Tonkin Consulting
Job Number: 2007.0212
Filename: 100yr_LT_Scenario9_A3.wor
Drawn: TDC
Date 10/04/2014

-0.25 0 0.25 0.5 0.75

Kilometres (Scale: 1:20,000)

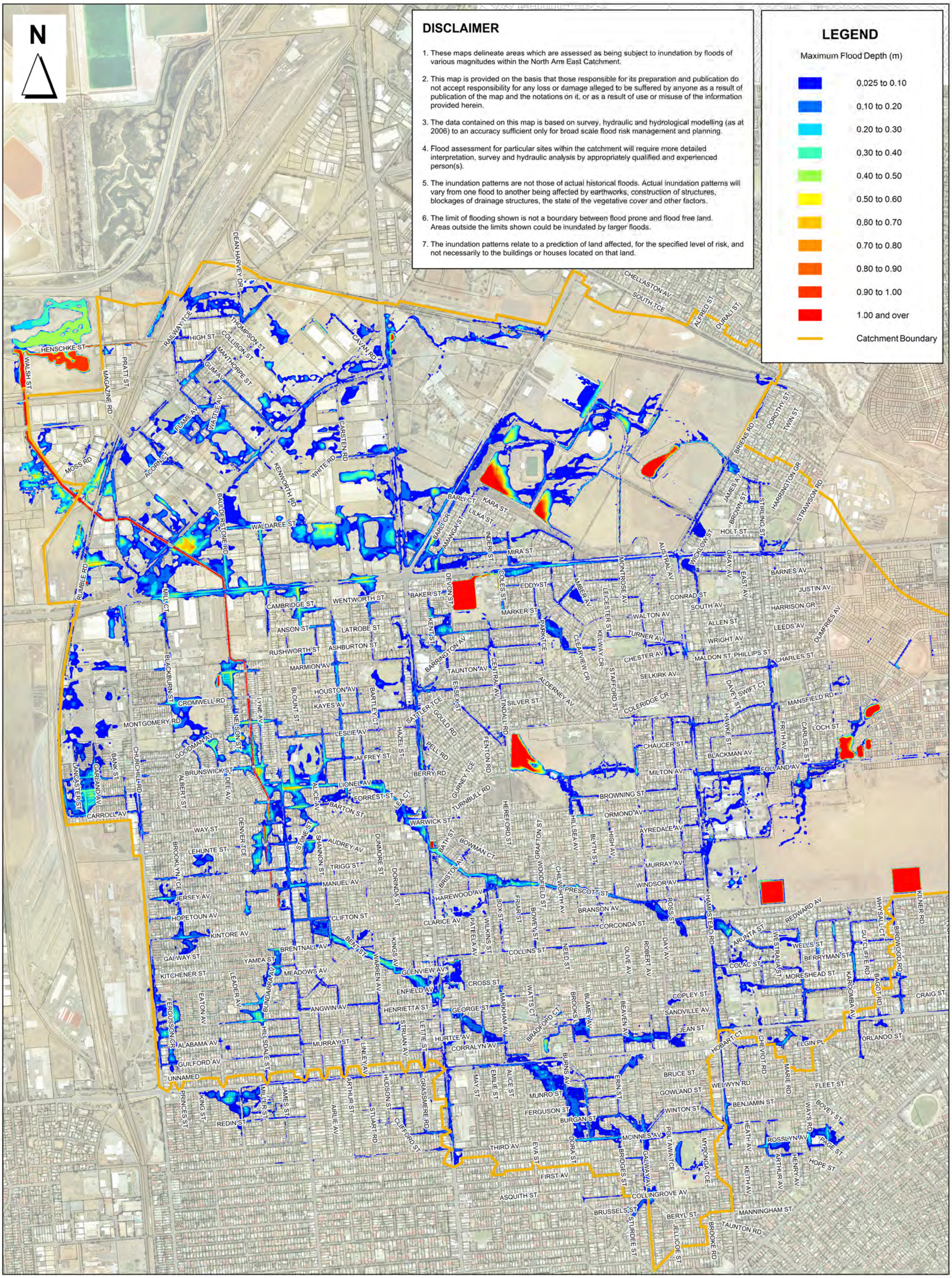
City of Port Adelaide Enfield

100yr ARI Long-term Flood Inundation Map

Scenario 9

North Arm East Catchment

Figure A.10



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MAP DETAILS

Cadastral Data:	DEH
Flood Mapping:	Tonkin Consulting
Job Number:	2007.0212
Filename:	100yr_LT_Scenario10_A3.wor
Drawn:	TDC
Date	10/04/2014

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Kilometres (Scale: 1:20,000)

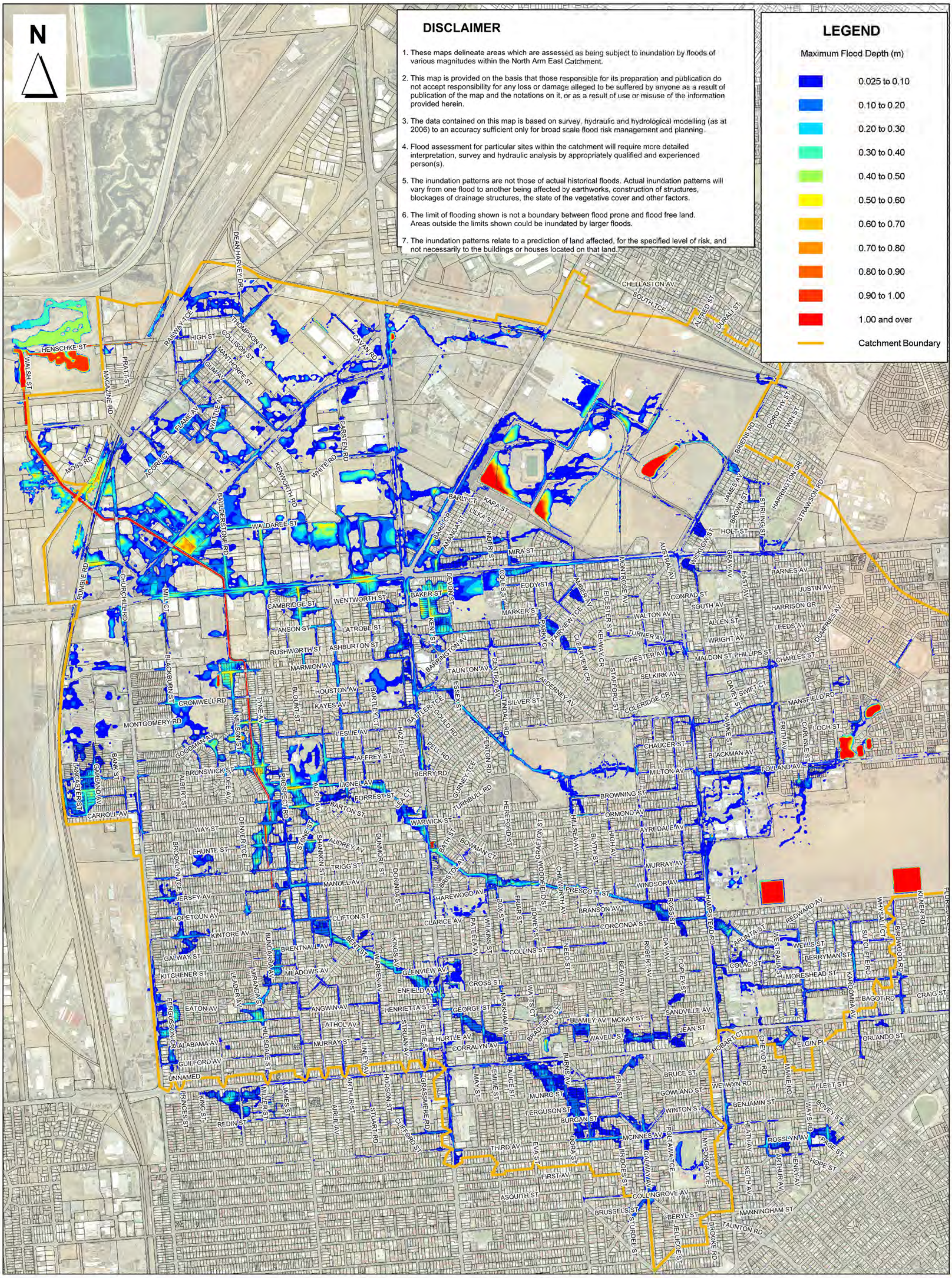
City of Port Adelaide Enfield

100yr ARI Long-term Flood Inundation Map

Scenario 10

North Arm East Catchment

Figure A.11



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MAP DETAILS

Cadastral Data:	DEH
Flood Mapping:	Tonkin Consulting
Job Number:	2007.0212
Filename:	100yr_LT_Scenario11_A3.wor
Drawn:	TAK
Date:	30/05/2016

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Kilometres (Scale: 1:20,000)

City of Port Adelaide Enfield

100yr ARI Long-term Flood Inundation Map
Scenario 11

North Arm East Catchment

Figure A.12

Appendix D

Optimised Decision Making Scoring Spreadsheet

NAE Catchment

				Option Subject to Assessment									
				State Sports Park diversion + harvesting		Cemetery diversion and basin		Marmion Avenue drain		Enfield High School Basin		Outfall channel upgrade	
Criteria	Criteria Weighting	Sub-Criteria	Sub-criteria Weighting	Score (max=4)	Weighted Score	Score (max=4)	Weighted Score	Score (max=4)	Weighted Score			Score (max=4)	Weighted Score
Flood Protection of Development	30	Improved flood protection	100	2	15	2	15	2	15	2	15	2	15
		Weighted Score sub-total	100	15		15		15		15		15	
Runoff Quality and Effect on Barker Inlet Wetlands	15	Reduction in gross pollutants	20	2	1.5	1	0.75	0	0	1	0.75	0	0
		Reduction in suspended solids	40	2	3	1	1.5	0	0	1	1.5	0	0
		Reduction in nutrients	20	2	1.5	0	0	0	0	1	0.75	0	0
		Reduction in phosphorus	20	2	1.5	0	0	0	0	1	0.75	0	0
		Weighted Score sub-total	100	7.5		2.25		0		3.75		0	
Beneficial Use of Stormwater	15	Direct Infiltration	15	3	1.69	2	1.13	0	0	2	1	0	0
		Storage and Reuse	85	3	9.56	1	3.19	0	0	2	6.38	0	0
		Weighted Score sub-total		11.25		4.31		0		7.5		0	
Social values	10	Improved visual amenity	35	1	0.88	0	0	0	0	3	2.63	0	0
		Improved public safety	20	1	0.5	2	1	2	1	2	1	2	1
		Additional useful open space	40	1	1	0	0	0	0	3	3	0	0
		Disruption during implementation	5	2	0.25	2	0.25	2	0.25	2	0.25	1	0.13
		Weighted Score sub-total	100	2.63		1.25		1.25		6.88		1.13	
Environmental Benefit	5	Habitat creation	70	2	1.75	0	0	0	0	2	1.75	0	0
		Increased biodiversity	30	1	0.38	0	0	0	0	1	0.38	0	0
		Weighted Score sub-total	100	2.13		0		0		2.13		0	
Capital, Benefit Cost Ratio and Maintenance Cost	25	Capital Cost	45	1	2.81	1	2.81	1	2.81	1	2.81	0	0
		Economic viability	45	3	8.44	3	8.44	2	5.63	2	5.63	0	0
		Recurring / Maintenance Cost	10	1	0.6	2	1.25	3	1.88	1	0.63	3	1.88
		Weighted Score sub-total	100	11.88		12.50		10.3125		9.06		1.88	
Total Criteria Weighting	100	Total Weighted Score / 100		50.4		35.3		26.6		44.3		18.0	

Capital Cost Estimate ($Millions)	State Sports Park diversion + harvesting	Cemetery diversion and basin	Marmion Avenue drain	Enfield High School Basin	Outfall channel upgrade
	2.1	2.0	3.1	6.0	29.2

Appendix E

Consultation Summary

City of Port Adelaide Enfield

NAE Catchment

Consultation Summary

City of Port Adelaide Enfield

NAE Catchment

Consultation Summary

Principal Contacts
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September 2016
Ref No 20070212RA7B

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Document History and Status

Rev	Description	Author	Reviewed	Approved	Date
A	Final	TAK	VS	TAK	24/10/13
B	Revised Final (Renewal SA consultation included)	TAK	VS	TAK	14/09/16

Table of Contents

1 Introduction

The draft North Arm East (NAE) Stormwater Management Plan (SMP) was made available for public consultation over the period from late February to late March 2013. In included the following activities:

- Advertisement placed in the Public Notices section of the Advertiser on Wednesday, February 27, 2013 and 3 local Messenger newspapers
- Article in the Council Newsletter (Pen 2 Paper) which is sent out to all households and business in the Council area
- Hard copies of the SMP were made available at the civic centre and at the Council libraries with details regarding how to provide comment
- Links to the plan were made available on the front page of the Council website, including access to a Survey Monkey questionnaire
- Letters and CDs were sent to relevant State Government agencies (EPA, Housing SA, SA Water, DPTI planning branch)
- Key stakeholders were made aware of the opportunity to provide comment on the plan (Adelaide Cemeteries Authority, Dogs SA)

The report summarises the comments that were received and provided responses to the feedback and indicates if it will change the contents of the SMP.

Actual copies of feedback received in letter format are included in Appendix A. Feedback from the Survey Monkey in contained within Section 2.4.

In addition to the public consultation outlined above, Renewal SA were consulted between 2014 and 2016 in relation to the potential for flood mitigation works within the former Enfield High School site. No formal comment on the SMP was provided by them. However, the meetings provided them with a good understanding of what was proposed and helped to inform their negotiations with Council in relation to the future use of the land.

2 Feedback

2.1 Dogs SA Feedback

The Dogs SA feedback comprises of the first two pages of Appendix A of this report.

2.1.1 Response

Further consultation was held with Dogs SA at a meeting held on 23 April 2013. It addressed a number of concerns outlined above and gave them a much better understanding of the works and confirmed with them that the works would not meant they could not longer use the site. The meeting was followed up with a written response. Based on the fact that the Council are not in a position to negotiate with Dogs SA at this stage the recommendation to consider works at the site has been removed as a recommendation from the SMP. However the work associated with the consideration of it as an option has still been included.

2.2 EPA Response

The EPA response comprises of the third page of Appendix A of this report.

2.2.1 Response

The SMP is to be modified to include a recommendation that there be a review of the management arrangements for the wetlands.

Reference has been made to the DesignFlow report within Section 2.4 (previous studies).

2.3 SA Water Response

(copy of email sent to Wally Iasiello from Greg Ingleton on 2 April 2013)

Thanks for providing us with the opportunity to comment on the stormwater management plan for North Arm East. Overall the plan is well structured and the detail regarding each of the options is thorough and logical.

From an agency perspective there is very little in the options that would directly impact on SA Water. From a knowledge of the area, gained from our construction of the HEP pond ASR scheme, there are a few generic comments that you may like to consider. These are as follows:

- In regards to the construction of basins, it would be recommended that these are lined with an impermeable layer (probably around 10-9, but suggest you check this with EPA or a dam engineer) to ensure that there is no infiltration of contaminated groundwater into the basins, and more importantly, that there is no perceived change to the movement of contaminated groundwater that belongs to others (we had an issue with a neighbouring property at Barker Inlet as they thought our ASR would change the movement of their contaminated groundwater, and the EPA suggested at the time that any changes to the movement of the contamination could make SA Water liable for remediation work, even though the contamination had nothing to do with us).
- I would suggest that a review of the performance of the NAE pond is warranted as this may undermine your effort on water quality in the catchment. From my observations of both the NAE and the HEP ponds there is a deterioration of water quality as it passes through the ponds, due to carp and wind and wave action, all of

which contribute to a resuspension of sediment. Whilst these ponds were designed, and operated, as nutrient and sediment sinks in the past I believe they are now a source of sediment and nutrients due to the accumulation of sediment within the pond. Perhaps one way to ensure the ponds get funded is to have the targets (discussed in Section 3.3.2) being assessed at the outlet end of the NAE pond, not the inlet end.

- I would guess that the option to install a 19 well ASR scheme would cost in excess of $20 million, and would require a large area of land to locate the bore field on.
- I like the idea of replacing part of the degraded concrete channel with a vegetated earthen channel, as this will improve amenity, water quality etc. This may also enable some losses to the shallow groundwater table to replenish the shallow aquifer, but as mentioned above, you may need to be mindful on any potential impact on contaminated groundwater plumes.

As mentioned, the layout and content of the plan is very good and provides the council with a good basis for exploring and implementing the preferred option.

Please contact me if you require further information about the dot points above.

Cheers

Greg

Greg Ingleton
Principal Advisor - Recycled Water
SA Water Corporation
Level 4, 250 Victoria Square,
Adelaide SA 5000

2.3.1 Response

The first dot point is a matter for the detailed design of any future basins and will not change the content of the SMP

The second dot point has been covered in Section 6.2.9 of the plan which outlines that additional monitoring of the wetlands performance in warranted and that this may trigger additional investigations to work out how this can be remedied. This recommendation can be included in Section 9 (recommendations) of the SMP.

In relation to the third dot point the report only outlines the work that has been done by others on assessing the ASR potential in the area. It is not within the scope of the preparation of the SMP to review the methodology used in deriving the proposed ASR scheme.

The comments in relation to the fourth dot point are noted but will not change the content of the SMP. However this groundwater issues would be a consideration should further design development occur.

2.4 Survey Monkey Responses

Some of the responses were supporting of the plan, while Dogs SA made reference to their more detailed written response which is outlined in Section 2.1. All responses to the 7 questions contained within the survey have been collated below.

1.) The catchment includes the suburbs (or part) of Gepps Cross, Northfield, Northgate, Clearview, Enfield, Blair Athol, Kilburn, Sefton Park, Broadview, Greenacres and Wingfield. Do you live in the North Arm East Catchment area?

1 response – Yes

2 responses – No

2.) Do you operate a business or own other property in the North Arm East Catchment area?

2 responses – Yes

1 response – No

3.) What do you think are the most important issues in regard to stormwater management generally?

- All 3 Responses showed agreement with all nominated key issues
- 1 Open comment response –

"I am very excited about the idea to restore the drain from Northcote Street, Kilburn to Marmion Road, and create a more natural waterway. The idea of a "grassed" area puzzles me, though. Is it going to be a reed bed, which will help filter and clean water? I think it would be a valuable and community-promoting project, and I support this idea even though it means relocating tenants in 13 properties."

4.) Are the options outlined in the Draft Stormwater Management Plan valuable in addressing these issues?

- 2 responses –Yes
- 1 response – No
- 1 Open comment –

"Having read the report carefully, I feel that the money invested in addressing the issues is money well-spent for the long-term. I like the way the plan addresses a range of aspects, including not just the practicalities of avoiding and mitigating stormwater damage, but more broadly at improving water quality so that it can be harvested and reused. Now it needs to be implemented"

5.) Do you agree with the key Goals and Objectives of the Draft Stormwater Management Plan for the North Arm East Catchment ?

- 3 responses – Yes.
- 1 Open comment -

"It would be valuable to implement community and business programs to reduce rubbish and other pollutants from entering the drains in the first place. Catching solid waste in traps is unsightly, (though necessary)."

6.) Do you have any comments on any of the particular options outlined in the Draft Plan for flood management or water harvesting opportunities ?

- 1 Open comment -

"The plan does not optimise the use of current Crown Land and fails to address compensation for the business in the areas affected by the plan. Primarily the Canine Association"

7.) Do you have any other general comments or feedback about the Draft Stormwater Management Plan?

- 2 Open comments –

(1) " Dogs SA will be submitting a detailed submission identifying their concerns "

(2) The stormwater management plan refers to runoff coefficients (section 2.8.4). What Tonkin actually mean are percentages of directly connected impervious area. A runoff coefficient refers to either a volumetric coefficient (relating runoff volume to rainfall volume), or deterministic runoff coefficient (relating peak flow to a design rainfall intensity, with a duration equal to the time of concentration of the catchment). The correct terminology should be used. Figure 2.7 shows significant increases through the catchment in directly connected or effective impervious area percentage (labelled as runoff coefficient increase). The flood management objectives (section 5.3.1) discuss the required standard for both minor and major systems, but does not have any objective relating the maintenance of the standard with further development. The objectives should include an objective that at least retains existing standards, and actions required to ensure that this occurs. The plan focuses mainly on the major system, and physical works, rather than the management of infill development. Objectives and strategies that address the impact of infill development on both runoff peak flows and flow volumes are required. The only mention of on-site mitigation measures is contained in section 6.1.9, that states that the current 1kL tank requirement is not generally effective in flood management. In summary the plan does not address the impact of infill development, or provide any means of mitigating this impact. The plan must do this. In addition the plan should maintain correct engineering terminology I note that from Appendix A costings have been done over a period of time, dating back to 2010. The plan should ensure that all costings are on a common and up to date basis."

2.4.1 Response

Items 1 through to 6 are of a fairly general nature. The only response is in relation to the second open comment in relation to question 7.

The wording of the figures in relation to Section 2.8.4 will be modified in the revised SMP.

The SMP has stated in Section 2.4 that:

"For all ARI events the difference in flooding between existing and long-term development conditions was relatively minimal. The extent and magnitude of flooding did increase when the long-term development conditions were modelled but the increases were not dramatic. When comparing the results from the existing and long-term development conditions, it was evident that the increase in extent and magnitude of flooding was less for the 100 year ARI event than for the 5 and 20 year ARI events. This was due to the future development producing proportionally more runoff during the smaller ARI events."

Therefore the focus of the SMP has been to look at trying to alleviate existing known flooding problem spots, rather than managing the increase in runoff due to infill development as the modelling has indicated that the increase in flooding due to infill is not dramatic. Furthermore Section 6.1.9 of the SMP has been expanded to include additional discussion in relation to on-site mitigation measures.

Given the first order nature of the generalised assessment that forms the basis for the costs estimates that are based on concept designs only a change in the costing is not warranted.

Appendix A

Feedback Received

South Australian Canine Association inc Trading as Dogs SA

"Leading the Community to responsible Dog Ownership"

15 March 2013

North Arm East Stormwater Management Plan Consultation'
City of Port Adelaide Enfield
PO Box 110
Port Adelaide SA 5015.

RE: North Arm East Catchment – Stormwater Management Plan

Dogs SA (identified as Canine Association in the Plan) have some significant concerns within the plan as presented for public comment. There are a number of assumptions made which would be opposed by Dogs SA as they would render the current property of Dogs SA unsuitable for it's current and intended use, plus the property would become economically non-viable as an asset due to it's not being able to sold or developed.

Some of the concerns of Dogs SA are as follows:
The report fails to identify parcels of land which are currently owned by the state government which would also have the capability to be developed into stormwater retention ponds. These areas include the now disused school grounds within the area or large areas of railway land which is currently being redeveloped.
The weightings for the Canine Grounds is not considered accurate as there appear to be assumptions made without consultation examples of these are;
Social Values – There will be no improved visual amenity as the grounds are already mown and kept in a clean and tidy state:
Social Values – Disruption during implementation. The grounds would be completely unusable during implementation which would deprive Dogs SA of its principle source of income for approximately 2 years.
Environmental Benefit – Habitat creation, Where is there any benefit to the habitat when the area has significant trees on its boundaries which would need to be destroyed for the development.
Capital and Maintenance Costs – The only reason why the site appears favourable is because there has been no allowance made for the purchase of the property and compensation for lost income.

There also appears to be a number of areas where the report is not fully disclosing information or the information was simply not provided. An area of this is at Section 4 of the plan where the report fails to mention either the Council Depot or the Associations Grounds as either having problems or opportunities. A significant problem for the plan would be if Dogs SA decided not to sell or allow the Council to use the land identified in the report.

The land of Dogs SA does not meet the criteria for Stormwater Management Objectives as there would be no storage capacity and no beneficial water re-use from the site. This capacity is a principle objective of the plan. In actual fact the land of the Association is not considered favourably in 5 of the 6 Criteria as identified at Section 3 of the plan.

Paragraph 6.1.5.2, identifies that the Canine Association is willing to facilitate further discussion. This is correct however from the design provided at Appendix B of the plan; the size of the basin (approx. 30,400 M2) and at 1.5M deep would render the ground unusable for the current use of the ground.

Table 7.5 Construction Cost Estimates for Canine Association Detention Basin – has a significant miss-calculation, and that being land acquisition. Given the plan provided the current site would no longer be suitable for the Association to conduct its business. Prior to the recently completed $500,000 redevelopment the Association costed a number of options to relocate the development to another site. The estimated cost to relocate to a similar site (eg demographically central to the membership base) and to construct similar facilities would cost approximately $12M. This was outside of the Associations capability and so the members elected to remain at the existing site. Given this additional cost which has not been identified in the report the true cost at Table 7.5 should be $15,300,000. Plus legal costs for compulsory acquisition if it came to that.

Section 8 of the plan does not have any scenarios where the Council Depot is being considered. Given this is current Council land that would not require compensation to private land owners this option would have been on the plans priority listing. Given the now true cost of the Canine-Association option as compared to the Council Depot, this should now be investigated further.

At Table 8.2 Summary of properties flooded Needs to be adjusted to reflect the true cost of Element D from the proposed $3M to the estimated $17M. 8.2.12 also identifies that the widening of the channel would be more beneficial in reducing the risk of flooding in a 100ARI event.

Table 8.3 Optimised Decision Making Rating of Options clearly shows the benefit of utilising the Canine Association Basin the least beneficial, even with the ratings for Social Values, Environmental, and Capitol and Maintenance Cost being miss-represented.

Section 9 Priorities, Timeframes and Responsibilities – In this section the Canine Association Basin only rates as Priority 5. The Flood Reduction Benefits identifies the channel will need significant maintenance over the next 10 years and should an upgrade be developed in conjunction the cost of the Canine Association Basin Option would not be warranted.

Given the plan does not fully support the use of the Canine Association grounds as a desirable alternative and the fact the cost of land acquisition and disruption to the Association have not been considered in the Plan I would suggest that the City of Port Adelaide Enfield reconsider its options and remove the Canine Association grounds from the Plan. Removal of the option from the Plan will give the Association permanency within the area and can continue to provide a service for its members and the community at large.

Should the City of Port Adelaide Enfield not consider removing the option as viable then the association is willing to meet with them to discuss if there are any viable alternatives to what is being proposed which may be in the interest of both the Association and City of Port Adelaide Enfield.

Yours Sincerely,

MR BRIAN PARKER
PRESIDENT

Environment Protection Authority
www.epa.sa.gov.au

EPA
South Australia

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Country areas 1800 623 445

EPA 05/13/0521

Ms Verity Sanders
Strategic Planning
City of Port Adelaide Enfield.
PO Box 110
PORT ADELAIDE SA 5015

Dear Ms ~~Sanders~~ Verity,

Thank you for your letter dated 12 March 2013 regarding the City of Port Adelaide Enfield *North Arm East Catchment Draft Stormwater Management Plan* (the Plan). The Environment Protection Authority (EPA) welcomes the opportunity to provide comments on the Plan.

The EPA has legislative responsibility under the *Environment Protection Act 1993* and the *Environment Protection (Water Quality) Policy 2003* to ensure water quality outcomes in the State's waters, including stormwater. Accordingly, comments on the Plan are focussed on water quality outcomes.

From the draft Plan, it is noted that the entire North Arm East Catchment outlets to the Barker Inlet Wetland prior to discharge to the Barker Inlet. The draft Plan does acknowledge there are some issues associated with the management and performance of the wetland and follows with recommendations for further stormwater quality improvement strategies to be undertaken within the catchment, which are supported. However, the strategies do not address improving the management, maintenance and performance of the wetlands, which are critical to improving stormwater quality outcomes and impacts to receiving waters.

The EPA recommends that since the wetlands are critical to treatment of all stormwater from this catchment, responsibility for care, control, monitoring and management of the wetlands is articulated in the Stormwater Management Plan. If required, actions to clarify responsibility for functioning, care, monitoring and maintenance of the wetlands should be incorporated. Further, the report, "*North Arm East wetland condition assessment*" (DesignFlow, November 2012) should be acknowledged and actions to address the recommendations incorporated.

Articulation of responsibility for the care, control and management of the wetlands should include:

- conduct of required monitoring of the wetlands as indicated in section 6.2.9 of the Plan
- responsibility for improvements and further management actions should the monitoring indicate that wetlands are not performing as expected
- acknowledgment of the wetland assessment condition report (DesignFlow report) and how these recommendations will be addressed.

For further information on this matter, please contact Ms Ruth Ward, Senior Environment Protection Officer (Stormwater) on telephone 8204 2065 or via email ruth.ward@epa.sa.gov.au.

Yours sincerely

Peter Dolan

DIRECTOR, SCIENCE AND ASSESSMENT

ENVIRONMENT PROTECTION AUTHORITY

Date: 10/4/13

Appendix F

North Arm East Catchment Development Trends

North Arm East Catchment Development Trends

August 2011
City of Port Adelaide Enfield

Contents

1.0 Background

In 2003 Jensen Planning and Design, with input from Tonkin Consulting, prepared a confidential report for the City of Port Adelaide Enfield and the City of Charles Sturt: *North West Region, Initial Urban Stormwater Master Plans: Planning and Development Issues.*

The report provided background information relating to development trends to be factored into relevant catchment stormwater management plans. Additionally, a number of predictions were made regarding likely future development scenarios.

The purpose of this report is to assess the accuracy of the 2003 development projections for the Catchment that have been used as a basis for stormwater management planning by Council in the intervening years.

This report will also project future development trends based on recent development history and the State Government's currently policy approach to urban policy and water management.

Both the 2003 report and this report exclude industrial areas as these are, for the most part, fully developed. Conversely, increased dwelling numbers are anticipated to significantly contribute to the increase in impervious area within the North Arm East Catchment and thus the analysis focuses on existing and potential residential development.

This report refers to a number of developments under current assessment or earmarked for future redevelopment. It should be emphasised that this report represents a 'point in time' analysis and thus proposals under assessment or future development opportunities may not eventuate as anticipated.

2.0 North Arm East Catchment

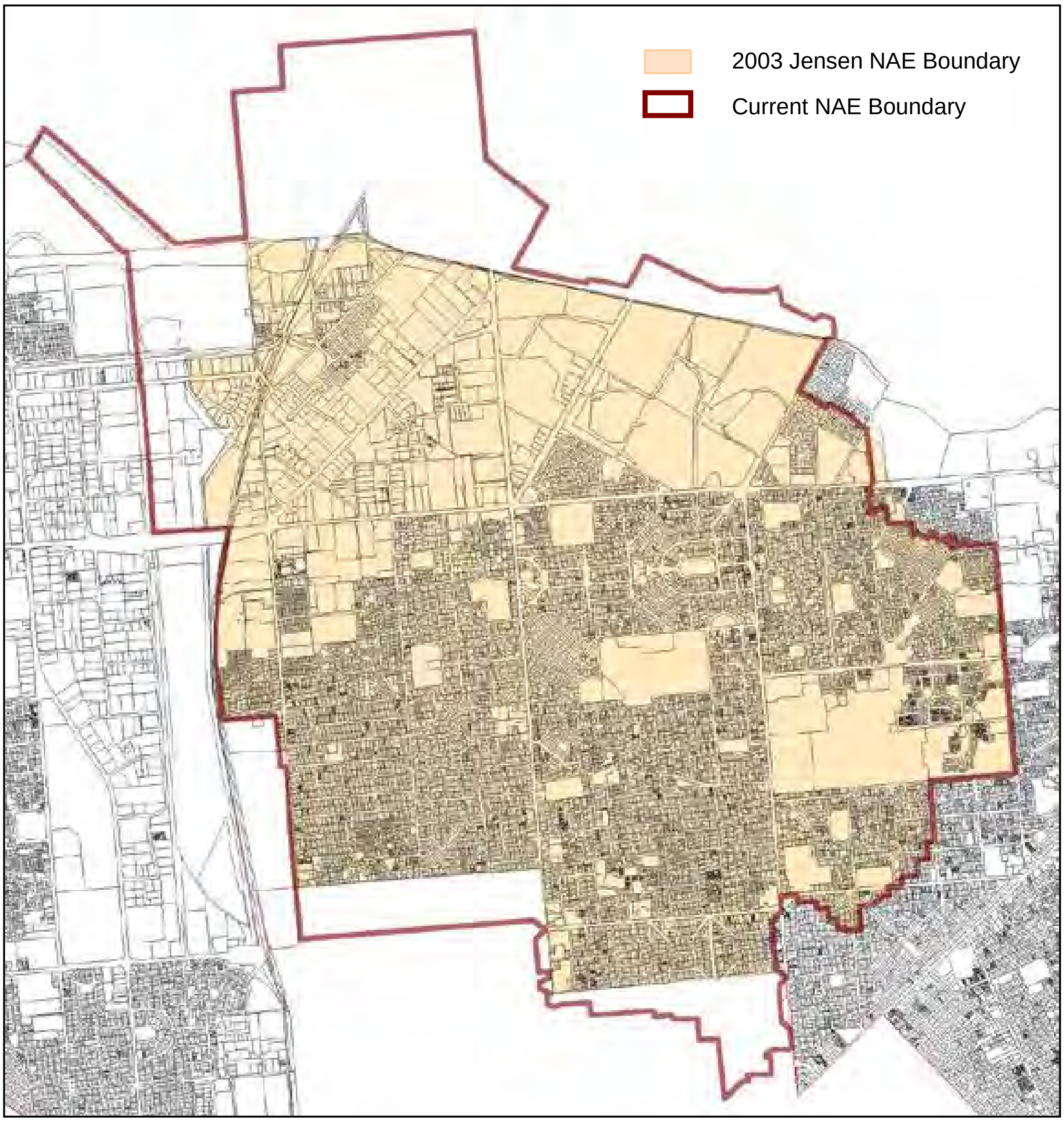
The below map identifies the current North Arm East (NAE) Catchment boundary as well as the boundary utilised in the Jensen report.

The areas to the south, located within the Prospect Council area, have been excluded from this report as they were excluded in the 2003 Jensen report.

The current NAE Catchment boundary incorporates additional areas to the north, containing wetlands and part of the Dry Creek salt pans. Given that these areas are undeveloped, it is unlikely that the discrepancy between the two boundaries has any impact on stormwater run-off levels.

However, the current NAE Catchment boundary includes a portion of the 'cast metals' precinct, in the north-western section, that was not encapsulated within the 2003 Catchment boundary and contains a large area of undeveloped land.

Figure 1: the North Arm East Catchment Area



3.0 Development Trends: Retrospective

3.1 Net increase of dwellings

The NAE Catchment boundary slightly encroaches into the City of Prospect to the south and this land has been excluded from the analysis.

The Jensen Report stated that there were 10,945 dwellings within the North Arm East Catchment area in 2003. According to Council's property and rating data, currently there are 12,183 residential properties. This number encompasses all types of residential accommodation, including boarding houses, home industries and the like. However, these less conventional categories represent only a small number of the overall total.

It is important to note that Council's systems record only 9,844 residential properties within the Catchment area in 2003. This is a significant difference when compared with the number referenced in the Jensen Report (10,945 total dwellings). While the source of this figure is unclear, it would have likely originated from Council's database. Council converted to a new IT system in 2003 and it is possible that the older system was less sophisticated, making it difficult to extract accurate data. Alternatively, the discrepancy may have arisen from the application of inadequate filters when extracting the data. At any rate, the analysis provided in this report will use the 9,844 total as it is verifiable (refer to Appendix 1 for further details on the method of data extraction).

The increase of dwellings in the NAE Catchment area from 9,844 in 2003 to 12,183 in 2011 represents an increase of 2,339 dwellings (or an increase of 24%). The number of additional dwellings per annum for the years 2004-2010[1] ranges from 211 to 513, with an overall average of 317 additional dwellings per year.

The Jensen Report predicted an increase of 3080 dwellings (or 28% increase) in the short term (5 - 10 years), which appears to be accurate. Multiplying 317 (average increase in dwellings per year) by ten years results in 3170 additional dwellings (or 32% increase), which is just over the number predicted by Jensen.

The Jensen Report assumes 60% of the ultimate theoretical development scenario will be achieved over a 50 year period, which equates to:

- An average of 80 additional dwellings per annum over 50 years; or

- Approximately 300 new dwellings per annum in the first 10 years, followed by an average of 26 dwellings per year for the subsequent 40 years.

The short term prediction of 300 new dwellings per annum within the first 10 years appears accurate, based on the average increase of 317 new dwellings per annum. However, while it is too early to ascertain the accuracy of the 50 year prediction, the stated "26 dwellings per year for the subsequent 40 years" appears less certain given the increases in dwelling numbers over the past several years and remaining capacity for growth at Northgate.

Significantly, during 2004-2010 the suburb of Northgate recorded an additional 276 dwellings. This equates to an average of 39 additional dwellings per year at Northgate or 12% of the average yearly increase of 317 new dwellings across the entire

[1] 2011 is excluded as it represents only half a calendar year.

Catchment. Given that the remainder of the Catchment contains established residential areas, then it indicates that the majority of new dwellings (88 percent) are infill while only 12 percent are greenfields.

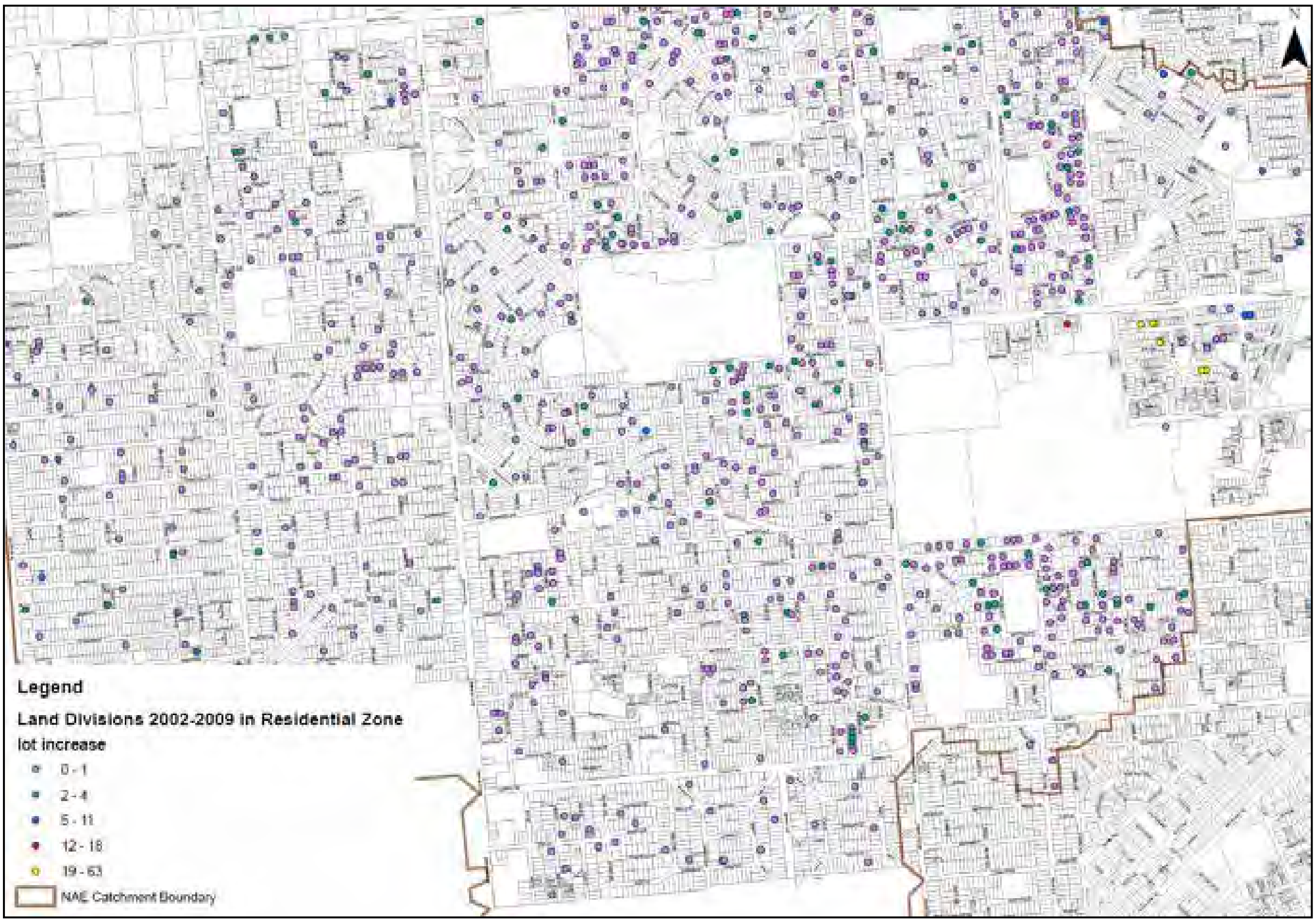
3.2 Additional Residential Allotments

Land division data from 2002-2009 indicates that within the NAE Catchment 1358 additional residential allotments were created during the eight year period, equating to an average of 170 additional residential allotments per annum. This means that approximately 54% of additional dwellings within the Catchment area are being built on new blocks.

Many of the dwellings built on new allotments will have occurred within the Northgate greenfields development. The remainder will be infill development of the 'two for one' variety. This typically involves the demolition of an existing dwelling and subdivision of the allotment into two land parcels with two new dwellings constructed on each allotment. In this scenario one of the two dwellings will be a replacement dwelling. In other instances, the existing house is retained and the yard is subdivided off to create a new allotment. This form of subdivision usually occurs on corner blocks or alternatively results in 'hammerhead' allotments where one dwelling is located behind another.

The below map shows the location and number of new allotments created in the Catchment area during 2002-2009:

Figure 2: North Arm East Catchment land divisions within the Residential Zone, 2002-2009



3.3 Dwelling Development Approvals

Council records indicate that 1652 development approvals were issued for dwellings during 2004-2010. This equates to an average of 236 planning consents issued per year, with many approvals being for multiple dwellings. In some circumstances proponents will lodge a second application to gain approval for a different dwelling design, whilst other approvals may lapse and then require re-lodgement. As such, the figure of 236 is an indicative figure of application approvals per annum and not the actual number of dwellings approved for construction.

3.4 Dwelling Demolition Approvals

Between 2004 and 2010, Council recorded a total of 1272 approved dwelling demolition applications within the Catchment, which equates to an average of 182 approvals per year. It is important to note, as with the dwelling approvals, that the number of approved applications does not reflect the actual numbers of demolitions as some applications sought the removal of more than one dwelling (usually of the semi-detached dwelling variety). However, a perusal of the base data shows that most of the demolition applications were for one dwelling.

A conservative supposition that 182 dwellings are demolished per year (i.e. one per approved application) considered against the average net increase of 317 dwellings per year, suggests that at least 34% of dwellings are replacement dwellings.

3.5 Retrospective Development Totals

A summary of the key findings from this section is provided below:

- Total dwellings in 2003: 9,844
- Total dwellings in 2011 (as of 27 July 2011): 12,183
- Increase in dwellings: 2,339 dwellings (or an increase of 24%)
- **Average increase in dwellings per annum: 317** (based on 2004-2010 data)

- The Jensen Report's short-term prediction (5-10 years): 3080 additional dwellings or 28.1% increase.
- Current situation: 317 average yearly increase multiplied by 10 years is 3170 additional dwellings or 32 % increase.

- Land divisions 2002-2009: 1358 additional residential allotments or an average of **170 additional residential allotments per annum**.

- Dwellings approvals 2004-2010 inclusive: 1652 or **236 planning consents per annum** (note that the number of the consents is not indicative of the actual number of dwellings approved for construction).

- Approved applications for dwelling demolitions between 2004 and 2010: 1272, which equates to **182 demolition consents per annum** (note that the number of consents is not indicative of the number of dwellings actually approved for demolition).

4.0 Development Trends: Future

4.1 Residential Densities

In past years there has been a trend towards higher density development in locations such as Newport Quays and Northgate. Additionally, infill development has occurred in many areas of Council and especially within the NAE Catchment area. Residential infill development commonly occurs on an ad-hoc, site-by site basis. Thus, unlike large scale developments such as Northgate, there is little scope for stormwater to be managed on-site, leading to a significant (cumulative) impact of increased stormwater generation within the Catchment system.

The trend for larger houses on smaller blocks further exacerbates the level of stormwater generation. The below image clearly illustrates the difference between the 'old' and 'new' residential forms and the implications for increased flows.

Old versus new: Marker Street, Enfield: This image demonstrates the significant reduction in pervious area as a result of in-fill development.

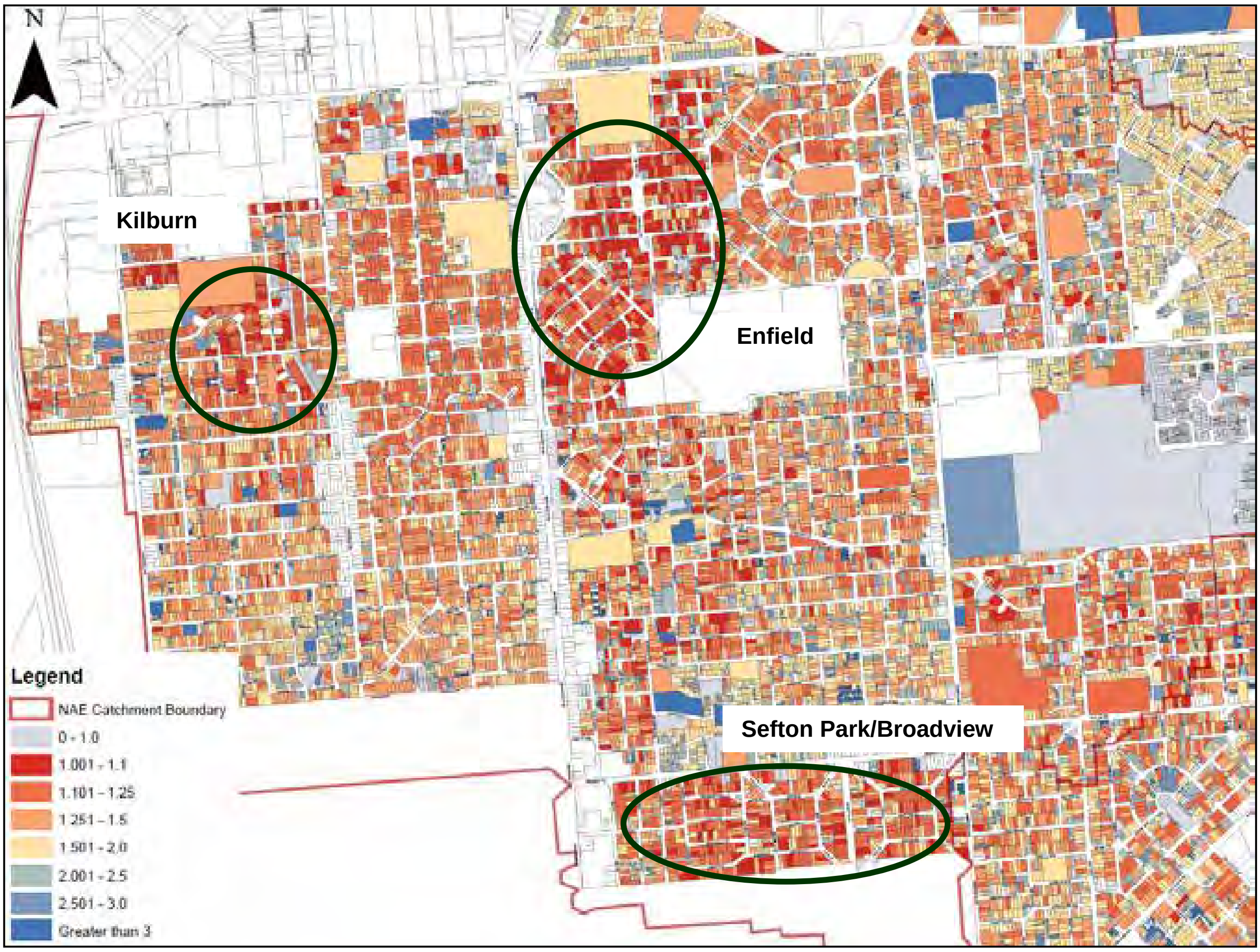
4.2 Infill Development

A great deal of the redevelopment potential within the NAE Catchment area is via infill development. One indicator of infill opportunities is the capital value and site value (SV:CV) ratio. Site value is the value of an allotment without taking into account any improvements, whilst capital value is the value of an allotment with improvements (e.g. buildings).

The SV:CV analysis helps to identify sites where the existing buildings and structures contribute little to the overall property value and therefore make the property attractive for redevelopment. The Jensen Report states that Planning SA (now Department of Planning and Local Government) considered allotments with a value of 1.2[2] or less to be developable in the short term (5-10 years). However, the analysis in this report focuses on those sites with a value of 1.25 or less.

The below SV:CV map highlights several hotspots in Enfield and Kilburn as being particularly viable for redevelopment. An area south of Regency Road in Sefton Park/Broadview is also highlighted in the analysis as having a high number of properties with a low SV:CV ratio. However, this area is located within the Enfield Policy Area in Council's Development Plan, which seeks to preserve the existing residential character and stipulates a 450sqm minimum allotment size. As such, the potential for sub-divisions in the Sefton Park/Broadview locality is constrained.

Figure 3: Site value to capital value ratio in the North Arm East Catchment Area



2 A value of 1.2 indicates that the capital value of a site is 20 percent higher than the site value. This means that the improvements to the property (e.g. buildings) contribute relatively little to the property's overall value. Conversely, a value of, for example, 2.0 indicates that the capital value of the property is twice that of the site value. This means that the buildings and other improvements constitute half of the property's value.

Using GIS, residential allotments were identified as being developable in the short term by applying the following criteria:

No	Criteria	Justification/comment
1	Allotments that are located within the Residential East Policy Area 43 or Comprehensive Development Policy Area 44	Policy Areas 43 and 44 cover most of the residential zoned land in the Catchment area and allow for a minimum allotment size of 300 sqm. Northfield Policy Area 50 was excluded as it applies to the Northgate greenfields development. Also, the Enfield Policy Area 45 was excluded as it seeks to protect existing character and stipulates a minimum allotment size of 450sqm, which constrains subdivision potential.
2	Allotments that have a minimum allotment size of 600sqm	Allotments that are 600sqm or greater theoretically have the potential for sub-division into two allotments, given the allowable minimum allotment size of 300sqm.
3	Allotments that accommodate dwellings built between 1941-1960	Post-war housing constructed during 1941-1960 represents the majority of the housing stock within the NAE Catchment and is considered to be coming to the end of its economic life. Whilst there are some older houses in the catchment, the number is comparatively small and these dwellings often display attractive character attributes that people tend to value and seek to retain, although none are specifically protected by Development Plan policies. Similarly, dwellings built after 1960 are considered to contain economic value and therefore are less viable for demolition.
4	Allotments that have a site value to capital value ratio less than 1.25	Site values below 1.25 are considered economically attractive to re-develop. [Note that the Jensen Report stated that Planning SA (now DPLG) considered properties with a value of 1.2 or less to possess short-term development potential].

Out of 13,114 total allotments (inclusive of all land-uses) located within the Residential Zone and inside the NAE Catchment area, 1,553 allotments fit the above criteria.

These allotments can be considered to be developable within the short-term. Assuming that most redevelopment will consist of a subdivision from one allotment into two, it could be expected that 1,553 additional residential allotments and dwellings will be created during the next 5-10 years.

The 50-year long-term scenario identifies 5,921 allotments that will potentially be subdivided and redeveloped. This scenario does not consider the age of the dwellings or the SV:CV values as these factors will not be relevant in 50 years time. Jensen's assertion that 60 percent of the maximum development scenario is likely to occur, indicates that only 3553 allotments will realistically be developed within the next 50 years.

However, for the purposes of sound long term stormwater planning, it is better practice to assume that the maximum development potential scenario will occur (i.e. the maximum number of allotments that can be subdivided, will be subdivided). This will ensure stormwater planning and investments can allow for the potential maximum growth.

Figure 4: Table of Short-Term Development Criteria

Allotments within NAE Catchment	Residential Zone	Policy Areas 43 & 44	Allotments 600sqm +	Dwellings built 1941-1960	SV:CV ratio 0-1.25	TOTALS (no. of allotments)
						13,114
						5,921[3]
						3,434
						1,553

4.3 Northgate

The Northgate development has been a significant greenfields development for the Port Adelaide Enfield Council area. Northgate contemplates higher densities than elsewhere in the Council area but stormwater management is also factored into its design and therefore the stormwater run-off has minimal impact on the NAE Catchment system.

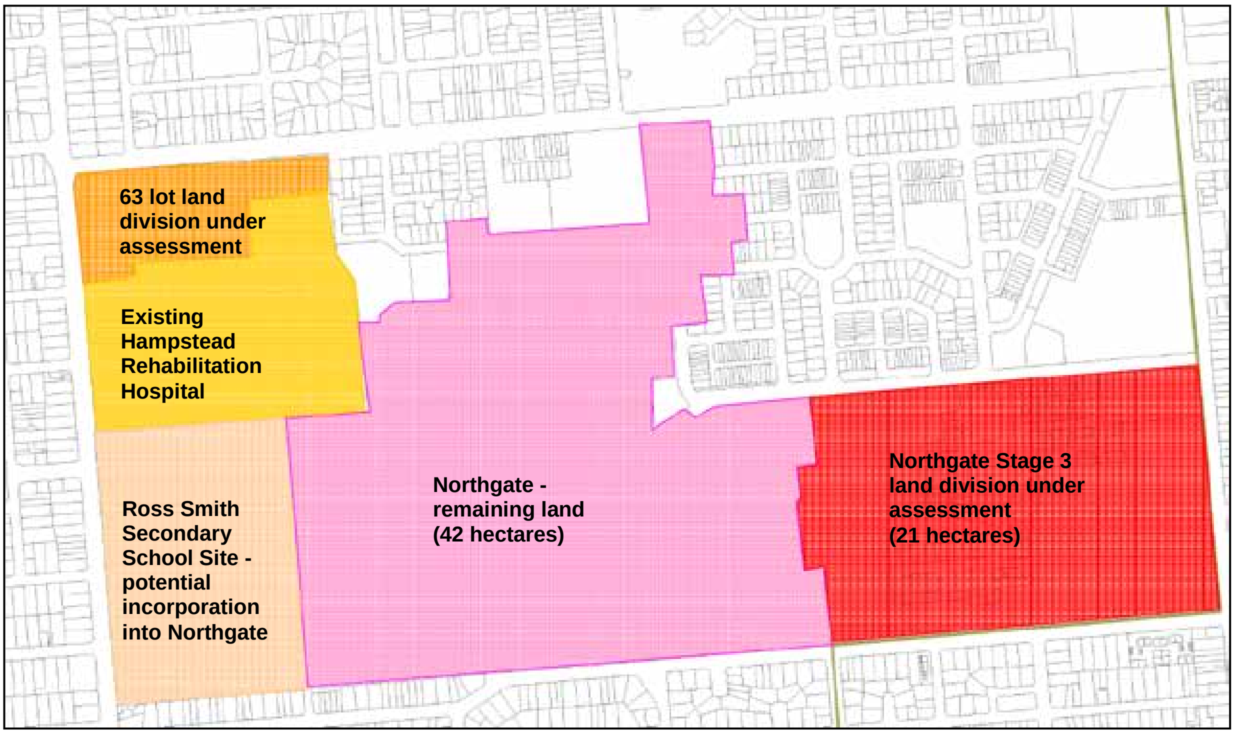
At the time of writing the Minister is preparing a Development Plan Amendment (DPA) for Northgate. Whilst Council is not aware of the details of the DPA, it is likely that even higher densities may be contemplated.

Based on the current Stage 3 land division application being assessed by Council, which contemplates 466 allotments within a 21 hectare site, the remaining land within Northgate, consisting of 42 hectares, could be expected to yield approximately 932 residential allotments. As such, the Stage 3 land, together with the remaining vacant land, will yield approximately 1398 residential allotments. A 155 dwelling retirement village and 110-place aged care facility will also be accommodated in the remaining stages.

Another significant development within the vicinity of Northgate (but not connected to Northgate) is a land division proposal currently under assessment for a 63 lot residential development on the corner of Hampstead Road and Folland Avenue. One of the allotments is earmarked for a future community title, medium density, development. This development is also large enough for stormwater to be managed on-site and therefore will have minimal impact on the NAE Catchment system.

[3] Note that there are 70 reserves within the NAE Catchment area, located within Residential Policy Areas 43 and 44, that are over 600sqm in area and which have been excluded from this calculation. The 'dwellings built 1941-1960' and 'SV:CV ratio' filters by their nature automatically exclude the reserves.

Figure 5: Northgate (and surrounds): future development



4.4 Surplus School Sites

There are a number of school sites being closed within the Port Adelaide Enfield Council area as part of the State Government's 'super schools' initiative:

- Kilburn Primary School, located within the NAE Catchment, has been consolidated into Gepps Cross Primary School (now known as Blair Athol North Primary School).

- Gepps Cross Girls High School, Enfield High School and Ross Smith Secondary School, all located within the Catchment, have recently been closed with the opening of the new super school at Briens Road, Gepps Cross.

- Ferryden Park Primary School and Mansfield Park Primary have been consolidated into the Ridley Grove Primary School (now known as Woodville Gardens Primary School). However, these school sites are outside of the NAE Catchment.

Ross Smith Secondary School is likely to be consolidated into Northgate and redeveloped for residential purposes, with the existing ovals retained for recreation/open space/stormwater detention. Similarly, Enfield High School will likely be developed for a mixture of residential and open space purposes. In particular, Council has been advocating for the retention of the existing ovals at Enfield High School for sporting ovals.

The Gepps Cross Girls High School is surrounded by industry and likely to be utilised for industrial/commercial purposes.

The future of Kilburn Primary School is less certain. However, Council is strongly in favour of the entire site (around 3.58 hectares) being retained for community and recreation/open space facilities. This would probably result in a similar breakdown of the pervious and impervious areas that currently exist.

4.5 Other Opportunities

Whilst this report has focussed on future *residential* scenarios, it is worth noting that, although most of the industrial precincts within the NAE Catchment are fully developed, the former Gepps Cross Girls High School (5.88 hectares with approximately 60% of undeveloped land) has capacity for further development and a large portion of the Industry (Cast Metals) Zone remains vacant (approximately 11 hectares). Combined, these parcels represent considerable future development potential. However, given the size of the parcels, stormwater should be able to be managed on-site and have minimal impact on the NAE Catchment.

4.6 Future Development Prediction Totals

A summary of the key findings from this section is provided below:

Infill development

- Short term development scenario (5-10 years):**1,553 allotments**
- Long term development scenario (50 years): **5921 allotments (maximum development scenario)**

Greenfields/Schools

- Northgate (Stage 3 land division under assessment): 466 residential allotments
- Northgate (remaining land): 932 residential allotments
- Land division corner Hampstead Rd/Folland Ave: 63 residential allotments
- Ross Smith High School redevelopment: unconfirmed residential component
- Enfield High School redevelopment: unconfirmed residential component

Industry

- Gepps Cross Girls High School: 5.88 ha site (with around 60% of land currently undeveloped)
- Cast Metals precinct: 11 hectares vacant land.

5.0 State Government Strategic Directions

The State Government's 30 Year Plan for Greater Adelaide promotes Water Sensitive Urban Design (WSUD) and states *"Measures such as smaller housing choices, better building standards, and more medium-density housing can often provide opportunities for stormwater capture and recycling and are fundamental to reducing the rate of water consumption".*

The 30 Year Plan water-related policies are as follows:

- Incorporate water-sensitive urban design (WSUD) techniques in new developments to achieve water quality and water efficiency benefits.
- Require WSUD techniques to be incorporated in Structure Plans and Precinct Requirements for State Significant Areas.
- Mandate WSUD for new development (including residential, retail, commercial, institutional, industrial and transport developments) by 2013 (consistent with Water for Good[4]).
- Require new Greenfield developments that are subject to Structure Plans from 2011 to source water for outdoor use from non-mains water supplies. This recognises the need to plan alternative water sources at the commencement of new large Greenfield developments, rather than retrofit these sources for latter stages of the development.
- Protect water supply catchments and the watershed by preventing high risk development in catchments and water areas that are considered vulnerable, consistent with the water quality risk hierarchy associated with the Mount Lofty Ranges Watershed priority areas, and ensure that new developments have a beneficial, or at least neutral, impact on water quality in the watershed.
- Incorporate the protection of relevant coastal and riparian areas and Ramsar wetlands in Structure Plans and Development plans
- Identify and protect locations for potential stormwater harvesting schemes
- Ensure appropriate policy links and consistency between Stormwater Management Plans, Structure Plans and Development Plans to address stormwater and flood management matters.

If these policies are implemented in a meaningful and achievable way, then future development will assist in alleviating stormwater management issues.

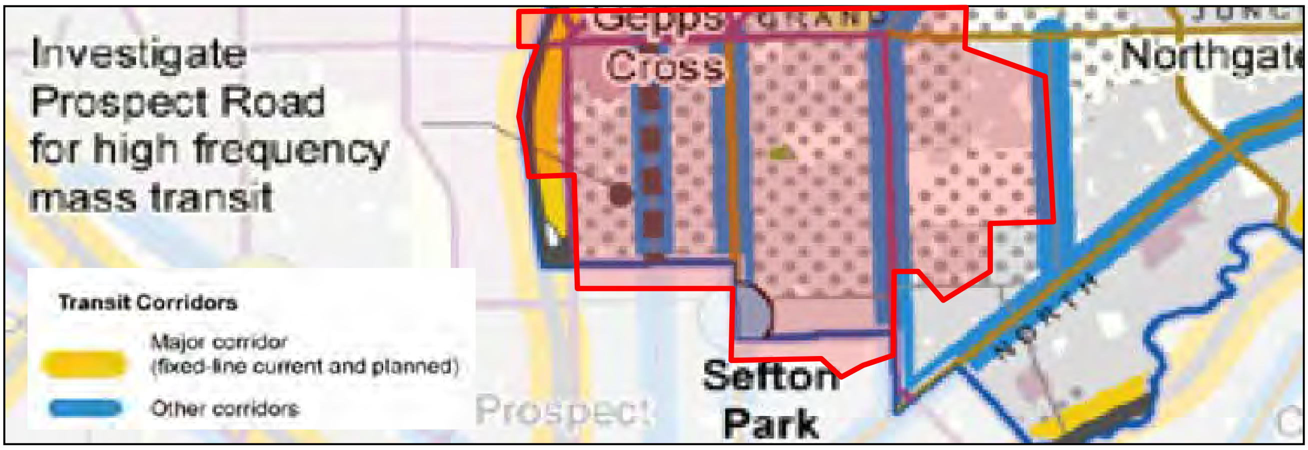
However, currently only large scale developments are able to employ WSUD techniques, such as provision of open spaces for stormwater detention.

The 30 Year Plan's vision of higher density residential development around transport nodes and along transit corridors has the potential to result in fragmented infill that does not (or is incapable of) reducing stormwater run-off on a site-by-site basis. Thus, the cumulative impacts of increased impervious surfaces without a holistic approach to stormwater management will potentially exacerbate existing stormwater management issues.

[4] *Water for Good* is a critical plan, prepared by the State Government, to reduce water usage and manage water resources appropriately. One of the stated actions in the Plan is that "Water-sensitive urban design will be mandated through new planning regulations which will dovetail with the Plan for Greater Adelaide and apply to new residential and commercial urban development".

The North Arm East Catchment is partially bordered on the west by the Gawler passenger rail line - a designated 'major corridor' in the 30 Year Plan. The remainder of the Catchment contains portions of main roads that are designated by the Plan as 'other corridors': Prospect Road, Main North Road, Hampstead Road and Foster's Road on the far eastern boundary. Thus, there is scope for significant in-fill development to occur in accordance with the aims of the 30 Year Plan. Therefore, any potential future rezoning or policy changes to provide for increased residential densities within these corridors (or elsewhere in the Catchment area) will need to consider the impact of increased stormwater generation and incorporate infrastructure planning into the rollout of new development.

Figure 6: Excerpt from the 30 Year Plan for Greater Adelaide - Northern Region Plan



Indicative location of North Arm East Catchment Boundary

Since 1 July 2006 most new homes (including home extensions larger than 50 square metres) are required to have an alternate water source plumbed into the home. In most cases this will be from a rain water tank but in some cases, where it is available, from 'third pipe recycled water'. Embedding such requirements into legislation or codes, such as the Building Code of Australia and Development Regulations, is a key way of achieving sustainable water design outcomes, particularly for infill residential development.

6.0 Water Management in Planning Policy

Council is currently in the process of converting the Port Adelaide Enfield (City) Development Plan into the Better Development Plan (BDP) format, which has been devised by the Department of Planning and Local Government.

The BDP Policy Library consists of core policies that are considered to be best practice and have been prepared in consultation with relevant agencies.

The 'Natural Resources' module of the policy library contains a specific section on Water Sustainable Design. The core BDP policies, combined with additional Council-specific policies provide a comprehensive guide to the sustainable management of water. Proposed Principle of Development Control 16(a) and (b) is referenced below (the entire module is provided at Attachment 2) and demonstrates the type of policies to be used for assessing future development proposals. Note that the black text is core BDP policy and the green text is Council's 'local addition':

Stormwater management systems should:

(a) maximise the potential for stormwater harvesting and re-use, either on-site or as close as practicable to the source

(b) utilise, but not be limited to, one or more of the following harvesting methods:

- *(i) the collection of roof water in tanks designed in accordance with the average rainfall for the area and roof size*
- *(ii) the discharge to open space, landscaping or garden areas, including strips adjacent to car parks*
- *(iii) the incorporation of detention and retention facilities*
- *(iv) aquifer recharge*

Once the Development Plan is converted into the BDP format there will be sufficient guidance for the implementation of WSUD design principles. However, it is likely that principles will be applied where the development site is large enough to facilitate some of the aforementioned techniques. This will mean that in many cases infill residential development will be precluded from employing WSUD principles.

It is therefore important that the State Government is able to implement other aspects of the Water for Good plan such as large scale stormwater harvesting and recycling projects, which do not rely on new small-scale development to deliver sustainable water management outcomes.

7.0 Conclusion

Infill residential development within the North Arm East Catchment area has the potential to generate significant amounts of additional stormwater. It is predicted that in the short term (5-10 years) as many as 1483 allotments could be subdivided to provide for an additional dwelling. In the long-term (50 years) as many as 5921 allotments (maximum development scenario) could be developed in a similar way.

Whilst the Better Development Plan (Conversion) Development Plan Amendment will provide up-to-date guidelines relating to WSUD practices, these are more applicable to large-scale developments and are generally not called upon for ad-hoc infill residential development.

Other redevelopment opportunities within the Catchment area, such as Northgate and the surplus school sites will be able to employ water sensitive design systems (e.g. stormwater detention basins) as the development sites are large enough to accommodate them.

Infill development may exceed the predicted totals if the State Government pursues higher densities along identified transit corridors within the Catchment (e.g. Prospect Road, Main North Road and Hampstead Road), as envisaged in the 30 Year Plan for Greater Adelaide. However, this would require a change to the minimum allotment sizes currently specified within the Residential Zone's Residential East and Comprehensive Development policy areas.

Appendix 1: Method of Data Extraction for Dwelling Totals

The dwelling property data was gathered by first obtaining the land numbers for each allotment within the North Arm East Catchment area, using Council's GIS system. Then, those allotments attached to a residential land-use number, as recorded in Council's Property and Rating system, were extracted.

The following table shows all residential land-use descriptions and the number of allotments recorded against each description.

The numbers provided for 2003 are a total, whilst the following years show the number of *additional* properties recorded for that year. The last column is a grand total. Note that whilst all other years are full years, the data for 2011 only relates to the year to 27 July 2011. For this reason, most of the averages discussed in the body of the report exclude data for 2011 and instead work with the data for full calendar years.

Increase of total dwelling numbers within the North Arm East Catchment 2003-2011

		Dwelling increase per year								
Dwelling Type/Description	**2003 Total**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011***	**Grand Total***
House	7350	372	251	167	168	222	190	120	37	8877
Maisonette	1112	38	16	8	8	53	25	13		1273
Ground Floor Unit Only	484	8	11	19	5	10	10	13	12	572
S/S Flats-Purpose Built	210	11	3	4	1	1	4	3	5	242
Independent Living Unit	139		16	37		6			11	209
Townhouse/Ground & 1st Floor	47	57	13	10	18		6	8	3	162
Detached Single Storey Unit	55	11	5	19	5	1	4	9	22	131
Grnd Flr. Unit - Multi Str.Blk	123	3				3				129
First Floor Home Unit	115	3				6				124
Unfinished House	14		3	3	2	20	35	33	11	121
House w/unestablished grounds	8	2	2	4	3	24	37	27	1	108
2/S & Higher Flats-Purpose Blt	60				1					61
Row House	45	2		2		6	1			56
FLATS (URBAN)	19	1		1			1		14	36
Shop & Dwelling	2									2
Town House Style Flats	14	1						1		16
House & Granny Flat	14					1				15
Retired and Aged Accommodation	9									9
HOME UNITS (URBAN)	1	4		4						9
S/S Flats-Converted House							2		2	4
House & Office	5									5
S/S Flats-Pair of Maisonettes	2									2
S/S Flats-Built for Strata	4									4
Second Floor Home Unit						3				3
Other Instit Resi Accommodation	2									2
House & Flat				1						1
Home Industry (Owner Occupied)	3									3
T/House Flats-Pair 2/S maisonette	2									2
Religious Quarters-Monast etc	1									1
Private Hotels Boarding Houses	1									1
Other Res Hall or Dormitory	1									1
Institutional Residential Accom	1									1
House with Man & Ser. Industry	1									1
Grand Total	**9844**	**513**	**320**	**279**	**211**	**356**	**315**	**227**	**118**	**12183**

**As of 27 July 2011*

Appendix 2: 'Natural Resources' Better Development Plan module

Natural Resources

OBJECTIVES

1 Retention, protection and restoration of the natural resources and environment.

2 Protection of the quality and quantity of South Australia's surface waters, including inland, *marine and estuarine* and underground waters.

3 The ecologically sustainable use of natural resources including water resources, including *marine waters,* ground water, surface water and watercourses.

4 Natural hydrological systems and environmental flows reinstated, and maintained and enhanced.

5 Development consistent with the principles of water sensitive design.

6 Development sited and designed to:

(a) protect natural ecological systems

(b) achieve the sustainable use of water

(c) protect water quality, including receiving waters

(d) reduce runoff and peak flows and prevent the risk of downstream flooding

(e) minimise demand on reticulated water supplies

(f) maximise the harvest and use of stormwater

(g) protect stormwater from pollution sources.

7 Storage and use of stormwater which avoids adverse impact on public health and safety.

8 Native flora, fauna and ecosystems protected, retained, conserved and restored.

9 Restoration, expansion and linking of existing native vegetation to facilitate habitat corridors for ease of movement of fauna.

10 Minimal disturbance and modification of the natural landform.

11 Protection of the physical, chemical and biological quality of soil resources.

12 Protection of areas prone to erosion or other land degradation processes from inappropriate development.

13 Protection of the scenic qualities of natural and rural landscapes.

PRINCIPLES OF DEVELOPMENT CONTROL

1 Development should be undertaken with minimum impact on the natural environment, including air and water quality, land, soil, biodiversity, and scenically attractive areas.

2 Development should ensure that South Australia's natural assets, such as biodiversity, water and soil, are protected and enhanced.

3 Development should not significantly obstruct or adversely affect sensitive ecological areas such as creeks, wetlands, estuaries and significant seagrass and mangrove communities.

4 Development should be appropriate to land capability and the protection and conservation of water resources and biodiversity.

5 Unavoidable stormwater and effluent outfalls discharged across a beach should do so at beach level from properly constructed pipes or channels.

Water Sensitive Design

6 Development should be designed to maximise conservation, minimise consumption and encourage re-use of water resources.

7 Development should not take place if it results in unsustainable use of surface or underground water resources.

8 Development should be sited and designed to:

- (a) capture and re-use stormwater, where practical
- (b) minimise surface water runoff
- (c) prevent soil erosion and water pollution
- (d) protect and enhance natural water flows
- (e) protect water quality by providing adequate separation distances from watercourses and other water bodies
- (f) not contribute to an increase in salinity levels
- (g) avoid the water logging of soil or the release of toxic elements
- (h) maintain natural hydrological systems and not adversely affect:
  - (i) the quantity and quality of groundwater
  - (ii) the depth and directional flow of groundwater
  - (iii) the quality and function of natural springs.

9 Water discharged from a development site should:

- (a) be of a physical, chemical and biological condition equivalent to or better than its pre-developed state
- (b) not exceed the rate of discharge from the site as it existed in pre-development conditions.

10 Development should include stormwater management systems to protect it from damage during a minimum of a 1-in-100 year average return interval flood.

11 Development should have adequate provision to control any stormwater over-flow runoff from the site and should be sited and designed to improve the quality of stormwater and minimise pollutant transfer to receiving waters.

12 Development should include stormwater management systems to mitigate peak flows and manage the rate and duration of stormwater discharges from the site to ensure the carrying capacities of downstream systems are not overloaded.

13 Development should include stormwater management systems to minimise the discharge of sediment, suspended solids, organic matter, nutrients, bacteria, litter and other contaminants to the stormwater system.

14 Stormwater management systems should not create conditions conducive to the breeding of vectors of disease and nuisance pests.

15 Stormwater management systems should preserve natural drainage systems, including the associated environmental flows.

16 Stormwater management systems should:

(a) maximise the potential for stormwater harvesting and re-use, either on-site or as close as practicable to the source

(b) utilise, but not be limited to, one or more of the following harvesting methods:

(i) the collection of roof water in tanks designed in accordance with the average rainfall for the area and roof size

(ii) the discharge to open space, landscaping or garden areas, including strips adjacent to car parks

(iii) the incorporation of detention and retention facilities

(iv) aquifer recharge

(c) take into account the safety of children and other likely users

(d) minimise impacts on the useability of public open space

(e) incorporate Gross Pollutant Traps installed at inlets to all basins and wetlands to remove gross pollutants

(f) where used for temporary detention, comprise surcharge systems that avoid inundation from events more frequent than a 1-in-1 year average return interval flood event.

17 Major drainage systems should be designed to accommodate existing upstream flows.

18 Where it is not practicable to detain or dispose of stormwater on site, only clean stormwater runoff should enter the public stormwater drainage system.

19 Retention basins designed for the permanent retention of stormwater should be designed to:

(a) a minimum depth that avoids the proliferation of reeds

(b) incorporate rails or barriers along hard edges where required to maintain public safety

(c) provide visual interest if located in public open space

(d) function as landscape features.

20 Artificial wetland systems, including detention and retention basins, should be sited and designed to:

(a) ensure public health and safety is protected

(b) minimise potential public health risks arising from the breeding of mosquitoes

(c) function as a landscape feature.

21 All land and development should be capable of being properly drained to a legal point of discharge.

22 Areas for the washing and cleaning of vehicles, plant and/or other equipment and wastewater should be contained and/or bunded and disposed of to exclude the entry of external surface stormwater runoff.

23 Wastewater from vehicle washing and cleaning areas should be drained to either a treatment device (such as sediment traps and/or a coalescing plate oil separator) with subsequent disposal to sewer; or a holding tank which can be emptied as required by an authorised liquid waste contractor.

24 Development that gives rise to stormwater discharges to off-site receiving environments should incorporate stormwater management systems designed to achieve the following pollution reduction objectives:

Pollutant	Stormwater Treatment Objective (with development modelled using software showing how targets would be achieved)
Suspended solids	80 per cent retention of average annual load
Total phosphorous	45 per cent retention of average annual load
Total nitrogen	45 per cent retention of average annual load
Litter	Retention of litter greater than 50 millimetres for flows up to the 3-month average recurrence interval peak flow
Coarse sediment	Retention of sediment coarser than 0.125 cubic millimetres for flows up to the 3-month average recurrence interval peak flow
Oil and grease	No visible oils for flows up to the 3-month average recurrence interval peak flow
Flows	Maintain discharges for the 1-in-5 year average return interval flood event at pre-development levels

Water Catchment Areas

25 Development should ensure watercourses and their beds, banks, wetlands and floodplains are not damaged or modified and are retained in their natural state, except where modification is required for essential access or maintenance purposes.

26 No development should occur where its proximity to a swamp or wetland will damage or interfere with the hydrology or water regime of the swamp or wetland.

27 A wetland or low-lying area providing habitat for native flora and fauna should not be drained, except temporarily for essential management purposes to enhance environmental values.

28 Along watercourses, areas of remnant native vegetation, or areas prone to erosion, that are capable of natural regeneration should be fenced off to limit stock access.

29 Development such as cropping, intensive animal keeping, residential, tourism, industry and horticulture, that increases the amount of surface run-off should include a strip of land at least 20 metres wide measured from the top of existing banks on each side of a watercourse that is:

(a) fenced to exclude livestock

(b) kept free of development, including structures, formal roadways or access ways for machinery or any other activity causing soil compaction or significant modification of the natural surface of the land

(c) revegetated with locally indigenous vegetation comprising trees, shrubs and other groundcover plants to filter run-off so as to reduce the impacts on native aquatic ecosystems and to minimise soil loss eroding into the watercourse.

30 Development resulting in the depositing of an object or solid material in a watercourse or floodplain or the removal of bank and bed material should not:

(a) adversely affect the migration of aquatic biota

(b) adversely affect the natural flow regime

(c) cause or contribute to water pollution

(d) result in watercourse or bank erosion

(e) adversely affect native vegetation upstream or downstream that is growing in or adjacent to a watercourse.

31 The location and construction of dams, water tanks and diversion drains should:

(a) occur off watercourse

(b) not take place in ecologically sensitive areas or on erosion-prone sites

(c) provide for low flow by-pass mechanisms to allow for migration of aquatic biota

(d) not negatively affect downstream users

(e) minimise in-stream or riparian vegetation loss

(f) incorporate features to improve water quality (eg wetlands and floodplain ecological communities)

(g) protect ecosystems dependent on water resources.

32 Irrigated horticulture and pasture should not increase groundwater-induced salinity.

33 Development should comply with the current *Environment Protection (Water Quality) Policy*.

Biodiversity and Native Vegetation

34 Development should retain existing areas of native vegetation and where possible contribute to revegetation using locally indigenous plant species.

35 Development should be designed and sited to minimise the loss and disturbance of native flora and fauna, including marine animals and plants, and their breeding grounds and habitats.

36 The provision of services, including power, water, effluent and waste disposal, access roads and tracks should be sited on areas already cleared of native vegetation.

37 Native vegetation should be conserved and its conservation value and function not compromised by development if the native vegetation does any of the following:

(a) provides an important habitat for wildlife or shade and shelter for livestock

(b) has a high plant species diversity or includes rare, vulnerable or endangered plant species or plant associations and communities

(c) provides an important seed bank for locally indigenous vegetation

(d) has high amenity value and/or significantly contributes to the landscape quality of an area, including the screening of buildings and unsightly views

(e) has high value as a remnant of vegetation associations characteristic of a district or region prior to extensive clearance for agriculture

(f) is growing in, or is characteristically associated with a wetland environment.

38 Native vegetation should not be cleared if such clearing is likely to lead to, cause or exacerbate any of the following:

(a) erosion or sediment within water catchments

(b) decreased soil stability

(c) soil or land slip

(d) deterioration in the quality of water in a watercourse or surface water runoff

(e) a local or regional salinity problem

(f) the occurrence or intensity of local or regional flooding.

39 Development that proposes the clearance of native vegetation should address or consider the implications that removing the native vegetation will have on the following:

(a) provision for linkages and wildlife corridors between significant areas of native vegetation

(b) erosion along watercourses and the filtering of suspended solids and nutrients from run-off

(c) the amenity of the locality

(d) bushfire safety

(e) the net loss of native vegetation and other biodiversity.

40 Where native vegetation is to be removed, it should be replaced in a suitable location on the site with locally indigenous vegetation to ensure that there is not a net loss of native vegetation and biodiversity.

41 Development should be located and occur in a manner which:

(a) does not increase the potential for, or result in, the spread of pest plants, or the spread of any non-indigenous plants into areas of native vegetation or a conservation zone

(b) avoids the degradation of remnant native vegetation by any other means including as a result of spray drift, compaction of soil, modification of surface water flows, pollution to groundwater or surface water or change to groundwater levels

(c) incorporates a separation distance and/or buffer area to protect wildlife habitats and other features of nature conservation significance.

42 Development should promote the long-term conservation of vegetation by:

(a) avoiding substantial structures, excavations, and filling of land in close proximity to the trunk of trees and beneath their canopies

(b) minimising impervious surfaces beneath the canopies of trees

(c) taking other effective and reasonable precautions to protect both vegetation and the integrity of structures and essential services.

43 Horticulture involving the growing of olives should be located at least:

(a) 500 metres from:

(i) a national park

(ii) a conservation park

(iii) a wilderness protection area

(iv) the edge of a substantially intact stratum of native vegetation greater than 5 hectares in area

(b) 50 metres from the edge of stands of native vegetation 5 hectares or less in area.

44 Horticulture involving the growing of olives should have at least one locally indigenous tree that will grow to a height of at least 7 metres sited at least every 100 metres around the perimeter of the orchard.

Soil Conservation

45 Development should not have an adverse impact on the natural, physical, chemical or biological quality and characteristics of soil resources.

46 Development should be designed and sited to prevent erosion.

47 Development should take place in a manner that will minimise alteration to the existing landform.

48 Development should minimise the loss of soil from a site through soil erosion or siltation during the construction phase of any development and following the commencement of an activity.