BUCKLAND PARK PROPOSAL

FLORA TECHNICAL REPORT

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1. INTRODUCTION

The Buckland Park proposal is a joint venture of Walker Corporation and Daycorp. The site has an area of 1,308 hectares.

The site is located on and west of Port Wakefield Road within the City of Playford, west of Virginia, and around 32 km north of the Adelaide CBD and 14 km from Elizabeth, see Figure 1.

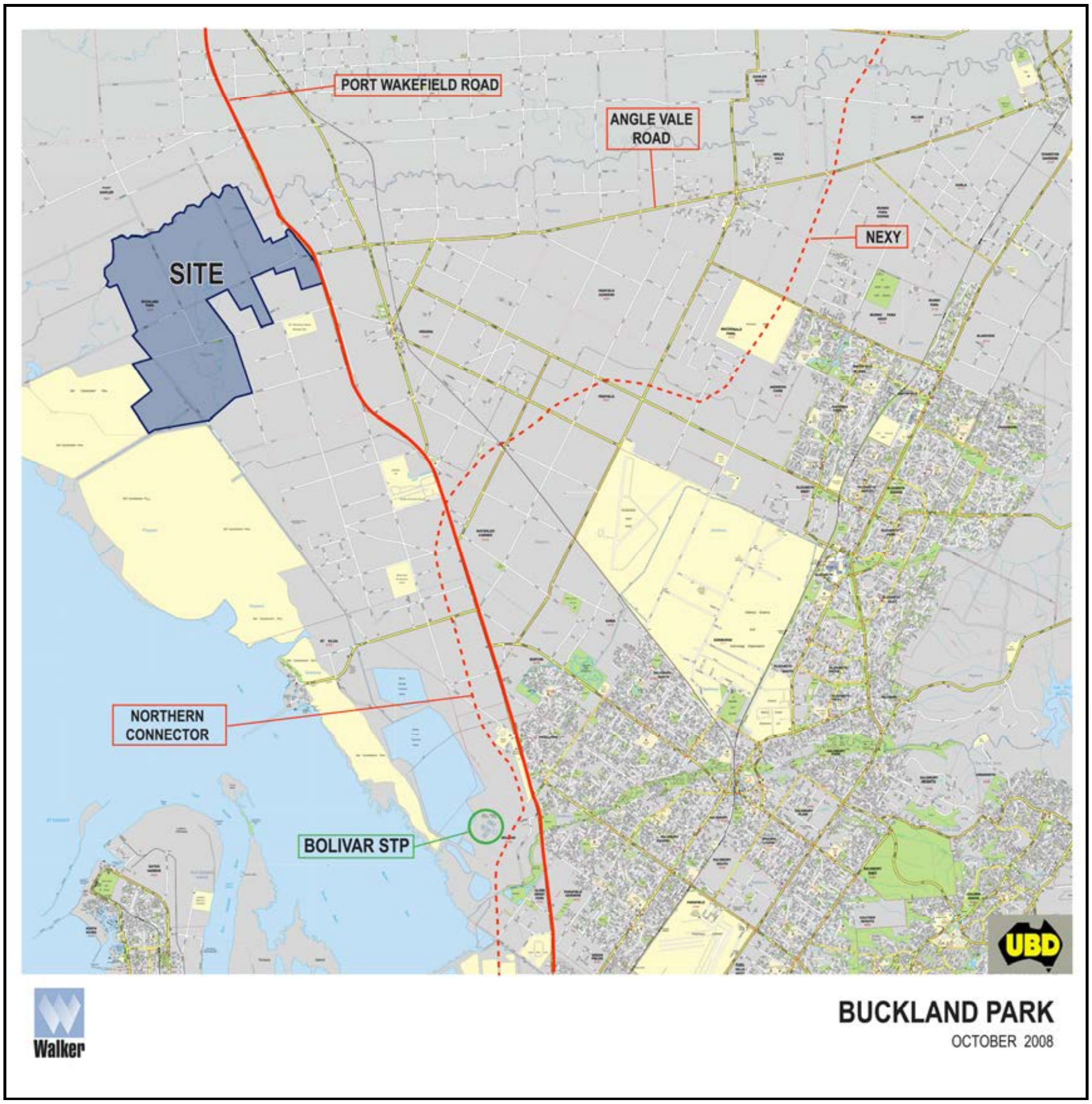
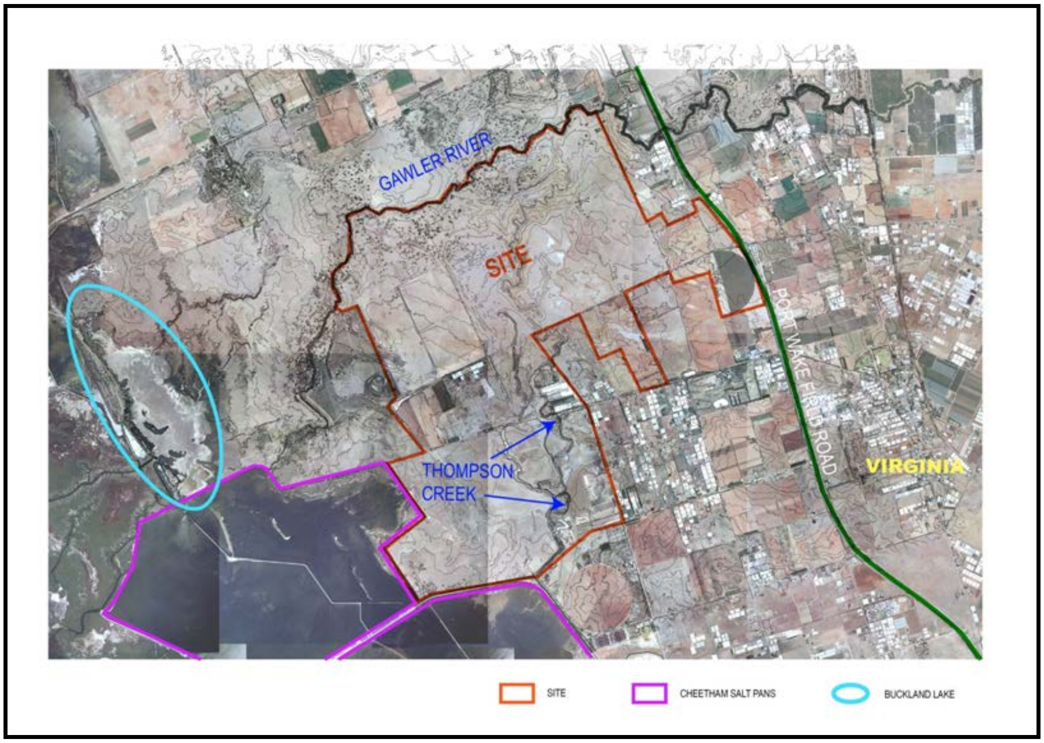


Figure 1: Buckland Park Locality Map

The site is bounded by Port Wakefield Road, the Gawler River, Cheetham Salt Limited saltpans and horticultural areas. The site is between 2.5 and 4 km from the Gulf St Vincent coastline and is relatively flat arable land primarily used for low intensity grazing and horticulture.

Remnant native vegetation occupies parts of the site's north west and south west portions, which can be seen on the aerial photograph in Figure 2.



Aerial photo supplied by Walker Corporation.

Figure 2: Site superimposed on aerial photograph

The Cheetham saltpans, adjoining the south west boundaries of the site, are man made structures.

It is anticipated the proposal will comprise 12,000 residential allotments, with an average size of 500m^2, supported with multiple purpose open space, and commercial, retail, community and employment uses. The proposal is illustrated in the Masterplan at Figure 3.

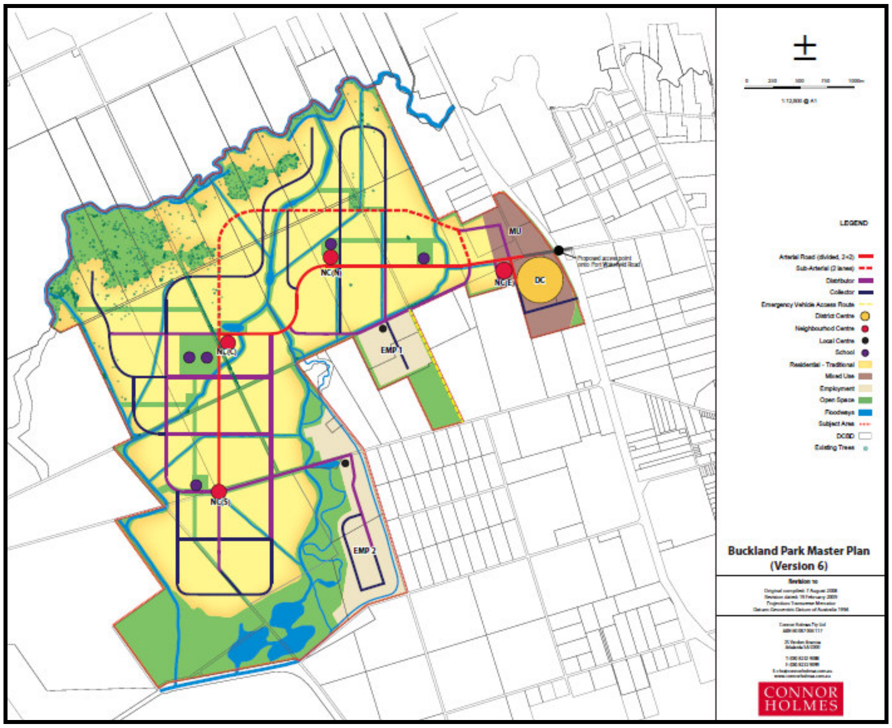


Figure 3: Master Plan of Buckland Park

The proposal will be implemented in stages over a period of 25 years. Stage 1 is planned for 2010 to 2016, as illustrated in the staging plan below in Figure 4.

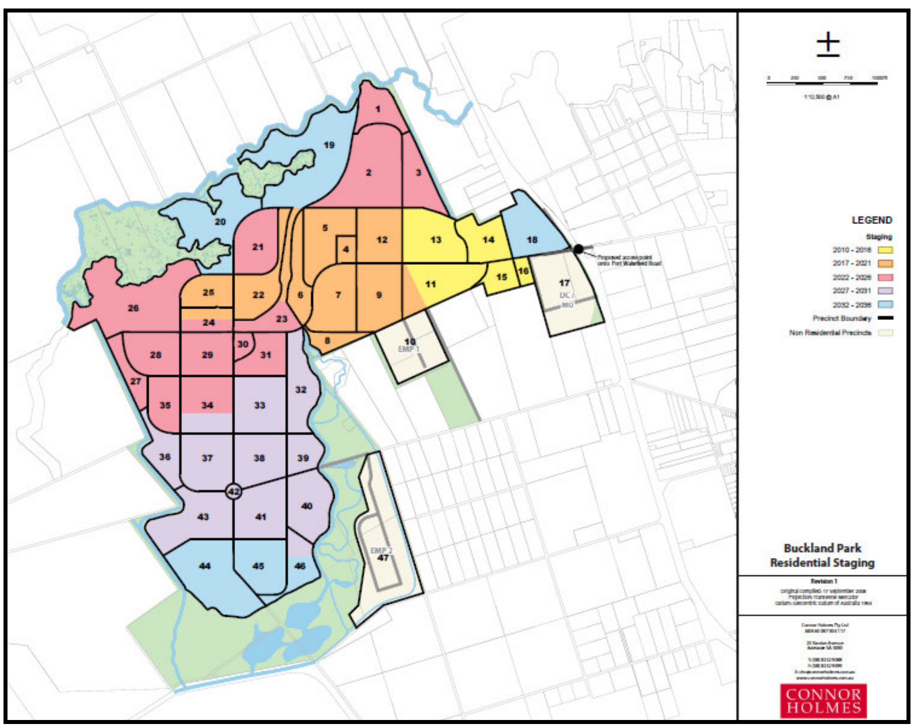


Figure 4: Proposal Staging

Walker Corporation commissioned Dr Bob Anderson to prepare an assessment of the potential impacts on the vegetation and flora associated with the proposal for inclusion in the Environmental Impact Statement (EIS).

Accordingly, this Technical Report considers the vegetation and flora of the region, including the site. It includes review and description of the:

- the region's environment
- site's environment
- indigenous (native) vegetation communities and flora species
- introduced flora, including pest species
- likely and potential impacts of the proposal, plus recommendations for management strategies and actions to avoid or minimise adverse impacts.

1.1 Report Structure

The structure of this report is as follows:

- Section 1 is the introduction to the report.
- Section 2 summarises the legislation and policy relevant to the topic.
- Section 3 explains the materials and methods applied during the assessment.
- Section 4 details background information relevant to vegetation of the region and site.
- Section 5 provides the results and data from all sources, including the field assessments of the site.
- Section 6 discusses the impacts of the proposal plus, mitigation and management strategies and actions.
- Section 7 is a conclusion of the assessment.
- Section 8 contains the references cited.
- Appendix A contains the original figure of the distribution of vegetation and flora across the whole site.
- Appendix B illustrates aspects of the site through photographs.
- Appendix C includes a list of abbreviations and a glossary of terms.

2. LEGISLATION AND POLICY

The legislation and policy applicable to biological aspects (vegetation and flora) of the proposal is discussed below.

2.1 National

The ***Environment Protection and Biodiversity Conservation Act 1999*** (EPBC Act) relates to the definition, protection and management of all matters of national environmental significance such as ecological communities, species and their habitat and sites. It also establishes national strategies, nationally applicable threatening processes and provides for the proposal of recovery, action and threat abatement plans.

It is illegal to undertake an action that will have a significant adverse impact on a matter of national environmental significance.

2.2 State

National Parks and Wildlife Act 1972 (NPW Act) especially Schedules 7, 8 and 9 of this Act (as revised in 2008) which list threatened flora species. The Act protects native flora and fauna and provides lists of species that are endangered, vulnerable and rare in South Australia. The NPW Act does not formally protect vegetation communities.

Native Vegetation Act 1991 as amended and its Regulations, which was established to protect and control the clearance of South Australia's native vegetation.

Natural Resources Management Act 2004 (NRM Act) which repeals the Animal and Plant Control (Agricultural Protection and Other Purposes) Act 1986 and the Soil Conservation and Land Care Act 1997 and incorporates the functional requirements of these Acts under the NRM Act. This Act establishes provisions for the management of the State's natural resources, including pest plants and animals and the land and water resources.

The ***Development Act 1993*** contains provisions for the definition of significant trees. This matter is applicable to the proposal.

The ***Local Government Act 1999*** indicates that control of public roads is vested in the local council within local government districts. Management of native vegetation is included in this Act.

The following strategy and policies are applicable to the proposal.

South Australia's Strategic Plan 2007 (Government of South Australia 2007) contains both a vision and objectives for the State. Objective 3: ***Attaining Sustainability*** includes four targets for biodiversity.

The State Government policy, ***No Species Loss - A Biodiversity Strategy for South Australia 2006–2016*** is the key policy for protection of biodiversity in the State and is applicable to the proposal.

Tackling Climate Change: South Australia's Greenhouse Strategy 2007-2020 also relates to the sustainable management of natural resources and includes requirements to assess the potential risks associated with climate change influences on native and invasive species.

The ***South Australian Biosecurity Strategy 2008-2013*** (Draft for public consultation) is a risk management framework that provides a summary review of threats posed by pests in the State, plus potential management and implementation requirements. This Strategy is applicable to the proposal, as will be the final Strategy (when finalised, approved and published).

2.2.1 Department for Transport, Energy and Infrastructure (DTEI)

DTEI has a range of environmental policy, planning and management documents which will probably apply to aspects of the proposal, particularly on those parts of the site adjacent to some of the current roads and declared easements, and traffic planning and control impacts associated with Port Wakefield Road (Highway 1). From an environmental perspective, some of the most important documents by the Commissioner of Highways (Section 26 of the ***Highways Act 1926***) include:

- ***Care, Control and Management of Roads Operational Instruction 20.1***
- ***Environmental Approval Procedures Operational Instruction 21.1***
- ***Environmental Code of Practice for Construction***.

2.2.2 Playford City Council

Specific policies applicable to the proposal include the City of Playford's (Council) environmental and sustainability policies and Development Plan.

Council has a particularly strong commitment to sustainability, including recognition and management of remnant native vegetation and extensive revegetation works in its area.

The provisions of the ***Local Government Act*** in relation to development will apply to the proposal.

3. METHODS AND MATERIALS

A literature review and accession of database records from State and local Government authorities was undertaken and the resulting data compiled to provide a comprehensive model of the occurrence of communities, habitats and species, historically and currently.

The search tool of the Department of the Environment, Water, Heritage and the Arts (DEWHA) (Cwlth) EPBC Act was used to produce a Protected Matters Report for the site and region. This report is a predictive assessment of matters of national environmental significance, primarily species and habitats of communities and species of national significance.

Discussions and consultation with local council officers and representatives included Brian Pledger (City of Salisbury), Bill Doyle (City of Playford), and Andrew Cowley (City of Port Adelaide Enfield). Consultation was undertaken with the Adelaide and Mount Lofty Ranges NRM Board and other State Government groups, the coastal management group of DEH (Doug Fotheringham) and officers of DWLBC involved with vegetation management on behalf of the Native Vegetation Council (Craig Whisson and Graham Carpenter).

Field surveys primarily assessing vegetation were undertaken between 13 October 2007 and 4 May 2008 by the author, Bob Anderson, with a minimum of two days/month and a total of 22 days spent on site. Incidental observations were also made of some areas over July to October 2008.

To assist in the assessment process, the site was divided into sections, with most survey effort being expended in the areas of remnant native vegetation. These areas were reviewed each month in order to assess seasonal variation in the occurrence of species. The assessed area is illustrated in Figure 5.

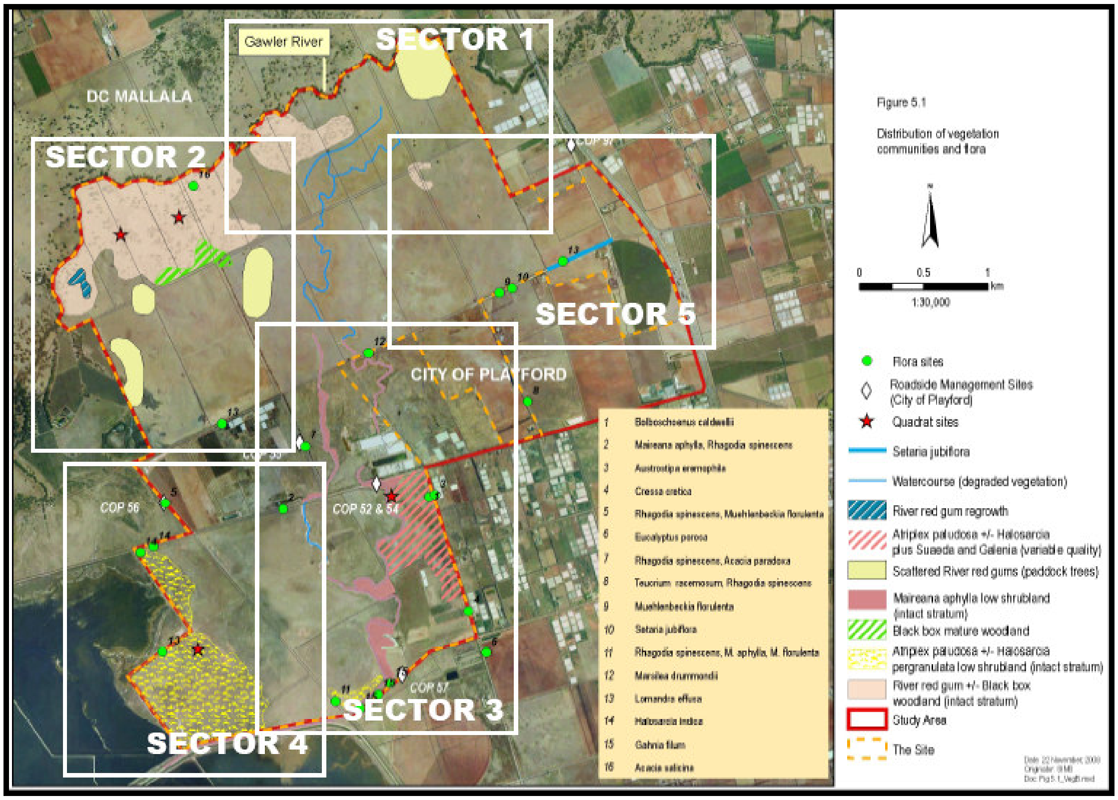


Figure 5: Site Assessment

A colour aerial photo with the site marked was provided by Connell Wagner and was used as the basis for the field survey. There are some discrepancies between the actual, current location of features, and their depiction on the photo. This is primarily due to areas being used for other activities and different 'foot-prints' for some buildings after the photograph was obtained. Nonetheless, the photo was sufficiently accurate to assess the site.

The method used in the field was to identify areas of potential biological significance using information from the databases and literature survey and mark these onto the aerial photograph. These formed ‘target areas’ for more detailed assessment.

The assessment method used in the field was to obtain permission from each landholder within the site, and to slowly (<5km/h) drive along all roads, tracks, and, where permitted by the landholder and practicable, cross country. If native plants or unusual or significant weeds infestations were present, the vehicle was stopped and the area was assessed in detail on foot. Areas not accessible by vehicle were also assessed on foot. All roadside areas adjacent to public roads were assessed and specific sites of significance and management were recorded. No DTEI Roadside Significant Sites (RSS) are present, although there is a number of City of Playford Roadside Management Sites (RMS) on and adjacent to the site (Figure 5).

Assessed locations were recorded on the aerial photograph and/or by using a Garmin 12 Geographic Positioning System (GPS). Field notes were recorded for each location, especially on species composition, the presence of threatened species, abundance and threats, and photographs were used to record many locations.

The location co-ordinates of all large remnant trees were recorded using a differential GPS by Connell Wagner and each tree was assessed under the provisions of the ***Development Act 1993*** (SA) for significant tree status i.e. those with a single trunk or multiple trunk circumference of 2 m or greater measured at 1 m above the natural ground level.

Measurements of individual trees were made using a Richter 5 m or 10 m forester's diameter tape at 1.3 m (diameter at breast height, dbh) and 1 m above the ground surface.

Vegetation quadrats were assessed using the ***Biological Survey of South Australia*** remnant vegetation survey methodology (Department of Housing & Urban Development 1997, also referred to as Heard and Channon 1997).

Cutten and Hodder (2002) provided the guidelines used for the assessment of scattered trees (also referred to as ' paddock trees').

Photographs were recorded using a Nikormat SLR camera with 55 mm macro lens and an Olympus C-300 digital camera.

Multiple visits to particular areas and locations were undertaken in order to confirm the seasonal variation component of the flora. Herbarium collections were made at some sites and, following curation, the collections will be lodged with the State Herbarium. The identity of some species was confirmed using the reference collection of the State's flora in the Herbarium.

Data management included depiction of recorded information onto ArcInfo GIS. GIS spatial datasets have been created from GPS records collected during field assessments and ground-truthing activities and via desktop digitising. Data captured during field visits were recorded initially using a non-differential Garmin 12 GPS, in degrees minutes and seconds. Data were downloaded and converted to decimal degrees, and then finally to GDA94, Zone 54. Where data were not captured via GPS, it was digitised manually using ESRI ArcMap 9.2 software, based on information visible on the raster image Buckland_Park.tif, supplied by Connell Wagner in December 2007.

All datasets were manipulated using ESRI ArcGIS 9.2 software. Shapefiles were created of each individual dataset, for classification, statistical analysis where relevant, and final report presentation. Metadata have been provided to Connell Wagner for the proposal's GIS database.

Appendix B contains photographs of examples of the vegetation in the site.

3.1 Definitions, Limitations and Acknowledgments

Specific definitions, including the significance criteria, applied during this report are explained in this section. Limitations and acknowledgments are provided.

3.1.1 Definitions

Site: 1,308 ha as defined on Figure 2. Other locations outside the site, particularly along its boundaries, which may be impacted by the proposal are considered as part of the site. These include areas where indirect or consequential environmental effects may occur as a result of the proposal and include specific areas mentioned in the Guidelines for the EIS.

Region: An area generally within 2 to 5 km of the site.

Wider region: Areas more distant than the region, including areas in a similar coastal setting to that of the site. The wider region generally includes the eastern side of the area illustrated in the locality plan at Figure 1.

Botanical names and associated nomenclature accord with Barker et al. (2005) unless stated otherwise.

The term 'vegetation association' is used inter-changeably with 'vegetation community' and the latter is used throughout the report.

Appendix C contains a list of abbreviations and glossary.

3.1.2 Significance criteria sources

National: A number of criteria are provided under the EPBC Act, including threatened communities and species, threatening processes and plans adopted to manage these matters.

State: DEH databases, DEH (2005), Neagle (1995) and the ***National Parks and Wildlife Ac***t and its Schedules 7, 8 and 9.

Regional: Lang and Kraehenbuehl (2002, Florlist 2008 update) and the City of Playford and DTEI databases and maps of the distribution of native vegetation communities and species.

Local: All remnant native plants have some value in the region, hence all occurrences are locally significant.

3.1.3 Limitations

The scope of services applicable to this report was defined by the Client, by the budgetary constraints and by access to the site. In preparing this report, I have relied on the accuracy of information provided by the Client and other sources as acknowledged. Except as stated I have not verified the accuracy of these data.

2006/2007 and 2007/2008, were years with below average rainfall over winter to summer and typically hot summers. Temperatures during early autumn were significantly above average in 2008 and while rainfall was average to slightly below average over April to August, September and October 2008 rainfall was well below average.

These factors, combined with earthworks and heavy grazing pressure in some areas, and continual mowing of some roadside areas, has probably resulted in some populations and/or species not being recorded. The passage of time, the seasonal factors referred to above, latent conditions, impacts of future events or factors may require additional assessment, plus re-evaluation of findings and conclusions.

3.1.4 Acknowledgments

It is pleasure to acknowledge the co-operation of all landholders during the fieldwork, especially Geoff and Dianne Ayres, who provided access to much of the 1,000 ha of the site.

Permission to use data from DEH, including the State Herbarium, and the SA Museum is gratefully acknowledged also, with specific referral to these data being through citation in the text of this report.

With the exception of the base of Figure 5, the figures in the body of this report were provided by Walker Corporation.

4. REGIONAL ENVIRONMENT

The site is part of the Eyre and Yorke Block Bioregion and is a component of the Northern Adelaide Plains geographical region. It is located in the City of Playford local government area and the Adelaide and Mount Lofty Ranges Natural Resource Management Board (AMLRNRM Board) region.

The vegetation communities of the region have resulted from the interaction between physical environment factors such as climate, topography, soil type and the availability of water and past and current land use. A summary of key issues and information about historical aspects of vegetation is provided in this section.

4.1 Geology, landform and soils

The region and site are in Province 3 (Mount Lofty Block) of Laut et al. (1977) which is part of the outwash plain of the Mt Lofty Ranges. Most of the region is within the Northern Adelaide Plains of the Adelaide Plains geographical region. Areas of red-brown earths occupy much of the site and adjacent areas. Soils are typically alkaline (sometimes calcareous), deep, relatively fertile and with excellent water holding capacity. Some of these are medium clays to grey-black earths, especially in low lying areas which originally contained swamps and annual wetlands.

Around the major drainage line, the Gawler River, areas of deep, transported soils (alluvium and colluvium) occur as part of the riverine floodplain, combined with the outwash plain deposits. These contain gravel, cobble and boulder beds and silty clays, as well as shallow aquifers. All deposits are associated with the past flood patterns of the watercourse.

Other areas are naturally salty, primarily along the western edge of the region and site (saline muds), areas along the original course of Thompson Creek and areas of secondary salinisation associated with irrigation are also present. Thompson Creek was originally an estuarine (marine and freshwater) drainage system that has been cut-off by development of the Cheetham salt pans and other land uses.

Other soil types present in specific locations or potentially present include small areas of medium and heavy clay, including cracking clays, alkaline, red-brown duplex earths and sand rises and low dunes.

Further to the west along the coastal plain there is a complex of terrestrial, freshwater and marine deposits, including small areas of saline clays and gypseous or saline deposits in the soil profile, as well as shell-grit and marine sands as stranded beach deposits. Acid sulphate soils and potential acid sulphate soil deposits are likely to be present.

The slope of the site is minimal and to the west and south, and due to its proximity, the region would have received large amounts of runoff water as overland and channel flow from the Mount Lofty Ranges foothills prior to European settlement. The region was prone to flooding during most winters and following intense rainfall at other times of the year, for example in 1992 and 2006.

Shallow swale drains and deeper drains, usually based on existing drainage patterns, coupled with levee banks and detention basins, have been constructed through the region and site as flood risk mitigation to allow for farming and closer settlement.

4.2 Current land use

The site and region are characterised by horticulture and agriculture. The site has been cleared and used for intensive farming for the past 100+ years. Large land users include open ground and enclosed horticulture (intensive use for vegetables, fruit trees, olives and flowers, plant nurseries, vines and hay), livestock grazing (sheep and cattle), horses, a plant nursery, housing, and stormwater management. Irrigation such as centre pivot, overhead and low throw sprinklers and drip systems are typically used on these properties.

Two large scale activities are the Cheetham salt pans associated with salt production (as a feed stock for soda ash production) to the west of the site and Jefferies' commercial composting facility and demonstration farm south of the site.

Little to nil remnant native vegetation remains in most of the region and the site away from the coastal fringe and the Gawler River corridor. The areas west and north west of the site include Buckland Park Lake and Port Gawler Conservation Park. Due to their diverse biological attributes, both are important conservation areas (Durant 2007, 2007a, Paton et al. 1991).

Areas of revegetation have been established in the region by Playford Council and State Government groups, including wetlands revegetation projects at Buckland Park and along part of Thompson Creek, the latter contained within a Council drainage reserve. Private land owners have primarily planted plantations, wind breaks along roadsides and fence lines, and shade trees in paddocks.

4.3 Pre-European Settlement Vegetation Communities and Flora

Kraehenbuehl (1996) provides the only detailed historical account of the region's vegetation prior to European settlement and his information includes a summary of past data and references, plus the conditions and species present in the past and up to 1995. Cleland (1953), Kinhill Stearns (1985) and Lange (1976) contain historical information about the adjacent region. Summaries of these and other data sources are included in Anderson (2007), which is a desktop analysis of the biological environment of the site and region.

The vegetation and flora Technical Paper for the Northern Expressway (NExy) project (Kellogg Brown & Root (KBR) 2007) and the Environmental Report for the NExy proposal (DTEI 2007) provide a detailed review of the regional environment and vegetation which are relevant to the current study. This Technical Report uses KBR (2007) and DTEI (2007) as sources of information for the region east and south of the site.

Brown & Root Services (2000), Turner (2001) and Daniels and Tait (2005) provide recent synopses of additional historical information about some aspects of the region, primarily in relation to the Adelaide Plains and areas south of the site.

Data about some aspects of the biological environment associated with the salt pans and their surrounds are extensive and available through Penrice Soda Products Pty Ltd (Penrice, now Cheetham Salt Pty Ltd (Cheetham) owned by Ridley Corporation), for example, Penrice (1998). Since 1993 most of these reports have been produced by Delta Environmental Consulting (Delta).

Reports with particular relevance to the vegetation of the region and site and which also include some historical information, include Paton et al. (1991), Pedlar and Matheson (1993), Tout-Smith and Healy (1997), Coleman and Coleman (2000), Hassell Pty Ltd (2002), Delta (2003) and Anderson (2007). In addition to the references cited in this section, other published and unpublished reports and data on the vegetation, primarily the areas of remnant native vegetation, are available from Salisbury and Playford Councils and Penrice (Cheetham) and these are referred to in this report when relevant.

Kraehenbuehl (1996) identified five main vegetation communities which occurred prior to European settlement in the region namely:

- ***Eucalyptus camaldulenis*** var. ***camaldulensis*** (river red gum) woodland and forest along the banks, margins and flood plains of the Gawler River and Little Para River. This community also included areas of ***E. largiflorens*** (black box) woodland along the floodplain of the Gawler River. This community would have occupied the northern and central sections of the site.

- ***Eucalyptus porosa*** (mallee box) woodland and mallee across the Peachey Belt. The Peachey Belt Forest, originally dominated most of the area between Penfield, Angle Vale and Virginia, with trees approximately 8 to 10 m in height. This community almost certainly extended into the southern part of the site.

- Native tussock low grassland dominated by winter growing species such as ***Austrodanthonia*** spp. (wallaby grasses) and ***Austrostipa*** spp. (spear grasses) and summer growing species, such as ***Bothriochloa macra*** (red-leg grass), ***Chloris truncata*** and ***Enteropogon acicularis*** (windmill grasses), ***Setaria*** spp., especially ***S. jubiflora*** (Warrego summer-grass) and, possibly, ***Themeda triandra*** (kangaroo grass), to the west and south of the Peachey Belt, and parts of the site.

- Chenopod low shrublands, dominated by ***Halosarcia*** spp. (samphires) and ***Atriplex*** spp. (saltbush) with areas of salt tolerant sedgelands, along the eastern edge of the coastal plain. Thompson Creek probably included a complex of vegetation types, although it too would have originally included both ***Maireana*** and ***Atriplex*** dominated chenopod shrublands (and possibly ***Rhagodia***-dominated shrublands).

- All of the areas referred to above were and are bordered to the west by ***Avicennia marina*** (grey mangrove) woodlands along Gulf St Vincent.

In freshwater sites, such as in and adjacent to watercourses and swamps, a number of other vegetation communities occurred, including:

- tall grassland dominated by ***Phragmites australis*** (common reed)

- tall sedgeland of ***Typha domingenis*** (cumbungi)
- low sedgeland of ***Bolboschoenus caldwellii*** (salt clubrush)
- dense, low to tall shrubland of ***Muehlenbeckia florulenta*** (lignum). This was once dominant throughout the region and occurred in some salty, and, more especially, freshwater sites.

The majority of these occurrences were as the understorey to other vegetation communities, although they also occurred as mono-specific communities. These areas were too small to be mapped in Kraehenbuehl (1996).

In the region, Kraehenbuehl (1996) documents the vegetation up to the Gawler River. NatureMaps data (DEH 2007) contains more recent information about the region and refers to the dominant tree species in the vegetation community along the Gawler River as being river red gum +/- ***Eucalyptus leucoxylon*** (South Australian blue gum) forest to woodland. Additional data for the region, but not the site, are available from the Biological Survey of South Australia and these are available in DEH (2007).

Armstrong et al. (2003), Cleland (1953), Penrice (1998) and Turner (2001) provide additional information relevant to the region. These references record patches of communities of mallee scrubland dominated by one to a few mallee Eucalypt species, particularly mallee box along the margin of the Gawler River floodplain and ***Eucalyptus socialis*** (red mallee) along the coast and more occasionally inland and north and south of the Gawler River. ***Callitris gracilis*** (native pine, southern cypress pine) low woodland may have occurred on dunes of the Gawler River floodplain. The species currently occurs in the coastal dunes west of the site at Port Gawler in similar settings north to Port Wakefield and on the Gawler River floodplain about 9 km east of the site (Anderson, pers. obs., 1995 to 2008, DTEI 2007).

Areas of river red gum and black box forest and woodland and mallee box were recognised by the early settlers as growing on areas which had excellent cropping characteristics and these areas were targeted for agriculture. Local areas of vegetation were cleared soon after European settlement in the region, with a larger portion of the woodlands progressively removed to make way for mixed farming (cereal growing and livestock production). With time, this has resulted in the almost complete destruction of these forests and woodlands.

Small areas, including the overstorey along the river bank fringe and more occasionally on the flood plain were left, primarily to assist in erosion control and river bank stabilisation. Within the region, the only relatively large, intact area of forest and woodland occurs as a riparian corridor along the Gawler River, in the northern part of the site, on the Gawler River flood plain, and on private property and on roadsides on the flood plain north of the River.

Due to the lack of permanent water in the rivers and creeks in the region, the in-stream and riparian flora was probably never extensive or diverse. However, there would have been much more than is currently present. Based on Kraehenbuehl (1996), riparian areas are likely to have had an intermittent small to tall tree to tall shrub storey of ***Acacia salicina*** (willow wattle) with occasional thickets of this wattle over a lower shrub storey of lignum in many areas and a more extensive grass, sedge and forb understorey, with instream herblands in many locations. Small areas of these communities are still present in and along the Gawler River.

The native grasslands in the region were considered to provide an ideal environment for grazing of introduced stock, especially sheep. Consequently, these areas were rapidly removed within a very few years of colonization and European settlement. These areas were subsequently used for improved pastures, especially dairying using lucerne, and agricultural and horticultural crops.

Brown and Root (2001) and Seaman (2002) identified small areas of ephemeral and annual wetlands associated with the outwash plains of the region. These were classified as ***Amphibromus nervosus*** (common swamp wallaby-grass) low grassland with ***Amphibromus nervosus*** over ***Eleocharis acuta*** (common spike-rush) and ***Rumex dumosus*** (wiry dock), with ***Sclerolaena muricata*** var. ***villosa*** (five-spined copper-burr) occupying the edges and dryland areas of these locations. The only remaining area of this community known in the region, and, indeed the State, was recorded over about 25 ha on Parafield Airport land and around Bennett Road and the Mawson connector road from Main North Road.

Areas of ***Marsilea*** (nardoo) fernland, usually as ***M. drummondii***, were originally present along freshwater ponds, seeps and soaks in the region. The community was likely to have been sporadic in occurrence, small in area and present throughout the region. Occurrences of this community in the wider region include Parafield (Brown & Root 2001), on SA Water land at the Bolivar WWTP, along the Port Wakefield Road near the intersection of McEvoy Road and at Angle Vale (Smith and Brewer 2000, Anderson, pers. obs. 1995 to 2007).

A prostrate perennial herbland of ***Wilsonia rotundifolia*** (round-leaved wilsonia) +/- ***Cressa cretica*** (rosinweed) occurred on salty, low lying areas in this region, including at Bolivar (Smith and Brewer 2000), Parafield (Brown & Root 2001), around Buckland Park Lake (DEH 2007), from Angle Vale south to Waterloo Corner (DTEI 2007), and elsewhere along the coastal fringe (Anderson, pers. obs., 1995 to 2008). It currently has a patchy distribution, although much more of it remains extant than the fernland in the wider region and region.

KBR (2007) considered that this herbland is likely to have been a component of a ***Maireana aphylla*** (cottonbush) +/- ***Nitraria billardieri*** (nitre bush) low shrubland that originally occurred in the region and site and which also remains at Bolivar (Smith and Brewer 2000), around Virginia and Two Wells and a few other sites in the region (Anderson, pers. obs. 2000 to 2007).

Both round-leaved wilsonia and rosinweed are also able to colonise bare, wet, salty soils and can occur without a native overstorey. ***Sclerolaena muricata*** var. ***villosa*** (five-spine copperburr) shrubland also occurred in association with, or adjacent to, the cottonbush shrubland, but its current occurrence, for example around Dry Creek and Salt Creek in the wider region, may represent relictual areas of a relatively unpalatable species, rather than a primary distribution.

Muehlenbeckia florulenta (lignum) dense to open shrublands were associated with low lying sites and swamps adjacent to drainage lines, especially Dry Creek and the Little Para River, and along the floodplains of the Gawler River. Some of these were nearly mono-specific shrublands without an overstorey, while others would have formed the understorey of part of the river red gum +/- black box forest and woodland. The only relatively large area of this shrubland remaining in the region is associated with the shallow, freshwater wetland of Buckland Park Lake, including flood out areas adjacent to the Lake, the Gawler River floodplain along parts of Thompson Creek (usually as isolated remnants) and west of Beagle Hole Road.

As noted in DTEI (2007), areas of ***Gahnia*** spp. (cutting grasses), especially ***G. filum*** (smooth cutting grass), also occurred in these poorly drained sites, including some low lying salty areas. Almost all of these swamp areas have been cleared in the region. Until recently a few tiny remnants occurred well south of the site, including west of Salisbury Highway (around the current location of Ryans Road) and adjacent to Port Wakefield Road. The largest remnant areas occur at Bolivar through to St Kilda with smaller areas along Thompson Creek and along Brooks Road. Coleman and Coleman (2004) review the current distribution of the species in the region.

In relation to the site, Delta (2003) provides a useful summary of the distribution of some of the native and introduced vegetation communities and species along Thompson Creek.

5. RESULTS – EXTANT VEGETATION AND FLORA

Kraehenbuehl (1996) indicates that all of the major communities originally present in the region are still represented there. However, less than 4% of the natural vegetation communities remain on the Adelaide Plains and remnants are usually small, isolated and often degraded. For example, within the City of Playford, no more than 1% of the original area of terrestrial, dryland vegetation remains on the plains. Based on an assessment of historical data presented in Kraehenbuehl (1996), about 260 native species were probably originally present within the wider region, of which 67 species are considered to be extinct and relatively recent records are available for 193 species in the region. Of this total, an unknown number may not now be present i.e. relatively recent extinctions.

The site is on the edge of two of the State Hundreds. It is in the northern most part of the Hundred of Port Adelaide, which contains 11.8% remnant native vegetation of which 4.3% is formally reserved. The Hundred of Port Gawler, north of the Gawler River contains 15.3% remnant native vegetation of which 4.4% is formally conserved. This is considered to be a low remnancy status for each Hundred. Both Hundreds include local Council areas other than the City of Playford.

Most of the remnant native vegetation is located along the coast and there is a disproportionate representation of coastal samphire and mangrove vegetation communities in these totals. Based on analysis of regional data only about 1.2% of the original terrestrial, inland vegetation is present as remnant vegetation.

Since European settlement much of the river red gum woodland and forest and areas of black box woodland along the Gawler River have been cleared, leaving a ‘riparian ribbon’ of overstorey vegetation along the River and nil or a degraded understorey. By observation, these woodlands extended further south than shown by Kraehenbuehl (1996), and patches occurred between the Gawler River and the Little Para River in a mosaic.

The site contains remnant riparian and floodplain woodlands, plus individual and small areas of scattered 'paddock' trees only in its northern areas. By observation of the extant trees and stumps, the original woodland was more extensive than currently recorded. Areas in the north west of the site are equal to or close to the extent of the tree density expected to have occurred in Pre-European settlement woodlands as discussed in Kraehenbuehl (1996) (see Figure 7).

Tree density counts in the northern part of the site, including the stumps of trees cut down in the past, indicate a density of 24 to 27 large or mature trees/ha (plus 5 to 7 stumps/ha). Density along the Gawler River, which appears to be intact, is 28 to 32 trees/ha (plus 1 to 3 stumps/ha). Wood (1937) and Kraehenbuehl (1996) indicate that 25 to 38 large, mature trees per hectare were typical of these woodlands at the time of European settlement.

DEH Biological Survey data for the region (NatureMaps 2007) indicates that ***Eucalyptus leucoxylon*** (South Australian (SA) blue gum) also occurs here as a co-dominant with river red gum over a degraded understorey. This species has not been recorded by the author in the site or region and the authenticity of the record is unknown.

Occasional individuals of small trees and tall shrub native species occur as remnants in the region, usually along roadsides and the Gawler River, and patches of tall grasslands and sedgelands dominated by ***Cyperus gymnocaulos*** (spiny sedge). Common reed, cumbungi, salt club-rush, spear grasses and wallaby grasses also occur along the river corridor.

Little remains of the original understorey and woody weeds dominate the shrub and under storeys of the communities, including the in-stream areas. Originally this site was more probably saline than some others, primarily due to the estuarine influence of Thompson Creek (see Delta 2003 for recent water quality data).

Remnant vegetation of the area south of the floodplain, which was primarily mallee box woodland, is now confined to roadsides and occasional locations on private land to the east of the site. Individuals of species from all storeys of vegetation are now uncommon to rare.

Delta (2003), Durant (2007, 2007a), Hassell Pty Ltd (Hassell) (2002), Penrice (1998), Pedlar and Matheson (1993) and Paton et al. (1991) provide reviews of the native vegetation in the region and/or the site.

The MFP, Tout-Smith and Healy (1997) and the City of Playford, through the Urban Forests Biodiversity Program (UFBP) and the Urban Forest-Million Trees Program, have also undertaken a review of the roadsides of the site as part of regional assessments. These were not comprehensive surveys during different seasons and it is expected that a number of species were not recorded or were overlooked. The culmination of these reviews resulted in the identification of roadside sites, which are marked in the district as Council roadside marker sites i.e. RMS 52, 54, 55, 56 and 57. Several relatively intact sites were defined, of which one, Thompson Creek, has had a vegetation management plan prepared and actioned (Seaman et al. 2000).

Other roadside areas, such as the eastern section of Legoe Road, are pegged and have obviously been assessed, but a RMS is not present, presumably due to the relatively poor quality of the native vegetation.

No DTEI Roadside Significant Sites (RSS) are present on the site.

Ongoing revegetation and management works are being undertaken in the site by the City of Playford and the local community, primarily in the Thompson Creek drainage reserve on Park Road, adjoining the site to the south.

Roadside areas with small areas of reasonable to good quality remnant native vegetation occur along Park, Reedy, Legoe (both sections), Tippetts Bridge and Thompson Roads. By observation, small areas of remnant understorey native vegetation occur along most of the roads in the site.

5.1 Indigenous Communities

Extant vegetation communities recorded on the site are considered in this section. Their distribution is recorded in Figures 6, 7, 8, 9 and 10. Figure 5 shows the locations of the assessed sectors of the site.

5.1.1 River Red Gum +/- Black Box Woodland over Spiny Sedge and Anthropogenic Understorey

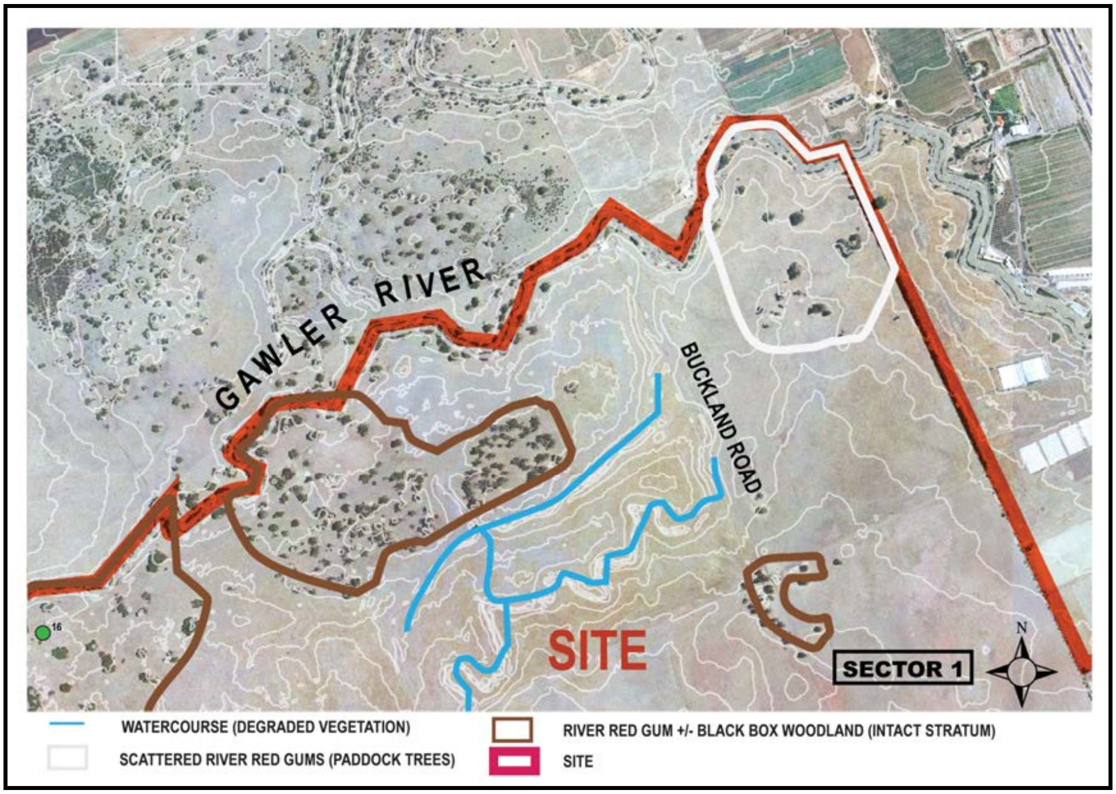


Figure 6: The Gawler River Corridor – Sector 1.

Along and surrounding the Gawler River is a corridor of remnant forest and woodland as overstorey and which is dominated by a range of Proclaimed and environmental weeds in the understorey.

Only native understorey species resistant to grazing occur. Native species such as common reed, cumbungi, lignum and spiny sedge are present at locations on the site and elsewhere along the River, and other regionally threatened native sedges and shrubs have been recorded in the region east of the site by Pastock et al. (1998).

The condition of the understorey community observed along the western reach of the Gawler River is rated as fair to good.

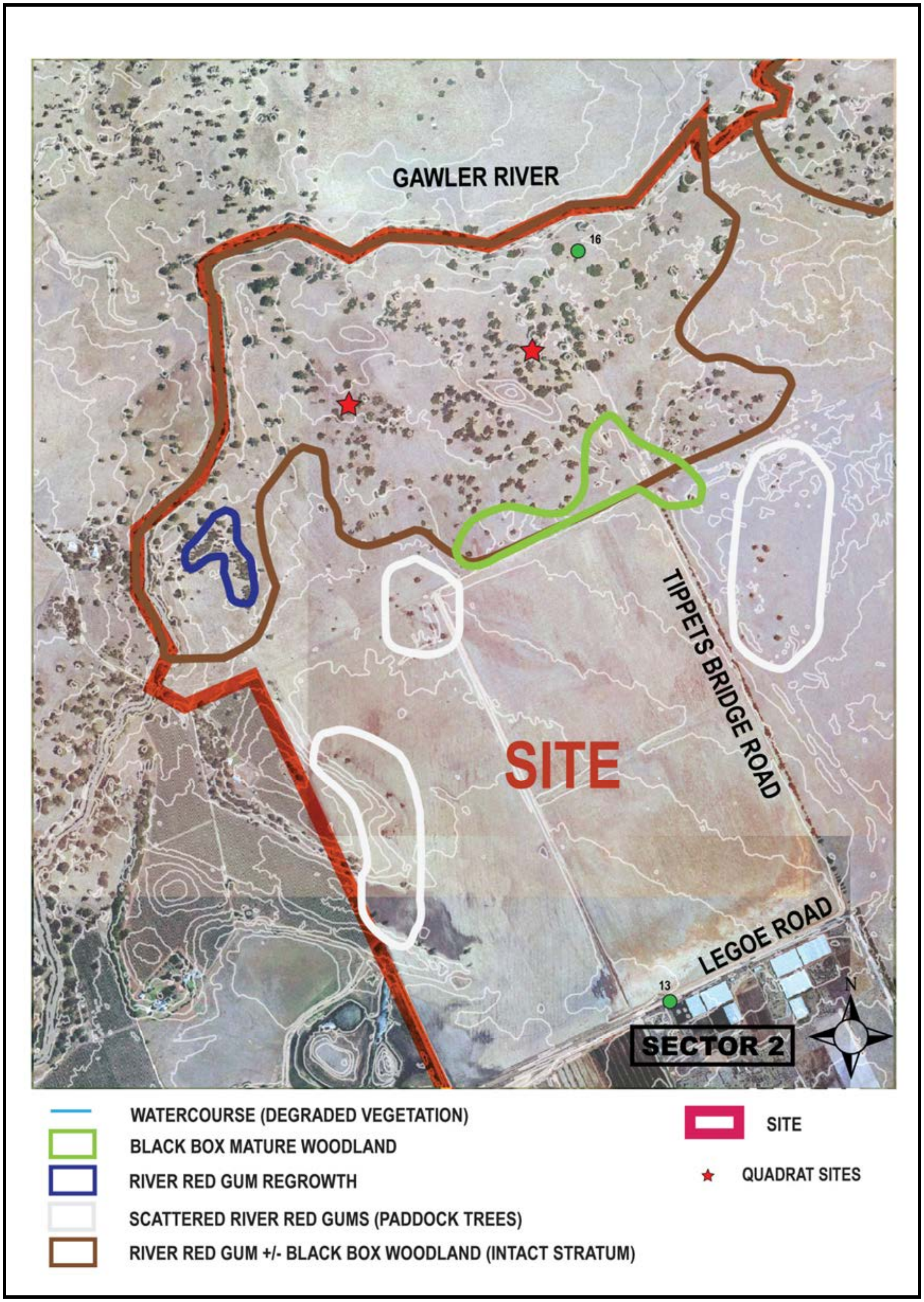


Figure 7: North West – Sector 2.

The largest area of river red gum woodland, about 128 ha, is located in the north west of the site. Based on tree density, this area is "a substantially intact stratum" as defined under the ***Native Vegetation Act***.

Mapping of this area includes a small buffer zone of about 10 m around the edge of the community.

River red gum also occurs as scattered single trees and small areas of woodland remnants elsewhere on the site and roadsides and other properties throughout the region.

Within the site there appears to be four age classes of overstorey river red gum. Very large, senescent trees which are alive and with a circumference at breast height of at least 8 m and a diameter at breast height (dbh) of 2+ m. These trees contain numerous hollows. Large trees of this age class which are dead are also present. Many of the dead or senescing trees have been cut down and removed, presumably for firewood.

The next age class is trees with a circumference of up to about 4 m and a dbh of 1.25 m. A third age class is those trees with a circumference of about 2.4 m and a dbh of about 0.75 m.

The final age class is regrowth seedlings and young trees with a height of 5 to 8 m and a dbh of 5 to 20 cm. This age class was only present along a few sections of the Gawler River and in the north west section of the site. Elsewhere in the site, this age class is absent, presumably due to grazing pressure from live stock and pest herbivores, such as brown hare and fallow deer.

Occasional single black box trees are present along the Gawler River, with the only group of mature to senescent trees occurring in the northern part of the site, as very open tall woodland occupying about 6.4 ha. There is only one age class of this tree species and no seedlings or small trees were recorded.

The community occurs on a range of soil types, especially grey, cracking clays. While damage by livestock, such as bark rubs and exposure of surface roots caused by 'stock camps', and by cultivation was observed, the trees are generally considered to be in good condition. However, some individual trees and groups are in poor conditions with tree canopy dieback of 30% to 70%.

One mature tree of ***Acacia salicina*** (willow wattle) was recorded on site. No re-growth of this species was recorded on the site, although areas of regeneration of this species were present along the Gawler River.

The shrubstorey of the woodland in the site comprises introduced species and the understorey of the woodland is primarily anthropogenic, with only annual native species and grazing resistant perennial species present. The area has been heavily grazed by livestock for many years and this, plus the recent drought conditions and lack of flooding, has been responsible for degradation of the flora complement.

5.1.2 Muehlenbeckia florulenta (Lignum) Low to Tall Shrubland

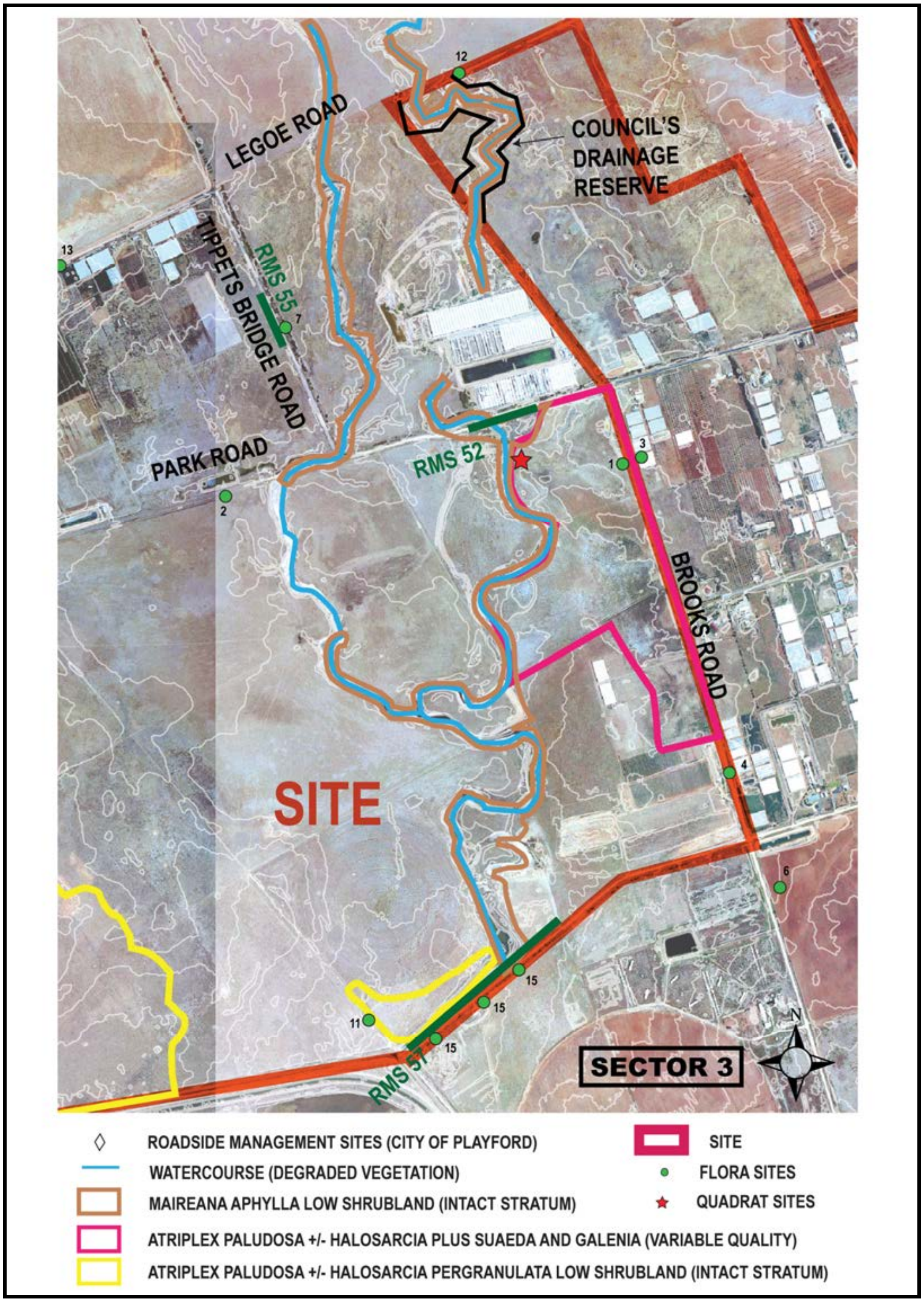


Figure 8: Thompson Creek – Sector 3.

This shrubland occurs as small remnants at a number of locations in the site, with its largest occurrence along Thompson Creek, especially adjacent to Park Road. The largest and best quality areas are adjacent to the site (e.g. west of Beagle Hole Road) and elsewhere in the region, especially around Buckland Park Lake.

5.1.3 *Maireana aphylla* (Leafless Cottonbush) Low Shrubland

This shrubland occurs along and immediately adjacent to Thompson Creek, occupies about 23 ha of the site and typically has high species diversity. See Figure 8.

The better quality areas include relatively high species diversity as various chenopod shrubs, native grasses and herbs and forbs, such as round-leaved wilsonia and rosinweed. The community grades into marsh saltbush low shrublands and is present along sections of Park, Tippets Bridge and Thompson and Beagle Hole roads.

5.1.4 *Phragmites australis* (Common Reed) Tall Grassland

The small areas of this grassland are confined to areas of relatively freshwater entering Thompson Creek adjacent to Park Road and along the Gawler River. See Figures 7 and 9.

5.1.5 *Bolboschoenus caldwellii* (Salt Clubrush) Sedgeland

Small areas were recorded along Park Road, in and adjacent to Thompson Creek and adjacent to Legoe Road (west). It is present elsewhere in the region and is likely to be more widespread in low lying areas following a year of average rainfall.

5.1.6 *Atriplex paludosa* (Marsh Saltbush) and *Halosarcia pergranulata* (Black-Seeded Samphire) Low Shrubland

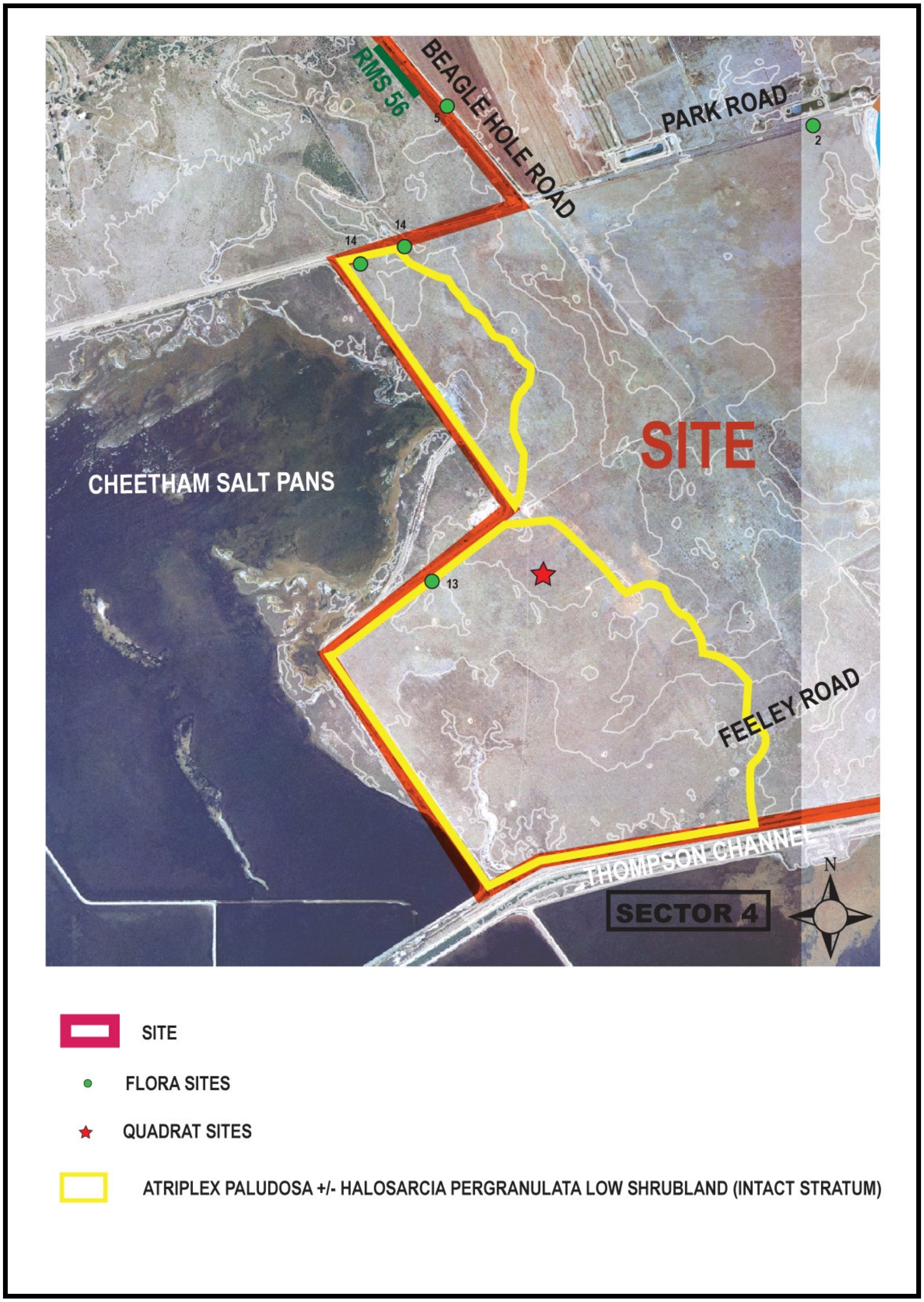


Figure 9: South West – Sector 4.

This saltmarsh community occurs in varying forms and condition throughout much of the central and southern sections of the site. The largest area is along the western edge of the southern section of the site (about 72 ha) and while disturbed, this area is in good condition and some parts of it represent a substantially intact stratum.

This community is also represented in an area of about 32 ha along and adjacent to the southern reach of Thompson Creek, mostly south of Park Road, although good quality examples are less common and weed infestations are high. It contains small areas of a substantially intact stratum. Its occurrence is primarily along the upper slopes of the Creek and on small floodplains includes a number of native species variously located according to soil type, salinity tolerance and elevation.

Other occurrences of this community are present as variously sized degraded patches elsewhere in the site (about 36 ha) and both low and good quality areas are present along most roadsides, especially Park and Thompson Roads. The community includes one plant species of particular interest and conservation significance, ***Rhagodia spinescens*** (spiny saltbush).

5.1.7 Indigenous Low Grassland

Small areas of remnant native grasses are present throughout the site, the Gawler River corridor and roadsides. Most occurrences are secondary grasslands which have colonised after vegetation clearing. ***Austrostipa eremophila, A. nitida, A. scabra, Austrodanthonia setacea***, ***A. caespitosa*** and ***Enneapogon nigricans*** are species typical of this type of community.

Some areas which appear to be remnant understorey plants, possibly of the original grassland occurrences, are present. The most important of these remnants occur along roadsides, for example the areas of Warrego summer-grass along the northern side of Legoe Road east and along Park Road. See Figure 10.

5.1.8 *Wilsonia +/- Cressa* forbland

These halophyte species form a community, or a component of other communities, only on some parts of the site. Elsewhere, it occurs as re-growth of one or both species, both of which adapted to colonise and survive low lying, salty conditions and grazing pressure. This type of environment is widespread on the site.

5.1.9 *Marsilea drummondii* (nardoo) Fernland

The fernland was recorded as a small remnant area of about 10 m x 4 m adjacent to Thompson Creek on privately owned land immediately adjacent to the site.

5.1.10 Other aquatic communities

Small areas of ***Ruppia tuberosa*** (Widgeon grass) occur in Thompson Creek during winter and spring and occasional areas of ***Eleocharis acuta*** and ***Triglochin striatum*** are also present adjacent to the Creek.

5.1.11 Individual Species

Other individual locations or particular species of native vegetation of regional conservation status, include:

- willow wattle recorded as one mature remnant tree
- irongrass at four locations, three of which are along roadsides and one on private property
- smooth cutting grass in three locations along the southern section of Thompson Creek
- areas of round-leaved wilsonia and rosinweed throughout road sides in much of the site
- areas along Thompson Creek and elsewhere in the site which include lignum and spiny saltbush (See Table 1 for detailed information about individual species and Appendix A for the location of occurrences).

5.2 Anthropogenic Communities

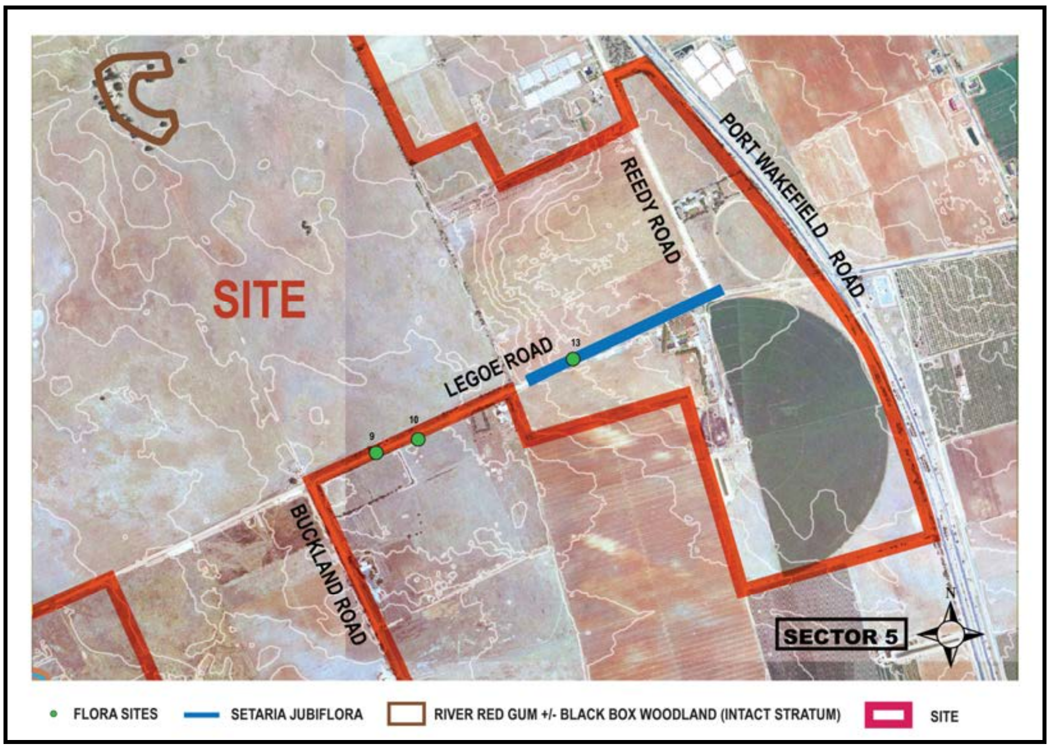


Figure 10: Eastern – Sector 5.

These communities dominate the site. They occur as three main types and as a range of anthropogenic vegetation on land used for agriculture and horticulture. Many of these areas are degraded with few if any native species, and where they occur, it is as secondary grasslands or shrublands i.e. areas in which native grasses and a few low shrubs have colonised after vegetation clearance. Each community is discussed below.

Farming land (intensive agriculture or horticulture). Nil native vegetation present.

Grazing land and other farming areas with some native species regrowth. Vegetation regrowth is present in these areas but varies considerably in diversity and condition according to the location, ranging from dense African boxthorn to areas of ***Maireana brevifolia, Suaeda australis*** and occasional other native, pioneer species, including ***Enchylaena tomentosa*** (ruby saltbush), grasses and round-leaved wilsonia.

Planted trees including native vegetation. Revegetation has been undertaken throughout the region. Small areas have been planted along roadsides and along the margins of some properties. These locations represent a considerable investment in local resources.

A number of broad scale revegetation sites are in the region, including various UFBP projects and the Million Trees Program.

There are individual and small areas of native plants along the length of Legoe Road's eastern end. The northern side of Legoe Road contains a population of Warrego summer-grass and there are smaller areas of spear-grasses, wallaby-grasses and lignum along this roadside.

5.3 Threatened Communities

All remnant communities have a high conservation priority in the region (Neagle 1995, Armstrong et al. 2003) and the site contains areas with a relatively high diversity of plant species and areas of good quality fauna habitat. A number of these sites are currently being managed by local Councils through the UFBP.

All of the communities originally present the region and on the site are now considered to be threatened at a regional level by Kraehenbuehl (1996), Armstrong et al. (2003) and AMLRNRM Board (2007). None is formally listed under Commonwealth or State legislation or the Draft Regional Recovery Plan for the Adelaide and Mount Lofty Ranges (DEH 2008).

Neagle (1995) considers mallee box woodland is poorly conserved in South Australia. While this community occurs elsewhere in the region it is not present on the site.

The river red gum woodland on seasonally inundated flats of the region is considered to be vulnerable in the region, and similar communities elsewhere in the State's pastoral zones are considered vulnerable (DEH 2005). The community is not listed as a priority target in DEH (2008).

Iron-grass tussock grassland may have been present in small areas in the region but does not appear to have been present as a community on the site (Kraehenbuehl 1996). This community was recently listed as nationally endangered (DEWHA 2007). The occurrence of individual plants on the site is rare and appears to be as a component of the understorey, rather than the nationally threatened community.

5.4 Threatened Flora Species

Based on all records and site assessments, a total of about 230 species have been recorded in the region and on site, of which about 75 are indigenous and 155 are introduced.

Table1 lists those species with a conservation status recorded during the field assessment or known to be present in the region based on information from literature surveys and field assessments for other projects. Most of these fifty eight (58) species are present or are predicted to have originally occurred in the region according to Kraehenbuehl (1996) and State Herbarium databases. Additional species are likely to be present following a year of average to above average rainfall.

Table 1 Indigenous flora species recorded or predicted to occur in the region and site and their conservation status

Family	Species	Common Name	Conservation status			Location	
			AUS	SA	SL	Site	Region
Amaranthaceae	***Hemichroa pentandra***	trailing hemichroa			R	-	+
Apocynaceae	***Alyxia buxifolia***	sea box			R	-	+
Centrolepidaceae	***Centrolepis cephaloformis*** ssp. ***cephaloformis***	dwarf centrolepis		R	R	-	+
Chenopodiaceae	***Atriplex australasica***	native orache		R	R	-	+
	Maireana aphylla	leafless cottonbush			V	+	+
	M. decalvans	black cottonbush		E	E	-	+
	M. enchylaenoides	wingless fissure weed			Q	+	+
	M. suaedifolia	lax bluebush			R	+	+
	Halosarcia indica ssp. ***bidens***	brown-head samphire			K	+	+
	H. flabelliformis	bead samphire	V	V	V	-	+
	Rhagodia parabolica	fragrant saltbush			V	-	+
	R. spinescens	spiny saltbush			E	+	+

Family	Species	Common Name	Conservation status			Location	
			AUS	SA	SL	Site	Region
	Sclerolaena muricata var. ***villosa***	five-spine copperburr		R	R	-	+
	Sclerolaena uniflora	small-spine bindyi			K	+	+
Compositae (Asteraceae)	***Brachyscome basaltica*** var. ***gracilis***	swamp daisy		R	T	-	+
	Brachyscome trachycarpa	smooth daisy			K	-	+
	Senecio runcinifolius	thistle-leaf daisy			K	-	+
Convolvulaceae	***Cressa cretica***	rosinweed			V	+	+
	Wilsonia rotundifolia	round-leaved wilsonia			V	+	+
	W. humilis	silky wilsonia			U	-	+
Cyperaceae	***Carex bichenoviana***	knotched sedge			U	-	+
	Gahnia filum	smooth cutting-grass		R	R	+	+
Euphorbiaceae	***Adriana quadripartita***	coast bitterbush			U	+	+
Gramineae	***Aristida australis***	wire-grass		R	K	-	-
	Austrostipa curticoma	short-crest spear-grass			U	-	+
	A. elegantissima	feather spear-grass			U	+	+
	A. eremophila	rusty spear-grass			U	+	+
	A. platychaeta	flat-awn spear-grass			T	-	+
	Eragrostis dielsii var. ***dielsii***	mulka			K	-	+
	Eragrostis infecunda	barren cane-grass		R	R	-	+
	Enteropogon acicularis	umbrella grass			Q	+	+
	Setaria constricta	knotty-butt paspalidium			R	-	+

Family	Species	Common Name	Conservation status			Location	
			AUS	SA	SL	Site	Region
	Whalleya proluta	rigid panic			R	-	+
Juncaceae	***Juncus radula***	hoary sea-rush		V	E	-	+
Juncaginaceae	***Triglochin mucronatum***	prickly arrowgrass			K	-	+
Labiatae (Lamiaceae)	***Teucrium racemosum***	grey germander			T	+	+
Leguminosae	***Acacia hakeoides***	hakea wattle			K	-	+
	Acacia ligulata	umbrella Bush			K	+	+
	Acacia salicina	willow wattle			V	+	+
	Acacia victoriae	elegant wattle			V	-	+
Liliaceae	***Lomandra effusa***	scented matt-rush (irongrass)			R	+	+
Malvaceae	***Lawrencia squamata***	thorny lawrencia			V	-	+
Marsiliaceae	***Marsilea drummondii***	nardoo			R	+	+
Myoporaceae	***Eremophila longifolia***	weeping emu-bush			V	-	+
	Myoporum platycarpum ssp. ***perbellum***	sugarwood			R	-	+
Myrtaceae	***Eucalyptus largiflorens***	black box			V	+	+
	Eucalyptus porosa	mallee box			U	-	+
	Eucalyptus socialis	red mallee			U	-	+
	Melaleuca lanceolata ssp. ***lanceolata***	dryland tea-tree			U	+	+
Orchidaceae	***Caladenia tensa***	greencomb spider-orchid	E	E	E	-	-
	Prasophyllum pallidum	pale leek-orchid	V	V	V	-	-
Pittosporaceae	***Pittosporum angustifolia***	native apricot			R	+	+
Polygonaceae	***Muehlenbeckia florulenta***	lignum			R	+	+
	Rumex dumosus	wiry dock		R	R	-	-

Family	Species	Common Name	Conservation status			Location	
			AUS	SA	SL	Site	Region
Primulaceae	***Samolus repens***	creeping brookweed			U	+	+
Santalaceae	***Santalum acuminatum***	quandong			V	-	+
Scrophulariaceae	***Mimulus repens***	creeping monkey-flower			R	-	+
Solanaceae	***Nicotiana maritima***	coast tobacco			R	+	+

Notes: Aus = Australia, SA = South Australia, SL= Southern Lofty botanical region, + = recorded, - = not recorded or unknown

National Conservation Status according to EPBC Act; E- Endangered, V - Vulnerable.

South Australian Conservation Status - The codes are based on the Schedules of the National Parks and Wildlife Act 1972 as amended in 2008.

Regional conservation status - The botanical region as defined by the State Herbarium (Plant Biodiversity Centre).

E Endangered: rare and in danger of becoming extinct in the wild.

T Threatened: likely to be either Endangered or Vulnerable but insufficient data available for more precise assessment.

V Vulnerable: rare and at risk from potential threats or long term threats that could cause the species to become endangered in the future.

K Uncertain: likely to be either Threatened or Rare but insufficient data available for a more precise assessment.

R Rare: has a low overall frequency of occurrence (may be locally common with a very restricted distribution or may be scattered sparsely over a wider area). Not currently exposed to significant or widespread threats, but warrants monitoring and protective measures to prevent reduction of population sizes.

U Uncommon: less common species of interest but not rare enough to warrant special protective measures.

Q Not yet assessed but flagged as being of possible significance.

5.4.1 National

Three nationally threatened plant species are predicted to occur in the region using the search tool for matters of national environmental significance of the EPBC Act. Of these, ***Caladenia tensa*** (greencomb spider-orchid, endangered) and ***Prasophyllum pallidum*** (pale leek-orchid, vulnerable) occur in woodland and mallee communities.

Greencomb spider-orchid has two recent records of occurrence from relatively intact areas of mallee and native pine community over 25 km east of the site.

Pre-European settlement, the site would have mostly included vegetation communities not preferred by both of these orchids. The site has been cleared and used for intensive farming, and, as a result, does not contain suitable habitat for either species. The likelihood of either of these orchid species occurring on the site is nil.

Halosarcia flabelliformis (bead glasswort) (Vulnerable) occurs in coastal samphire communities, salinas and gypseous soils. The distribution of this species is well documented for the wider region (State Herbarium specimen database and D. Fotheringham, Coast Protection Branch, DEH 2006 and February, 2008, pers. comm.) It is almost entirely confined to areas within 1 km of the eastern coastline of Gulf St Vincent. There are relatively large populations of the species north of the site.

There is potential habitat for the species within the site, but despite extensive site assessment at the correct time of the year to detect the species, it was not recorded. The species is currently being reviewed for de-listing as a species of national significance.

5.4.2 State

Eight flora species of state conservation significance (listed under Schedules of the National Parks and Wildlife Act, but excluding those species considered under the EPBC Act), have been recorded in the region.

Maireana decalvans (black cottonbush), endangered, and ***Juncus radula*** (hoary sea-rush), vulnerable, have been recorded at Bolivar on SA Water land about 15 km south of the site and west of the Port Wakefield Road. Neither was recorded on the site, although suitable habitat for both is present.

Eight State rare species have been recorded in the wider region.

Aristida australis (wire-grass) occurs in the wider region about 9 km east of the site. Suitable habitat for the species is on the Gawler River floodplain.

Eragrostis infecunda (barren cane-grass) is present in the wider region, south of the site. The species is present on low lying areas over clay around Greyhound and Mill Roads and on SA Water land at Bolivar, all locations of which are well south of the site (13 km and 15 km respectively). Potential habitat for the species is present on the site.

The distribution of smooth cutting-grass was recorded in the region and site by Coleman and Coleman (2004). It was recorded during the field assessment as small populations along the southern section of Thompson Creek, including planted occurrences, and suitable habitat for the species occurs elsewhere in the site.

Rumex dumosus (wiry dock) was not recorded on the site or in the region, but it is present in the wider region (Salisbury Highway about 20 km south of the site). The remaining four species were not recorded on the site and are unlikely to occur there due to the lack of suitable habitat.

5.4.3 Regional

Flora species with listed conservation significance for the Southern Lofty botanical region, as defined by Lang and Kraehenbuehl (2002, 2008 update), are reviewed in this section (excluding those considered under the previous section). Their significance rating is a guide only and does not have standing under legislation. Nonetheless, this assessment of significance is prepared by acknowledged experts on the South Australian flora and its inclusion is a requirement of any formal assessment of flora in the State.

Endangered. One species, ***Rhagodia spinescens*** (spiny saltbush).

Threatened. Two species, ***Austrostipa platychaeta*** (flat-awn spear-grass) and ***Teucrium racemosum (grey germander).***

Vulnerable. Nine species, with many species recorded north of the Gawler River, and several with a sporadic distribution south of the Gawler River.

Rare. Seven species, most of which are distant from the site

Other conservation significance categories include Uncertain (K), three species, Uncommon (U), six species, and Not Yet Assessed (Q), two species. Many of these regionally significant species have only been recorded north of the Gawler River. Suitable habitat for some of them is present on the site, but they are unlikely to be recorded in a drought year.

5.5 Introduced Plant Species

The region, and the site, is dominated by anthropogenic communities with many introduced plant species. Over 185 introduced plant species have been recorded in the region, with about 100 of these recorded or expected to occur in the site.

Table 2 lists the most important introduced species recorded in the region based on past field assessments by the author, analysis of DEH, DTEI and State Herbarium records and data provided in other reports relevant to the site and region. All but one of these species, Spartina, was recorded in or immediately adjacent to the site.

Table 2: Introduced plant species of particular significance in the region and the site

Family	Species	Common Name
Asparagaceae	***Asparagus asparagoides**	bridal creeper
Boraginaceae	***Echium plantagineum**	salvation jane
	Heliotropium europaeum	common heliotrope
Cactaceae	***Opuntia** spp. (x3)	prickly pear
Compositae (Asteraceae)	***Acroptilon repens***	creeping knapweed

Family	Species	Common Name
	Chondrilla juncea	skeleton weed
	Chrysanthemoides monilefera	boneseed
	Cirsium vulgare	spear thistle
	Cynara cardunculus	artichoke thistle
	Oncosiphon (Pentzia) suffruticosum	Calomba daisy
	Pallenis spinosa	golden pallenis
	Senecio pterophorus	African daisy
	Silybum marianum	variegated thistle
	Xanthium spinosum	Bathurst burr
	Xanthium strumarium	Noogoora burr
Convolvulaceae	***Convolvulus arvensis***	field bindweed
Cyperaceae	***Cyperus eragrostis***	drain sedge
	Cyperus rotundus	nut-grass sedge
Cruciferae (Brassicaceae)	***Diplotaxis tenuifolia***	Lincoln weed
	Myagrum perfoliatum	musk weed
Dipsacaceae	***Scabiosa atropurpurea***	scabious
Euphorbiaceae	***Ricinus communis***	castor oil plant
Gramineae (Poaceae)	***Arundo donax***	bamboo
	Cenchrus spp. especially ***C. longispinus***	innocent weed
	Eragrostis curvula	African lovegrass
	Hyarrhenia hirta	Coolatai grass, Tambookie grass
	Pennisetum clandestinum	kikuyu
	Pennisetum macrourum	African feathergrass
	Pennisetum villosum	feathertop grass
	Phalaris aquatica	Phalaris
	Piptatherum miliaceum	rice millet

Family	Species	Common Name
	Spartina anglica	Spartina
Guttiferae	***Hypericum perforatum***	St John's wort
Juncaceae	***Juncus acutus***	Spiny rush
Iridaceae	***Homeria flaccida***	one-leaf cape-tulip
Labiatae (Lamiaceae)	***Marrubium vulgare***	horehound
	Salvia verbenaca	wild sage
Liliaceae	***Allium triquetrum***	three-cornered garlic
	Allium vineale	crow garlic
	Asparagus (Myrsiphyllum) asparagoides	bridal creeper
	Asphodelus fistulosus	onion weed
Oleaceae	***Fraxinus angustifolia***	desert ash
	Olea europaea	olive
Oxalidaceae	***Oxalis pes-caprae***	sour-sob
	Argemone ochroleuca	Mexican poppy
Polygonaceae	***Emex australis***	three-cornered jack
Resedaceae	***Reseda lutea***	cut-leaf mignonette
Rosaceae	***Rosa canina***	dog rose
Solanaceae	***Lycium ferocissimum***	African boxthorn
	Solanum elaeagnifolium	silverleaf nightshade
Umbelliferae (Apiaceae)	***Foeniculum vulgare***	fennel
Zygophyllaceae	***Tribulus terrestris***	caltrop

*Proclaimed plants in South Australia. ***Natural Resource Management Act 2004***.

Fifty four weed species present in the region are of particular environmental concern due to their agricultural impacts and/or adverse effects on remnant native vegetation and native fauna.

Many of these species are represented by a limited distribution, such as ***Spartina***, while others are widespread, such as silverleaf nightshade. Species of particular concern to the Adelaide Plains section of the AMLR NRM Board and other authorities, such as DTEI, are discussed below.

Oncosiphon (***Pentzia***) ***suffruticosum*** (Calomba daisy) was recorded at a number of locations during the site assessment, especially in Sector 2 (see Figure 8) and along some roads and tracks. This is considered to be a priority weed for the State and the region and it is gradually spreading south from the Mid North.

Spartina anglica (spartina) was not recorded on site, but it is known to occur in the region. It is a particularly dangerous environmental weed in estuarine areas, hence its inclusion in Table 2. Fotheringham (pers. comm., March 2008) indicates that the species has been controlled in the region.

Hyarrhenia hirta (Coolatai grass) was recorded once on the southern side of the western portion of Legoe Road in February 2008. As the species has primarily been recorded east and south east of the site, this is a new record of the species in the region. The clump of grass was removed and destroyed by the author. Two small infestations have been previously recorded in the City of Playford around Munno Para. The main infestations of this species are south and east of the site.

Noogoora burr was recorded along the Gawler River, but not on the site. Bathurst burr was relatively common, especially in the northern parts of the site and along tracks, around stock water points and around the edge of saline depressions.

Solanum elaeagnifolium (silverleaf nightshade) is a perennial that is widespread and occurs along most roadsides and in many areas of cultivated land in the site. It is of particular concern since the species spreads by stem and root cuttings and seeds.

Other species of potential concern include bridal creeper, prickly pear and rope cactus, African boxthorn, St John's wort, olive tree, castor oil tree, innocent weed and caltrop.

5.6 Threatening Processes and Plant Pathogens

One national, key threatening process listed under the EPBC Act has been recorded in the region namely "Dieback caused by the root-rot fungus (***Phytophthora cinnamomi***)". A threat abatement plan has been established for this process (DEWHA 2001). The site is considered to be a moderate risk location for this disease.

Mundulla Yellows has been recorded on the site and region on various host trees and a number of trees with yellow foliage, aberrant growths on foliage and large amounts of canopy die-back have been reported in the immediate region. This may be due to spray drift from chemicals used on adjacent properties or a combination of effects, such as drought, salinity and chemical spray impacts.

There are very few pest herbivores present on the site. European rabbit was recorded in very small numbers only at one site and the only other large pest herbivore seen was fallow deer (5 animals). These are discussed in the Fauna Technical Report (Anderson 2008).

5.6.1 Other Impacts

Currently, farming and horticulture are having a direct impact the site's flora and vegetation. Areas used for broad scale cropping have few native vegetation values associated with the understorey, although there are a number of relatively small occurrences of native species, especially round-leaved wilsonia. Areas used for grazing have some understorey values and some of the shrublands are of biological value. The horticultural areas have negligible native vegetation value.

Roadside remnant native vegetation along Park Road, Tippets Bridge Road and the northern section of Beagle Hole Road is affected by illegal dumping of rubbish, including hard rubbish as car bodies (some incinerated), used tyres and engine parts; waste oil and coolant; fuel and chemical drums and containers; disused furniture and building materials; cartons and other packaging materials; and green wastes as mowings, clippings, prunings and disused hydroponic growing media and associated containers.

Runoff from intensive horticulture areas and chemical spray drift was observed during the field assessment.

6. IMPACTS OF THE PROPOSAL AND MITIGATION

The site contains large areas of a highly disturbed, anthropogenic environment with a long history of disturbance with the major land use being intensive agriculture and horticulture.

There are also some biologically significant areas and species present in this anthropogenic matrix. Impacts on all aspects of the site and adjacent areas are discussed in this section.

Construction of the proposal will be staged over 25 years, with Stage 1 constructed between 2001 and 2016.

The approach to identifying potential impacts and mitigation measures adopted in this report therefore considers the proposal as two phases:

- Stage 1
- Remaining stages.

6.1 Onsite Impacts: Stage 1

Stage 1 is approximately 150 ha or 11% of site's total area. It is almost entirely confined to disturbed, anthropogenic areas and is within Sector 5 of the site - see Section 5. Consequently there will be no major impact, and very few minor effects, on native vegetation in the area associated with Stage 1.

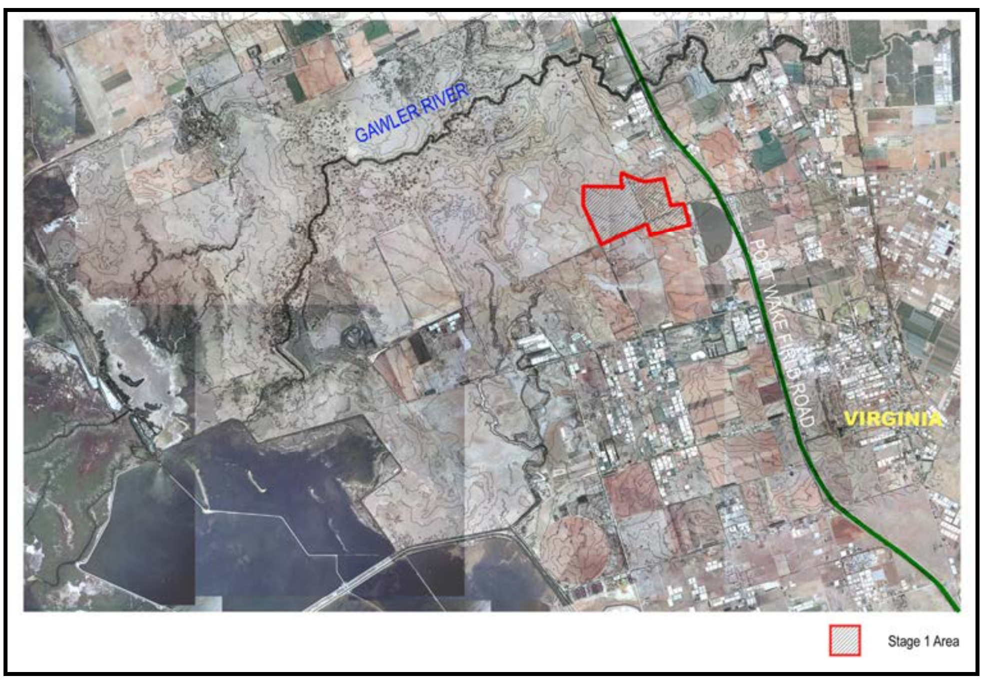


Figure 11: Stage 1 Site Plan

However, Stage 1's Construction Environmental Management Plan must include:

- Measures for identifying, collecting and transplanting indigenous grasses to landscaped areas in the public domain.
- Measures to minimise the spread of weed species outside of construction zones.

Design Guidelines for new houses within Stage 1 should include a range indigenous species for inclusion in gardens.

Landscape designs should include indigenous species for the public domain.

Community building programmes should include activities which educate and involve the new community in the biodiversity of their surrounds.

6.2 Onsite Impacts: Future Stages

The likely and potential environmental impacts of the proposal on both native vegetation communities and species have been estimated using the Master Plan, at Figure 3.

Impacts in anthropogenic sites are low due to the lack of native vegetation. However, without mitigation, impacts will be high in and around locations which contain reasonable to good quality native vegetation (see Sections 5.1 and 5.3).

Figure 12 illustrates the Masterplan's relationship to the vegetation communities considered in Section 5.1.

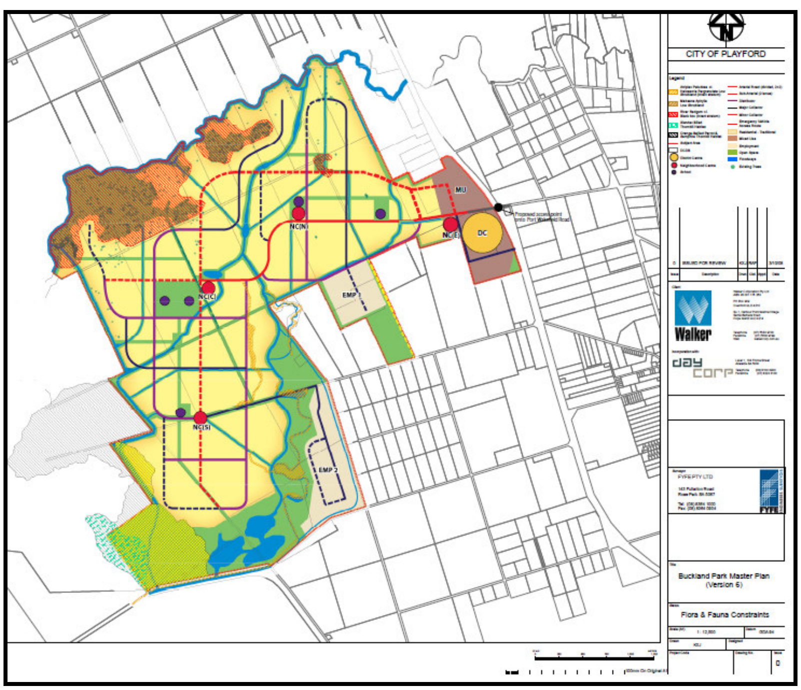


Figure 12: Master Plan overlay on vegetation areas

6.2.1 Gawler River floodplain woodlands – Sectors 1 and 2

The Gawler River riparian corridor (Sector 1) is shown in the Masterplan as incorporated into an open space area. It includes occurrences of a number of species of conservation significance. Removal of trees and areas of native understorey species in the Gawler River riparian corridor is not proposed. The understorey along the corridor is dominated by weed species (See Section 5.1.1).

Undertaking revegetation and rehabilitation works along the corridor to reconstruct the vegetation communities and habitat areas would have a potential for large, positive regional outcomes. This approach should be formalised in Rehabilitation and Revegetation Plans and Management Plans assessed by Government authorities prior to the approval of the proposal's northern stages.

The Masterplan shows most of the Gawler River floodplain red river gum and black box woodlands of Sector 2 contained within proposed open space areas. However, some of the woodland and the areas with lower density trees are incorporated into low density residential areas. The proposal's stormwater channels will also pass through the woodlands.

Potential impacts on the woodlands include:

- Removal of trees and parts of communities and their buffer areas.
- Fragmentation of communities and associated fauna habitats.
- Placement of buildings and gardens too close to woodlands i.e. without an appropriate buffer.
- Inappropriate fire regimes (arson and bushfire).
- Damaging trees, especially damaging or removing tree canopies and roots during construction.
- Redirecting storm and ground water away from woodland areas and trees.
- Compaction of soil around trees during construction.
- Introduction and spreading of weeds.

In Sectors 1 and 2 it is proposed to:

- Design future stages to minimise vegetation clearance and tree removal, rehabilitate and revegetate retained woodlands and their diversity.
- Incorporate scattered trees and small patches of trees into the detailed landscape design of future stages.
- Prepare Construction Management Plans for government approval as part of each future stage. An environmentally sensitive construction approach is required to ensure that the construction and proposal 'footprint' along the boundary of woodland areas is minimal and that individual trees are preserved, managed appropriately and not cleared.

Detailed Rehabilitation and Revegetation Plans and Management Plans will be required as part of the assessment documentation for future stages.

While the trees are of botanical interest as a vegetation community and most are significant trees as defined under the ***Development Act***, their particular value is as fauna habitat, especially for avifauna and some mammals, especially bats. This matter is discussed in detail in the Fauna Technical Report (Anderson 2008).

Accordingly, the Management Plans and landscape design will require elements which ensure residents and the general public do not have uncontrolled access to these areas. These measures are required to protect people, but particularly to protect the trees and revegetated areas.

Woodlands containing mature and senescent trees are almost unique on the Northern Adelaide Plain. These trees are old and relatively fragile. They will drop limbs during and following times of stress, such as drought or strong winds. The Management Plan must allow for these dropped limbs to be tolerated, and not removed, as they are part of the site's ecological values.

The same provisions must be made for individual trees in residential and public space areas.

6.2.2 Thompson Creek Shrublands, Sedgelands and Grasslands

This is a complex of related communities, with the two dominant ones being:

- marsh saltbush +/- black seeded samphire +/- Austral seablight low chenopod shrubland in the southern section of the site
- leafless cottonbush shrubland in the central geographic sections of the creek system.

Small areas of tall sedgeland and grassland dominated by cumbungi, common reed and salt clubrush are also present in a mosaic along sections of the creek. This area is within Sector 3 and discussed in detail in Sections 5.1.2 – 5.1.5.

Approximately 24 ha of low chenopod shrubland and 6 ha of leafless cottonbush shrubland are proposed for removal in areas proposed for residential development and stormwater channels. Current weed infestations of adjoining areas and the potential to introduce existing and new weeds during construction will be an issue in these communities. However, much of the area along and adjacent to the eastern reach of Thompson Creek is included in open space areas and will not be impacted by construction of the stormwater channels.

Other locations of these communities are along the roadside areas, including the RMS, and no disturbance is proposed to take place in those areas which contain remnant native vegetation.

6.2.3 Southern Chenopod Shrublands

These are the most extensive native vegetation communities on the site and contain a number of important plant species of regional significance.

They are of significant value as fauna habitat for nationally and state threatened bird species (Anderson 2008). They are within Sector 4 and discussed in detail in Section 5.1.6.

The two areas are:

- A relatively intact community in the south west of the site of which 6.3 ha is proposed for removal for the residential proposal and 3.4 ha is to be removed for a stormwater channel. The channel will remove a corridor of native vegetation and potentially introduce weed species into the adjacent shrubland.

- Sparse and degraded areas of the community east of the relatively intact community. This area includes areas of round-leaved wilsonia and rosinweed as the understorey. About 68 ha containing these areas are within a future residential area.

A strict policy of revegetation using native samphire and chenopod species to rehabilitate the channel earthworks will be required.

6.2.4 Wilsonia and Cressa

These occur throughout the saline areas, including roadsides. All areas proposed to be removed are included under the Thompson Creek and southern chenopod shrubland communities.

6.2.5 Other aquatic communities

These are included in the impacts on the Thompson Creek vegetation communities.

6.2.6 RMS areas, other roadside native vegetation and Indigenous low grasslands

Impacts on these areas are not predicted to occur at this stage. However, if areas are likely to be affected as future detailed planning is undertaken, then appropriate mitigation actions will be undertaken. These could include fencing of areas, salvage of plants or collection of propagating material followed by use of propagated plants in revegetation schemes on the site.

Most native grassland areas are along roadsides, including RMS, and no disturbance is proposed in locations which contain grasslands or RMS.

6.2.7 Anthropogenic areas

Anthropogenic areas comprise most of the site and clearance of these areas will not impact native vegetation.

6.2.8 Individual Species

These areas and individuals can be avoided by specifically excluding impacts from their locations, or, if this is not practicable, then salvage or collecting the plants for use elsewhere in the site.

6.3 Mitigation of Impacts

The Masterplan shows areas native vegetation removed for new residential areas at the sites shown in Figure 12. It must be noted, that at this early stage of design, these areas are not established in detail. More design work will be undertaken prior to the commencement of future stages.

This section describes the mitigation measures incorporated in the proposal to achieve a significant environmental benefit (SEB). These measures will be the subject of ongoing discussions with the South Australian Government as future stages are designed.

Offset ratios for SEB would apply to all native vegetation proposed for clearance. The criteria for different ratios are described below in Table 3.

Table 3 Significant Environmental Benefit guidelines

The following guidelines are to be used to determine the area of set-aside (SEB – Significant Environmental Benefit area) required where the "Scattered Tree SEB Interim Guidelines" do not apply: (Native Vegetation Council 2007 Policy 1.2.11)

Where proposed clearance is considered to be minor and of limited biodiversity impact, eg lopping of overhanging limbs only or minor clearance of shrubs in areas otherwise considered as highly disturbed:

No SEB area

Where proposed clearance is in areas dominated by introduced species, the area of native vegetation is largely reduced to scattered trees, indigenous understorey flora reduced to scattered clumps and individual plants:

SEB area to be based on an area of: 2:1

Where the proposed clearance is of mostly intact overstorey vegetation but there is still considerable weed infestation amongst the understorey flora:

SEB area to be based on an area of: 4:1

Where the proposed clearance is of mostly intact overstorey vegetation with moderate but not severe weed infestation amongst the understorey flora. Clearance is not seriously at variance with the Principles:

SEB area to be based on an area of: 6:1

Where the proposed clearance is of mostly intact overstorey and understorey vegetation, weed infestation is moderate to low, but the original vegetation is still dominant. Clearance is assessed by the Native Vegetation Council to beat variance with the Principles:

SEB area to be based on an area of: 8:1

Where the proposed clearance is of diverse vegetation with very little weed infestation. Clearance is assessed by the Native Vegetation Council to be seriously at variance with the Principles:

SEB area to be based on an area of: 10:1

The Native Vegetation Council will review future clearance of native vegetation in accordance with the principles in the Act's Regulations.

"***Native vegetation should not be cleared, if, in the opinion of the Council -:***

- ***it contains a high level of diversity of plant species;***
- ***it is an important wildlife habitat;***
- ***it includes rare, vulnerable or endangered plant species;***
- ***the vegetation comprises a plant community that is rare, vulnerable or endangered;***
- ***it is a remnant of vegetation in an area which has been extensively cleared;***
- ***it is growing in, or associated with, a wetland environment;***
- ***it contributes to the amenity of the area;***
- ***the clearance of vegetation is likely to contribute to soil erosion, salinity, or flooding;***
- ***the clearance of vegetation is likely to cause deterioration the quality of surface or underground water;***
- ***after clearance, the land is to be used for a purpose which is unsustainable".***

It is considered that the first seven principles are relevant to the good quality areas of native vegetation on the site. Detailed information about fauna habitat and species is provided in the Fauna Technical Report (Anderson 2008).

The definition of broad scale clearance and clearance of a substantially intact stratum would also apply to some of the areas on the site. Based on the proposal's Masterplan some of these areas will be removed for incorporation into new residential areas.

Any clearance of native vegetation would require a SEB as compensation. SEBs can be achieved through the following measures:

- establish and actively manage new areas of native vegetation on the site and/or at an agreed area of the same or similar community(ies) in the region.
- protect and manage native vegetation on the site, including formal protection by a Heritage Agreement.
- establish a Heritage Agreement for other areas of native vegetation, with a Vegetation Managment Plan.
- payment into the Native Vegetation Fund
- a combination of the above management options.

6.3.1 Scattered and Paddock Trees

The Masterplan incorporates scattered and paddock trees into residential areas. Detailed design of future stages will incorporate many of these trees into parks. Pruning and rehabilitation of some of these trees may be required in the interests of public safety.

If clearance of a scattered tree (paddock tree) is required then the guidelines established in Cutten and Hodder (2002) would be applied to establish a SEB.

While this has minimal impact on flora values, the adverse impact on some fauna species currently using these trees will be more important, as described in the Fauna Technical Report (Anderson 2008).

6.3.2 Retained Vegetation in Open Space Areas

Approximately 193.8 ha of good to very good quality remnant native vegetation will be retained in open space areas within the Masterplan.

Active rehabilitation, revegetation and management of these areas will contribute to achievement of a SEB. Active management will include pest species control, revegetation using locally indigenous species as part of habitat re-construction and monitoring. Fencing of the boundary of areas will be required.

Along the Gawler River corridor, the removal of weeds and revegetation as part of rehabilitation will result in positive environmental impacts.

In addition, a specific management action for the river red gum woodland will be to establish a flood management scheme. This will assist in enhancing the health of the woodland, especially the old, senescent trees, and provide for recruitment of young trees.

The ownership of these areas will be the subject of negotiation with State Government. However, formally reserving these areas as part of the State's conservation network would add to the value of the SEB and would comply with the State Biodiversity policy.

In respect of these areas the proponents will undertake the following:

- Ensuring detailed design of future stages incorporates measures to retain vegetation, and landscape plans incorporate open space corridors, minimising potential fragmentation of vegetation communities.

- Preparing and implementing Rehabilitation and Revegetation Plans and Management Plans.

Within Sector 4, conditions are suitable for revegetating dryland areas with low chenopood shrubland and aquatic areas with appropriate species from grassland, sedgeland and shrubland communities. An example of successful habitat establishment in a similar environment is the Greenfields and Barker Inlet wetland complex.

This is practicable for the site and would provide another valuable component of the SEB. The Masterplan's open space areas can accommodate these revegetation proposals.

The use of locally indigenous species for revegetation of new stormwater channels and assisting in the revegetation and management of RMS along roadsides would also be suitable for providing part of the SEB.

New residential areas adjacent to retained native vegetation will place pressure on that vegetation due to access by people. Access must be strictly controlled if these areas remain as conservation areas. The Rehabilitation and Management plans for retained vegetation areas must include fencing. Fencing must be included in Landscape Plans for future stages of the proposal.

Future detailed designs should consider new species, communities and threatening processes established by the Commonwealth and State governments in the future.

In addition, the condition of the site and its native vegetation may change significantly over 25 years, especially in response to drought. Therefore, a detailed review process will be required prior to each development stage being approved in future.

6.3.3 Vegetation within the Region

There are opportunities for SEB works to be undertaken in areas of conservation significance adjacent to the site, such as the Gawler River corridor, or areas in the region, such as Buckland Park Lake, Port Gawler Conservation Park, or other areas of State owned land along the coast, shown in Figure 13.

Cooe (2008) described the degraded state of some of these areas in its report ***Marine and Coastal Environment and Potential Impact Assessment***.

> ***Our survey of the coastal plain west of the Site found ecologically significant vegetation and habitat, but has suffered degradation from feral animals and general rubbish. The impacts of Cheetham's salt pans, with changes to land form and hydrology were also evident.***

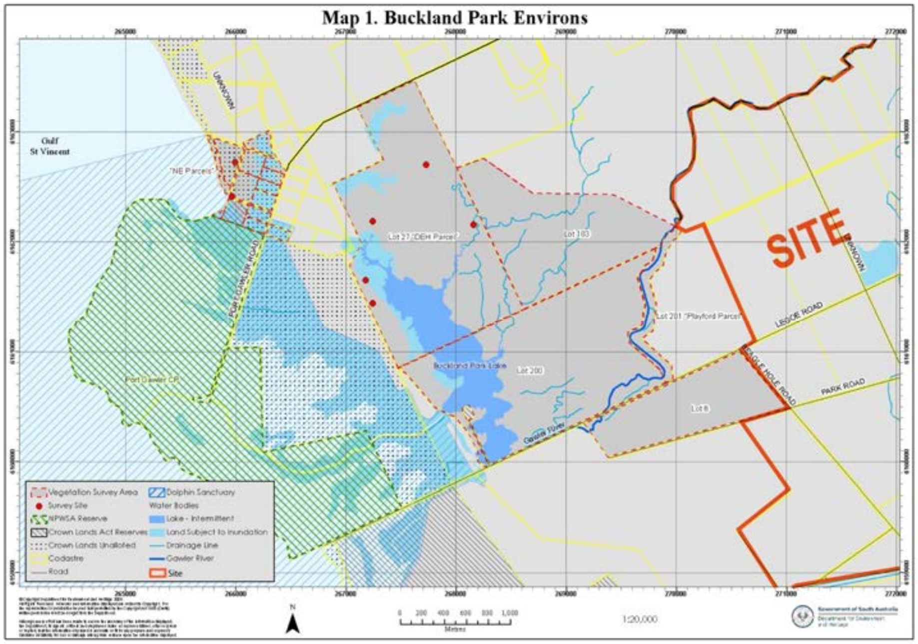


Figure 13: Areas of biological importance in public ownership and within the site's region

Establishing an environmental improvement program in these areas would provide a suitable contribution towards achievement of a SEB. These actions could be part of the Draft Regional Recovery Plan for threatened species and ecological communities (DEH 2008).

Works that could be undertaken by the Proponent, or funded through the Native Vegetation Fund, include:

- Removal of feral animals.
- Removal of weeds and rubbish.
- Revegetation.
- Drainage and erosion control works.

These works would be subject to preparation of Rehabilitation and Revegetation Plans and Management Plans for the targeted land. Active participation in the Draft Regional Recovery Plan (DEH 2008) is a realistic contribution to the proposal's SEB.

6.4 Weeds

Throughout the region and site there is a wide range of annual and perennial weed species. About 220 species of introduced plants have been recorded in the region. Of these, about 54 species are of particular concern due to their impacts on agriculture and remnant native vegetation and these species are considered in Table 2. Examples of these species and impacts are discussed below.

Most of the roadsides and many of the paddock areas through which construction traffic will pass are weed infested. The movement of soil and vehicles has the potential to transport weeds through the region and the site.

Earthworks and native vegetation clearance for the new stormwater channels also have the potential to introduce weeds, directly into adjoining, intact, retained vegetation.

Much of the site is anthropogenic and is likely to experience minimal environmental impacts given the disturbed nature of the region and site. However, without suitable and stringent management actions, weed species will be transported from construction zones into adjacent areas, resulting in the degradation of the small areas of remnant native vegetation existing on the site.

A Weed Species Management Plan must be prepared to mitigate this potential impact. It must be prepared in accordance with the NRM Act and the State's Biosecurity Strategy (Government of South Australia 2008). A new plan must be prepared for each future stage of the proposal, prior to commencing construction of that stage.

In particular, a targeted weed management strategy for the Gawler River corridor would result in positive environmental outcomes, contributing a SEB. The river bed and its banks are densely infested with weeds such as African boxthorn, briar rose, castor oil plant, Noogoora burr, fennel, prickly pear and olive, which are proclaimed or major environmental weeds in South Australia. Bridal creeper, a weed of national significance (WONS) also occurs along the River.

Weed infestations occur along the whole Gawler River length, east and west of the site. In order to be effective, an integrated management programme involving Councils and other land owners is required.

6.5 Offsite Impacts

The most likely adverse off site impact will arise from a large new population in a region that is currently sparsely populated.

The environmental pressures associated with people will likely be an increased incidence of use on the Cheetham saltfields, the coastal plain, the Gawler River corridor, Buckland Park Lake and Port Gawler Conservation Park. This will include both legal access and illegal trespassing.

It is noted there is no public road access to the coastal plain from the site.

Other environmental pressures and risks will be in the form of illegal removal of trees and deadfall timber for firewood; arson; the use of unsuitable garden plants; and the illegal dumping of green wastes, especially from properties which are adjacent to areas of high quality native vegetation. All of these activities will slowly erode the integrity of the native vegetation, both as communities and species.

Mitigation measures include:

- Fencing of biodiversity areas within the site, as described above.

- Educating new residents about the biodiversity around their homes, including creation of wildlife friendly gardens, control of domestic animals. This will be done through the community development manager, through 'welcome packs' and activities which focus on biodiversity areas, for example community planting days, walks and talks from ecologists. Council already undertakes such activities for its existing residents.

- Provision of adequate waste management facilities for residents.

- Design Guidelines which include indigenous species in plant specifications for revegetation.

- Appropriate landscape design, including liaison with Country Fire Service and Metropolitan Fire Service authorities to establish fire management requirements.

It is noted that population pressure is not an impact uniquely associated with the site and proposal. Wherever a new population is placed these issues arise.

6.6 Combined and Cumulative Impacts

Playford City Council (2008) notes sea levels are predicted to rise by 0.3m from 2002 levels by 2050, with a further 0.7m rise occurring by 2100. Sea level rise has the potential to impact on vegetation communities in low lying areas near the coast. In this region the communities potentially affected are the chenopod and samphire areas which are, at or just above, sea level.

In respect of sea level rise and the migration of plant communities, Cooe (2008) concluded:

> ***The loss of extensive areas of seagrass along the Adelaide metropolitan coast has caused the mobilisation of exposed sediment. Resuspended sediment moves northwards and is deposited on sand banks (such as Section Bank) off Outer Harbor and the northern beaches (Mifsud*** et al. ***2004, Fox*** et al. ***2007). The build-up of sediment and detritus around the mangrove pneumatophores appears to be causing the loss of mangroves on the shore front; the mangroves retreat further inland if suitable land is available (Mifsud*** et al.***, 2004). However, in Buckland Park the Cheetham Salt levee banks west of the site, prevent the retreat of mangroves.***
>
> ***Sea level rise, attributed to climate change, will increase the pressure on seagrass, mangroves and samphire communities to advance further inland, or retreat (Harvey 2002). This will become more pronounced along coastlines that are characterised as low gradient, such as the upper Gulf St Vincent. This topic is dealt in more detail elsewhere in proposal's environmental assessment.***
>
> ***The retreat of coastal vegetation as sea level rises is prevented by the Cheetham salt pans, which create a barrier at the eastern edge of the coastal plain. Accordingly the proposal will not influence the outcomes of coastal retreat in this area.***

As the anthropogenic areas of the site have little to no native vegetation, inclusion of these areas in future urban areas will be unlikely to have an adverse combined or cumulative impact on native vegetation.

The proposal's Design Guidelines will require indigenous plants to be used extensively in the public domain, including streets, parks and commercial and community spaces. New residents will also be encouraged to use indigenous plantings in their gardens. Consistent implementation of these Guidelines will result in a net environmental benefit from the replacement of anthropogenic areas.

The cumulative and combined impacts of urban growth on the native vegetation and fauna habitat throughout northern Adelaide needs to be considered in the State Government's strategic planning.

The State is currently identifying land for new suburbs to accommodate urban growth. As well as the Buckland Park proposal, other areas in northern Adelaide are being considered, including Dry Creek, approximately 20 km south of the site (Minister for Urban Development and Planning 2008).

6.7 Environmental Management

Mitigation of impacts will be through environmental management, the principles of which are discussed in this section. Management will include formal review and updated planning mechanism at the detailed design stage of each future stage, prior to approval and commencement of construction.

Detailed, specific management actions tailored to the particular characteristics of each stage will be incorporated in an Environmental Management Plan (EMP) for that stage.

6.7.1 Principles Adopted to Minimise Effects

An EMP will provide general measures aimed at avoiding or minimising adverse environmental impacts, through specific mitigation measures, and for achieving SEBs.

Construction Environmental Management Plans (CEMPs) will include the detailed requirements for construction works. CEMPs will include the methods and requirements for achieving SEBs.

Specific performance criteria will be established. The Proponent has considerable experience with environmental policies and management requirements for large and similarly complex projects. The key issues, impacts and mitigation include planning and design, construction and operation.

6.7.2 Measures to Minimise Effects during Planning and Design

The first key management action was to inform the Masterplan design by identifying remnant communities and individual species through site assessment, and to validate the results by checking and consultation.

The planning and design phase for the proposal started with the field assessments that have been undertaken over 2007 and 2008. As far as practicable, these have identified areas of remnant native vegetation and areas of native vegetation planted by local councils and others and the location of these areas has been recorded by GPS, in a database and mapped.

As far as possible, species in all site sectors have been identified accurately, although there have been some areas for which species identification has not been able (due to the drought conditions during 2007/08). This identification process, of both communities and species, was confirmed by independent review of existing reports, databases and sites provided by government agencies and individuals.

These areas were mapped (see Figure 5 and Appendix A). This map was used to establish broad open space areas required within the Masterplan and to allow consideration of the requirements for SEB. Adjustments were made to the location of proposed residential areas and the stormwater channel in the vicinity of Thompson Creek in response to vegetation constraints.

However, this identification is a ‘work in progress’. Ongoing site survey will occur over winter and spring to assess if additional areas or species of winter growing plants are present during a year of average rainfall. Results will be reported in future planning reports assessed by government prior to the approval and commencement of construction of each future stage.

There is a commitment to ensuring that local flora only is used in the landscape design and revegetation planting of the project. All storeys of native vegetation will be used and the placement of these species in the landscape will, as far as practicable, accord with that which would have originally been present prior to 1836.

To achieve this commitment, collection of propagating materials from different biotypes from the same species within the site and region will be required.

Cuttings of those species which are difficult to propagate from seeds will be taken and plants set and grown on at a later stage. Timing of this activity will not be immediate, but will coincide with the need to establish a known quantity of plants in a particular location. The amount of seeds of each species (for direct seeding) and the numbers of plants required as tube stock (seedlings and struck cuttings) will be determined after the exact areas with particular soil characteristics and uses are identified at the detailed design stage.

These results will be incorporated into landscape designs, Design Guidelines for new dwellings, CEMPs and other management plans.

6.7.3 Measures to Minimise Effects during Construction

Immediately prior to construction, constructions sites will be surveyed on foot. Areas of native vegetation present will be assessed. If these are common species, such as a sparse occurrence of native colonising species (e.g. short-leaf bluebush or rough spear-grass), then no addition approvals or mitigation actions will be required.

If there are species that are unusual or threatened, even isolated plants or small clumps, then the species will be protected by collection, either of the plants, followed by transplanting into a secure area, or of propagating material (seeds or cuttings).

Prior to construction, builders and contractors will be formally briefed about the importance of native vegetation through an induction briefing. Each individual builder, contractor and sub-contractor will verify agreement by attendance at this briefing and by signature to an agreed Code of Practice.

An Environmental Officer will be responsible for ensuring that compliance occurs or if it does not, then establishing remedial requirements, and, if necessary, contract penalties. The key responsibility of all will be to avoid all areas of native vegetation marked on management maps and in the field.

Native vegetation clearance will not occur in most of the anthropogenic areas because none is present.

Prior to the removal of any area of native vegetation, all approvals will be obtained from all relevant groups. Formal approval will be obtained from the NVC through the submission of a vegetation clearance application.

SEB and net gain requirements will apply to the proposal and each of its future stages. Assessment of trees and native vegetation potentially affected by the proposal along the Gawler River floodplain, Thompson Creek and in the southern section of the site will be undertaken in consultation with the NVC.

Ongoing liaison with Council and state government officers will be maintained during construction. This will include inspection and agreement as to which areas should be planted and established.

6.7.4 Measures to Minimise Effects during Post-Construction

Once construction has been completed then a management and maintenance plan will be established for the biodiversity areas of the site. From a biological perspective, this will include management requirements for the conservation and revegetation areas, such as watering and replacement of plantings and maintenance of all areas. Council would be expected to be involved in these activities.

7. CONCLUSIONS

Field assessment of the region and the site was combined with review of databases and consultation with environmental staff representing the State Government and local councils.

Most of the native vegetation in the region and much of the site has been cleared. Therefore, the remnant communities and species of native vegetation in the region are valuable, both intrinsically, and as examples of the past biodiversity of the region.

The proposal Masterplan shows new urban areas predominately on previously cleared agricultural land which contains little or no native vegetation. There is no direct impact on matters of biological significance in these areas.

There are areas of remnant native vegetation on the site, primarily in the extreme northern and southern areas of the site. Elsewhere, there are small to tiny remnant areas of the vegetation communities considered to have been present prior to European settlement, especially along sections of Thompson Creek. A few of the better quality locations are on public roadsides and are listed as RMS.

The Gawler River floodplain woodlands will, for most part, not to be cleared. Remnant, mature river red gum areas and individual trees will be preserved as a conservation resource. These areas also contain some species with a listed conservation rating for the Southern Lofty botanical region.

Most of the scattered river red gums and a small area of black box woodland are proposed for inclusion in a residential area. In these locations individual trees will be preserved in parkland or on larger residential allotments.

As part the detailed design of future northern stages, provision must be made for a replacement buffer area around the retained woodland areas. This will be required for access and bush fire protection.

Two other important, large areas of native vegetation are located in the south and centre of the site and these will be impacted by the proposal in its current form, namely:

- chenopod low shrubland areas
- leafless cottonbush low shrubland and smaller areas of remnant native vegetation along parts of Thomson Creek.

Some of the potential impacts and mitigation measures of the proposal are related to ‘fine tuning’ the position of future residential areas to avoid specific, small areas of native vegetation during detailed design of future stages.

If avoidance is not practicable, then active management of the native flora remnants will be undertaken by various means, including removing and transplanting plants, and collection of seeds or cuttings, followed by propagation and re-planting as part of the landscape rehabilitation works.

All areas adjacent to construction zones will require protection wherever practicable. Collection of propagating material from native plant species must be undertaken to ensure that as many species and biotypes as possible are represented in the collections used for future landscaping and revegetation.

Within the constraints imposed by the weather, time and land access conditions over 2007/08, most sections were not assessed over winter to spring with average or above average rainfall. Ideally this should be undertaken in order to fully assess species which were dormant.

Once the exact area of impact within the site is determined, then parts of the site may require further survey to allow for identification of vegetation to be removed and the improvement of mitigation measures. This would be undertaken in consultation with State Government authorities.

With over 220 species of introduced plants recorded in the region, the proper management of both winter and summer growing weeds is required or it could become a major adverse impact. Mitigation measures will include control of infestations in construction zones and management of the inadvertent transport of weeds from construction zones as part of the earthworks.

Species such as bridal creeper, St John's wort, silverleaf nightshade, African boxthorn, Bathurst burr, Noogoora burr, three-cornered jack and caltrop are examples of Proclaimed and environmental weed species that must be controlled during all stages of the project. Species such as Coolatai grass (one roadside infestation) and Calomba daisy (isolated infestations throughout much of the site) are present and must not be spread from the construction zones into adjacent areas.

Areas of planted native vegetation may be impacted by the proposal's later stages. These have not been assessed in detail. A few areas may require assessment under Council's vegetation policy and survey and assessment requirements. If required, following assessment, suitable compensation plantings will be established in consultation with local Council authorities. Inclusion of these in landscaped parks may be possible, and designs and layouts should avoid the fragmentation of these areas.

No areas of ***Phytophthora cinnamomi*** (die-back fungus, cinnamon fungus) or Mundulla Yellows were recorded. However, some of the trees appear to have aberrant growths and canopy die-back, possibly as a result of drought or agricultural impacts, including exposure to agricultural chemicals or salinity.

The removal of native vegetation, such as low chenopod and cotton-bush shrubland and the impact of incorporating fringe areas of river red gum woodland, and black box open woodland into future residential areas may require SEBs.

All information indicates that the risk of causing a major or significant impact to other areas of vegetation and flora within the site is relatively low, so long as the core areas of important vegetation are avoided and suitable management actions are taken in agreement with the State Government authorities.

7.1 Environment Protection and Biodiversity Conservation Act

None of the native vegetation communities or species listed under the EPBC Act as potentially present in the region occur on the site.

None of the communities or species listed in the draft Regional Recovery Plan (DEH 2008) was recorded on the site.

Bead glasswort was not recorded and it is considered very unlikely to be present, although a few areas of potential habitat suitable for the species are present.

7.2 National Parks and Wildlife Act

Smooth cutting-grass, which is listed as rare under Schedule 9 of the NPW Act occurs as a small population to the south of the site. Suitable habitat is present for five other species of State significance, although none was recorded during the surveys.

7.3 Development Act

Significant trees along the Gawler River floodplain proposed for removal (if any) will be formally assessed under both the ***Development Act*** and the ***Native Vegetation Act***. All other large trees proposed for removal which are not a significant tree will be assessed under the Native Vegetation Act.

7.4 Native Vegetation Act

This Act, as amended and including its Regulations, is applicable to all areas of native vegetation on the site. The NVC and its advisors in the DWLBC have prepared guidelines to assess in detail areas of native vegetation proposed for removal, plus suitable off-set measures to ensure that significant environmental benefit (SEB) requirements under the Act are met. These methods and measures will apply to this proposal.

Broadscale clearance of native vegetation is prohibited under any circumstances. Clearance of an intact stratum or substantially intact stratum of native vegetation is prohibited without SEB being available and of suitable quality.

If individual trees require clearing in future then a formal review, assessment and approval (including SEB) is likely to be required.

There are opportunities within the proposal for the creation of suitable SEB to offset the proposed removal of native vegetation. These are described in Section 6.2 and include the permanent preservation of important areas of native vegetation and the rehabilitation and management of other areas.

7.5 Other species of conservation significance

Fifty eight plant species recorded in the region and twenty one species on or immediately adjacent to the site have listed conservation significance for the Southern Lofty botanical region.

Most of the latter group of species will or could be directly impacted by the proposal, but the exact impact will be subject to the location of construction zones.

If disturbance of these species is required, then appropriate mitigation measures will be established to safeguard these populations, for example, through collection and propagation.

This will be the subject of detailed assessment prior to the approval and commencement of construction of future stages.

7.6 Stage 1

Stage 1 of the proposal will have little or no impact on areas of native vegetation; there is none present apart from scattered understorey native vegetation along the roadside of Legoe Road.

7.7 Future stages

Assessment and preparation of detailed mitigation measures will continue as part of the detailed design and assessment of each future stage. The most important areas of native vegetation are included in areas which will not be impacted by the proposal for up to 15 to 20 years.

The approval process of each stage will include agreement on impacts and SEB requirements with government authrorities.

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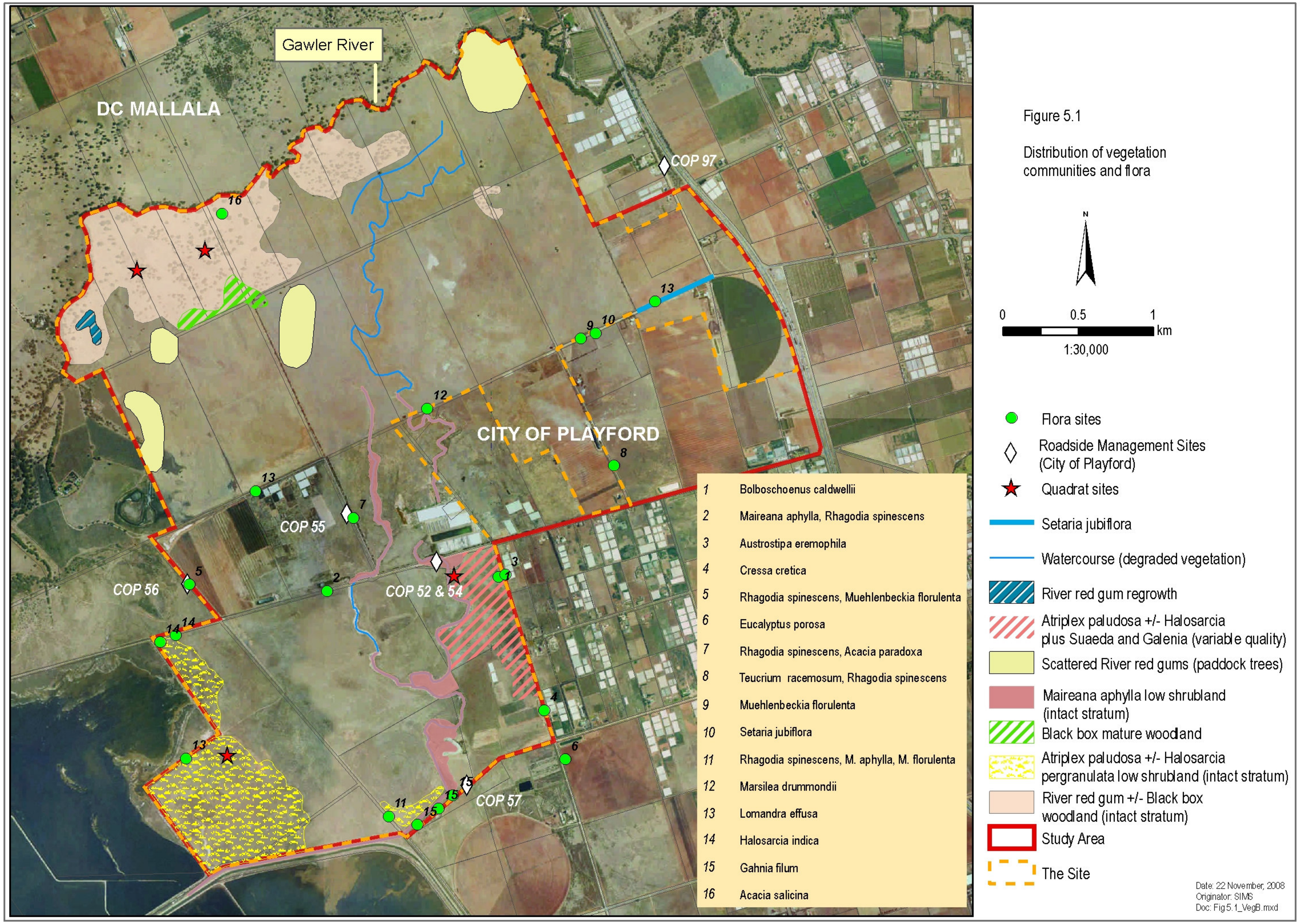
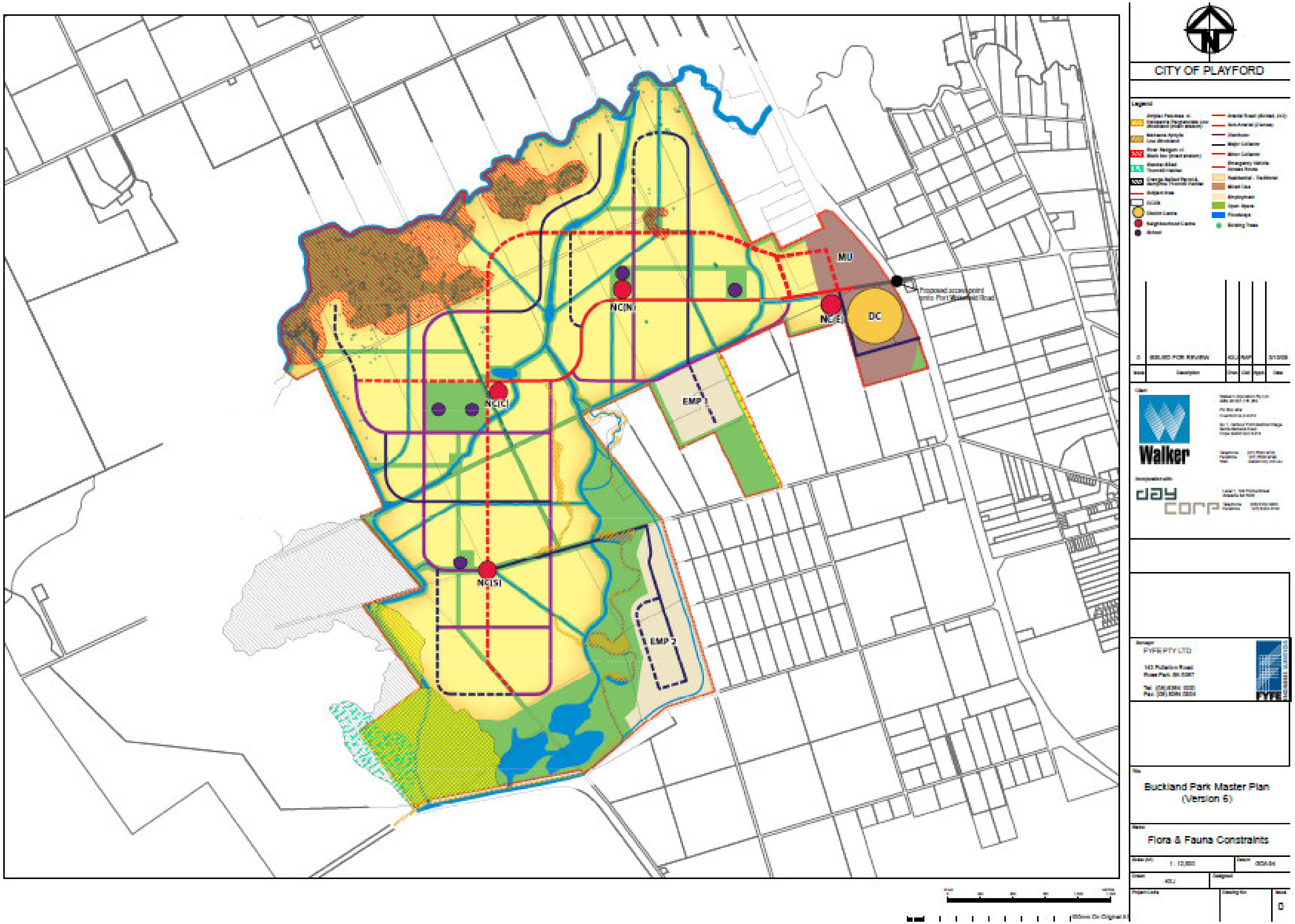
APPENDIX A REPORT FIGURES



Gawler River
DC MALLALA
CITY OF PLAYFORD
COP 97
COP 55
COP 56
COP 52 & 54
COP 57
1 Bolboschoenus caldwellii
2 Maireana aphylla, Rhagodia spinescens
3 Austrostipa eremophila
4 Cressa cretica
5 Rhagodia spinescens, Muehlenbeckia florulenta
6 Eucalyptus porosa
7 Rhagodia spinescens, Acacia paradoxa
8 Teucrium racemosum, Rhagodia spinescens
9 Muehlenbeckia florulenta
10 Setaria jubiflora
11 Rhagodia spinescens, M. aphylla, M. florulenta
12 Marsilea drummondii
13 Lomandra effusa
14 Halosarcia indica
15 Gahnia filum
16 Acacia salicina
Figure 5.1
Distribution of vegetation communities and flora
N
0 0.5 1 km
1:30,000
Flora sites
Roadside Management Sites (City of Playford)
Quadrat sites
Setaria jubiflora
Watercourse (degraded vegetation)
River red gum regrowth
Atriplex paludosa +/- Halosarcia plus Suaeda and Galenia (variable quality)
Scattered River red gums (paddock trees)
Maireana aphylla low shrubland (intact stratum)
Black box mature woodland
Atriplex paludosa +/- Halosarcia pergranulata low shrubland (intact stratum)
River red gum +/- Black box woodland (intact stratum)
Study Area
The Site
Date: 22 November, 2008
Originator: SIMS
Doc: Fig5.1_VegB.mxd


CITY OF PLAYFORD
MU
DC
NC(N)
NC(E)
NC(C)
NC(S)
EMP 1
EMP 2
Proposed access point onto Port Wakefield Road
Walker
day corp
FYFE PTY LTD
Buckland Park Master Plan (Version 6)
Flora & Fauna Constraints

APPENDIX B PHOTOGRAPHS

Vegetation and flora

Photo1: Mature river red gum woodland over spiny sedge and anthropogenic understorey

Photo 2: Mature River red gum and Black box woodland over anthropogenic understorey

Photo 3: Scattered River red gum as paddock trees with remnant Willow wattle tree over cereal stubble

Photo 4: Scattered paddock trees of River red gum in grazing paddock

Photo 5: Complex of Lignum shrubland, Leafless cottonbush low shrubland plus sedgeland and grassland along Thompson Creek

Photo 6: Leafless cottonbush low shrubland

Photo 7: Marsh saltbush and Black-seeded samphire low shrubland

Photo 8: Degraded samphire low shrubland dominated by introduced flora

Photo 9: Anthropogenic grassland with Artichoke thistle

Photo 10: Rosinweed-dominated salt scald along Thompson Creek

APPENDIX C

Table C.1 Abbreviations

CEMP	Construction Environmental Management Plan
DEH (SA)	Department for Environment and Heritage (SA)
DEWHA	Department of the Environment, Water, Heritage and the Arts (Cwlth)
DTEI	Department for Transport, Energy and Infrastructure (SA)
DGPS	Differential Global Positioning System
ha	hectare
EMP	Environmental Management Plan
EPBC Act	Environment Protection and Biodiversity Conservation Act 1999 (Cwlth)
KBR	Kellogg Brown & Root Pty Ltd
km	Kilometre(s)
LGA	Local Government Area
m	metre(s)
NExy	Northern Expressway
NRM Act	Natural Resources Management Act 2004 (SA)
NPW Act	National Parks and Wildlife Act 1972 (SA)
NVC	Native Vegetation Council
RMS / RSS	Significant roadside remnant native vegetation recognised by a marker system; RMS (roadside marker system) and RSS (roadside significant site)
SA	South Australia
SEB	significant environmental benefit
syn.	synonym
sp.	species (singular)
spp.	species (plural)
ssp.	subspecies
UFBP	Urban Forest Biodiversity Program
WONS	Weed of National Significance
WWTP	Wastewater Treatment Plant

Table C.2 Glossary

Aeolian	Relating to or caused by wind, such as a dune.
Adelaide Plains	A relatively flat area from the Northern Adelaide Plains to the Willunga basin in the south, covering about 560km² (see also Northern Adelaide Plains)
Agriculture	The science of producing healthy plants and animals for food and other uses.
Alkaline	Having a pH greater than 7.
Alluvium	Sediment deposited by flowing water, as in a riverbed, flood plain, or delta.
Anthropogenic	Caused by humans
Aquifer	A layer of permeable rock, sand, or gravel through which groundwater flows, containing enough water to supply wells and springs
Biodiversity	The variety of all life forms; different plants, animals and micro-organisms, the genes they contain, and the ecosystems they form part of.
Clearance application	As required under the Native Vegetation Act 1991. An application required for the clearance of native vegetation, which must contain details of the clearance, aerial photography and the location of ameliorative measures (i.e. areas set aside or other measures on which SEBs may be achieved). The NVC is the assessment body for all applications.
Depauperate	Lacking or depleted in the variety of species
Ephemeral wetlands	Wetlands that temporarily hold water
Gypseous	Containing large amounts of gypsum (calcium sulphate)
Habitat	The locality or environment where a plant, animal, population or community of interest lives. Each living organism has a preferred habitat with the physical surroundings having a direct bearing on the organism's function and survival.
Horticulture	Intensive cultivation of flowers, fruits, vegetables, or ornamental plants.
Indigenous	Originating and living or occurring naturally in an area or environment.
In-stream flora	Plant species growing in an aquatic environment.
Introduced species	An animal or plant that has been introduced to an area where it normally does not occur.
Invasive	A species is regarded as invasive if it has been introduced by human action to a location, area, or region

	where it did not previously occur naturally (i.e., is not native), and becomes capable of establishing a breeding population in the new location without further intervention by humans, spreading widely throughout the new location.
Kunkar	Rock formed by the evaporation of calcium carbonate mineralise water at the surface of the soil.
Net gain	Actions that contribute to improving the condition of the environment and biodiversity of the region. See also Significant Environmental Benefit (SEB).
Outwash plain	A broad, outspread flat or gently sloping alluvial deposit of soil or rock in front of or beyond the outflow of water.
Peachey Belt	An area in the Northern Adelaide Plains that is defined by a 2 km stretch of road, Peachey Road, and characteristic mallee woodland communities that were mostly cleared for primary production in the first 80 years of European settlement.
Pre-European	Before European settlement (1836 in South Australia).
Recent	Geological time period from the present day to 10,000 years BP.
Region	The general vicinity in which the project area is located.
Remnant	A small surviving component of an original extent; remnant vegetation includes all intact and predominantly intact indigenous vegetation communities.
Riparian	Relating to the banks of a watercourse or other water body.
Salina	A salt lake.
Samphire	Salt-tolerant vegetation
Significant Environmental Benefit (SEB)	As required under the Native Vegetation Act 1991. To be demonstrated by the Proponent (commonly through restoration projects or the contribution of funds) in order for the NVC to allow clearance of native vegetation. See also net gain.
Significant Tree (under the Development Act 1993)	'Significant' trees include all exotic and native trees with a trunk circumference of 2 m or greater, or in the case of trees with multiple trunks, those with trunks with a total circumference of 2 m or more and an average circumference of 625 mm or more. Measurements are taken at 1 m above natural ground level.
Stratum	A layer, such as of vegetation or soil.
Site	1,308 ha as defined on Figure 2. Other locations outside the site, particularly along its boundaries, which may be impacted by the proposal are considered as part of the site. These include areas where indirect or consequential environmental effects may occur as a result of the proposal and include specific areas mentioned in the

	Guidelines for the EIS.
Subcrop	Rock layer present just beneath the soil surface which does not outcrop.
Terrestrial	Living or found on land, as opposed to in water bodies or the atmosphere.
Threatening process	A process that threatens, or may threaten, the survival, abundance or evolutionary development of a native species or ecological community.
Native	Animals or plants that originate in the region in which they are found i.e. not introduced and naturally occurring in an area.
NExy	A DTEI project which includes construction of a new roadlink between the Gawler and Port Wakefield Road, exiting at Port Wakefield Road near Taylors Road.
Northern Adelaide Plains	A relatively flat area covering approximately 750 km2 centred 30 km north of Adelaide's CBD, and forming part of the larger St Vincent (Sedimentary) Basin.
Overstorey	The roughly horizontal uppermost layer of mature vegetation (i.e. trees) that overtops all other layers of foliage in the understorey (e.g. mallee, river red gums).
Understorey	The small trees, shrubs, herbs and grasses which make up the lower layers of vegetation in a vegetation community.
Vegetation community (association)	The composition of the vegetation according to the plant species present and the relative amount and cover of each.

BUCKLAND PARK PROPOSAL

FAUNA TECHNICAL REPORT

Prepared for:

WALKER CORPORATION PTY LTD

Prepared by:

DR BOB ANDERSON

February 2009

CONTENTS

FIGURES

TABLES

APPENDICES

1. INTRODUCTION

The Buckland Park proposal is a joint venture of Walker Corporation and Daycorp. The site has an area of 1,308 ha.

The site is located on and west of Port Wakefield Road within the City of Playford, west of Virginia, and around 32 km north of the Adelaide CBD and 14 km from Elizabeth, see Figure 1.

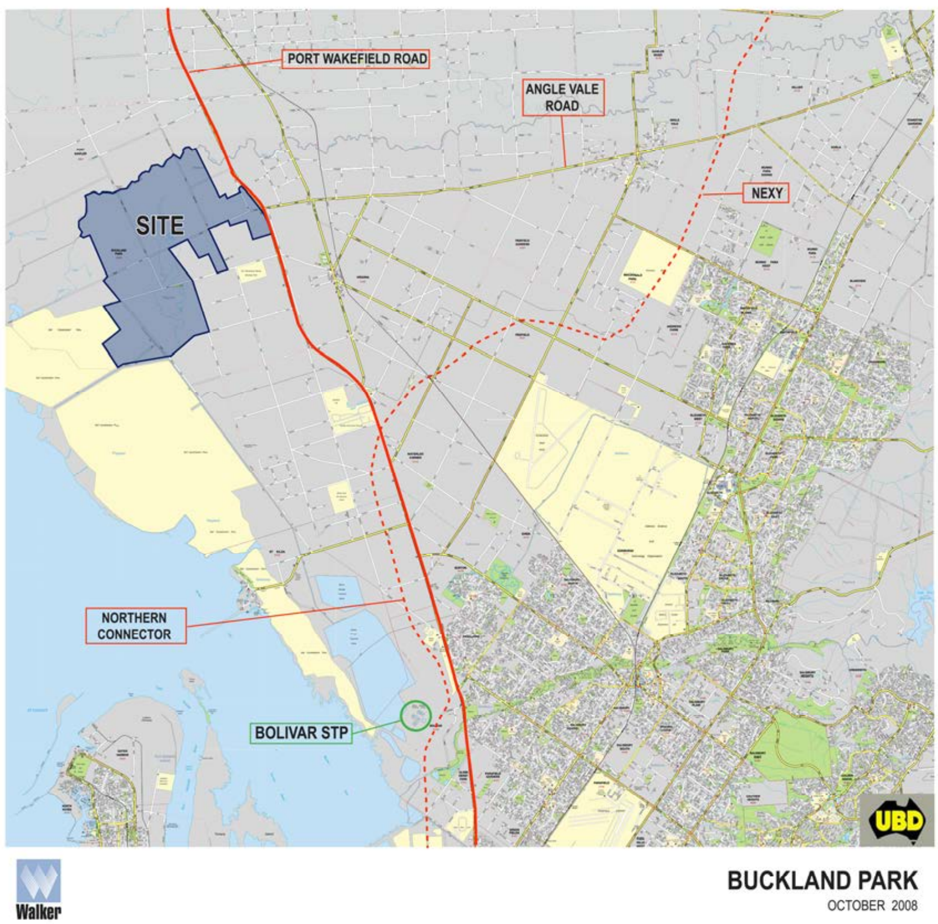
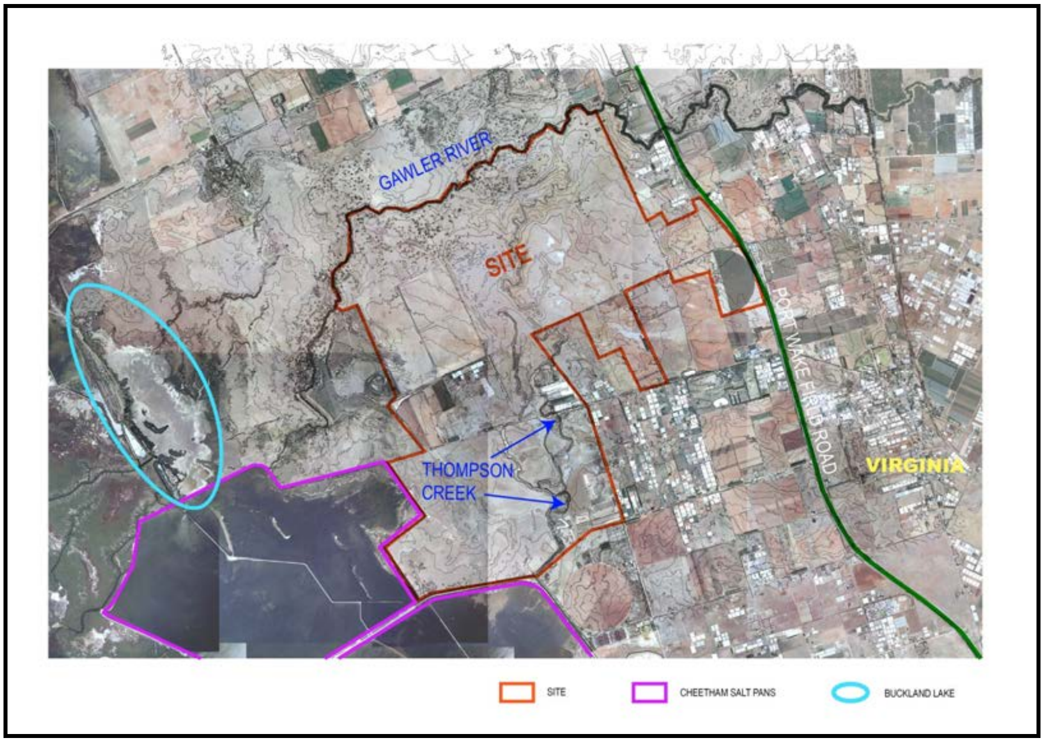


Figure 1: Buckland Park Locality Map

The site is bounded by Port Wakefield Road, the Gawler River, Cheetham Salt Limited saltpans and horticultural activities. The site is between 2.5 and 4 km from the Gulf St Vincent coastline. The site is relatively flat, arable land primarily used for horticulture, cereal cropping and low intensity grazing.

Remnant native vegetation occupies parts of the site's north west and south west portions, which can be seen on the aerial photograph in Figure 2.



Aerial photo supplied by Walker Corporation.

Figure 2: Site superimposed on aerial photograph

The Cheetham saltpans, adjoining the south west boundaries of the site, are man made structures.

It is anticipated the proposal will comprise 12,000 residential allotments, with an average size of 500m^2, supported with multiple purpose open space, and commercial, retail, community and employment uses. The Proposal is illustrated in the Masterplan at Figure 3.

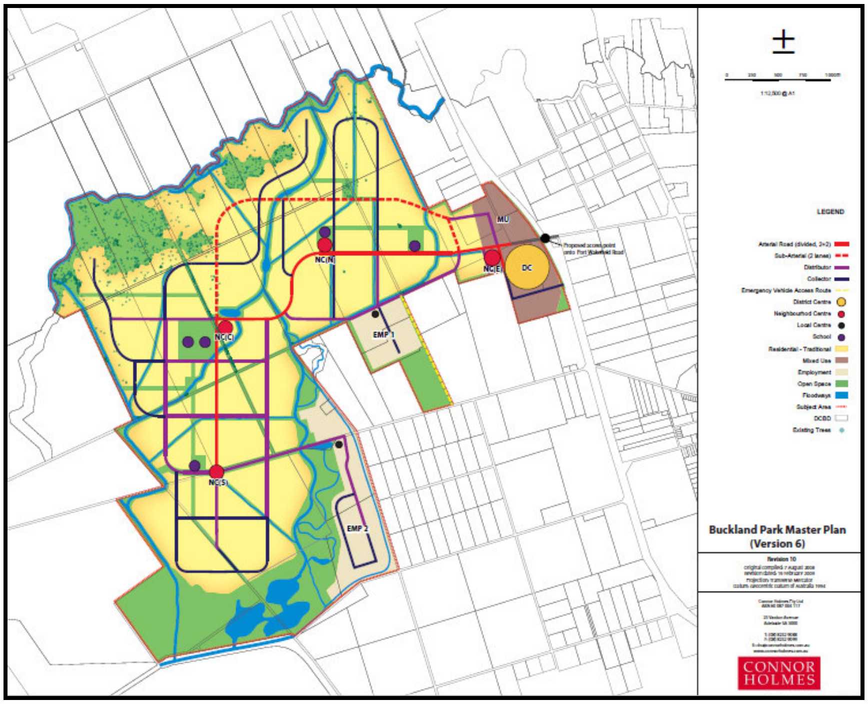


Figure 3: Master Plan of Buckland Park

The proposal will be implemented in stages over a period of 25 years. The first stage is planned for 2010 to 2016, as illustrated in the staging plan below in Figure 4.

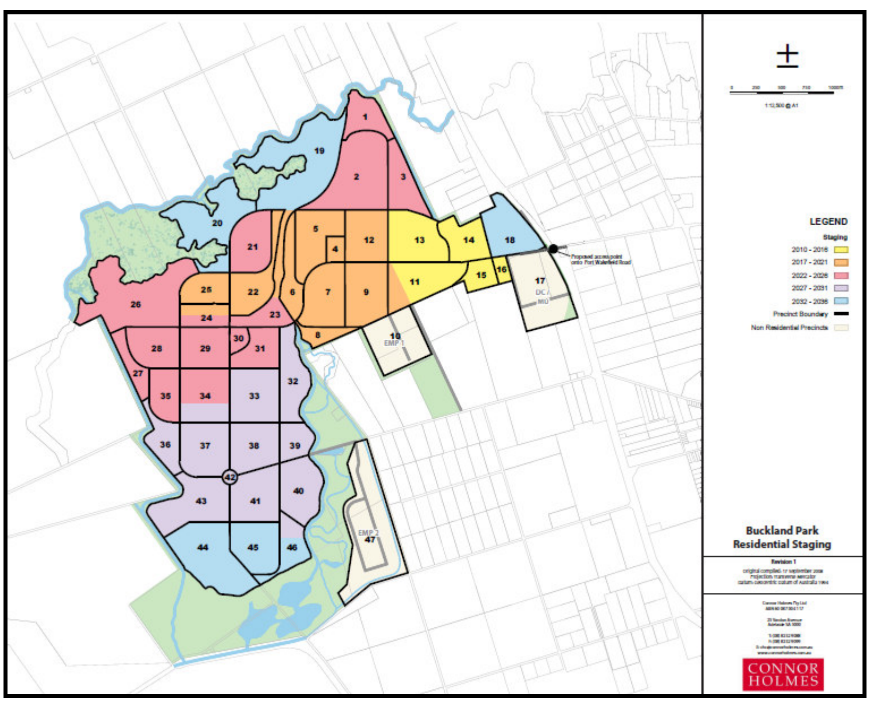


Figure 4: Proposal Staging

Walker Corporation commissioned Dr Bob Anderson to prepare an assessment of the potential impacts on fauna associated with the proposal for inclusion in the Environmental Impact Statement (EIS) for the Buckland Park proposal.

Accordingly, this Technical Report reviews the habitat for all terrestrial faunal groups and species of the region, which includes the site. Summary data are provided about aquatic fauna of the Gawler River, which forms the site's northern boundary.

The Report includes review and description of the:

- The regional environment.
- The site.
- Native fauna habitat and species.
- The occurrence of introduced fauna, including pest species.
- Likely and potential impacts of the proposal.

1.1 Report Structure

The structure of this report is as follows:

- Section 1 is the introduction to the report.
- Section 2 discusses the legislation and policy pertinent to the topic and proposal.
- Section 3 explains the materials and methods applied during the assessment.
- Section 4 details background information relevant to vegetation and other habitats of the region and site.
- Section 5 provides the results and data from all sources, including the field assessments for the region, and site.
- Section 6 discusses the impacts of the proposal.
- Section 7 is the conclusion of the assessment.
- Section 8 documents the references cited in text.
- Appendix A includes species lists for the wider region, region and site.
- Appendix B contains the site survey plan.
- Appendix C provides photographs of habitats in the site.
- Appendix D contains a list of abbreviations and a glossary.

2. LEGISLATION AND POLICY

The legislation and policy applicable to biological aspects (fauna) of the proposal is discussed in this section.

2.1 National

The ***Environment Protection and Biodiversity Conservation Act 1999*** (EPBC Act, Commonwealth) provides for the protection and conservation of matters of national environmental significance, and for the management of Commonwealth owned and controlled areas.

The matters of national environmental significance, as they relate to fauna and the proposal, are:

- listed threatened species and their habitat and communities.
- listed migratory species and their habitat.
- marine species and the general environment.
- threatening processes with an impact on fauna, including threat abatement plans.
- recovery plans, action plans and similar documents applicable to species or groups.

The EPBC Act provides for the implementation and administration of international agreements to which Australia is a signatory, namely:

- CITES—Convention on International Trade in Endangered Species of Wild Fauna and Flora (1973)
- JAMBA—Agreement between the Government of Japan and the Government of Australia for the Protection of Migratory Birds and Birds in Danger of Extinction and their Environment (1974)
- CAMBA—Agreement between the Government of Australia and the Government of the Peoples Republic of China for the Protection of Migratory Birds and their Environment (1986)
- Bonn Convention—Convention on the Conservation of Migratory Species of Wild Animals, for which Australia is a range state under the Convention (1979)
- Earth Summit—Convention on Biological Diversity (Rio de Janeiro, 1992).

A referral under the EPBC Act must be submitted to the Commonwealth Minister of Environment for any proposal which may have an adverse impact upon matters of National Environmental Significance.

The Minister will assess the referral and determine if it is a controlled action and a formal assessment process (principally public environment report or environmental impact statement) is required.

The subsequent amendments to the EPBC Act also apply, including the Environment and Heritage Legislation Amendment Act (No 1) 2003 and the amendments of 2006. The former amendment establishes a Commonwealth heritage regime that focuses on matters of National significance and Commonwealth responsibility; and lists places of National heritage significance. The latter amendments aim to reduce complexity and duplication, plus improve the assessment and approval process.

A bilateral assessment process has been recently established between the Commonwealth and the State Government for assessments by EIS.

2.2 State

The ***National Parks and Wildlife Act 1972*** (NPW Act) provides for the conservation of wildlife in a natural environment at a State level. Schedules 7, 8 and 9 (as revised in 2008) list species classified as endangered, vulnerable and rare respectively. Application to the State Government (Environment Minister) for activities that are likely to interfere with listed species and their habitat is required under the Act.

The ***Native Vegetation Act 1991*** as amended and its Regulations were established to protect and control the clearance of South Australia's native vegetation. One of the provisions of this Act is that native vegetation clearance may not be approved if the vegetation provides habitat for threatened native fauna. This Act applies to the proposal.

The ***Natural Resources Management Act 2004*** (NRM Act) repeals the Animal and Plant Control (Agricultural Protection and Other Purposes) Act 1986 and the Soil Conservation and Land Care Act 1997 and incorporates the functional requirements of these latter Acts under the NRM Act. The NRM Act establishes provisions for the management of the State's natural resources, including pest plants and animals and the land and water resources.

The ***Development Act 1993*** is applicable to the proposal primarily through its protection of vegetation, although it does not have specific fauna protection provisions.

South Australia's Strategic Plan 2007 (Government of South Australia 2007) contains both a vision and objectives for the State. Objective 3: Attaining Sustainability includes four targets for biodiversity.

The State Government policy, ***No Species Loss – A Biodiversity Strategy for South Australia 2006–2016*** is the key policy for protection of biodiversity in the State and is applicable to the proposal.

Tackling Climate Change: South Australia's Greenhouse Strategy 2007-2020 also relates to the sustainable management of natural resources and includes requirements to assess the potential risks associated with climate change influences on native and invasive species.

The ***South Australian Biosecurity Strategy 2008-2013*** (Draft for public consultation) is a risk management framework that provides a summary review of threats posed by pests in the State, plus potential implementation requirements. This Strategy is applicable to the proposal, as will be the final Strategy (when approved and published).

The policy and three strategies are relevant to the proposal.

2.2.1 Department for Transport, Energy and Infrastructure (DTEI)

DTEI has a range of environmental policy, planning and management documents which will probably apply to aspects of the proposal, particularly on those parts of the site adjacent to some of the current roads and declared easements, and traffic planning and control impacts associated with Port Wakefield Road (Highway 1).

From an environmental perspective, some of the most important documents by the Commissioner of Highways (Section 26 of the Highways Act 1926) include:

- ***Care, Control and Management of Roads Operational Instruction 20.1***
- ***Environmental Approval Procedures Operational Instruction 21.1***
- ***Environmental Code of Practice for Construction***.

3. Methods and Materials

A literature survey and accession of database records from State Government authorities (South Australian Museum and DEH Biological Survey databases, including NatureMaps) was undertaken and the resulting data compiled to provide a comprehensive model of the occurrence in the region of habitats and species in the past and currently (Table A.1 in Appendix A).

The Protected Matters search tool of the Department of the Environment, Water Heritage and the Arts (DEWHA, Cwlth) was used to provide the basis of a predictive assessment of matters of national environmental significance, especially species occurrence and habitats of species.

Field surveys were undertaken from October 2007 to September 2008. Specialist assessments were undertaken by the South Australian Museum (SAM, Terry Reardon) of the insectivorous (micro-chiropteran) bat populations and Rodney Attwood undertook much of the diurnal bird surveys. Survey dates are provided in each section relating to the methods used to assess each faunal group. Figure 5 records the location of assessment sites for different fauna groups in the region and site. See Appendix B also for a larger figure

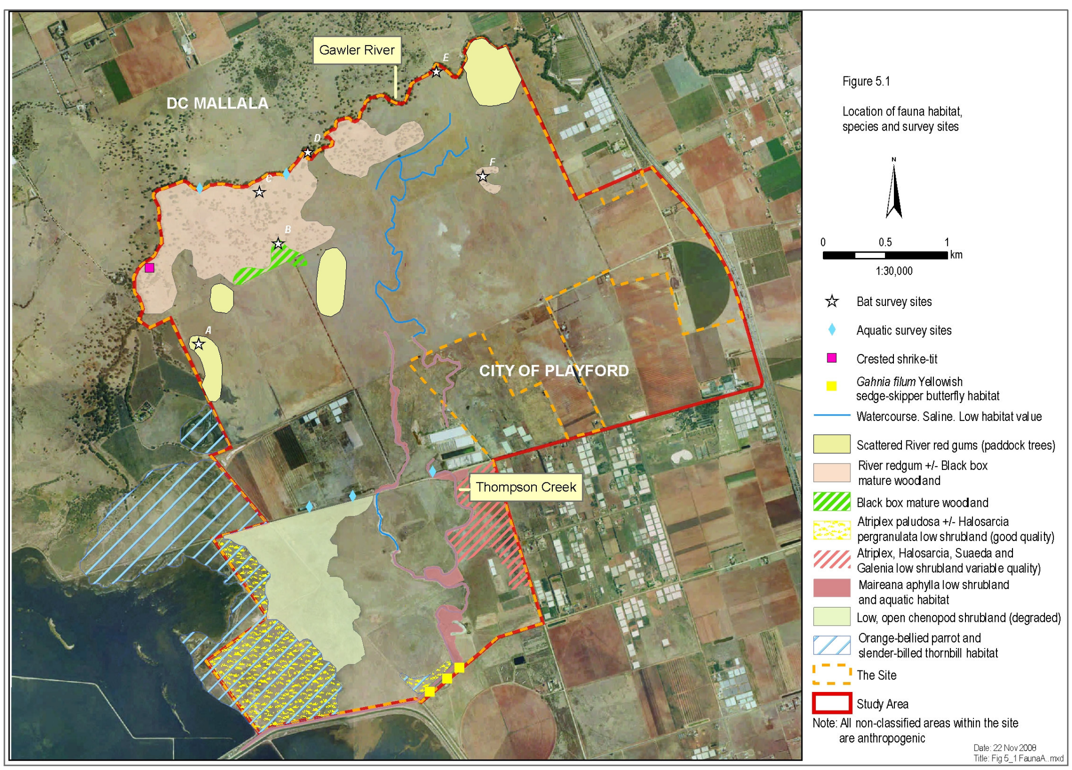


Figure 5: Location of Fauna Habitat, Species and Survey Sites

Discussions and consultation with local council officers included Mallala Council, City of Playford, City of Salisbury and City of Port Adelaide Enfield. Consultation with specialists, especially shore, aquatic and wading bird experts and others with specialist knowledge of the region was undertaken. Specific data provided by these groups and individuals are referred to in this Report.

Due to the lack of habitat for ground-dwelling species on much of the site, the relatively simple fauna assemblages present in parts of the region, the abundance of pest species and, especially, concerns about injury to livestock by the landholder, assessment by pitfall traps and box and cage traps was not undertaken. Only direct observation, including active searching, was used to detect ground fauna species.

Based on an appraisal of past data, four faunal groups were considered to warrant more detailed survey, as discussed in Sections 3.1 to 3.4.

3.1 Crepuscular and Nocturnal Fauna

Arboreal and terrestrial mammals and night birds were surveyed using spotlight surveys from last light (sun down) to first light (sun up). The most productive time for possums was the first two hours after sunset, while birds, such as owls and nightjars, and some reptiles were either seen or identified by their calls throughout the night.

Lightforce spotlights with 80w and 100w globes and a red filter (to enhance the eye shine of some species) were used. All surveys were undertaken on foot and repeated several times in each area over mid November 2007 to early March 2008. A total of 31 hours spotlighting was undertaken.

Each area of woodland along and south of the Gawler River, Thompson Creek and the chenopod shrublands in the southern and western section of the site (south of Park Road) were reviewed twice.

3.2 Insectivorous Bats

The survey was conducted by Terry Reardon of the South Australian Museum (SAM) over five nights, 25th to 28th January 2008 and on the 18th February 2008. Weather conditions were generally good for bat survey over all the nights, with day temperatures ranging from 30–38^{o}C with still to light wind conditions. The night of the 18th February was clear, warm and with a full moon which set at 4:00 am.

The land managers did not allow access to the site at night during the first period of the survey due to the presence of livestock in the assessment areas, therefore only echolocation call detectors were used during that phase of the work. Access was allowed for trapping on the night of 18th February, 2008.

Echolocation call detectors (ANABAT II) were deployed at a total of six localities (Figure 5) in the northern section of the site over five nights giving a total of 15 detector nights of recording. Detectors were set to record during the entire night.

Identification of calls was based on comparison with reference calls recorded in the Mount Lofty Ranges and Adelaide Plains and held by the SAM.

All calls were initially scanned on ANALOOK W and an inventory of all species present was compiled. An ANASCHEME key for all species in the inventory was generated and all calls were reanalysed using ANASCHEME.

Survey locations were chosen to maximise the chance of recording all bat species present. All locations were either near stands of mature river red gums or adjacent to two open top water tanks adjacent to the Gawler River where bats were predicted to frequent for drinking. No recordings were conducted in open grazing paddocks or shrublands. Past experience has shown that these areas do not provide representative data.

On 18th February 2008, mist nets were used for two hours over one of the open water tank and at a small remnant pool in the river bed near the tank. Two harp traps were set at last light in river red gun woodland and checked at 10:30 pm and then the following morning at 6:30 am.

The SAM's collection database and the Department for Environment and Heritage's (DEH) fauna database provided records of bats at Buckland Park and the surrounding region. These records, combined with those from bat surveys conducted for the Northern Expressway (NExy) proposal (SAM 2007 in DTEI 2007), at the Little Para River (SAM 2007a) and from a year-long bat study of the Adelaide parklands (Scanlon 2006), were used to help interpret the results of the survey.

The SAM Scientific Permit and animal ethics and animal welfare approvals from DEH applied to the assessment for bats.

3.3 Birds

Avifauna is a particularly important faunal group in this region of South Australia. Due to their mobility and the seasonal occurrence of some species, the wider coastal region must be part of the assessment area for this group. Therefore, bird surveys previously undertaken by others of all known and predicted biologically significant sections of the region and wider region were obtained and considered.

These included the Gawler River, Buckland Park Lake, Port Gawler Conservation Park, Cheetham salt fields, South Australian Water Corporation (SA Water) lagoons at Bolivar, and constructed water treatment wetlands. These data provided a comprehensive regional baseline against which data from the site assessment was compared.

Records for Cheetham saltfields and environs are available for over 60 years, with detailed population data for some species available since 1985 (Close and McCrie 1976, Day 1997, Penrice Soda Products Pty Ltd (Penrice) 1998, D. Close, J. Cox and R. Attwood, pers. comm. 2005 to 2008). These data were used to establish a baseline for bird surveys and data.

Species lists and notes about many species are also available for the Greenfields and Barker Inlet wetlands since their construction in the 1990s (Cox 1993, 2008).

Additional data for the Barker Inlet wetlands, including historical information, are summarised in KBR (2004), which includes a review of field observations made over November 2003 to February 2004 at this and other nearby sites. Species lists for the Barker Inlet region and wetlands and observations of fauna in both areas were provided by the wetlands ranger for these areas.

Paton et al. (1991) provides a summary of avifauna associated with Buckland Park Lake and historical survey data for this site are available from Day (1997), the Birds Australia library and Birdpedia.

Data for the Port Gawler Conservation Park are summarised in ANCA (1996) with additional data from Birds Australia and Birdpedia.

The survey was primarily undertaken over 28th October and 14th November 2007, with repeat surveys of areas of the site undertaken each 7 to 8 days over 14 November to 26th December 2007 and 25th January to 3rd May 2008. Additional day surveys were undertaken in July and September as part of the national survey for orange-bellied parrot in South Australia. A total of 38 days, or part days, were spent on the avifauna survey. Night birds were detected by taped call playback, listening for calls, spotlighting and direct observation (Section 3.1).

Surveys on the site and immediately adjacent areas were generally undertaken using the '2 ha 20 minutes, or longer' procedure of Birds Australia (Barrett et al. 2003). Assessments were generally carried out for one to two hours at dawn and dusk. In order to provide comprehensive diurnal variation records, surveys were also undertaken during the day and evening, primarily between one hour after sunset and 1:00 am for the latter.

Opportunistic sightings were recorded of species throughout the site and region, including road killed animals.

Bird numbers and species moving to and from assessed locations were also recorded, especially for the northern and southern areas of the site, along its boundaries and along the Gawler River and Thompson Creek.

While records were kept of all bird species as per the Birds Australia procedure, particular attention was focussed on the presence or absence of specialised wetland species that are cryptic, such as rails, crakes and bitterns; transequatorial migratory shorebirds; and nationally threatened species, such as slender-billed thornbill and orange-bellied parrot.

3.4 Amphibians

The South Australian EPA Frogwatch protocol (SA EPA 2002) was modified and used to record the diversity and relative number of amphibian species at sites along Gawler River, Thompson Creek adjacent to a wetland on Beagle Hole Road and at two dams on Park Road. 'Voice' activated tape recorders were set at last light and retrieved at first light at two locations on the Gawler River. Tapes were then played and an analysis of all advertisement calls undertaken.

This method was supplemented by listening for calling frogs for 1 to 2 hours during the early morning, late afternoon, and last light. The species and number of individuals that were calling were noted.

Finally, taped calls of brown toadlet were played and responses, if any, noted.

3.5 Other Groups and Species

Due to the lack of permanent water on site the only assessment of aquatic fauna was in remnant pools of the Gawler River in October and November 2007. Dip netting only was undertaken in the River. Assessment of macro-invertebrates was not undertaken.

Observation during field surveys provided opportunistic records of fauna. Active searching was undertaken and involved log, branch and leaf litter searches and turning over debris, such as pieces of dumped timber, bricks, tiles, cardboard and corrugated iron. All records of fauna occurrences from these methods were compiled as field notes. This resulted in specific site records for certain species, including road kill statistics of native and introduced species. No other specific survey methods were used.

3.6 Definitions, Limitations and Acknowledgments

This section summarises the definitions, including significance criteria, plus the limitations and acknowledgements applicable to the assessment and report.

3.6.1 Definitions

Site: 1,308 ha as defined on Figure 2. Other locations outside the site, particularly along its boundaries, which may be impacted by the proposal are considered as part of the site. These include areas where indirect or consequential environmental effects may occur as a result of the proposal and include specific areas mentioned in the Guidelines for the EIS.

Region: The general vicinity in which the site is located. For avifauna, especially species that are migratory or use very large foraging areas, this area is large. Where ever possible, the assessment has tried to distinguish between resident species and those that use the site occasionally.

Wider region: Areas more distant than the region, including areas in a similar coastal setting to that of the site. The wider region generally includes the eastern side of the area illustrated in the locality plan at Figure 1. Bird species in particular use the entire region.

Fauna names and associated nomenclature accord with Robinson et al. (2000) unless stated otherwise.

Significance criteria sources are as follow:

National A number of criteria are provided under the EPBC Act, including threatened communities and species, threatening processes and plans adopted to manage these matters.

State DEH and SAM databases, National Parks and Wildlife Act Schedules 7, 8 and 9 (2008).

Regional Carpenter and Reid (2000) for avifauna and the City of Salisbury and City of Port Adelaide Enfield databases on the distribution of native fauna.

Local All native fauna have some value in this region hence all occurrences have local status.

Appendix D contains a glossary and list of abbreviations.

3.6.2 Limitations

The scope of services applicable to this report was defined by the Client, by the budgetary constraints and by access to the site. In preparing this report, I have relied on the accuracy of information provided by the Client and other sources as acknowledged. Except as stated I have not verified the accuracy of these data. 2006/2007 and 2007/2008, were years with below average rainfall over winter to summer and typically hot summers. Temperatures during early autumn were significantly above average in 2008 and while rainfall was average to slightly below average over April to August, September and October 2008 rainfall was well below average.

These factors, combined with earthworks and heavy grazing pressure in some areas, and continual mowing of some roadside areas, has probably resulted in some populations and/or species not being recorded. The passage of time, the seasonal factors referred to above, latent conditions, impacts of future events or factors may require additional assessment, plus re-evaluation of findings and conclusions.

3.6.3 Acknowledgments

It is pleasure to acknowledge the co-operation of all landholders during the fieldwork, especially Geoff and Dianne Ayres, who provided access to much of the 1,000 ha of the site.

Permission to use data from the SA Museum and DEH is gratefully acknowledged also, with specific referral to these data being through citation in the text of this report.

4. Regional environment

For fauna, past conditions and environmental factors are equally as relevant as current conditions on influencing the distribution of habitats and species. In particular, the past distribution of habitats and species available from historical accounts are important in understanding the changes in native and introduced fauna populations. Therefore, this section discusses both past and present information relevant to the distribution of flora (habitat) and fauna.

4.1 Existing regional environment and land use

Horticulture and intensive agriculture and residential, retail and industrial activities characterise the past and existing land use in the site and region. The large area land users of the region and site include horticulture (vegetables and flowers, rose plant production, vines and trees, and hay), livestock grazing (sheep and cattle), horse studs, housing, town centres and stormwater management facilities.

Less than 1% of the original native vegetation remains in the inland sections of the region. Coastal areas contain a better representation, with about 14 to 15% conserved (DTEI 2007).

Revegetation schemes and many smaller areas of revegetation have been established in the region by the State Government, local councils and other authorities and individuals. The SA Urban Forests One Million Trees Program, Mangroves to Mallee Program and SA Water are key participants in the region.

The current vegetation mostly consists of anthropogenic (introduced plant species, especially weeds and crops, in a disturbed environment). Shrubstorey and ground storey 'communities', with occasional indigenous plants as individuals or small patches occurring along roadsides and more rarely, as larger areas on private land and along roadsides.

Areas around the Gawler River contain remnant, tall eucalypt-dominated woodland and forest. The plains and dunes north of the Gawler River have areas of remnant mallee scrubland-woodland and native pine woodland (Beecroft et al. 1981). Little remnant overstorey vegetation occurs in the southern and central sections of the site. Where these occur, they are limited to individual, isolated trees to small copses. Thompson Creek includes various types of remnant vegetation and the western section of the site includes various remnant shrublands.

A detailed appraisal and review of the regional fauna recently completed as part of the Northern Expressway environmental assessment, DTEI (2007) and KBR (2007) forms the basis of much of this section.

4.2 Pre-European settlement faunal habitats and fauna

Prior to and just after 1836, the Adelaide Plains region supported a diverse range of fauna from all faunal groups. Detailed information of these records is available through the South Australian Museum database, Wood Jones (1923) and Waite (1929) with excerpts of historical accounts, of the colony of South Australia and more recent information summarised in Twidale et al. (1976), Turner (2001) and Daniels and Tait (2005).

The habitats originally present in the site were diverse, ranging from tall woodlands and forests to mallee woodlands and scrublands to open shrublands and grassland plains. Aquatic and riparian areas, especially the freshwater swamps, with a complex of woodland, shrublands and tall grasslands and sedgelands maintained a diverse and abundant assemblage of animal species. Based on historical accounts the region was probably one of the most biodiverse sites for fauna in South Australia (Turner 2001).

However, within 20 years of white settlement, many terrestrial species were extinct or approaching extinction due to habitat destruction, predation by introduced species and competition with introduced species. This trend continued through settlement, especially for small and medium sized mammals, a wide range of which have been regionally extinct for 50 to over 100 years (Daniels and Tait 2005, DTEI 2007). Insectivorous (micro-chiropteran) bats are one of the few groups to have survived relatively intact and a few other native species have been able to adapt to anthropogenic conditions.

Some bird and amphibian species had similar fates to their mammalian counterparts, although bird and reptile species assemblages have remained reasonably intact, with an occasional 'total extinction' only. However, while the total bird species diversity in the wider region has remained similar to that in 1836, there have been significant changes in the composition of the bird fauna, including species richness, with the local extinction of many woodland bird species (Tait et al. 2005).

The aquatic fauna was similarly decimated, with most of the fauna assemblages and species being severely impacted and many replaced by non-native species, including the fish species and aquatic mammals.

4.3 Background and regional fauna information

The search of the Biological Databases of South Australia (Department for Environment and Heritage) and the South Australian Museum fauna databases resulted in a total of 1,729 records of vertebrate fauna species previously recorded in the vicinity of the site (Appendix A). Additional records were sourced from published observations for the region, including SA RAOU records (SA Ornithologist), Birdpedia, unpublished records, and discussions with individuals who have particular knowledge of the region.

Based on all records and databases, a total of 302 species from all vertebrate faunal groups were identified as having occurred, are currently present or may be present in the site and adjacent region. 77% were bird species of which most are present in the coastal plain and Buckland Park Lake.

The total included 231 bird species of which 220 species are native, 25 mammal species of which 17 are native, 40 reptile species and six amphibian species all of which are native species.

The areas likely to contain the highest diversity of fauna species from all groups are the ***Eucalyptus camaldulensis*** (river red gum) woodlands along the Gawler River and the coastal wetlands and low shrublands.

The woodlands contain large, mature river red gums, as individual trees and as a relatively intact community associated with freshwater. Many trees contain multiple hollows and all trees have canopy characteristics suitable for use by fauna. These woodlands provide suitable habitat for roosting, resting and breeding by common and threatened fauna species. In addition, the riparian woodlands provide a biodiversity corridor for some migratory species.

The coastal wetlands and associated shrublands, including Buckland Park Lake, are known to host a wide array of faunal groups and species. The natural, seasonal freshwater wetlands which originally occurred in the region, primarily as flood-out areas and flood plains, have mostly been destroyed, and ‘man-made’ wetlands have replaced them.

Buckland Park Lake is now the most important freshwater habitat refuge for avifauna in the region and eastern Gulf St Vincent. It also hosts a range of fauna species other than birds (Paton et al. 1991). It is the only large, ‘natural’ freshwater wetland remaining on the Adelaide Plains.

Other wetlands in the wider region constructed recently include stormwater treatment wetlands, particularly those associated with water management initiatives by the City of Salisbury. These include a larger area of fresh and saline wetlands in the Greenfields and Barker Inlet wetlands and smaller, coastal wetlands between Dry Creek and the Little Para River.

The only relatively recent published survey on the biological environment of Buckland Park Lake, west of the western boundary of the site is Paton et al. (1991). This latter account is based on detailed observations at and around the Lake recorded over 1989 and 1990. They recorded over 60 bird species in the lake and its associated samphire and lignum shrublands. Nine aquatic species were breeding of which blue-billed duck was a significant record. A number of migratory wading birds of international conservation significance, plus crake and rail species were present. Sixty three (63) terrestrial bird species were also recorded for the Lake and incidental records were provided for fish and other faunal groups. Detailed records of aquatic macro-invertebrates were provided also.

A key conclusion of their study was that the Lake is "…..clearly the most important breeding habitat for a range of waterfowl within the Adelaide region….." In addition, Paton et al. (1991) provides a historical baseline for comparison of species observations and data from the current site, especially for terrestrial species.

Additional avifauna observations of the Lake are available from Day (1997), as part of a more general account of Cheetham's salfields, historical records of Birds Australia journals, primarily the South Australian Ornithologist, local bird watchers as personal observations and more recently through records in Birdpedia.

DEH and DWLBC (2003) lists the Port Gawler and Buckland Park Lake area and the Cheetham salt field and pans as being wetlands of State significance, with both of the former sites being listed in the Register of the National Estate as heritage places of particular natural significance i.e. the EPBC Act applies.

The wetlands in the region have mostly been constructed to assist in flood management and water treatment, are part of waste water treatment areas or are part of the Cheetham salt fields. Most are present at areas which historically contained wetlands, especially floodplain communities, samphire shrublands and other saline wetlands. The Greenfields wetland complex, Barker Inlet wetlands and various detention basins adjacent to Port Wakefield Road and the Little Para River provide suitable habitat for a number of bird and aquatic species. Smith Creek, Dry Creek and some of the larger drains, such as Whites Road drain, contain smaller areas of habitat suited to some bird, frog, reptile and aquatic species. The water treatment lagoons, native vegetation and revegetation on SA Water land at Bolivar provide habitat for a relatively high diversity of species.

A number of bird species, such as birds of prey, also use the region for feeding, roosting and breeding. These species use all habitats.

The past literature assessments for the region are summarised in KBR (2005) Anderson (2007) and DTEI (2007) which provides information on the likely presence and abundance of most fauna species within the region.

The areas likely to contain the highest diversity of woodland species are the river red gum woodlands along the Gawler River.

Small patches of mallee box woodland, mallee scrubland and native pine forest and woodland also occur within the region but not on the site.

A large proportion of the remaining region and the site is extensively cleared of native vegetation, and is of low quality as habitat for native fauna. Despite this, remaining areas would still provide habitat for a range of common species. The relatively intact coastal habitats present along Gulf St Vincent are likely to contain the best habitat for a wide range of faunal groups.

Revegetation areas were confined to roadsides or as small areas along fence lines on private land and the majority were degraded. Nonetheless, they would offer some habitat value to a variety of fauna species. It is likely that the majority of the fauna species using these areas are common species.

4.4 Fauna habitat

Anderson (2007) discussed the amount and condition of fauna habitat in the region. He concluded that most habitats have been reduced to very small and degraded areas, although the large areas of woodland and shrubland in parts of the region were reasonably intact with good quality fauna habitat. Relatively large areas of river red gum woodland and forest and areas of black box woodland were present along most of the Gawler River and its floodplain between Gawler and Port Gawler prior to European settlement (Kraehenbuehl 1996). Since European settlement much of the overstorey vegetation has been cleared, leaving only a 'riparian corridor' of woodland along the River, plus small areas of woodland both north and south of the lower reach of the Gawler River (west of Port Wakefield Road) and occasional remnant trees.

With the clearance of overstorey vegetation, the impacts of grazing by introduced stock, and the infestation of pest plants and animals, very little remains of the original understorey vegetation and the understorey ground cover (natural branch and leaf litter) required by some fauna species. What habitat remains is usually degraded.

The habitats available within the region and site were also documented in KBR (2005), Brown & Root (2004), KBR (2006a), DTEI (2007) and Anderson (2007) and include:

- ***Marine habitats and coastal woodland as mangrove woodlands.*** Not part of the site. These occur west of the site, but some of the resident and migratory fauna species in these areas move between the woodlands and other areas inland, including the site.

- ***Coastal chenopod shrublands and samphire native chenopod low shrubland.*** Primarily in the southern section of the site and west of the western boundary of the site. Habitat for some specialist bird species and a range of common reptiles

- ***Artificial wetlands, including water treatment and saline pans and associated wetlands, in-stream areas, drains, dams and water treatment wetlands***. These occupy the largest area and include the Cheetham saltfields, Barker Inlet wetlands and Greenfields wetlands (excluding the wastewater treatment lagoons at Bolivar). All are 'man-made' habitats and each provides important feeding and refuge habitat for aquatic birds and migratory shorebirds.

- ***Gawler River estuary and delta, Buckland Park Lake and Port Gawler Conservation Park.*** Buckland Park Lake is an 'artificial' lake formed by damming the estuary of the Gawler River by a causeway in the nineteenth century and more lately in the 1920s. Nonetheless, this has established the only substantial freshwater habitat of the Adelaide Plains and it remains as the largest and most important breeding habitat for aquatic birds within the region. Much of the Lake is owned by the State Government and the remainder is under private ownership.

- ***Natural wetlands, including saline areas and salt pans***. These are present on and near the site, but there is no record of past surveys apart from Thompson Creek (Delta 2003). These areas may be important, but the degree of importance will depend on seasonal conditions. Important remnants for birds and amphibians are present adjacent to the site and in the site after floods.

- ***Chenopd shrubland*** along the eastern fringe of the mangrove woodland and along low lying, saline areas throughout the region and site.

- ***Woodland***, primarily the indigenous mature river red gum woodlands associated with freshwater riparian areas, provide important habitat and include small stormwater detention basins that have importance for some aquatic birds and amphibians.

- ***Watercourses and drains***. While often weed infested and degraded, these areas provide some wetland habitat values for reptiles, amphibians and a few birds. The largest of these sites is Dry Creek, about 19 km south of the site, although there are smaller stormwater drains that occur under roads in and adjacent to the site.

- ***Fragmentary, high value habitats, such as sedgelands***. These are usually tiny remnants of native vegetation, such as the ***Gahnia*** (cutting-grass) sedgelands at Bolivar and St Kilda which are being restored. They have limited value as major faunal group habitat, but they may, in future, provide critical habitat for one or a few threatened invertebrate species, such as butterflies.

- ***Revegetation areas, primarily as woodlands and tall shrublands including landscaping and amenity plantings***. The sites include specific revegetation areas created by the State Government groups, Council and private land owners.

- ***Anthropogenic areas and structures***. These include areas of agriculture and horticulture, undeveloped land, areas of cropland that is not being cropped, some roadside areas and buildings and other structures.

5. Results

This section considers information about the habitat characteristics and species assemblages recorded on site during the field assessment and predicted to occur here.

5.1 Habitat Areas

Habitat for all faunal groups on the site or immediately adjacent areas are summarised in Table 1.

The value of each type of habitat varied within the region and site, depending on the quality and condition of the different habitats present. Horticultural and agricultural areas contain simple habitat areas. These provide little habitat for fauna and that habitat is of poor quality fauna habitat only. Some areas of native vegetation contain numerous weed species. Relatively few native fauna species would utilise the other areas, and these would usually be the common native and introduced bird species, and, potentially, birds of prey which may utilise these areas for feeding, resting and roosting.

The woodlands and forest along the Gawler River has the highest habitat value. In particular, the presence of mature trees with large numbers of hollows increases the value of this habitat type significantly.

Table 1 Habitat type and value observed within the site and region

Habitat Type	Habitat Value
River red gum woodland (Gawler River and floodplain)	High to very high
Chenopod shrublands	High to very high
Wetlands (Thompson Creek)	High
Remnant indigenous grasslands & sedgeland	Moderate to high
Isolated paddock trees	High
Cropping and grazing land and anthropogenic structures	Low
Planted vegetation	Low

The Gawler River riparian corridor, and the woodland in the north west portion of the site is one of the last remaining relatively intact areas of remnant woodland vegetation in this region and on the Adelaide Plains. Based on the literature survey and the field data it was identified as likely to contain the highest diversity of species in the site.

The community includes mature river red gums, many of which contain multiple hollows, identified as potential bat roost trees and habitat areas for local fauna and common bird species.

Isolated trees and small patches of large to mature river red gums are present throughout the surrounding area.

Scattered trees and isolated paddock trees are common throughout this region. These areas provide habitat for species such as magpie-lark, wood duck, black duck, blue-bonnet parrot and noisy miner. Species such as brown falcon and peregrine falcon also use the woodlands as a feeding area, roosting site and breeding site.

By observation, there is intense competition between native and introduced species for hollows for roosting and breeding. In particular, feral pigeons and common starlings were particularly common breeding residents in these woodlands and some other hollows were observed to be occupied by feral European honeybee colonies.

Grassland areas and the stubble of cereal crops still provide habitat for species such as Richard's pipit and stubble quail. These sites also provide occasional feeding locations for species such as sacred ibis, ravens and magpies.

5.2 Fauna Groups and Species

This section provides a review of the species previously recorded in or adjacent to the site and records from the current assessment.

5.2.1 Mammals

Paton et al. (1991), PPK Consultants (1992), Brown & Root (2001, 2004) and KBR (2006a) recorded a range of mammals as occurring in the region. Table 2 lists all mammal species recently recorded in the region and site.

Table 2 Mammal species in the region and site

		Occurrence and conservation status		
Common name	**Scientific name**	**CS**	**Region**	**Site**
short-beaked echidna	***Tachyglossus aculeatus***		+	+
water rat	***Hydromys chrysogaster***		+	+
white-striped mastiff bat	***Tadarida australis***		+	+
yellow-bellied sheath-tail bat	***Saccolaimus flaviventris***	Rare SA	+	

		Occurrence and conservation status		
Common name	**Scientific name**	**CS**	**Region**	**Site**
Gould's wattled bat	***Chalinolobus goudii***		+	+
chocolate wattled bat	***Chalinolobus morio***		+	+
lesser long-eared bat	***Nyctophilus geoffroyi***		+	+
large forest bat	***Vespadelus darlingtoni***		+	+
southern forest bat	***Vespadelus regulus***		+	+
southern freetail bat	***Mormopterus sp.***		+	+
common brushtail possum	***Trichosurus vulpecula***	Rare SA	+	+
common ringtail possum	***Pseudocheirus peregrinus***		+	+
euro	***Macropus robustus***		+	+
western grey kangaroo	***Macropus fuliginosus***		+	+
New Zealand fur seal	***Arctocephalus forsteri***		+	
*house mouse	***Mus domesticus***		+	+
*brown rat	***Rattus norvegicus***		+	
*black rat	***Rattus rattus***		+	+
*brown hare	***Lepus capensis***		+	+
*European rabbit	***Oryctolagus cuniculus***		+	+
*European red fox	***Vulpes vulpes***		+	+
*cat	***Felis catus***		+	+
*fallow deer	***Cervus dama***		+	+
*cattle	***Bos taurus***		+	+
*goat	***Capra hircus***		+	
*sheep	***Ovis aries***		+	+

* Introduced species. CS = conservation status.

Native mammal numbers observed on the site were low. Large native mammal species recorded in the field were western grey kangaroo (***Macropus fuliginosus***) and Euro (***Macropus robustus***), each as an occasional vagrant, including animals of both species in the coastal plain west of the site. Common ringtail possum

(***Pseudocheirus peregrinus***) and common brushtail possum (***Trichosurus vulpecula***) were recorded along the Gawler River and in the woodlands on the site.

Water rat (***Hydromys chrysogaster***) uses both saline and freshwater wetland areas in the region and is likely to be present in and along most wetland areas. It was observed in the site along the western reach of the Gawler River and in the southern section of Thompson Creek. Echidna (***Tachyglossus aculeatus***) was recorded along Beagle Hole Road and along the western fence line of the southern portion of the site.

There is minimal habitat available in the region for larger mammals, especially south of the Gawler River. Most of the woodland in the region has been removed for agricultural purposes with only isolated fragments left. Construction of roads has enhanced the effects of fragmentation by isolating habitat suitable for some mammal species. Outside of the Gawler River riparian corridor and adjacent areas of woodland and declared conservation areas, the remaining woodland areas occur as small fragments and the limited size of these vegetation communities renders them unable to support mammal populations.

Many of the mammal species identified are relatively common north of the site, where coastal habitat is less fragmented.

The SAM survey (2008) recorded seven common bat species in the northern sections of the site, primarily in and around the woodlands of the Gawler River (Table 2). The number of calls recorded during the survey was more than expected and large numbers of animals were trapped. All species are considered to be common in the region and the State (SAM 2008).

The seven bat species recorded at Buckland Park during this survey are consistent with the known distribution of each species. The same seven species were also recorded in 2006 on the Gawler River, 10km upstream from Buckland Park (SAM 2007) and from the Little Para River (SAM 2007 a). The species complement found during this survey is therefore consistent with expectations.

Three additional bat species were not recorded during the survey, but Buckland Park falls within or near their known distributions. ***Scotorepens balstoni*** is now rare in the Adelaide Plains and Mt Lofty Ranges. A sub-adult individual of this species was found in Adelaide in mid February 2008, the first for 78 years. This species may still occur at Buckland Park but if so, presumably in low density. ***Vespadelus vulturnus*** is the smallest species of the forest bats. It occurs in the Adelaide Hills (45 km from Buckland Park) but has not been recorded on the Adelaide Plains and its absence from this survey is not surprising. Equally, the detection of ***Saccolaimus flaviventris*** was not expected during this survey. It is a rare visitor to the southern part of the state. There are less than 30 records of the species from South Australia and all have been made between March and July.

None of the seven species recorded at Buckland Park during this survey is listed as threatened under legislation. All seven are insectivorous, and all use tree hollows as their natural daytime roosts.

The site provides high quality habitat for this faunal group and roosting habitat in river red gum hollows is a major resource.

The introduced species, European red fox (***Vulpes vulpes***) and cat (***Felis catus***), were recorded in and adjacent to the site. These species are predators of a range of native species and were relatively common. Fallow deer (***Cervus dama***), brown hare (***Lepus capensis***) and European rabbit (***Oryctolagus cuniculus***) and house mouse (***Mus domesticus***) were also present. There are very few rabbits present and burrows were only present in the southern section of the site. Red deer may has been recorded in the region, but was not observed.

Black rat (***Rattus rattus***) and brown rat (***Rattus norvegicus***) were not recorded alive on the site, but, based on past records for the region, are almost certainly present. Several dead back rats were observed along Thompson Creek. Both species compete with native species for food, shelter and other resources and some are predators of some native species, especially black rat, which is a known predator of bird's eggs and nestlings.

5.2.2 Birds

A total of 89 bird species were identified during the site survey. Based on database searches of recent bird observation records for the Australian Bird Atlas proposal (Barrett et al. 2003) and historical records for the region, it is likely that 120 to 130 bird species would be resident or use the region as part of their seasonal habitat.

Appendix A provides a detailed summary of the species recorded according to the regional bird species list compiled for the proposal in relation to area and habitat.

The remnant vegetation communities of the Gawler River represent an important habitat for local bird species, both as a habitat for resident species and as a migration corridor. There are numerous nesting and roosting sites within the river red gum community, which is the dominant overstorey species recorded at those locations. However, it was observed there is intense competition for this habitat and conservation significant bird species that are hollow-dependent are unlikely to occupy these habitat fragments. The shrubstorey and understorey areas in the riverine corridor are almost entirely disturbed and anthropogenic, with large areas of a number of proclaimed and environmental weed species dominant. This reduces the available habitat for birds.

Most of the common native species that were present had reasonable sized populations and well established feeding and nesting areas. Australian magpie, magpie-lark, willie wagtail, crimson rosella, Adelaide rosella, noisy miner and silvereye were the native species most commonly recorded on a daily and seasonal basis during the field work.

Feral pigeon, spotted turtle-dove and common starling were the most commonly recorded introduced species in the survey period.

The largest group of native species are raptors (birds of prey), of which 15 species are present in varying numbers in the site and the immediately adjacent region.

Some, such as wedge-tailed eagle, white-bellied sea-eagle and peregrine falcon are known to be represented by one pair, or rarely two pairs of breeding birds. The habitat of these species is present on the site.

Some are relatively common species in the region, but occur as non-breeding visitors. Examples of these include swamp harrier, brown goshawk, collared sparrowhawk and little eagle. Other species are occasional to rare seasonal migrants or visitors, such as black kite, black falcon, spotted harrier and letter-winged kite. These species may be resident north of the region, in northern parts of the State and they have been recorded around the region from Port Gawler to Dry Creek occasionally or under exceptional circumstances. Most usually they are seeking food sources. Still others are breeding residents, including black-shouldered kite, whistling kite, brown falcon and nankeen kestrel which were recorded on site during most field surveys.

The key attractant of these species is the potential food sources available in the region, especially by the large numbers of aquatic and shorebird species. Refer to Appendix B for the general location of threatened native terrestrial bird species within the site. In addition, many of the woodland and areas and scattered trees provide roosting and nesting habitat.

Birds associated with wetlands are confined to Gawler River, Thompson Creek, dams on the site and on adjacent properties, Cheetham saltfields and a small wetland complex west of Beagle Hole Road. Duck species such as Pacific black duck, grey teal and chestnut teal, two species each of grebe and heron, dusky moorhen, black swan, spotted crake and buff-banded rail typically occur here, although not all species are found in each of the locations mentioned above.

Shrubland species are associated with all the chenopod (samphire) shrubland areas adjacent to Thompson Creek and in the south west portion of the site. White-winged fairy-wren was abundant and species such as singing honeyeater, New Holland, honeyeater, elegant parrot and white-fronted chat were recorded in this habitat during the assessment.

Anthropogenic areas, roadside vegetation and planted trees contained common species which utlise a wide range of habitats. Example species present during the site assessment include Australian magpie, magpie-lark, Richard's pipit, willie wagtail and welcome swallow. These species are more-or-less ubiquitous across the site and region.

5.2.3 Reptiles

Based on the literature survey and records in State databases, up to 27 species were recorded or are likely to be present in the region and site. Sixteen species have been recorded in or adjacent to the site, with thirteen of these species recorded during field surveys in 2007/08 (Table 3). The largest of these is sand goanna (***Varanus gouldii***), which is still relatively common north of the Gawler River and along the coastline. Common long-necked tortoise (***Chelodina longicollis***) is present in and along the Gawler River and parts of Thompson Creek. It was recorded during the site survey in a water storage dam along Park Road.

Pastok et al. (1998) recorded eastern tiger snake (***Notechis scutatus***) well to the east of the site. There is anecdotal evidence of this species occurring in the site and at Buckland Park Lake in the past (G. Ayres, pers. comm., March 2008).

Common death adder has been recorded along the coastal fringe of Gulf St Vincent, including the Adelaide metropolitan area, in the past and a few individuals may be present in or adjacent to the south western portion of the site. The last recent record of the species was about 60 km north of Port Gawler in 2002 (Anderson 2003).

Much of the region is cleared of native vegetation and is of low quality as habitat for reptiles. Despite this, within the region there are relatively large areas of remnant native vegetation, plus introduced vegetation and the debris, and buildings and activities which provide suitable habitat for a number of species.

No reptiles of conservation significance listed under legislation are believed to occur in the region. Common death adder is listed as rare in South Australia. The pygmy bluetongue lizard (***Tiliqua adelaidensis***), which is listed as critically endangered under the EPBC Act, originally occurred in the region. The last record of the species in the Adelaide region was 1959. Suitable habitat for these species does not occur on the site.

Table 3: Reptile species recorded within or adjacent to the site

Common Name	Scientific Name
western blue tongue lizard	***Tiliqua occipitalis***
eastern blue tongue lizard	***Tiliqua scincoides***
stumpy tail lizard	***Tiliqua rugosus***
eastern brown snake	***Pseudonaja textilis***
marbled gecko	***Christinus marmoratus***
eastern bearded dragon	***Amphibolurus barbatus***
painted dragon	***Ctenophorus pictus***
five-lined earless dragon	***Tympanocryptis lineata***
barking gecko	***Underwoodisaurus milli***
southern spiny-tailed gecko	***Strophurus intermedius***
red-tailed worm-lizard	***Aprasia inaurita***
lined worm-lizard	***Aprasia striolata***
eastern spotted ctenotus	***Ctenotus orientalis***
three-toed earless skink	***Hemiergis decresiensis***

Common Name	Scientific Name
four-toed earless skink	***Hemiergis peronii***
sand goanna	***Varanus gouldii***
common long-necked tortoise	***Chelodina longicollis***

5.2.4 Amphibians

Amphibian species recorded within the region are brown froglet (***Crinia signifera***), eastern pobblebonk (bull frog) (***Limnodynastes dumerilii***, southern call race), spotted marsh frog (***Limnodynastes tasmaniensis***, southern call race) and brown tree frog (***Litoria ewingi***). Painted frog (***Neobatrachus pictus***) is expected to occur and has been recorded for Buckland Park Lake (Paton et al. 1991). Brown froglet and spotted marsh frog were common and present in most drains, watercourses, ephemeral wetlands and areas which held water, such as deep pools along the roadside. Brown froglet, brown tree frog and eastern pobblebonk were present in and adjacent to the Gawler River. Brown froglet was recorded in Thompson Creek on Park Road during the survey.

Brown toadlet (***Pseudophryne bibronii***), a species of State conservation significance, may still be present, but it was not recorded in autumn 2008 during the site field survey.

5.2.5 Other Vertebrate Groups

Fish records are limited for the region, although historical data records 6 native fish species from the Gawler River and Buckland Park Lake (ANCA 1996) Recent data records three native fish and two pest fish species in the Gawler River near Virginia (Waterwatch, pers comm. 2007) and four native species were recorded in Buckland Park Lake by Paton et al. (1991).

Species recorded in remnant pools in the Gawler River during the site survey were the introduced mosquito fish (common) and native common jollytail (few only). No fish were recorded in Thompson Creek, although little or no water was present along much of the watercourse during the survey period.

5.2.6 Invertebrates

There is no definitive list of invertebrates for the region. Many of the species recorded in Turner (2001) would be expected to occur here.

5.3 Species of Conservation Significance

The following section provides an overview of the fauna species of national and state conservation significance which may occur within the site and region or which were recorded during the field assessment.

The results of the search of the Commonwealth DEWHA database noted a total of 25 fauna species of national conservation significance (listed under the EPBC Act) which may occur in the region. A further 30 fauna species of state conservation significance have been previously recorded within the vicinity of the site in State databases.

Hassell (2002) lists eight fauna species for the site, these being species of threatened conservation significance. However, it notes that the species list is not comprehensive and is indicative only.

Of the complete species list for the region in Appendix A, which includes all historical records, relatively few specieswould occur on the site, and many are extinct in the region. Species listed as extinct in the region include bettong, mallee fowl, azure kingfisher, regent honeyeater, plains wanderer, spotted quail-thrush and regent parrot.

Those species of listed conservation significance recorded during the site assessment, recorded in the last 10 years, or predicted to be present are discussed below.

DEH (2008a) has a draft recovery plan, constituted under the EPBC Act, for threatened communities and species in the Adelaide and Mount Lofty Ranges region of the State. Fifteen bird species listed under the Draft Recovery Plan are present in the site and potential habitat for a number of other species is present. Several species recorded on site are considered to be occasional visitors only.

Table 4 lists the terrestrial bird species, Table 5 the marine and aquatic birds and Table 6 the shorebird species recorded in the region. Only species of conservation significance are listed in these tables.

Table 4: Threatened native terrestrial bird species of the region and site

Common name	Scientific name	Site	Saltfields	Buckland Park Lake
letter-winged kite	***Elanus scriptus***	-	+	-
whistling kite	***Haliastur sphenurus***	+	+	+
white-bellied sea-eagle	***Haliaeetus leucogaster***	+	+	+
little eagle	***Hieraaetus morphnoides***	+	+	+
Australian hobby	***Falco longipennis***	+	+	+

Common name	Scientific name	Site	Saltfields	Buckland Park Lake
black falcon	***Falco subniger***	+	+	+
peregrine falcon	***Falco peregrinus***	+	+	+
Australian bustard	***Ardeotis australis***	-	+	-
brown quail	***Coturnix australis***	-	-	+
brush bronzewing	***Phaps elegans***	-	+	+
rainbow bee-eater	***Merops ornatus***	+	+	+
orange-bellied parrot	***Neophema chrysogaster***	-	+	-
elegant parrot	***Neophema elegans***	+	+	+
blue-winged parrot	***Neophema chrysostoma***	+	+	+
rock parrot	***Neophema petrophila***	-	+	+
white-throated needletail	***Hirundapus caudacutus***	+	+	+
fork-tailed swift	***Apus pacificus***	+	+	+
dollarbird	***Eurystomus orientalis***	+	+	-
crested shrike-tit	***Falcunculus frontatus***	+	-	+
white-browed scrubwren	***Sericornis frontalis***	+	+	+
slender-billed thornbill	***Acanthiza iredalei rosinae***	+	+	+

Table 5: Threatened aquatic bird species of the region

Common Name	Scientific Name	Bolivar WWTP (Paton 2002	Saltfields & Buckland Park Lake (Paton et al. 1991,Goonan 1993, ANCA 1996)	Greenfields & Barker Inlet Wetlands (Cox 1993, Brown & Root 2004, DTEI 2007)
blue-billed duck	***Oxyura australis***	+	+	+
freckled duck	***Stictonetta naevosa***	+	+	+
great crested grebe	***Podiceps cristatus***	-	+	+
musk duck	***Biziura lobata***	+	+	+

Common Name	Scientific Name	Bolivar WWTP (Paton 2002	Saltfields & Buckland Park Lake (Paton et al. 1991,Goonan 1993, ANCA 1996)	Greenfields & Barker Inlet Wetlands (Cox 1993, Brown & Root 2004, DTEI 2007)
Cape Barren goose	***Cereopsis novaehollandie***	-	+	+
Australasian shoveler	***Anas rhynchotis***	+	+	+
Ballion's crake	***Porzana pusilla***	-	+	+
spotless crake	***Porzana tabuensis***	+	+	+
Lewins rail	***Rallus pectoralis***	-	+	+
buff-banded rail	***Gallirallus philippensis***	+	+	+
pied oystercatcher	***Haematopus longirostris***	-	+	-
sooty oystercatcher	***Haematopus fuliginosus***	-	+	-
little egret	***Egretta garzetta***	+	+	+
intermediate egret	***Ardea intermedia***	-	+	+
cattle egret	***Ardea ibis***	-	+	+
nankeen night-heron	***Nycticorax caledonicus***	+	+	+
Australasian bittern	***Botaurus poiciloptilus***	+	+	+
glossy ibis	***Plegadis falcinellus***	+	+	+
white-bellied sea-eagle	***Haliaeetus leucogaster***	+	+	+
royal spoonbill	***Platalea regia***	+	+	+

Of the species listed in Table 5, Cape Barren goose (visitor), buff-banded rail (resident), all three egret species (visitors) and white-bellied sea-eagle (occasional visitor) were recorded in the site. Nankeen night-heron was present along the Gawler River during the survey.

Table 6: Threatened migratory shorebirds and other shorebirds of the region

Common Name	Scientific Name	Saltfields	Buckland Park Lake & Port Gawler CP
Migratory Shorebirds And Other Shorebirds			
Lathams snipe	***Gallinago hardwickii***	+	+
double-banded plover	***Charadrius bicinctus***	+	-
Pacific gull	***Larus pacificus***	+	+
gull-billed tern	***Sterna nilotica***	+	-
common tern	***Sterna hirundo***	+	-
little tern	***Sterna albifrons***	+	+
fairy tern	***Sterna nereis***	+	+
white-winged black tern	***Chlidonias leucopterus***	+	+
Wildlife Conservation Plan For Migratory Shorebirds (EPBC Act), Listed Species			
black-tailed godwit	***Limosa limosa***	+	+
bar-tailed godwit	***Limosa lapponica***	+	-
little curlew	***Numenius minutus***	+	-
whimbrel	***Numenius phaeopus***	+	+
eastern curlew	***Numenius madagascariensis***	+	+
common redshank	***Tringa nebularia***	+	-
common greenshank	***Tringa nebularia***	+	+
wood sandpiper	***Tringa glareola***	+	+
terek sandpiper	***Xenus cinereus***	+	+
common sandpiper	***Actitis hypoleucos***	+	+
grey-tailed tattler	***Tringa brevipes***	+	-
ruddy turnstone	***Arenaria interpres***	+	+
great knot	***Calidris tenuirostris***	+	+
sanderling	***Calidris alba***	+	-
red necked-stint	***Calidris ruficollis***	+	+

Common Name	Scientific Name	Saltfields	Buckland Park Lake & Port Gawler CP
long-toed stint	***Calidris subminuta***	+	+
pectoral sandpiper	***Calidris melanotos***	+	+
sharp-tailed sandpiper	***Calidris acuminata***	+	+
curlew sandpiper	***Calidris ferruginea***	+	-
broad-billed sandpiper	***Limicola falcinellus***	+	+
ruff	***Philomachus pugnax***	+	+
Pacific golden plover	***Pluvialis fulva***	+	+
grey plover	***Pluvialis squatarola***	+	+
greater sand plover	***Charadrius ruficapillus***	+	-
greater sand plover	***Charadrius ruficapillus***	+	-
oriental plover	***Charadrius veredus***	+	-
oriental pratincole	***Glareola maldivarum***	+	-
red-necked phalarope	***Phalaropus lobatus***	+	+

Very few of the species listed in Table 6 were recorded during the site survey and there is a lack of suitable habitat for this group. Individuals or small numbers of common greenshank, red-necked stint, pectoral sandpiper and sharp-tailed sandpiper were occasionally present along Thompson Creek during the survey.

5.3.1 Vertebrates

Apart from a few mammal species, all of the species of national and state conservation significance known to occur within the region and site are birds.

5.3.2 Mammals

Common brushtail possum is listed as rare for South Australia. While the species is widespread in the State, there has been a significant decline in its population outside of the metropolitan area. It is almost entirely associated with the river red gum woodland habitat in the region and site.

Yellow-bellied sheath-tail bat is rare in the State and relatively few records of the species are known for the southern part of the State (SA Museum 2008). There is one recent record about 25 km east of the site on the Gawler River and the species could occur in the site in small numbers. The river red gum woodlands are a preferred habitat of this species.

As discussed in Section 5.2.1, western broad-nosed bat has been recently recorded in the region after an absence of 78 years. This species is of regional significance and the river red gum woodlands provide its preferred habitat.

5.3.3 Terrestrial Birds

Orange-bellied parrot. The species is listed as nationally critically endangered. The site is within the original range and habitat of the species with records of the species in the saltfields from 1978. Unconfirmed sightings of the species adjacent to the site have occurred in the recent past (Coleman in Durant 2007), with one very recent and confirmed record of the species being made in October 2006 at Chapman Creek 4 km north west of the site.

The orange-bellied parrot was not recorded the site survey undertaken for this report between October 2007 to September 2008. Additional winter and spring surveys were undertaken the period when the parrot is most likely to occur during July to September 2008. The orange-bellied parrot was not recorded in the region during Australia-wide assessments undertaken by others.

A number of juvenile elegant and red-rumped parrots, which are similar in size and colour to orange-bellied parrot, were recorded on the site during February to May 2008, and adult and juvenile elegant and blue-winged parrot were present on the site during winter and spring 2008.

Potential habitat for the species is located in and immediately adjacent to the site (Threatened Species Scientific Committee 2006). See Figure 5 for the location of these areas.

Slender-billed (samphire) thornbill (central). Present in Port Gawler Conservation Park and in many of the good quality samphire areas along eastern Gulf St Vincent north of Adelaide. Recorded at one location in the site as 9 to 13 birds (see Figure 5.1).

There are three subspecies of the slender-billed thornbill (***Acanthiza iredalei***) and each subspecies is very similar in morphology to the others. Each subspecies has a separate conservation status under legislation, hence it is critical that accurate identification to subspecies is undertaken. The primary distinction between the subspecies is geographic distribution and the three subspecies do not appear to have distributions which overlap. The three subspecies are:

- Slender-billed thornbill (western) (***Acanthiza iredalei iredalei***). This subspecies occurs in the North Agricultural Districts of South Australia west into Western Australia. Intergradation between slender-billed thornbill (western) and slender-billed (samphire) thornbill (central) appears to have occurred in the past, for example around Port Broughton (DEWHA 2008). In recent years there appears to have been migration of individuals of the subspecies south and it is considered that the subspecies may be present near the northern Gulf St Vincent (P.

Taylor, Nantawarra, pers. comm.., November 2008). Slender-billed thornbill (western) is listed as vulnerable under the EPBC Act.

- Slender-billed (samphire) thornbill (central) (***Acanthiza iredalei rosinae***) is primarily confined to the eastern shoreline areas of Gulf St Vincent from Barker Inlet to Clinton. It is listed as vulnerable under the NPW Act, but is not listed under the EPBC Act. This is the subspecies recorded in and adjacent to the project area.
- Slender-billed thornbill (eastern) (***Acanthiza iredalei hedleyi***) occurs in the south east and through the eastern mallee areas of South Australia. There is no overlap with the distribution of the other two subspecies.

***Crested-shrike tit*.** A small family group of this species was recorded in river red gum woodland in the site during 2008 (Figure 5). The species is listed as rare in South Australia.

Elegant parrot was present in the southern portion of the site, especially over summer 2008 and this species and blue-winged parrot was present in the southern samphire areas in winter and spring 2008. Sufficient hollows are present in the river red gums on the site for elegant parrot to be a breeding resident. Both species are rare in South Australia.

Australian bustard has been recorded in the region in the past. One bird was recorded approximately 60 km north of the site in February 2006 (Anderson, pers. obs., 2006). It could occur as a rare visitor to the site. The species is rare in South Australia.

White-browed scrub-wren was present along the chenopod shrublands in the southern and south western sections of the site. While this species is of regional significance only, its numbers are declining and its presence indicates good quality habitat.

Fifteen bird species which occur on the site are listed in DEH (2008a) as part of a draft Regional Recovery Plan. These include buff-banded rail, crested shrike-tit, pallid cuckoo, peregrine falcon, red-capped robin, red-rumped parrot, sacred kingfisher, slender-billed thornbill, tawny frogmouth, tree martin, whistling kite, white-browed babbler, white-fronted chat, yellow-rumped thornbill and yellow-tailed black cockatoo. Eleven of these species were recorded as breeding residents or breeding visitors in the site during the assessment or the adjacent section of the Gawler River corridor.

5.3.4 Other Terrestrial Birds

Of the other species listed in Table 4, rock parrot would be expected to occur along the coastal plain west of the site and in the chenopod shrublands in the site.

White-throated needletail and fork-tailed swift over-fly the region, but the site does not provide particular habitat for these species.

5.3.5 Aquatic Birds

These include nationally and state threatened species such as egrets, Cape Barren goose, freckled duck, blue-billed duck, musk duck, bitterns, rails, crakes, painted and Lathams snipe and brown quail. All of these species are present at Buckland Park Lake or have been recorded there in the recent past. Most require areas of open water and/or dense aquatic vegetation around the margin of water bodies, none of which is present outside of the Lake and small sections of Thompson Creek. Many of these species have been recorded breeding in the Lake, including freckled duck (ANCA 1996). Buff-banded rail was present along Thompson Creek during the site survey.

5.3.6 Migratory Seabirds

This group includes at least six species of albatross and petrel. All are pelagic species, inhabitants of the open ocean, which breed elsewhere and are very rare to occasional visitors in the region. They are mostly recorded alive only following prolonged storms in the Southern Ocean which force them to the shores of Australia (where they shelter until calmer weather) or as dead specimens washed-up along the shoreline.

There are no areas of habitat for this group in the site or region.

5.3.7 Migratory Shorebirds

These are the various species of transequatorial wading birds that migrate into the region from the northern hemisphere (Asia) over spring and remain in the region to early autumn. They are mostly confined to the Cheetham saltfields and pans and inter-tidal areas of Gulf St Vincent and Buckland Park Lake.

The latter is used by species which prefer freshwater, as a feeding and roosting area and an occasional stop-over point for many of the birds. It is also used as a refuge during stormy and rough weather conditions offshore.

The region including the saltfields, Gulf St Vincent, Barker Inlet Wetlands and the Greenfields Wetlands (20 km south of the site) support 119 bird species, some of which are listed under the EPBC Act and/or Schedules of the NPW Act.

Shorebirds make extensive use of the region, which is the second-most important site for these species in South Australia (WWF 2002). Thirty five species of international migratory (20 species listed under the EPBC Act) and other native shorebirds, also known as wading birds or waders, have been recorded in the region. Farrelly (1998, cited in WWF 2002), Cox (1993 and unpublished) and Crowley (2004, pers. comm.) indicate that over 60,000 migratory shorebirds and up to 100,000 other shorebirds have been recorded in the region on occasions, but not the site.

The key attraction in the region for these bird species is the diversity of habitats for resting, roosting, feeding, and, for a few species, breeding. The region forms a very important component of the avifaunal habitat. However, the site does not provide important habitat for the group or these species, and only a few individuals of a very few species were recorded along Thompson Creek during the site survey.

The birds move about extensively, for example, from feeding areas along the coast to resting and roosting areas inland, although some retain high tide roost sites along the margin of the Gulf St Vincent. Consequently, migration along the east coast of Gulf St Vincent and inland from the coast to wetland areas inland occurs regularly. Continued access to an array of habitats is critically important to the ecology of these species.

The use of northern Gulf St Vincent by shorebird species has been responsible for recent discussions about the potential to establish a new Ramsar wetland for the Northern Gulf St Vincent, which is ranked as being one of the 10 most important sites for shorebirds in Australia (WWF 2002, DEH 2006).

5.3.8 Other Shorebirds

Little tern and fairy tern use the coastal plain, Buckland Park Lake and other wetlands, but large areas of habitat for these species is not present on the site. Both species were recorded in the Cheetham saltfields and along Thompson Creek as rare visitors during the site survey. The site does not contain important habitat for these species

White-bellied sea-eagle is not a resident species, but it uses the whole region as part of its habitat.

5.3.9 Other Raptors

In addition to white-bellied sea-eagle, a further 14 species have been recorded in the region, including occasional migrants such as black falcon and letter-winged kite. Regionally resident species, such as peregrine falcon and whistling kite occur on the site. The assessment recorded the former species on the site and elsewhere in the region and may use the site's woodlands as a breeding location. The latter species is a breeding resident.

5.3.10 Rainbow Bee-Eater and Dollarbird

Rainbow bee-eater is a Commonwealth listed migratory species that visits southern Australia over about October to April. It has been recorded as a relatively common breeding resident in the region in the past and was present during 2007 at Port Gawler and 2008 on the site during the survey.

Dollarbird is a species with a similar migratory habit to rainbow bee-eater. It has been present in the region in the past, with a recent record of a pair of birds north of the site in 2003 and 2006 (Anderson, pers. obs.). It could occur on the site in small numbers. Suitable breeding habitat for the species is provided by the remnant river red gum woodland on the site.

5.3.11 Invertebrates

These are poorly known, but at least thirteen species of butterfly of conservation significance have been recorded in the region (DEH 2006). Of these, Yellowish sedge-skipper (***Hesperilla flavescens flavia***) is considered to be endangered, although it does not have a formal conservation status listed under legislation. A recovery plan has been prepared for the species (Coleman & Coleman 2000).

Having not been recorded for some years, it therefore may be extinct in the region. Its habitat, ***Gahnia filum*** (cutting grass), is present on the site along the southern section of Thompson Creek, and larger areas may have been present there in the past (Coleman & Coleman 2000). Cutting grass was originally present elsewhere along the coastal fringe, including at Bolivar south to the Adelaide metropolitan area (Anderson 2008).

There may be potential to re-establish areas of this plant species in order to assist with conservation of the butterfly. This has been undertaken on the site and at St Kilda

No specimens of this species were recorded during the field assessment.

5.3.12 Introduced and Pest Species and Threatening Processes

Introduced and pest animals recorded in the region include nine mammal species, up to eleven bird species, of which four species are abundant, and a number of invertebrate species, especially insects, such as European honey bee, European wasp and land snails (KBR 2006a).

From an ecological and conservation perspective, these species occur throughout the region and all have been responsible for assisting in the degradation of its natural environment.

Three introduced fish, including two pest species, have been recorded in the region from the Gawler River and Buckland Park Lake (DTEI 2007, Paton et al. 1991).

No significant animal pathogens have been recorded in the region although a number of diseases of livestock occur seasonally. Mosquitoes, house fly and non-biting midges may be seasonally abundant.

Predation by European red fox and feral cat are listed as national threatening processes, as is the impact of European rabbit. These activities occur throughout the region and the site.

6. IMPACTS OF THE PROPOSAL AND MITIGATION

The site has a long history of disturbance, being broad scale and intensive agriculture and horticulture being carried out historically and currently. As a result, large portions of the site are highly disturbed environments.

There are some biologically significant habitat areas and species present in this anthropogenic matrix. Impacts on these areas of fauna habitat and fauna species are discussed in this section.

Construction of the proposal will be staged over 25 years, with Stage 1 constructed between 2001 and 2016.

The approach to identifying potential impacts and mitigation measures adopted in this report therefore considers the proposal as two phases:

- Stage 1.
- Remaining stages.

6.1 Site Impacts

Stage 1 is approximately 150 ha and almost entirely confined to disturbed, anthropogenic areas. Consequently there will be no impact on native vegetation, important faunal group habitat and fauna species of conservation significance on the site associated with Stage 1. However, management of weed species will be specifically required as part of construction so as to minimise the spread and transport of weed species into important habitats.

See the Flora Technical Report (Anderson 2008) for recommended management measures.

Figure 6: Stage 1 Site plan

6.2 Onsite Impacts: Future Stages

Identification of the proposal's potential environmental impacts on native vegetation communities, as fauna habitat, and on fauna species, has been based on the proposal Master Plan at Figure 3.

Impacts associated with future stages on anthropogenic areas are low as these areas lack fauna habitat.

However, without mitigation, impacts will be high in and around areas which contain reasonable to good quality native vegetation, since these areas provide habitat for a range of fauna groups and species. These aspects are discussed in this section, illustrated in Figure 7.

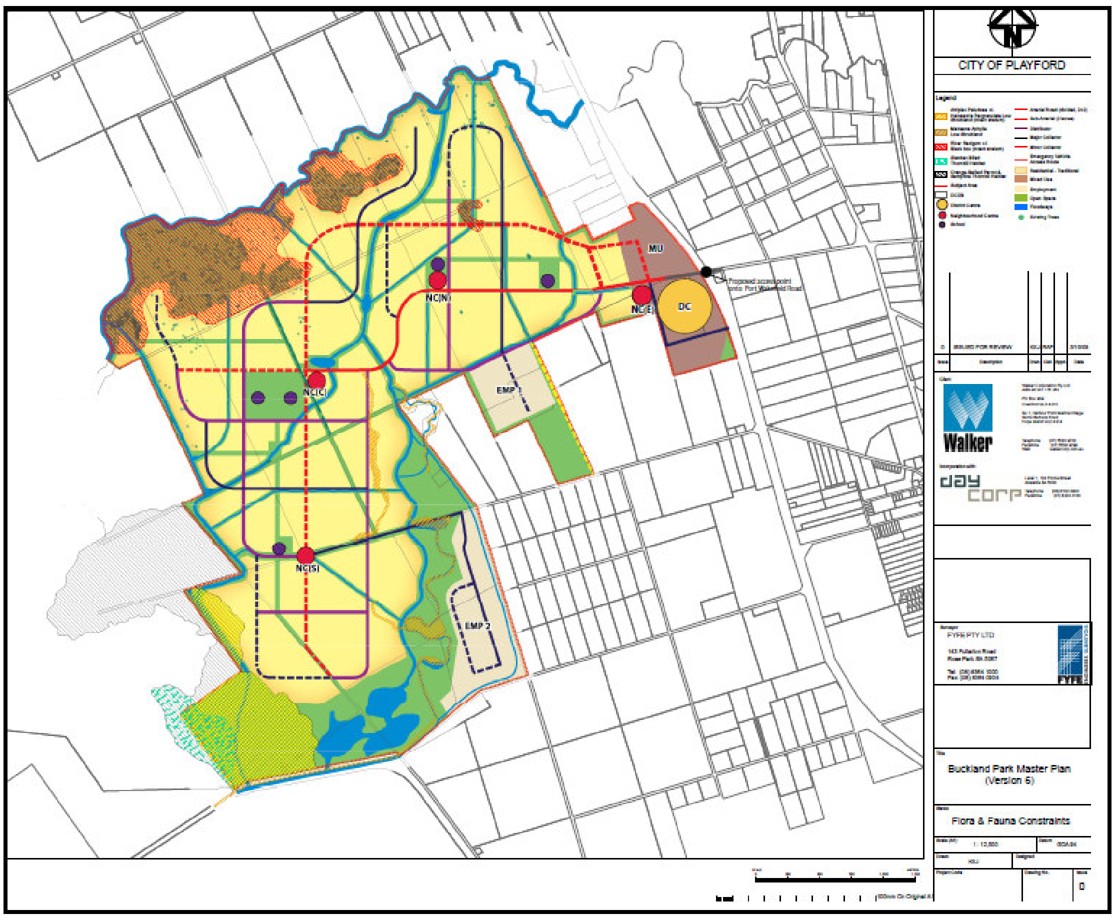


Figure 7: Master Plan overlay on vegetation areas

6.2.1 Gawler River Floodplain Woodlands

The Gawler River riparian corridor is shown in the Masterplan as incorporated into an open space area. It includes occurrences of a number of species of conservation significance. Removal of trees and areas of native understorey species in the Gawler River riparian corridor is not proposed. The understorey along the corridor is dominated by weed species.

Undertaking revegetation and rehabilitation works along the corridor to reconstruct the vegetation communities and habitat areas would have a potential for positive regional outcomes.

This approach should be formalised in Rehabilitation and Revegetation Plans and Management Plans, assessed by government authorities prior to the approval of the proposal's northern stages.

The Masterplan shows most of the Gawler River floodplain red river gum and black box woodlands contained within proposed open space areas. However, some of the woodland and the areas with lower density trees are incorporated into low density residential areas. The proposal's stormwater channels will also pass through the woodlands.

Potential impacts on the woodlands include:

- Removal of trees and parts of communities and their buffer areas.
- Fragmentation of communities and associated fauna habitats.
- Placement of buildings and gardens too close to woodlands i.e. without an appropriate buffer.
- Inappropriate fire regimes (arson and bushfire).
- Damaging or removing tree canopies and roots during construction.
- Inappropriate water regimes, such as redirecting storm water and ground water away from woodland areas and trees.
- Compaction of soil around trees during construction.
- Introduction and spreading of weeds.

Detailed Rehabilitation and Revegetation Plans and Management Plans will be required as part of the assessment documentation for future stages.

While the trees are of botanical interest as a vegetation community and most are significant trees as defined under the ***Development Act***, their particular value is as fauna habitat, especially for avifauna and some mammals, especially bats and possums.

Woodlands containing mature and senescent trees are almost unique on the Northern Adelaide Plain. These trees are old and relatively fragile. They will drop limbs during and following times of stress, such as drought or strong winds. The Management Plan must allow for these dropped limbs to be tolerated, and not removed, as they are part of the site's ecological values.

The same provisions must be made for individual trees in residential and public space areas.

Pest species, as introduced species, plus noisy miner, an aggressive native species, may be advantaged by proposal. Control programmes on the site would be wasted unless a regional approach could be implemented.

The Master Plan shows scattered trees and small areas of paddock trees would not be cleared. These would be incorporated into future detailed landscape designs as part of parks and gardens.

Pruning and rehabilitation of some of these trees may be required in the interests of public safety. This is likely to have an adverse impact on some fauna species currently using these trees, especially hollow dependent species and raptors which use the trees as roost and nest sites.

6.2.2 Southern Chenopod Shrublands

These shrublands are the largest area of any native vegetation community on the site and contain a number of important actual and potential habitats for various avifauna species, including threatened species. Therefore, they are of significant value as fauna habitat including for nationally threatened bird species.

Two areas are included:

- A relatively intact community in the south west of the site of which 6.3 ha is proposed for removal for residential proposal and 3.4 ha is to be removed for construction of a stormwater channel. Construction of the channel will remove a corridor of native vegetation and potentially introduce weed species along this corridor which can then spread into the adjacent shrubland.

- Sparse and degraded areas of the community east of the relatively intact community. About 68 ha are proposed to be removed for residential proposal.

Most of the habitat for slender-billed thornbill and white-browed scrub-wren, plus potential habitat suitable for orange-bellied parrot is not directly impacted.

However, it is likely that new residential areas potentially directly adjacent to the shrubland vegetation boundary will significantly increase the risk of disturbance to this area and its species.

6.2.3 Thompson Creek Shrublands, Sedgelands and Grasslands

This is a complex of related communities, with the two dominant ones being:

- marsh saltbush +/- black seeded samphire +/- Austral seablight low chenopod shrubland in the southern section of the site

- leafless cottonbush shrubland in the central part of the creek system.

Small areas of tall sedgeland and grassland dominated by cumbungi, common reed and salt clubrush are also present in a mosaic along sections of the creek. It is this complex of habitats along Thompson Creek that provide valuable ecological assets for fauna, primarily terrestrial and aquatic birds.

About 24.7 ha of low chenopod shrubland and 6.2 ha of cotton-bush will be removed for new residential areas and stormwater management channels, particularly along the western reach of Thompson Creek. Potential weed infestation of adjoining areas during construction will be an issue. Revegetation of disturbed areas to be included in open space will be required.

However, much of the area along and adjacent to Thompson Creek, and its eastern reach, will either not be directly affected and/or will be revegetated using native species and included in an open space precinct following channel construction.

6.2.4 Other Aquatic Communities

These are included in the impacts on the Thompson Creek vegetation communities.

6.2.5 RMS Areas, other Roadside Native Vegetation and Indigenous Low Grasslands

These areas are too small to provide significant fauna habitat and impacts on these areas are not predicted to occur at this stage.

However, if areas are discovered to be affected during detailed planning for future residential areas, then appropriate mitigation actions will be required. These could include fencing of areas, salvage of plants or collection of propagating material followed by use of propagated plants in revegetation schemes on the site.

Most of these areas are along the roadside areas, including the RMS, and no disturbance is proposed to take place in these areas which contain grassland.

Preventing weeds being transported from construction zones and infesting areas of native vegetation will be important.

6.2.6 Anthropogenic Areas

These open areas and planted trees comprise most of the site and are used by a range of common fauna species, mostly birds. Clearance of these areas will have little or no impact on native vegetation, habitat or fauna species.

6.3 Mitigation of Impacts

The Masterplan shows areas native vegetation removed for new residential areas at the sites shown in Figure 7. It must be noted, that at this early stage of design, these areas are not established in detail. More design work will be undertaken prior to the commencement of future stages.

This section describes the mitigation measures incorporated in the proposal to achieve a significant environmental benefit (SEB).

These measures will be the subject of ongoing discussions with the South Australian government, especially the Native Vegetation Council, as future stages are designed.

Offset ratios for SEB would apply to all native vegetation proposed for clearance, ranging from 2:1 for very poor quality native vegetation to 10:1 for good quality native vegetation (Native Vegetation Council 2007 Policy 1.2.11).

The Native Vegetation Council will review future clearance in accordance with the principles in the Act's Regulations.

"***Native vegetation should not be cleared, if, in the opinion of the Council -:***

1. ***it contains a high level of diversity of plant species;***
2. ***it is an important wildlife habitat;***
3. ***it includes rare, vulnerable or endangered plant species;***
4. ***the vegetation comprises a plant community that is rare, vulnerable or endangered;***
5. ***it is a remnant of vegetation in an area which has been extensively cleared;***
6. ***it is growing in, or associated with, a wetland environment;***
7. ***it contributes to the amenity of the area;***
8. ***the clearance of vegetation is likely to contribute to soil erosion, salinity, or flooding;***
9. ***the clearance of vegetation is likely to cause deterioration the quality of surface or underground water;***
10. ***after clearance, the land is to be used for a purpose which is unsustainable".***

In relation to the native vegetation as habitat, primarily the locations where native vegetation will be cleared, it is considered that principle two is particularly relevant. Fauna wildlife habitat is an important principle to the NVC, especially since the publication of DEH (2008a).

The definition of broad scale clearance and clearance of a substantially intact stratum would also apply to some of the areas listed in Table 7, below. Based on the proposal's Masterplan some of these areas will be removed for incorporation into new residential areas.

Any clearance of native vegetation would require a SEB as compensation. SEBs can be achieved through the following measures:

- establish and actively manage new areas of native vegetation on the site and/or at an agreed area of the same or similar community(ies) in the region.
- protect and manage native vegetation on the site, including formal protection by a Heritage Agreement.
- establish a Heritage Agreement for other areas of native vegetation, with a Vegetation Managment Plan.
- payment into the Native Vegetation Fund.
- undertake works in kind at an agreed location off the site within the same or similar community(ies).
- a combination of the above management options.

6.3.1 Retained Vegetation in Open Space Areas

Approximately 193.8 ha of good to very good quality remnant native vegetation will be retained in open space areas within the Masterplan.

Active rehabilitation, revegetation and management of these areas will contribute to achievement of a SEB for the project. Active management will include pest species control, revegetation using locally indigenous species as part of habitat re-construction and monitoring. Fencing of the boundary of areas will be required.

Along the Gawler River corridor, the removal of weeds and revegetation as part of rehabilitation will result in positive environmental impacts.

In addition, a specific management action for the river red gum woodlands will be to establish a flood management scheme. This will assist in enhancing the health of the woodland and provide for recruitment of young trees.

The ownership of these areas will be the subject of negotiation with State Government. However, formally reserving these areas as part of the State's conservation network would add to the value of the SEB and would comply with the State Biodiversity policy and the draft Regional Recovery Plan (DEH 2008a).

In respect of these areas the proponents will undertake the following:

- Ensuring detailed design of future stages incorporates measures to retain vegetation, and landscape plans incorporate open space corridors, minimising potential fragmentation of vegetation communities.
- Preparing and implementing Rehabilitation and Revegetation Plan and Management Plans.

In the southern part of the site conditions are suitable for revegetating terrestrial areas with low chenopood shrubland and aquatic areas with appropriate species from remnant grassland, sedgeland and shrubland communities.

This is practicable and would provide another valuable component of the SEB. The Masterplan's open space areas can accommodate these revegetation proposals. A strict policy of revegetation using native samphire, chenopod and monocot species to rehabilitate the channel earthworks will be required to re-constitute the habitat removed. An example of successful habitat establishment in a similar environment is the Greenfields and Barker Inlet wetland complex.

Wetland and stormwater management facilities will potentially provide a positive impact on the availability of habitat for native fauna. Rehabilitating or vegetating areas into high quality fauna habitat would make a significant contribution to the conservation of fauna species, especially aquatic avifauna. These areas would need to be appropriately maintained.

The use of locally indigenous species for revegetation of new stormwater channels, and assisting in the revegetation and management of RMS along roadsides would also be suitable for providing part of the SEB.

New residential areas adjacent to retained native vegetation will place pressure on that vegetation from access by people.

Access must be strictly controlled if these areas remain as conservation areas. The Rehabilitation and Revegetation Plan and Management plans for retained vegetation areas must include fencing. Fencing must be included in Landscape Plans for future stages of the proposal.

Future detailed designs should consider new species or communities included on lists of conservation significance by the Commonwealth or State governments in the future.

In addition, the condition of the site and its native vegetation may change significantly over 25 years. Therefore, a detailed review process will be required prior to each stage being approved in future.

In the woodland areas it is proposed to:

- Design future stages to minimise vegetation clearance and tree removal, rehabilitate and revegetate retained woodlands and their diversity.

- Incorporate scattered trees and small patches of trees into the detailed landscape design of future stages.

- Prepare for government approval Construction Management Plans for each future stage. An environmentally sensitive construction approach is required to ensure that the construction and proposal 'footprint' along the boundary of woodland areas is minimal and that individual trees are preserved, managed appropriately and not cleared.

The Masterplan incorporates scattered and paddock trees into residential areas. Detailed design of future stages will incorporate these trees into parks. Pruning and rehabilitation of some of these trees may be required in the interests of public safety.

While this has minimal impact on flora values, the adverse impact on some fauna species currently using these trees will be more important.

6.3.2 Vegetation within the Region

There are opportunities to for SEB works to be undertaken in areas of conservation significance adjacent to the site, such as the Gawler River corridor, or areas in the region, such as Buckland Park Lake, Port Gawler Conservation Park, or other areas of State owned land along the coast, shown in Figure 8.

Cooe (2008) described the degraded state of some of these areas in its report ***Marine and Coastal Environment and Potential Impact Assessment***

> ***Our survey of the coastal plain west of the Site found ecologically significant vegetation and habitat, but has suffered degradation from feral animals and general rubbish. The impacts of Cheetham's salt pans, with changes to land form and hydrology were also evident.***

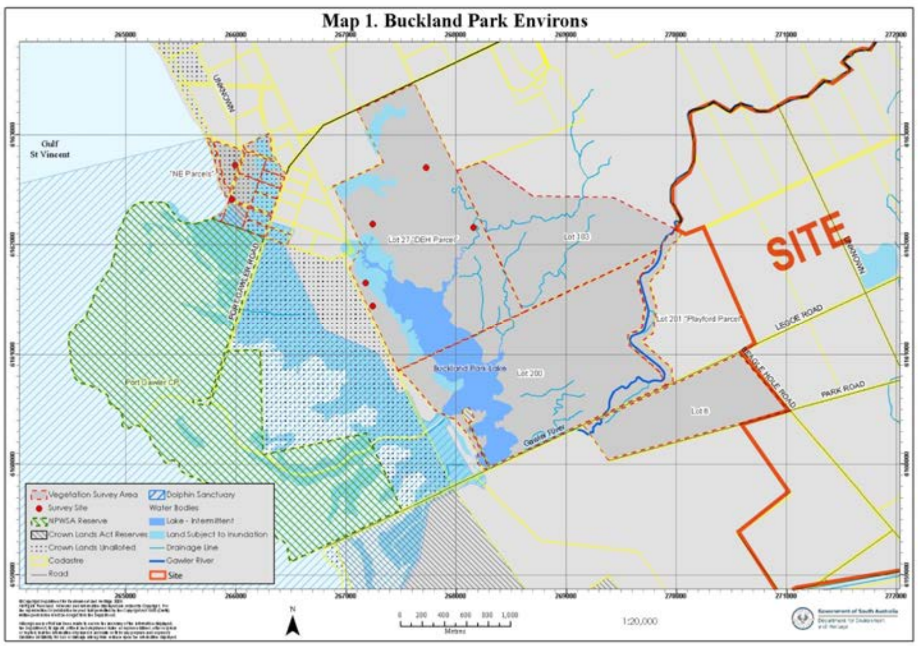


Figure 8: Areas of biological importance, in public ownership and within the site's region

Establishing an environmental improvement program in these areas would provide a suitable contribution towards achievement of a SEB. These actions could be part of the Draft Regional Recovery Plan for threatened species and ecological communities (DEH 2008a).

Works that could be undertaken by the Proponent, or funded through contributions to the Native Vegetation Fund include:

- removal of feral animals
- removal of weeds and rubbish
- revegetation
- drainage and erosion control works.

These works would be subject to preparation of Rehabilitation and Revegetation and Management Plans for the targeted land. Active participation in the Draft Regional Recovery Plan (DEH 2008a) is a realistic contribution to the proposal's SEB.

6.4 Weeds

Throughout the site there is a wide range and high incidence of annual and perennial weed species. Weeds have significantly degraded many areas in the region. The extensive movement of soil and vehicles has the potential to transport weeds through and into the region and the site. Without suitable and stringent management actions, weed species will be transported throughout the construction sites and into adjacent areas.

Most of the roadsides and many of the open areas in which the proposal will occur and through which the transport routes pass are weed infested. About 220 species of introduced plants have been recorded in the region. Of these, about 54 species are of particular concern due to their impacts on agriculture and remnant native vegetation. Species of concern from a habitat degradation perspective include prickly pears and rope cactus, Coolatai grass, Calomba daisy, African boxthorn, St John's wort, Bathurst burr and Noogoora burr, olive tree, castor oil tree, tree tobacco, innocent weed and caltrop.

The remainder of the site is likely to experience minimal environmental impacts given the existing disturbed nature and long history of disturbance. Further habitat fragmentation from both a flora and fauna perspective is likely to occur with the clearance of some areas of native vegetation. Given the already degraded nature of the environment it is unlikely to seriously impact on fauna of the region.

6.5 Other Bio-security Issues

Introducing such a large residential proposal has the potential to introduce additional pest species and pathogens. The proposal will comply with State Government biosecurity strategy and the NRM board requirements for pest species management.

6.6 Offsite Impacts

The most likely adverse off site impact will arise from a large new population in a region that is currently sparsely populated. The environmental pressures associated with people will likely be an increased incidence of use on the Cheetham saltfields, the coastal plain, the Gawler River corridor, Buckland Park Lake and Port Gawler Conservation Park. This will include both legal access and illegal trespassing. It is noted there is no public road access to the coastal plain from the site.

Other environmental pressures and risks will be in the form of illegal removal of trees and deadfall timber for firewood; arson; the use of unsuitable garden plants; and the illegal dumping of green wastes, especially from properties which are adjacent to areas of high quality native vegetation.

All of these activities will slowly erode the integrity of the native vegetation and fauna habitat, both as communities and species.

Mitigation measures include:

- Fencing of key biodiversity areas within the site, as described above.
- Educating new residents about the biodiversity around their homes, including creation of wildlife friendly gardens, control of domestic animals. This will be done through the community development manager, through 'welcome packs' and activities which focus on biodiversity areas, for example community planting days, walks and talks from ecologists. Council already runs such activities for its existing residents.
- Provision of adequate waste management facilities for residents.
- Design Guidelines which include indigenous species in plant specifications.
- Appropriate landscape design, including liaison with Country Fire Service and Metropolitan Fire Service authorities to establish fire management requirements for remnant native vegetation areas.

It is noted that population pressure is not an impact uniquely associated with the site and proposal. Wherever new population is placed these issues arise.

6.7 Combined and Cumulative Impacts

Playford City Council notes sea levels are predicted to rise by 0.3m from 2002 levels by 2050, with a further 0.7m rise occurring by 2100. Sea level rise has the potential to impact on vegetation communities in low lying areas near the coast. In this region the most likely communities potentially affected are the chenopod and samphire areas which are at or just above sea level.

In respect of sea level rise and the migration of plant communities, Cooe (2008) concluded as follows:

The loss of extensive areas of seagrass along the Adelaide metropolitan coast has caused the mobilisation of exposed sediment. Resuspended sediment moves northwards and is deposited on sand banks (such as Section Bank) off Outer Harbor and the northern beaches (Mifsud et al. ***2004, Fox*** et al. ***2007). The build-up of sediment and detritus around the mangrove pneumatophores appears to be causing the loss of mangroves on the shore front; the mangroves retreat further inland if suitable land is available (Mifsud*** et al. ***2004). However, in Buckland Park the Cheetham Salt levee banks west of the site, prevent the retreat of mangroves.***

Sea level rise, attributed to climate change, will increase the pressure on seagrass, mangroves and samphire communities to advance further inland, or retreat (Harvey 2002). This will become more pronounced along coastlines that are characterised as low gradient, such as the upper Gulf St Vincent. This topic is dealt in more detail elsewhere in proposal's environmental assessment.

The retreat of coastal vegetation as sea level rises is prevented by the Cheetham salt pans, which create a barrier at the eastern edge of the coastal plain. Accordingly the proposal will not influence the outcomes of coastal retreat in this area.

As the anthropogenic areas of the site have little or no native vegetation, inclusion of these areas in future urban areas will be very unlikely to have an adverse combined or cumulative impact on native vegetation and faunal habitat.

The proposal's Design Guidelines will require indigenous plants to be used extensively in the public domain, including streets, parks and commercial and community spaces. New residents will also be encouraged to use indigenous plantings in their gardens, particularly their front gardens.

The Design Guidelines will also recommend the proper management of domestic pets. In particular, new residents will be educated to keep their pets inside at night.

Consistent implementation of these Guidelines will result in a net environmental benefit from the replacement of anthropogenic areas.

The cumulative and combined impacts of urban growth on vegetation and fauna in northern Adelaide must be considered in the State Government's strategic planning.

The state is currently identifying land for future new suburbs to accommodate urban growth. As well as the Buckland Park proposal, other areas in northern Adelaide are being considered, including Dry Creek, approximately 20 km south of the site (Minister for Urban Development and Planning 2008).

6.8 Environmental Management

Mitigation of impacts will be through environmental management, the principles of which are discussed in this section. Management will include formal review and updated planning mechanism at the detailed design stage of each future stage, prior to approval and commencement of construction.

Detailed, specific management actions tailored to the particular characteristics of each stage will be incorporated in an Environmental Management Plan (EMP) for that stage.

6.8.1 Principles required to Minimise Effects

EMPs will provide general measures aimed at avoiding or minimising adverse environmental impacts, through specific mitigation measures, and for achieving SEBs.

Construction Environmental Management Plans (CEMP) will include the detailed requirements for construction works. CEMPs will include the methods and requirements for achieving SEBs.

Specific performance criteria will be established. The Proponent has considerable experience with environmental policies and management requirements for large and similarly complex projects. The key issues, impacts and mitigation include planning and design, construction and operation.

6.8.2 Measures to Minimise Effects during Planning and Design

The planning and design phase for the proposal started with the field assessments The first key management action was to inform the Masterplan design by identifying habitat areas and individual species through site assessment, and to validate the results by checking and consultation

The planning and design phase for the proposal started with the field assessments that have been undertaken over 2007 to 2008. As far as practicable, these have identified areas of remnant native vegetation and areas of native vegetation planted by local councils and others and the location of these areas has been recorded by GPS, in a database and mapped.

As far as possible, species in all site sectors have been identified accurately, although there have been some areas for which additional species are likely to occur (due to the drought conditions during 2007/08). This identification process, of both habitats and species, was confirmed by independent review of existing reports, databases and sites provided by government agencies and individuals.

These areas were mapped (see Figure 5 and Appendix A). This map was used to establish broad open space areas required within the Masterplan, and to allow consideration of the requirements for SEB. Adjustments were made to the location of proposed residential areas and stormwater channel locations in response to vegetation constraints.

However, this identification process is a work in progress. Ongoing site survey will occur in future over winter and spring to assess if additional species, especially orange-bellied parrot, are present during the appropriate season and, hopefully, a year of average to above average rainfall. Results will be reported in future planning reports assessed by government prior to the approval and commencement of construction of each future stage.

There is a commitment to ensuring that local flora only is used in the landscape design and revegetation planting of the proposal. All storeys of native vegetation will be used and the placement of these species in the landscape will, as far as practicable, accord with that which would have originally been present prior to European settlement in 1836. This will assist considerably in providing habitat for a number of faunal groups.

Wetland and stormwater management facilities will potentially provide a positive impact on the availability of habitat for native fauna. The Masterplan (see Figure 3) indicates a stormwater channels and a large area of open space in the site's south end. Rehabilitating or vegetating areas into high quality fauna habitat would make a significant contribution to the conservation of fauna species, especially aquatic avifauna. These areas would need to be appropriately maintained.

The best way of ensuring that fauna species remain and prosper is by protecting and rehabilitating important areas of existing habitat, improving its habitat values by revegetation combined with control of pest species.

To achieve this commitment, collection of propagating materials from different biotypes from the same species within the site and region will be required.

If this is not possible, then there are a number of studies and documents which incorporate wildlife and habitat planting requirements and guidelines for urban proposals, such as Birds Australia (2008) and DEH (2008).

These guidelines emphasise establishing habitat for various faunal groups through revegetation and other methods, such as physical features (logs, water areas and nest and bat boxes). Detailed actions associated with the Draft Regional Recovery Plan (DEH 2008a) are relevant to particular species and their habitat impacted by the proposal.

Revegetation activities as part of a Rehabilitation and Revegetation Plan are proposed to be established as part of the site's Master Plan. The landscape plan contains details of the types of strategies, activities and species combinations to be used.

6.8.3 Measures to Minimise Effects during Construction

Immediately prior to construction, construction zones will be surveyed on foot. Areas of native vegetation present will be assessed for fauna habitat value.

If these are common species with little or no habitat value, such as occasional plants of native colonising species (e.g. short-leaf bluebush or rough spear-grass), then no addition approvals or mitigation actions will be required.

If there are species that are unusual or threatened, even isolated plants or small clumps, then the species will be protected by collection, either of the plants, followed by transplanting into a secure area, or of propagating material (seeds and cuttings). These will form part of the habitat management and revegetation works for the proposal.

Prior to construction, builders and contractors will be formally briefed about the importance of native vegetation as fauna habitat at an induction briefing. Each individual builder, contractor and sub-contractor will verify agreement by attendance at this briefing and by signature to an agreed Code of Practice.

An Environmental Officer and an equivalent person from the construction contractor will be responsible for ensuring that compliance occurs or if it does not, then establishing remedial requirements, and, if necessary, contract penalties. The latter must be included in the Contract let for construction. The key matter will be to avoid all areas of native vegetation marked on management maps and in the field.

Native vegetation clearance will not occur in most of the anthropogenic areas because none is present.

Prior to the removal of any area of native vegetation, all approvals will be obtained from all relevant groups. Formal approval will be obtained from the NVC through the submission of a vegetation clearance application.

SEB and net gain requirements will apply to the proposal. Assessment of the trees and other native vegetation affected by the proposal along the Gawler River floodplain, Thompson Creek and in the southern section of the site will be undertaken in consultation with the NVC.

Ongoing liaison with local council and state government officers will be maintained during construction. This will include inspection and agreement as to which areas should be planted and established and the types of landscaping best suited to particular areas.

Approvals to re-locate fauna discovered during earthworks will be obtained from DEH.

6.8.4 Measures to Minimise Effects during Post-Construction Periods

Once construction has been completed then a Management Plan will be implemented for the biodiversity areas of the site. From a biological perspective, this will include management requirements for the revegetation areas, such as watering and replacement of plantings and maintenance of all areas. The City of Playford and DEH officers could be expected to be involved in these activities.

7. CONCLUSIONS

Little to nil remnant native vegetation remains on much of the site, which is characterised by an agricultural landscape.

Fauna is mostly restricted to areas of remnant vegetation. The areas with the highest incidence of habitat and fauna species include woodland, scattered trees and shrubland habitats along creek lines and the south western boundary. Roadsides, revegetation sites and constructed wetlands have fewer habitats and lower species numbers.

Remnant habitat is variable in extent and quality. Much of it is associated with the woodlands, chenopod srublands and aquatic areas, especially along the Gawler River and Thompson Creek.

The river red gum woodlands along the Gawler River and its floodplain in the site provide an important local and regional habitat for birds, bats and reptiles, with hollows in mature species critical for breeding of many species.

The Cheetham saltfields and Thompson Creek provide habitat for common aquatic birds as well as significant species such as the buff-banded rail and crakes. Small terrestrial bird species, such as fairy-wrens, scrub-wrens and small parrots also make extensive use of this habitat.

Cleared areas used for agricultural production is generally of poor quality as habitat with nil or a weed-dominated understorey providing limited resources to a number of common local fauna, mostly bird species.

The impact of the proposal on local and migratory fauna is predicted to be variable, but is potentially significant unless disturbance to critical habitats is avoided and minimised.

The two key habitats for common and threatened species are generally included in the Masterplan’s open space areas. However, approximately 154 ha of habitat of variable quality will be cleared or otherwise impacted by the proposal.

The lack of habitat, especially of mature woodland and its associated local fauna, across the region places an increasing emphasis on retaining and enhancing the integrity of remaining ecological assets.

The extent of impacts on the Gawler River floodplain woodland will largely depend on the construction methodology, but will be mitigated by careful planning and design and revegetation and restoration works.

By observation, animals, especially birds and reptiles, along Port Wakefield Road and the roads in the site are generally undeterred by the current transport corridors. Road kill is present and usually represents common, widespread species, including introduced (pest) species.

Increasing traffic on, and from, the site and along the adjacent section of Port Wakefield Road and widening and upgrading roads in the site will result in the number of road killed fauna increasing. Wetland species may be temporarily affected due to a loss of habitat, but given their adaptation to the existing agricultural landscape, are unlikely to be affected in the long term. The possible impacts on nationally and state significant species are summarised in more detail below.

Not all sites have been able to be subject to a detailed investigation, either as a result of conditions or due to a limited sampling effort. Where ever possible, site assessments have been combined with a review of existing databases and consultation with environmental planners and officers of local Councils to provide a broader indication of environmental conditions. The result of this approach is precautionary.

Even so, it indicates a low to negligible risk of causing a major or significant adverse effect to vegetation, as habitat, and fauna within the few areas not subject to a detailed assessment due to seasonal conditions.

Although much of the site lacks habitat and there will be predicted minimal impacts on local fauna, there are biological constraints associated with the relatively intact woodland, riparian and shrubland habitats.

Most of the mitigation effort will focus on avoiding the relatively large areas of habitat by including these areas where possible in the Masterplan's open space areas. Fine tuning the proposal, including road alignments and drainage works, will continue with future stages to minimise damage to native vegetation and habitats.

All areas of remnant native vegetation in this region are of value due to the small areas only remaining. They must be protected and appropriately managed where ever practicable. Active management of the native flora elsewhere on the site will be required to minimise the impacts to sections of scattered remnant woodland.

Disturbance of all habitats will be avoided as a first preference, and or appropriately managed in accordance with an Environmental Management Plan. Amongst other information, this plan will detail proposed contingency measures for sightings and management of conservation significant fauna within the site.

Revegetation of the landscape, such as roadsides, parks and swales with local indigenous species will in fact significantly enhance local biodiversity, and thus the resources and habitats available to native fauna. Additional revegetation of the areas of relatively intact woodland and shrubland will be undertaken.

Collection of named propagating material from all species will be undertaken to ensure that as many species and biotypes as possible are represented in collections to be used for landscaping and revegetation.

Care will need to be taken to ensure large areas of diverse indigenous understorey is replanted, especially high density plantings which include prickly and dense foliage species, thus encouraging use by native fauna whilst deterring introduced cats and foxes.

Appropriate waste management (particularly of food and green wastes) will also deter increases in pest animal populations.

Within the constraints imposed by the weather, time and land access conditions over 2007/08, several sections of the site have not been the subject of a detailed assessment under ideal conditions. These sections remain to be reviewed during winter to mid spring, plus following a year with average or above average rainfall.

7.1 Avifauna

Apart from two mammal species, both of which will be confined to the woodland areas, all of the species of national and state conservation significance known to occur within the region and site are birds.

There are:

- One species listed as nationally threatened under the EPBC Act, the orange-bellied parrot, which has been recently recorded as occurring in the region 4 km north west of the site. Note: the sub-species of slender-billed thornbill recorded in the site is not the sub-species of national conservation significance.

- 25 species listed under the EPBC Act under the National Wildlife Conservation Plan for Migratory Shorebirds (DEH 2006) occur within the region and parts of the site. These bird species are also listed under various international treaties or conventions to which Australia is a co-signatory. This represents 70% of all of the species listed under DEH (2006).

- Some 10 to 15 other species listed under international conventions or treaties to which Australia is a co-signatory and which are listed as being migratory, have habitat within the region and/or site or are conservation-dependent species.

- 31 species are also listed under SA legislation (Schedules 7, 8 or 9 of the NPW Act). Many of these species are also listed under the EPBC Act.

- 15 bird species which occur in the site are listed in DEH (2008a) as part of a draft Regional Recovery Plan. These include buff-banded rail, crested shrike-tit, pallid cuckoo, peregrine falcon, red-capped robin, red-rumped parrot, sacred kingfisher, slender-billed (samphire) thornbill, tawny frogmouth, tree martin, whistling kite, white-browed babbler, white-fronted chat, yellow-rumped thornbill and yellow-tailed black cockatoo. Eleven of these species are breeding residents or breeding visitors in the site or the adjacent section of the Gawler River corridor.

Aquatic species as defined in this report are those species that rely on aquatic habitat, for example some ducks, crakes, rails and bitterns associated with freshwater. In addition, other groups such as gulls and terns are also considered to be aquatic birds, although these are primarily marine species whose habitat does not occur on the site.

Buckland Park Lake is a particularly well established and important regional freshwater wetland. Bird life is prolific and the habitat is known to be a breeding area for many species. Birds such as Australasian bittern that are rare in south eastern Australia have found refuge at this wetland during the current drought and may breed in this area. Other wetland sites, such as the Barker Inlet and Greenfields wetlands (20 km south of the site) and the Cheetham saltfields have salt or brackish water and attract and maintain populations of migratory waders and other shorebird species. There is little doubt that the wider region as a whole has a wetland community of State and national importance. However, these habitats are rare on the site and a few of the species found in the region occur in the site in small numbers only.

The principle impact of the proposal is likely to be the direct loss of habitat through clearing of vegetation, plus effects along the edge of the small, ephemeral wetlands associated with Thompson Creek. Migratory birds covered by international treaties (JAMBA and CAMBA) and birds of national significance do not appear to use these areas either at all or are occasional visitors in small numbers. These wetlands are not significant as habitat, however, reduction in their size, and removal of associated vegetation is likely to impact a few of the common resident species.

Along the Gawler River riparian corridor, white-bellied sea-eagle, a number other raptors, duck species and nankeen night-heron were recorded. These species and groups are classified as nationally threatened. A range of common aquatic species were also observed at this location, such as heron species. The riparian corridor will not be directly be affected by the proposal.

It is important to note that the critical habitat areas for migratory shorebirds in the saltfields and along the tidal shoreline of Gulf St Vincent are separated from the site by Cheethams saltfields and the Gawler River.

The EPBC Act applies to both a species and its habitat; both the species and its habitat are protected by this Act. If an action is proposed to be undertaken which will have any sort of adverse impact on the species or its habitat, then the action must be referred to DEWHA (Commonwealth).

Based on detailed observations, birds of international significance and other shorebirds do not rely on the surveyed locations in the site. It is considered that direct adverse impacts on these species as a result of the proposal will be minimal.

7.1.1 Environment Protection and Biodiversity Conservation Act

Many species listed as species of national conservation significance under the EPBC Act, are extinct in the region and State, and have not been recorded in the region for many years, or are unlikely to occur due to the absence of suitable habitat.

The only bird species of listed significance was the orange-bellied parrot (critically endangered). The orange-bellied parrot was recorded in the 1970's in samphire habitat to the north west of the site, with a more recent authenticated record from Chapman Creek, 4 km north west of the site in October 2006. The orange-bellied parrot was not recorded the site survey undertaken for this report between October 2007 to September 2008. Additional winter surveys were undertaken the period when the parrot is most likely to occur during July to September 2008.

The orange-bellied parrot was not recorded in the region during Australia-wide assessments undertaken by others. However, suitable, high quality feeding habitat for the species occurs in the site, primarily in its south western portion, so the species could occur in and adjacent to the site.

The slender-billed thornbill was recorded in the site and the immediate region. However, the sub-species of slender-billed (samphire) thornbill recorded during the survey is not the nationally significant sub-species.

Review of the Gawler River riparian corridor for potential and actual nest sites of rainbow bee-eater indicated that the likelihood of this species occurring is high. Recent, active rainbow bee-eater nests were not recorded in the riverbank, but given the large number of the species present during early 2008, it is likely that the species breeds in or close to the site.

A large number of pest species would prey on the birds and their eggs, such as European red fox, domestic and feral cat and black rat.

It is unlikely that the proposal will include actions that will enhance any of the nationally listed threatening processes, such as the impacts of European red fox, cat or European rabbit. Each of these species is either already abundant in the region or parts of the region.

Nonetheless, specific management measures will be in place to avoid any positive impacts on these species and, where practicable, control measures will be in place. Cat management will be particularly important as a result of proposal of a large urban population adjacent to wetlands of International and national significance. This matter will likely require referral to DEWHA.

Overall, the proposal may impact some Commonwealth (national) matters of biological significance. Consequently, the proponent will provide a Referral to DEWHA for its consideration.

7.1.2 National Parks and Wildlife Act

Many species of state significance, as listed by the NPW Act schedules, have either not been recorded within the region for some time and appear to be regionally extinct, or are unlikely to occur due to a lack of suitable habitat. Those that have been recently sighted include a number of migratory and vagrant birds and two species of bat.

Wetlands, saltfields and watercourses provide habitat and resources for a variety of state listed species, including ducks, crakes, rails, and egrets and a number of raptor species. Many arrive as vagrants or migrants. However large populations of resident bird species can be present and consequently attract up to 15 raptor species that prey upon them. Few of these species use the wetlands and surrounding landscape, either at all or as a permanent habitat, therefore there is little likelihood the proposal will impact on them.

Local bat populations are large. The incorporation of protection measures for hollow trees into the EMP will ensure that roost sites are retained, so roadworks and other construction activities will be likely to have little or no effect upon the local populations. Enhancement of the native plant species and water sources as part of the biodiversity and landscape works may assist in providing more invertebrates for the bats to feed on and drinking water sources for this faunal group in future.

The habitat and therefore the mammal and bird species of conservation significance under State legislation are unlikely to be impacted by the proposal. However, impacts on Thompson Creek and the southern chenopod shrubland habitats are likely to include direct, permanent removal of habitat and removal of the existing vegetation and habitat to construct stormwater channels. While there will be a revegetation program in future, the displacement of fauna species using the area will be an impact. A number of species listed under the NPW Act use these habitats and are likely to be impacted by the clearance of habitat.

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APPENDIX A SPECIES LISTS

Table A.1 Fauna groups and species previously recorded within the region and wider region

Species	Common Name	Conservation Status	
		AUS	SA
BIRDS			
Acanthiza chrysorrhoa	yellow-rumped thornbill		
Acanthiza iredalei rosinae	slender-billed (samphire) thornbill		V
Acanthiza lineata	striated thornbill		
Acanthiza nana	yellow thornbill		
Acanthiza pusilla	brown thornbill		
Acanthiza reguloides	buff-rumped thornbill		
Acanthiza uropygialis	chestnut-rumped thornbill		
Acanthorhynchus tenuirostris	eastern spinebill		
Accipiter cirrhocephalus ++	collared sparrowhawk		
Accipiter fasciatus ++	brown goshawk		
Aegotheles cristatus	Australian owlet-nightjar		
Alauda arvensis*	Eurasian skylark		
Alcedo azurea	azure kingfisher	V	EX
Anas gracilis ##	grey teal		
Anthochaera carunculate	red wattlebird		
Anthochaera chrysoptera	little wattlebird		
Anthus novaeseelandiae	Richard's pipit		
Aphelocephala leucopsis	southern white-face		
Aquila audax ++	wedge-tailed eagle		
Ardea alba	great egret		
Ardea internedia	intermediate egret		R
Ardea pacifica	white-necked heron		
Ardeotis australis	Australian bustard		V
Artamus cinereus	black-faced woodswallow		
Artamus cyaqnopterus	dusky woodswallow		
Artamus personatus	masked woodswallow		
Artamus superciliosus	white-browed woodswallow		
Aythya australis ##	hardhead (white-eyed duck)		
Barnardius zonarius barnardi	Australian ringneck		
Biziura lobata	musk duck		R
Botaurus poiciloptilus	Australasian bittern		V
Cacatua galerita	sulphur-crested cockatoo		
Cacatua roseicapilla	galah		
Cacatua sanguinea	little corella		
Cacatua tenuirostris	long-billed corella		
Cacomantis flabelliformis	fan-tailed cuckoo		
Calidris acuminata	sharp-tailed sandpiper	IM	
Calidris ferruginea	curlew sandpiper	IM	
Calidris ruficollis	red-necked stint		
Calyptorhynchus funereus	yellow-tailed black-cockatoo		V

Certhionyx niger	black honeyeater		
Charadrius ruficapillus	red-capped plover		
Chenonetta jubata ##	Australian wood duck		
Chedramoeca leucostemus	white-backed swallow		
Chilidonias hybridus	whiskered tern		
Chrysococcyx Basalis	Horsfield's bronze-cuckoo		
Chrysococcyx lucidus plagosus	shining bronze-cuckoo		
Chrysococcyx osculans	black-eared cuckoo		
Cincloramphus cruralis	brown songlark		
Cincloramphus matthewsi	rufous songlark		
Cinclosoma punctatum	spotted quail-thrush	E	E
Circus approximans++	swamp harrier		
Circus assimilis ++	spotted harrier		
Cladorhynchus leucocephalus	banded stilt		
Climacteris picumnus	brown treecreeper		
Colluricincla harmonica	grey shrike-thrush		
Coracina novaehollandiae	black-faced cuckoo-shrike		
Corcorax melanorhamphos	white-winged chough		R
Cormorbates leucophaeus	white-throated treecreeper		
Corvus mellori	little raven		
Cotumix pectoralis	stubble quail		
Cracticus torquatus	grey butcherbird		
Cuculus pallidus	pallid cuckoo		
Cygnus atratus	black swan		
Dacelo novaeguineae	laughing kookaburra		
Daphoenositta chrysoptera pileata	varied sittella		
Daption capense	cape petrel		
Dicaeum hirundinaceum	mistletoebird		
Diomedea cauta	shy albatross	V,M	V
Diomedea palpebrata	light-mantled sooty albatross	M	V
Dromaius novaehollandiae	emu		
Drymodes brunneopygia	southern scrub-robin		
Egretta garzetta	little egret		
Egretta novaehollandiae	white-faced heron		
Elanus axillaries++	letter-winged kite	V	R
Elseyornis melanops	black-fronted dotterel		
Epthianura albifrons	white-fronted chat		
Epthianura tricolor	crimson chat		
Eudyptula minor	little penguin		
Eurostopodus argus	spotted nightjar		
Falco berigora #	brown falcon		
Falco cenchroides #	Nankeen kestrel		
Falco longipennis #	Australian hobby		
Falco peregrinus #	peregrine falcon		R
Falco subniger #	black falcon		
Falcunculus frontatus	crested shrike-tit		V
Fulica atra	Eurasian coot		
Gallinula ventralis	black-tailed native-hen		
Gallirallus philippensis	buff-banded rail		
Geopelia placida	peaceful dove		
Gliciphila melanops	tawny-crowned honeyeater		

Glossopsitta concinna	musk lorikeet		
Glossopsitta porphyrocephala	purple-crowned lorikeet		
Grallina cyanoleuca	magpie-lark		
Gymnorhina tibicen	Australian magpie		
Haematopus fuliginosus	sooty oystercatcher		R
Haematopus longirostris	pied oystercatcher		R
Haliastur sphenurus ++	whistling kite		
Hoeraaetus morphnoides ++	little eagle		
Himantopus himantopus	black-winged stilt		
Hirundo neoxena	welcome swallow		
Ixobrychus minutus	little bittern		E
Lalage sueurii tricolor	white-winged triller		
Larus novaehollandiae	silver gull		
Larus pacificus	Pacific gull		
Leipoa ocellate	malleefowl	V	V
Lichenostomus chrysops	yellow-faced honeyeater		
Lichenostomus omatus	yellow-plumed honeyeater		
Lichenostomus penicillatus	white-plumed honeyeater		
Lichenostomus virescens	singing honeyeater		
Limicola falcinellus	broad-billed sandpiper	IM	
Limosa lapponica	bar-tailed godwit	IM	
Ludensa brevirostris	Kerguelen petrel	M	
Macronectes giganteus	southern giant-petrel	M	V
Malurus cyaneus	superb fairy-wren		
Malurus lamberti assimillis	variegated fairy-wren		
Malurus leucopterus	white-winged fairy-wren		
Manorina melanocephala	noisy miner		
Megalurus gramineus	little grassbird		
Melanodryas cucullata	hooded robin		R
Melithreptus brevirostris	brown-headed honeyeater		
Melithreptus gularis	black-chinned honeyeater		V
Melithreptus lunatus	white-naped honeyeater		
Melopsittacus undulatus	budgerigar		
Merops omatus	rainbow bee-eater	M	
Microeca fascinans	jacky winter		R
Milvus migrans ++	black kite		
Mirafra javanica	Horsefield’s bushlark		
Myiagra inquieta	restless flycatcher		R
Neochmis temporalis	red-browed finch		
Neophema chrysogaster	orange-bellied parrot	CE	E
Neophema chrsostoma	blue-winged parrot		V
Neophema elegans	elegant parrot		R
Ninox novaeseelandiae	southern boobook		
Numenius madagascariensis	eastern curlew	IM	V
Nycticorax calendonicus	Nankeen night heron		
Ocyphaps Lophotes	crested pigeon		
Oxyura australis ##	blue-billed duck		R
Pachycephala inornata	Gilbert's whistler		R
Pachycephala pectoralis	golden whistler		
Pachycephala rufiventris	rufous whistler		
Pachyptila desolata	Antarctic prion	M	

Pachyptila salvini	Salvin's Prion	M	
Pachyptila turtur	Fairy prion	M	
Pardalotus punctatus	spotted pardalote		
Pardalotus striatus omatus	striated pardalote		
Pendionomus torquatus	plains-wanderer	V	V
Pelecanus conspicillatus	Australian pelican		
Petrochelidon ariel	fairy martin		
Petrochelidon nigricans	tree martin		
Petroica goodenovii	red-capped robin		
Petroica multicolour	scarlet robin		
Petroica phoenicea	flame robin		R
Phalacrocorax fuscescens	black-faced cormorant		
Phalacrocorax melanoleucos	little pied cormorant		
Phalacrocorax sulcirostris	little black cormorant		
Phalacrocorax varius	pied cormorant		
Phaps chalcoptera	common bronzewing		
Phaps elegans	brush bronzewing		
Phylidonyris albrifrons	white-fronted honeyeater		
Phylidonyris novaehollandiae	New Holland honeyeater		
Phylidonyris pyrrhoptera	crescent honeyeater		
Platycercus elegans	crimson rosella		
Plectorhyncha lanceolata	striped honeyeater		R
Plegadis falcinellus	glossy ibis	M	R
Pluvialis fulva	Pacific golden plover	IM	
Podargus strigoides	tawny frogmouth		
Poliocephalus poliocephalus	hoary-headed grebe		
Polytelis anthopeplus anthopeplus	regent parrot	V	V
Pomatostomus ruficeps	chestnut-crowned babbler		
Pomatostomus superciliosus	white-browed babbler		
Porphyrio porphyrio melanotus	purple swamphen		
Porzana fluminea	Australian spotted crake		
Psephotus haematonotus	red-rumped parrot		
Psephotus varius	mulga parrot		
Pterodroma lessonii	white-headed petrel	AM	
Puffinus tenuirostris	short-tailed shearwater	AM	
Pyrrholaemus brunneus	redthroat		R
Rhipidura albiscapa	grey fantail		
Rhipidura leucophrys	willie wagtail		
Rostratula benghalensis	painted snipe	M	V
Sericornis frontalis rosinae	white-browned scrubwren		
Smicromis brevirostris	weebill		
Stagonnopleura guttata	diamond firetail		V
Sterna bergii	crested tern		
Sterna caspia	Caspian tern		
Sterna hirundo	common tern		R
Sterna nereis	fairy tern		E

Sterna paradisaea	Arctic tern	M	
Stiltia Isabella	Australian pratincole	M	
Strepera versicolor	grey currawong		
Tachybaptus novaehollandiae	Australian grebe		
Taeniopygia guttata casstanotis	zebra finch		
Threskiornis molucca	Australian white ibis		
Threskiornis spinicollis	straw-necked ibis		
Todiramphus pyrrhopygia	red-backed kingfisher		
Topiramphus sanctus	sacred kingfisher		
Trichoglossu shaematodus moluccanus	rainbow lorikeet		
Tringa nebularia	common greenshank	IM	
Tringa stagnatilis	marsh sandpiper	IM	
Turnix varia	painted button-quail		R
Turnix velox	little Button-quail		
Tyto alba	barn owl		
Vanellus miles	masked lapwing		
Vanellus tricolour	banded lapwing		
Xanthomyza Phrygia	regent honeyeater	E	E
Xenus cinereus	Terek sandpiper	IM	
Zoothera lunulata	Bassian thrush		R
Zosterops lateralis	silvereye		
**** Carduelis carduelis***	European goldfinch		
**** Passer domesticus***	house sparrow		
**** Streptopelai chinensis***	spotted turtle-dove (Indian dove)		
**** Streptopelai "risoria"***	ringed turtle-dove		
**** Stumus vulgaris***	common starling		
**** Turdus merula***	Eurasian blackbird		
MAMMALS			
Antechinus flavipes	yellow-footed antechinus		V
Bettongia lesueur	burrowing bettong	E	E
Cercartetus concinnus	western pygmy-possum		
Chalinolobus gouldii	Gould's wattled bat		
Hydromys chrysogaster	water-rat		
Macropus fuliginosus	western grey kangaroo		
Macropus robustus	euro		
Mormoptenus planiceps	southern free-tail bat		R
Nyctophilus geoffroyi	lesser long-eared bat		
Phascolarctos cinereus	koala		R
Pseudocheirus peregrinun	common ringtail possum		
Saccolaimus flaviventris	yellow-bellied sheathtail bat		R
Tachyglossus aculeatus	short-beaked echidna		
Tadarida australis	white-striped freetail-bat		

Trichosurus vulpecula	common brushtail possum		R
Vespadelus regulus	southern forest bat		
****Capra hircus***	goat		
**** Cervus elaphus***	red deer		
**** Lepus capensis***	brown hare		
**** Mus musculus***	house mouse		
**** Oryctolagus cuniculus***	European rabbit		
**** Ovis aries***	sheep		
**** Rattus rattus***	black rat		
**** Vulpes vulpes***	European red fox		
REPTILES			
Aprasia inaurita	red-tailed worm-lizard		
Aprasia pseudopulchella	Flinders worm-lizard	V	
Aprasia striolata	lined worm-lizard		
Chelodina longicollis	common long-necked tortoise		
Christinus marmoratus	marbled gecko		
Cryptoblepharus carnabyi "CAC"	speckled wall lizard		
Cryptoblepharus cf plagiocephalus	desert wall skink		
Ctenophorus decresii	tawny dragon		
Ctenotus orientalis	eastern spotted ctenotus		
Ctenotus robustus	eastern striped skink		
Delma molleri	Adelaide snake-lizard		
Demansia psammophis	yellow-faced whipsnake		
Diplodactylus vittatus	eastern Stone gecko		
Egemia cunninghami	Cunningham's skink		V
Egernia striolata	tree skink		
Egernia whitii whitii	White's skink		
Eremiascincus richardsonii	broad-banded sandswimmer		
Hemiergis decresiensis	three-toed earless skink		
Hemiergis peronii	four-toed earless skink		
Lampropholis guichenoti	garden skink		
Lerista bougainvillii	Bougainville's skink		
Lerista dorsalis	southern four-toed slider		
Lialis burtonis	Burton's legless lizard		
Menetia greyii	dwarf skink		
Morethis adelaidenesis	Adelaide snake-eye		
Morethia obscura	mallee snake-eye		
Pogona barbata	eastern bearded dragon		
Pseudechis porphyriacus	red-bellied black snake		
Pseudemoia entrecasteauxii	southern grass skink		
Pseudonaja textilis	eastern brown snake		
Pygopus lepidopodus	common scaly-foot		
Ramphotyphlops australis	southern blindsnake		
Ramphotyphlops bituberculatus	rough-nosed blindsnake		
Tiliqua adelaidensis	pygmy blue-tongue	E	E
Tiliqua occipitalis	western bluetongue		
Tiliqua rugosa	sleepy lizard		
Tiliqua scincoids	eastern bluetongue		
Tympanocryptis lineata	five-lined earless dragon		
Varanus rosenbergi	heath goanna		R

AMPHIBIANS			
Crinia signifera	common froglet		
Limnodynastes dumerili (SCR)	bull frog		
Limnodynastes tasmaniensis (SCR)	spotted grass frog		
Litoria ewingi	brown tree frog		
Pseudophryne bibroni	brown toadlet		R
Neobatrachus pictus	painted frog		

Species listing is in alphabetic order, not taxonomic order.

Sources: Department of Environment and Heritage and the South Australian Museum databases; Paton et al. 1994. Note : additional species are present in the region. These are referred to in text.

* indicates an introduced species.

= species belonging to the Anatidae; ++ = species belonging to the Accipitridae; + = species belonging to the Falconidae

IM = international migratory shorebird species

M = migratory species of water or sea bird.

SCR = southern call race

AUS = Australia, SA = South Australia

National Conservation Rating (Aus)

V = Vulnerable; rare and at risk from potential threats in the long term

E = Endangered; rare and in danger of becoming extinct

CE = Critically endangered

State Conservation Rating (SA)

EX = Extinct

E = Endangered; rare and in danger of becoming extinct

V = Vulnerable; rare and at risk from potential threats in the long term

R = Rare having a low overall frequency, confined to a restricted range or scattered sparsely over a wider area

Table A.2 is a list of all terrestrial, aquatic, shore and wading bird species recorded in the region from authorities and references for the region and the project area. The list provides a summary of data from observations over October 2007 to October 2008 in the project area and site according to particular habitat zones as follows:

Zones A & B = Gawler River and site floodplain woodland

Zone C = Thompson Creek wetlands and shrublands and other wetlands, including farm dams, on the site

Zone D = disturbed areas, including farmland, horticultural areas and structures, planted vegetation and roadsides

Zone E = samphire and other chenopod low shrublands

Zone F = immediately adjacent to the project area, especially the wetlands and shrublands west of the site on Beagle Hole Road and the saltpans along the south west edge of the site.

Total survey indicates that the species was recorded during the survey in the project area or the immediately adjacent region i.e. the species is present or expected to occur on the site at some stage.

The presence of a species is confirmed by a + under the total survey column with the numbers recorded in each zone designated as S = < 5, M= 6 to 20, L = > 21.

B = breeding in 2007/08, b = recorded as breeding in the region by others (literature), M = migratory, * = introduced species.

The occurrence of species recorded during field surveys according to season is indicated under Sp = spring, Su = summer, A = Autumn and W = winter. The presence and numbers of each species according to season is indicated by C= common, O = occasional, U = uncommon, R = rare.

Table A.2 Bird species list for the project area and immediately adjacent to the project area

Zones A & B	Zone C	Zone D	Zone E	Zone F	Total Survey	Common name	Sp	Su	A	W	Notes
	S	S	S		+	Stubble Quail	O	O	R	R	
	S	S		M	+	Black Swan	C	C	U	C	b
		S		S	+	Cape Barren Goose	O	O	O	R	
	S	S		S	+	Australian Shelduck	C	C	C	C	b
S	S	M		L	+	Maned Duck (Wood Duck)	U	U	U	U	B
S	S	S		L	+	Grey Teal	C	C	C	C	B
	S			M	+	Chestnut Teal	C	C	C	C	b
S	S			M	+	Pacific Black Duck	C	C	U	C	B
S	S			S	+	Mallard*	U	U	U	U	*
	S			M	+	Australasian Shoveler	C	C	U	C	b
S	S			M	+	Hardhead	C	C	U	C	b
						Blue-billed Duck	U	U	O	R	b
S				S	+	Musk Duck	O	U	O		M

Zones A & B	Zone C	Zone D	Zone E	Zone F	Total Survey	Common name	Sp	Su	A	W	Notes
						Great Crested Grebe	O	O			
S	L			L	+	Hoary-headed Grebe	C	C	C	C	b
S	M			M	+	Australasian Grebe	C	C	C	C	B
S	S			S	+	Little Pied Cormorant	C	C	C	C	
	S			S	+	Pied Cormorant	R		R	R	
S				S	+	Little Black Cormorant	C	C	C	C	
S	S		S	S	+	Australian Pelican	C	C	C	C	
S	S	M	S	M	+	White-faced Heron	C	C	C	C	B
	S			S	+	Little Egret	C	C	C	U	
	S			S	+	White-necked Heron	O		O	R	
				S	+	Great Egret	C	C	C	C	
S	S			S	+	Cattle Egret	O	O	O	U	
S					+	Nankeen Night-Heron	O	U	U	O	
						Australasian Bittern	U	R	U	U	
						Glossy Ibis	U	U	O	O	
S	S	M	M	M	+	Australian White Ibis	C	C	C	C	
S		S		S	+	Straw-necked Ibis	O	O	O	O	
				S	+	Royal Spoonbill	U	C	C	U	
S	S			M	+	Yellow-billed Spoonbill	U	C	C	U	
S		S	S	S	+	Black-shouldered Kite	C	C	C	C	b, B
		S	S	S	+	Black Kite	O	O	O		
M	S	S	S	S	+	Whistling Kite	C	C	C	C	b, B
S				S	+	White-bellied Sea-eagle	O	O	O	R	
		S		S	+	Spotted Harrier	R	R	O	O	
		S		S		Swamp Harrier	C	C	C	C	
S				S	+	Brown Goshawk	U	U	U	U	b
S				S	+	Collared Sparrowhawk	U	U	U	U	b, B
S				S	+	Wedge-tailed Eagle	O	O	O	O	B
S				S	+	Little Eagle	U	U	U	U	
S		S	S	S	+	Brown Falcon	U	U	U	U	b,B

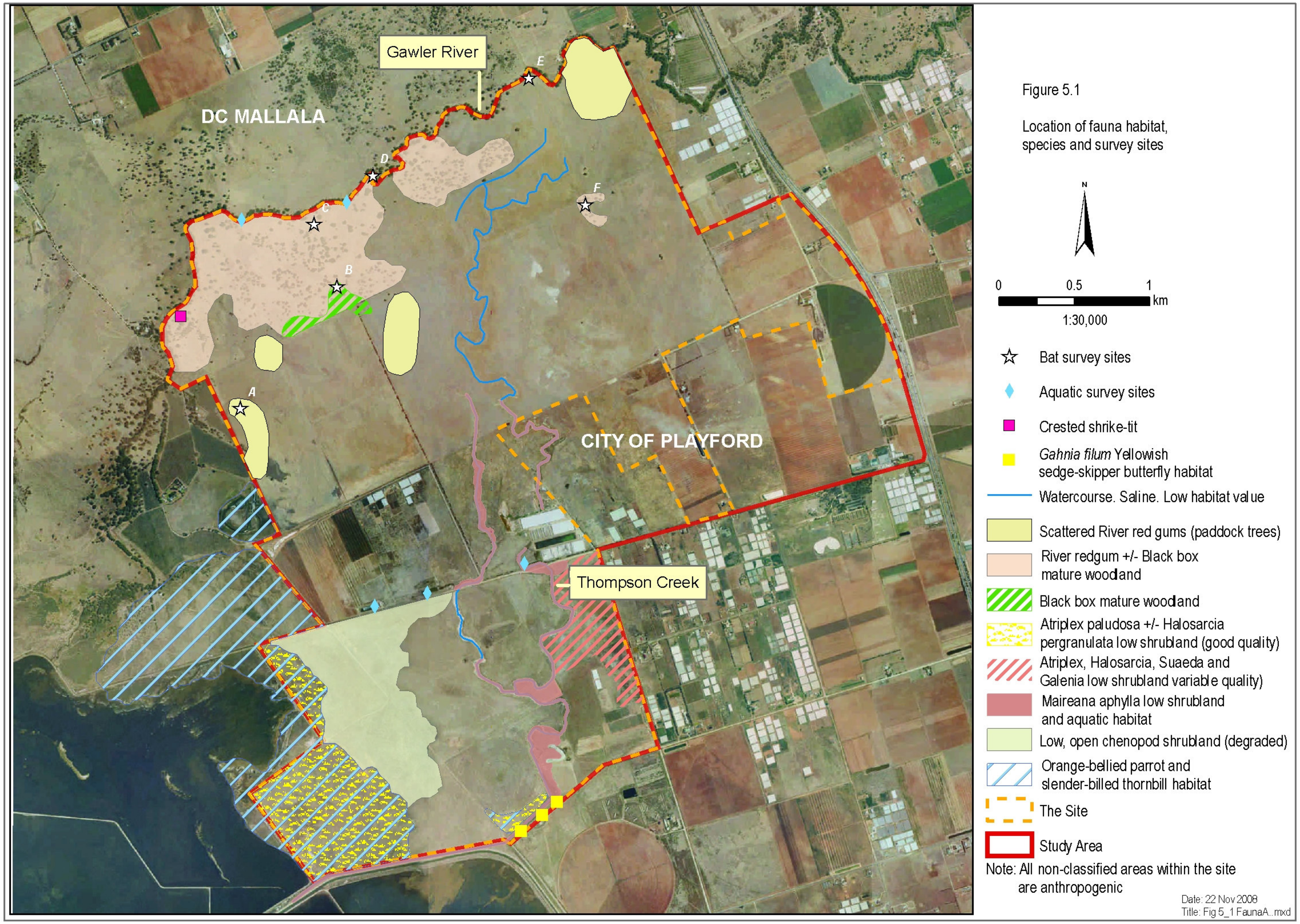
Zones A & B	Zone C	Zone D	Zone E	Zone F	Total Survey	Common name	Sp	Su	A	W	Notes
S	S	S		S	+	Australian Hobby	C	U	U	U	b
S					+	Black Falcon	O	O	O	U	
S				S	+	Peregrine Falcon	U	U	U	U	?
S		S	S	S	+	Nankeen Kestrel	C	C	C	C	b,B
	S			M	+	Buff-banded Rail	U	U	O	U	B
						Lewins Rail			R	R	
				S	+	Baillons Crake	C	C		U	B
				S	+	Australian Spotted Crake	C	C	C	U	B
S	S	M		M	+	Purple Swamphen	C	C	O	C	B
	S	S	M	M	+	Dusky Moorhen	C	C	C	C	B
S	S	L	M	M	+	Black-tailed Native-hen	C	C	C	C	B
M		L	L	L	+	Common Coot	C	C	C	C	B
						Little Buttonquail	R				
						Lathams Snipe	U	U		R	M
						Black-tailed Godwit		U		O	M
				S	+	Marsh Sandpiper	U	C	C	O	M
				S	+	Common Greenshank	U	C	C	U	M
	S			M	+	Wood Sandpiper	U	C	C	U	M
						Terek Sandpiper		R			M
	S			S	+	Common Sandpiper	U	U	U	O	M
				S		Ruddy Turnstone	O				M
				S		Red Knot				R	M
	S			M	+	Red-necked Stint	U	C	U	O	M
						Long-Toed Stint	U	U	O		M
	S			M	+	Pectoral Sandpiper	U	U	O		M
	S			M, L	+	Sharp-tailed Sandpiper	C	C	C	O	M
				S	+	Curlew Sandpiper	U	U	O	O	M
						Broad-billed Sandpiper	R	R			M
						Ruff (Reeve)		R			M
				S	+	Painted Snipe	R	O	R	R	M

Zones A & B	Zone C	Zone D	Zone E	Zone F	Total Survey	Common name	Sp	Su	A	W	Notes
	S			M	+	Black-winged Stilt	C	C	C	C	B
						Banded Stilt	U	U	U	O	
						Red-necked Avocet	U	U	U	O	
						Pacific Golden Plover	R	O			M
	S			S	+	Red-capped Plover	U	C	C	C	B
	S	M	M	M	+	Black-fronted Plover	C	C	C	C	B
	S			S	+	Red-kneed Dotterel	C	C	C	C	B
		S		S	+	Banded Lapwing	O	O	O	O	
S	S	M	M	M	+	Masked Lapwing	C	C	C	C	B
S	M	M	M	L	+	Silver Gull	C	C	C	C	B
	S			M	+	Caspian Tern	U	U	U	U	
	S			M	+	Whiskered Tern	C	C	C	U	
M	S	L	L	L	+	Feral Pigeon (Rock Dove)*	C	C	C	C	B*
						Barbary Dove*			R		
M	S	S	S	M	+	Spotted Turtle-Dove*	C	C	C	C	B*
S				S	+	Common Bronzewing				R	
L	M	M	M	L	+	Crested Pigeon	C	C	C	C	B
						Peaceful Dove			R		
S				S	+	Yellow-tailed Black-Cockatoo	R				M
L	S	L	S	L	+	Galah	C	C	C	C	B
L		S		S	+	Little Corella	O	O	O	O	B
S			S	S	+	Sulphur-crested Cockatoo	O	R	O	O	
S				S	+	Cockatiel	O		O	O	
M				M	+	Rainbow Lorikeet	O	O	U	U	
M			S	S	+	Musk Lorikeet	O	U	U	U	
						Purple-crowned Lorikeet	U	U	U	U	
M				M	+	Adelaide Rosella	O	O	O	U	B
M	S			M	+	Blue Bonnet		R			
L		S		M	+	Red-rumped Parrot	O	O	O	O	B
						Budgerigar	O	R			

Zones A & B	Zone C	Zone D	Zone E	Zone F	Total Survey	Common name	Sp	Su	A	W	Notes
			S	S	+	Blue-winged parrot	R				
S	S		M	S	+	Elegant Parrot	U	U	R	R	
						Rock Parrot	R	R		R	
S		S		S	+	Pallid Cuckoo	U	R		O	B
						Horsfield's Bronze Cuckoo	C	U	O	U	b
						Shining Bronze-Cuckoo	O				
S					+	Southern Boobook	R		O	O	B
S		S	S		+	Barn Owl	U	U	U	O	B
S					+	Tawny frogmouth	O	O	O	O	B
S					+	Owlet nightjar	O	O			B
	M			M	+	Fork-tailed Swift		O	O		M
				S	+	Red-backed Kingfisher	R				
S				S	+	Sacred Kingfisher	U	O	O		M
S	S		S	S	+	Superb Fairywren	U	U	U	U	
	M		M	L	+	White-winged Fairywren	U	U	U	U	B
S					+	Spotted Pardalote				R	b
S		S		S	+	Striated Pardalote	R			O	
						Brown Thornbill			R	O	
M	S			S	+	Yellow-rumped Thornbill	U	U	U	U	
						Orange Chat	R				
S		M	S	S	+	White-fronted Chat	C	C	C	C	B
M		S	S	M	+	Red Wattlebird	U	U	U	C	
	S			S	+	Spiny-cheeked Honeyeater	O		O	R	
L		S		L	+	Noisy Miner	O		O	O	B
						Yellow-faced Honeyeater			R		
S	S	S	M	M	+	Singing Honeyeater	C	C	C	C	B
						Yellow-plumed Honeyeater				R	
M	S	S	S	M	+	White-plumed Honeyeater	C	C	C	C	B
						White-naped Honeyeater			O		
M	S	M	S	S	+	New Holland Honeyeater	C	C	C	C	B

Zones A & B	Zone C	Zone D	Zone E	Zone F	Total Survey	Common name	Sp	Su	A	W	Notes
						Red-capped Robin	R		O	O	
S				S	+	Golden Whistler	O		R	O	
				S	+	Rufous Whistler	O	R	O	O	
S				S	+	Grey Shrikethrush	U	U	U	U	b
M	S	M	M	M	+	Magpie-lark	C	C	C	C	B
S				S	+	Grey Fantail	U	O	U	U	
M	S	S	S	M	+	Willie Wagtail	C	C	C	C	B
S			S	S	+	Black-faced Cuckoo-shrike	U	U	C	C	b
S		S		S	+	White-winged Triller	O	O		O	B
M	S	L	M	M	+	Australian Magpie	C	C	C	C	B
S	S	S	S	S	+	Australian Raven	C	C	C	C	B
S	S	S	S	M	+	Little Raven	C	C	C	C	
	S	S		S	+	Skylark*	C	C	C	C	B*
	S	S	S	S	+	Richard’s Pipit	U	U	U	U	B
M	M	L	L	L	+	House Sparrow*	C	C	C	C	B*
						European Greenfinch*	U	O	U	U	*
				S	+	European Goldfinch*	O	O	O	O	*
						Mistletoebird			O	O	
L	L	S	L	L	+	Welcome Swallow	C	C	C	C	B
M	S			M	+	Tree Martin	C	C	C	O	
M	M			M	+	Fairy Martin	C	C	C	O	B
S	S			M	+	Australian Reed-Warbler	C	C	C	U	B
S	S			S	+	Little Grassbird	C	C	C	C	B
						Rufous Songlark	U		R		
			S	S	+	Brown Songlark	U	U	O	U	b
						Golden-headed Cisticola	R		R	R	
S	S	L	S	M	+	Silvereye	U	U	O	U	B
M	S	S	S	M	+	Common Blackbird*	C	U	U	C	B*
L	L	L	L	L	+	Common Starling*	C	C	C	C	B*

APPENDIX B SITE SURVEY PLAN


Gawler River
DC MALLALA
CITY OF PLAYFORD
Thompson Creek
A
B
C
D
E
F
Figure 5.1
Location of fauna habitat, species and survey sites
N
0
0.5
1
km
1:30,000
Bat survey sites
Aquatic survey sites
Crested shrike-tit
Gahnia filum Yellowish sedge-skipper butterfly habitat
Watercourse. Saline. Low habitat value
Scattered River red gums (paddock trees)
River redgum +/- Black box mature woodland
Black box mature woodland
Atriplex paludosa +/- Halosarcia pergranulata low shrubland (good quality)
Atriplex, Halosarcia, Suaeda and Galenia low shrubland variable quality)
Maireana aphylla low shrubland and aquatic habitat
Low, open chenopod shrubland (degraded)
Orange-bellied parrot and slender-billed thornbill habitat
The Site
Study Area
Note: All non-classified areas within the site are anthropogenic
Date: 22 Nov 2008
Title: Fig 5_1 FaunaA..mxd

APPENDIX C SITE PHOTOGRAPHS

Fauna Habitat

Photo 1: Mature River red gum woodland

Photo 2: Regrowth River red gum woodland

Photo 3: Scattered River red gum paddock trees over anthropogenic understorey (paddock)

Photo 4: Scattered mature River red gum trees over grazed paddock understorey

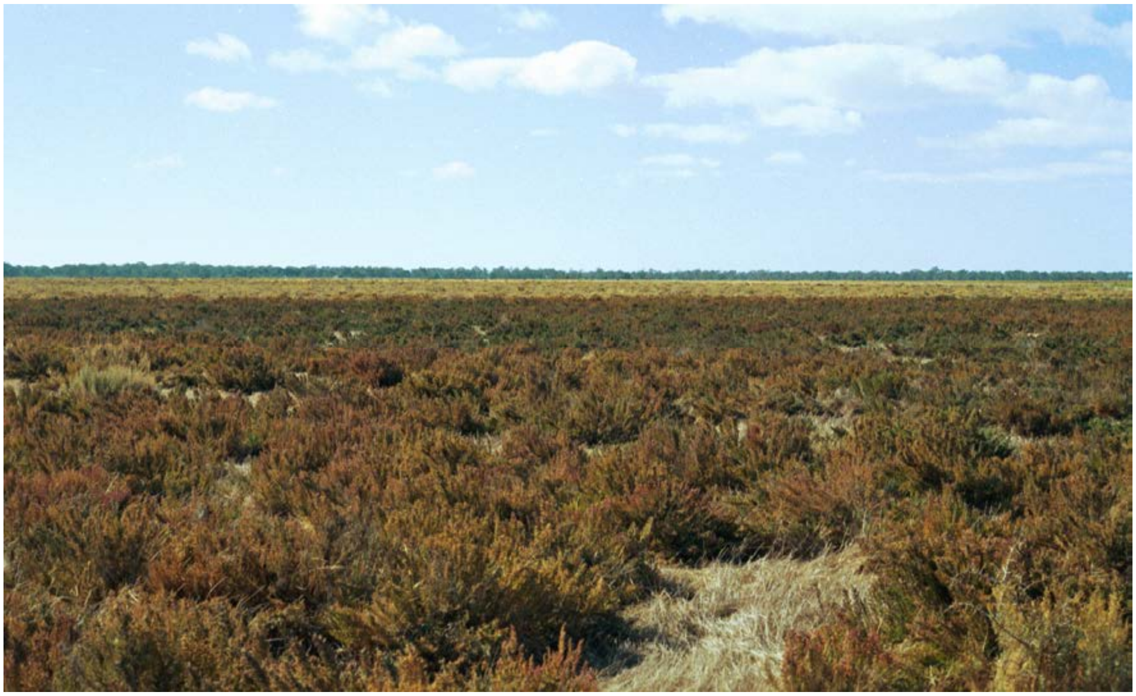


Photo 5: Low chenopod shrubland

Photo 6: Tall grassland along Thompson Creek

Photo 7: Low chenopod shrubland along Thompson Creek

Photo 8: Open paddock used for livestock grazing

Photo 9: Planted shelter belt along fenceline and cereal crop paddock

Photo 10: Northern portion of Thompson Creek. Reduced to a salt scald in grazing paddock

APPENDIX D ABBREVIATIONS AND GLOSSARY

List of abbreviations

AnaBat detector	An assessment method that permanently records and converts the echolocation signals of bats into audible electronic signals to assist in species identification
ANZECC	Australian and New Zealand Environment Conservation Council
CAMBA	Agreement between the Government of Australia and the Government of the Peoples Republic of China for the Protection of Migratory Birds and their Environment (1986)
CEMP	Construction Environmental Management Plan
CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora (1973)
DEH (SA)	South Australian Department for Environment and Heritage
DEWHA (Cwlth)	Department of the Environment, Water Heritage and the Arts
DTEI	Department for Transport, Energy and Infrastructure
dGPS	Differential Global Positioning System
EMP	Environmental Management Plan
EPA	Environment Protection Authority of South Australia
EPBC Act	Environment Protection and Biodiversity Conservation Act 1999 - Commonwealth
GPS	Global Positioning System
GIS	geographic information system
ha	hectares
JAMBA	Agreement between the Government of Japan and the Government of Australia for the Protection of Migratory Birds and Birds in Danger of Extinction and their Environment (1974)
KBR	Kellogg Brown & Root Pty Ltd
m	metres
NExy	Northern Expressway
NPW Act	National Parks and Wildlife Act (SA) 1972 - State
NRM Act	Natural Resources Management Act 2004 - State
NVC	Native Vegetation Council - State
SA	South Australia
SAM	South Australian Museum

SEB	significant environmental benefit
syn.	synonym

Glossary

Aeolian	Relating to or caused by wind.
Adelaide Plains	A relatively flat area from the Northern Adelaide Plains to the Willunga basin in the south, covering about 560km^2 (see also Northern Adelaide Plains)
Agriculture	The science of producing healthy plants and animals for food and other uses.
Alkaline	Having a pH greater than 7.
Alluvium	Sediment deposited by flowing water, as in a riverbed, flood plain or delta.
Anthropogenic	Caused by humans or related to human activity.
Arboreal	Living in or amongst trees.
Biodiversity	The variety of all life forms; different plants, animals and micro-organisms, the genes they contain, and the ecosystems they form.
Brackish	Slightly saline water that contains dissolved salts in the range 0.5-30 ppm, being less salty than seawater (35 ppm).
Calcareous	Composed of, containing, or characteristic of calcium carbonate, calcium, or limestone; chalky.
Calcrete	A conglomerate of gravel and sand cemented by calcium carbonate.
Crepuscular	Species which are active just after sunset and prior to dawn.
Ecology	The study of the interaction between living organisms, and with their physical, chemical and biological environments.
Ephemeral wetlands	Wetlands that temporarily hold water.
Floodplain	A plain bordering a river and subject to flooding.
Habitat	The locality or environment where a plant, animal, population or community of interest lives. Each living organism has a preferred habitat with the physical surroundings having a direct bearing on the organism's function and survival.
Horticulture	Intensive cultivation of flowers, fruits, vegetables, or ornamental plants.
Hydro-period	The period of time during which a wetland is covered by water.
Indigenous	Originating and living or occurring naturally in an area or environment.
Introduced species	An animal or plant that has been introduced to an area where it normally does not occur.

Invasive species	A species is regarded as invasive if it has been introduced by human action to a location, area, or region where it did not previously occur naturally (i.e., is not native), and becomes capable of establishing a breeding population in the new location without further intervention by humans, spreading widely throughout the new location.
In-stream flora	Plant species growing in an aquatic environment.
Limestone	A common sedimentary rock consisting mostly of calcium carbonate, CaCO3.
Lower stratum	Lowest layer of the vegetation canopy.
Micro-chiropteran	Insectivorous bats.
Middle stratum	Middle layer, usually as shrubs, of the vegetation.
Migratory species	A mobile organism that changes habitat according to season, climate, foot supply etc, often across vast distances and along defined paths
National Estate	Those places, being components of the natural or cultural environment of Australia, that have aesthetic, historic, scientific, or social significance, or other special value for future generations and for the present community.
Native	Animals or plants that originate in the region in which they are found, i.e., not introduced and naturally occurring in an area.
NExy North	The northern area of a new road being constructed by the State Government from Gawler to Port Wakefield Road and terminating at Taylor Road.
Northern Adelaide Plains	A relatively flat area covering approximately 750 km^2 centred 30 km north of Adelaide's CBD, and forming part of the larger St Vincent (Sedimentary) Basin.
Outwash plain	A broad, outspread flat or gently sloping alluvial deposit of outwash.
Overstorey	The roughly horizontal uppermost layer of mature vegetation (i.e. trees) that overtops all other layers of foliage in the understorey (e.g. mallee, river red gums).
Pre-European	Before European settlement (1836 in South Australia).
Ramsar Convention	The Convention on Wetlands, signed in Ramsar, Iran, in 1971 providing the framework for the conservation and wise use of wetlands and their resources, especially dependent avifauna species.
Recent	Geological time period from the present day to 10,000 years BP.
Region	The general vicinity in which the proposal is located.
Remnant	A small surviving area; remnant vegetation includes all indigenous vegetation communities.

Riparian	Relating to the banks of a watercourse or other water body.
Site	1,308 ha as defined on Figure 2. Other locations outside the site, particularly along its boundaries, which may be impacted by the proposal are considered as part of the site. These include areas where indirect or consequential environmental effects may occur as a result of the proposal and include specific areas mentioned in the Guidelines for the EIS.
Subcrop	An occurrence of strata immediately beneath the soil surface.
Terrestrial	Living or found on land, as opposed to in water bodies or the atmosphere
Threatening process	A process that threatens, or may threaten, the survival, abundance or evolutionary proposal of a native species or ecological community.
Understorey	The small trees, shrubs, herbs and grasses which make up the lower layers of vegetation in a vegetation community
Upper stratum	Tallest layer of the vegetation canopy
Vagrant	A species occurring outside its normal distribution or range.
Vegetation communities	The composition of the vegetation according to the plant species present and the relative cover of each

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Landscape Character & Visual Assessment

Buckland Park

25 March 2009, ref 07315_Final_rev1

Prepared for:
Walker Corporation

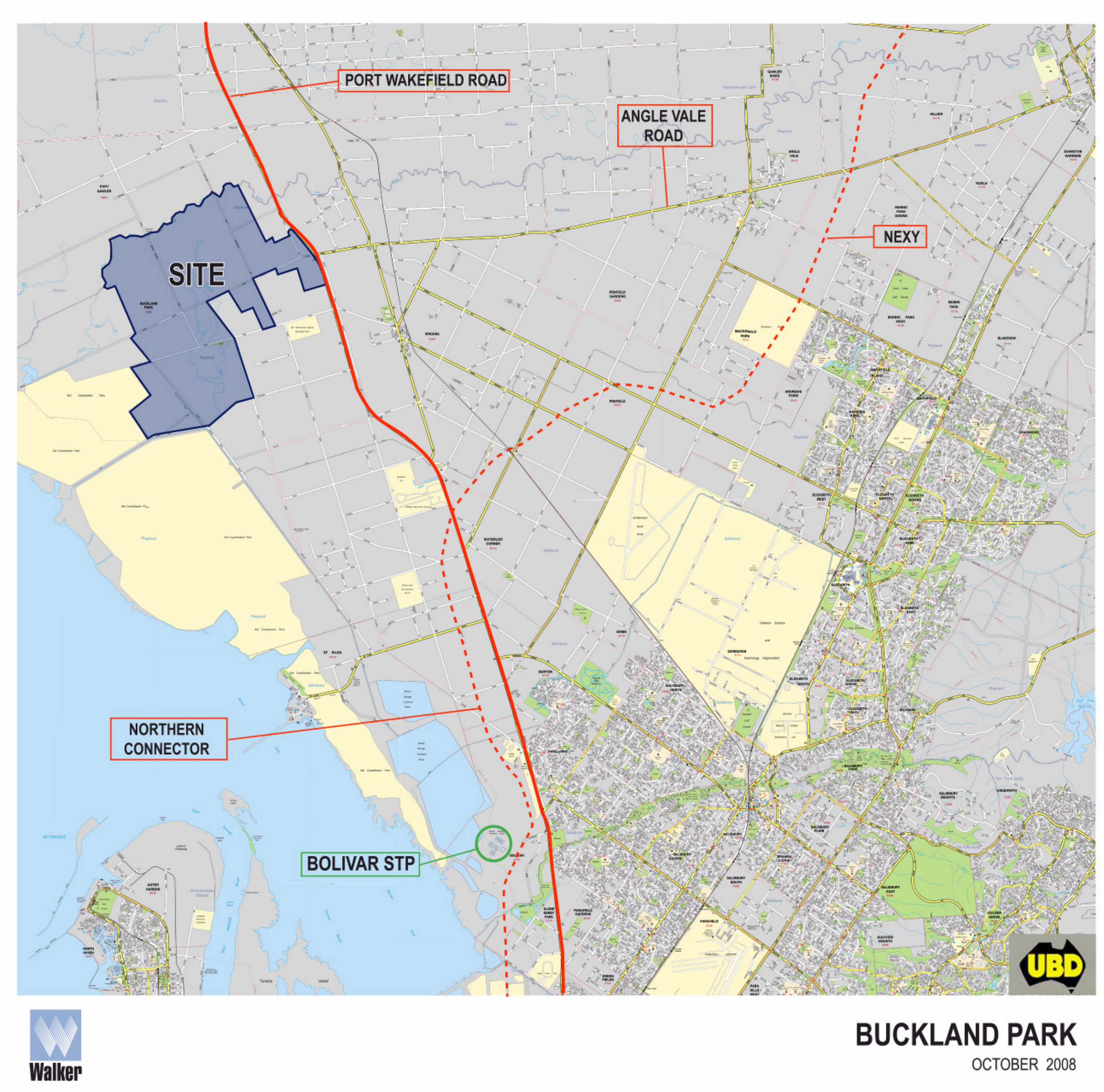
Contents

1. Introduction

The report relates to the Buckland Park proposal, located approximately 32km north of the Adelaide CBD and 14km north of Elizabeth. The Buckland Park proposal is a joint venture of the Walker Corporation and Daycorp.

The site is approximately 1340 hectares located between Virginia and Port Gawler, within the City of Playford (see Figure 1).

Figure 1 Site locality map (not to scale)



The site is bounded by Port Wakefield Road to the east, the Gawler River to the north, Cheetham Salt Limited to the west and arable horticultural land to the south. The site is approximately 5km from the Port Vincent Gulf coastline, with Port Adelaide and Outer Harbour a distant visible landmark to the south west.

It is anticipated that the proposal will comprise of 12,000 residential allotments with a range of densities with the average size of allotment to be approximately 500m2. Associated mixed use precincts will support the proposal with a range of schools and employment and retail precincts forming a diverse, sustainable community. Furthermore, the proposal includes a network of open space for connectivity, recreation, stormwater management and ecological sustainable environments for fauna and flora habitat. The proposed master plan is illustrated in Figure 2.

Figure 2 Master plan Buckland Park

This report will elaborate on the visual amenity of the locality with reference to the existing landscape character, land use, degree of visual complexity and scale of existing built form in the surrounding visual context.

2. Methodology

The preliminary stages of the assessment encompassed a literature review of the following documents

- Buckland Park Master Plan
- City of Playford Development Plan consolidated 7th August 2008
- Existing land use
- Connor Holmes (2008) Buckland Park Major Development Planning Report

The second stage involved a site assessment. The assessment was conducted on the 25th February 2009 to clarify the landscape character and potential visual effects of the proposal. To define the extent of the predicted visual locality a hand held Global Positioning System (GPS) was used to certify the potential viewshed and also to provide reference information on elevation of the potential visual observation of points along Port Wakefield Rd and surrounding publicly accessible locations to the north, south, east and west within a 5km radius.

The potential extent to which the proposal will be seen from the surrounding landscape region was determined by using a Global Positioning System (GPS) which provides accuracy to approximately 4 to 5 metres. During the field assessment, using the GPS, the location and visual extent of the proposal was recorded and plotted as Waypoints using latitude and longitude with a reference grid datum of GDA 1984.

The extent of the visual effect is discussed in section 4 of this report.

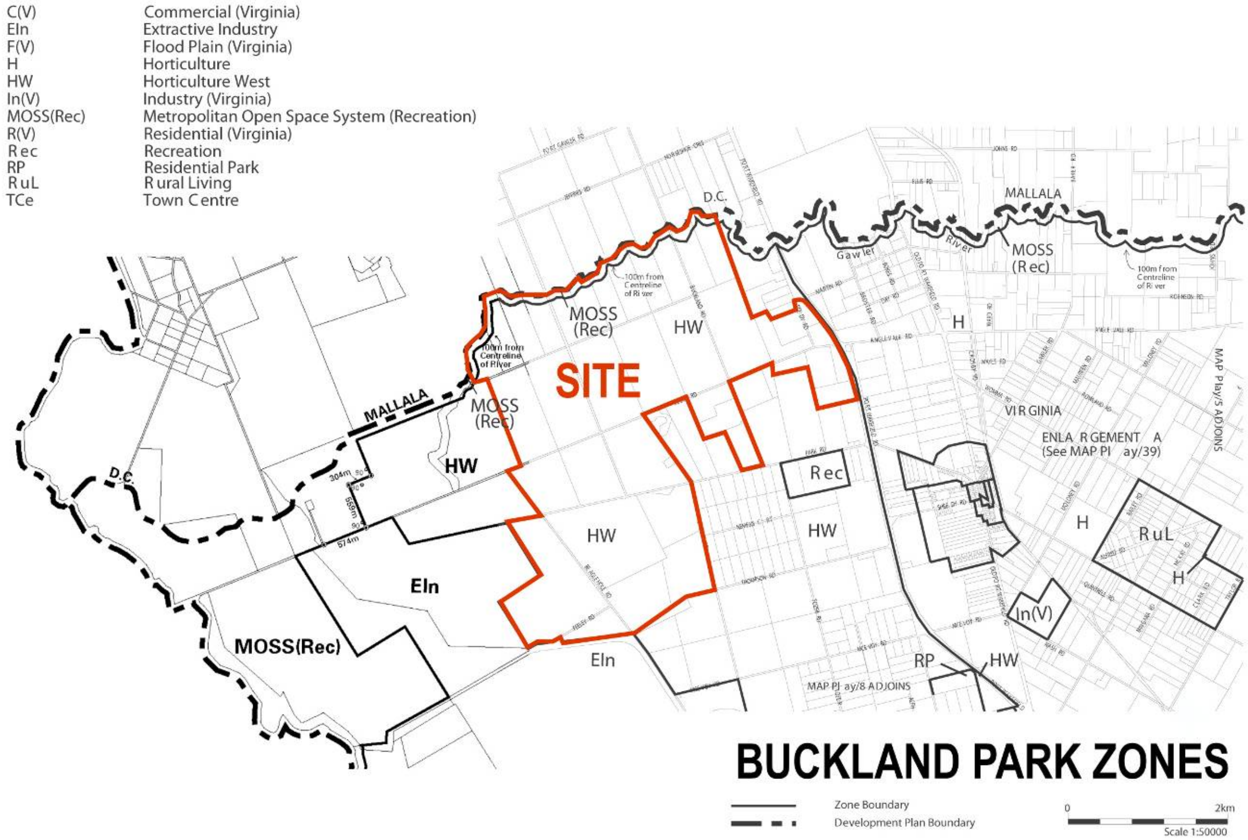
Following the site assessment, GPS coordinates were mapped and supported by a photographic survey which illustrates the visual effect. The photographic survey supports the discussion on the existing landscape character.

3. Context and Landscape Character

Landscape Context

The site is located at Buckland Park, west of Port Wakefield Rd and Virginia, and to the south of Port Gawler. It is located within the City of Playford and the existing development policy areas are illustrated in Figure 3.

Figure 3 Context plan



The site is located within the Horticulture West Zone.

This character zone is distinguished by open rural areas, market gardens, vineyards, orchards and open paddocks. These areas are supported by greenhouses, packaging sheds and residential rural living. The Gulf St Vincent is approximately 5km to the west of the site.

To the south, west and south west are areas of more intensive extractive land use, associated with Jeffries demonstration farm and composting facility and Cheetham salt pans. The salt pans are used to concentrate seawater through a series of gravity fed evaporation ponds ultimately resulting in salt being harvested and stockpiled. The process uses ground and mains water to create saturated brine which is pumped to Osborne where it is processed into Soda Ash. This environment is relatively stable providing habitat and food for a wide variety of birds. Buckland Park Lake is located to the north of Cheetham and forms an associated visual element to the salt pans.

Further to the west is a large expanse of coastal mangrove and estuaries associated with the Gawler River and local drainage swales. This policy area is designated as Metropolitan Open Space (Recreation). The character is defined by the low lying saltbush and samphire and dense mangroves closer to the coastal edge. Part of this coastal environment has been designated as Port Gawler Conservation Park, providing protection to a diverse arrangement of flora and fauna habitat.

To the south east of the site directly adjacent to Park Road is a recreational area used for the State Shooting Park (Office for Recreation and Sport) which provides 20 free pistol bays, 10 sets of turning targets and 2 skeet layouts. The shooting range has periphery fencing and a vegetation buffer limiting views into the site.

A disused silo located on the Jeffries demonstration farm is a dominant visual element. The silo is elevated above what is a denuded flat landscape with limited topographic or vegetative features. The silo is located approximately 350m to the south of the site boundary.

To the east approximately 2km across Port Wakefield Road is the small township of Virginia. Virginia is characterised by a mixture of rural residential living, greenhouses and horticultural practices to the periphery and a small commercial, retail precinct along Old Port Wakefield Road. There is no visual connection between Virginia and the Buckland Park site.

Port Wakefield Road forms a major transportation link to the north of Adelaide, providing connections for freight. This infrastructural form delineates the rural living context of Virginia to the east and more intensive horticultural practices.

Forming the site's northern boundary is the Gawler River, meandering in an east west direction. The river corridor is designated as Metropolitan Open Space (MOSS) recreation, providing a buffer of vegetation and open space, creating a defined character zone.

The proposal as illustrated in the Master Plan is consistent with the significance of the Gawler River corridor and the objectives of the MOSS (recreation) Zone.

Port Gawler is located approximately 2km to the north of the site, located at the intersection of Port Gawler Rd and Brownes Rd and is characterised by a small array of rural dwellings and associated farming equipment.

The environmental context of Buckland Park is changing to an extent where it is becoming more appropriate to consider the area for urban purposes. Some of the driving forces behind this rationale are;

- Relocation of the 7RAR Battalion with 1,200 personnel from Darwin to facilities at Edinburgh Defence Precinct, creating a significant demand for housing to the north of Adelaide.
- Construction of the Northern Expressway (NEXY). This will improve accessibility to the northern suburbs of Adelaide and surrounding regions.
- A decline in Metropolitan land stocks and housing affordability.

The Northern Expressway (NEXY) development is located to the south and east of the site, traversing to the south of Virginia. The road corridor will consist of a wide road reserve and overpass structures providing new visual elements within the regional landscape. The proposal will not be visible from the NEXY road corridor due to distance.

Referring to Conner Holmes (2008), the site is located within the Horticultural West and MOSS (recreation) zones of the City of Playford. The proposal does not comply with the principles and objectives of these zones as they currently documented. Subject to the proposal receiving approval from the Governor, a Development Plan Amendment (DPA) will be required. The DPA will seek to reclassify land parcels with a combination of zones reflecting the intended use of the land (as outlined in Figure 2). New principles need to be prepared for these zones which seek and to protect existing landuse so that coexistence with the proposal can be achieved.

The MOSS (Recreation) Zone will be retained and extended to include a network of open space.

The DPA investigations report will consider visual amenity and specific landscape character preservation.

Regional Landscape Character (2-5km radius of proposal)
(Refer to Appendix A for land use character zones)

The dominant landscape character is defined by a mixture of intensive grazing, horticultural practices and regimented, structured paddocks and greenhouses. The land is relatively flat with limited topographic features. The uniformity of the landscape diminishes the scenic amenity of the landscape.

Due to the low lying and flat landscape character, expansive views are experienced to the south of the site towards Port Adelaide and Outer Harbour. The scale of the shipping cranes provides a backdrop to a distant industrial character.

Infrastructural forms are scattered throughout the landscape, with major vertical and horizontal scaled elements such as transmission lines being collocated to road corridors, specifically Port Wakefield Road. The various scales of transmission lines (66kv and 11kv lines) aligned to various orientations, provides complexity to the skyline whilst traversing along road corridors. Some isolated visual elements are present in the form of a telecommunication tower and the disused silo located within Jeffries demonstration farm.

Figure 4 Greenhouses

Figure 5 Jeffries silo to the distance

Port Wakefield Road represents a major interstate transportation corridor in a north south orientation with an easement of approximately 60metres. The road corridor provides fragmented views with existing verge plantings filtering the depth of visual field. Located along Port Wakefield Rd are numerous tertiary roads which typically have development of greenhouses or isolated rural dwellings at the intersections.

The most dominant visual element within this landscape region is the Gawler River open space. The vertical scale of the remnant Eucalypts which align the riverbed provide a backdrop for views from the south and north. The meandering form of this vegetation corridor dissects the landscape providing a natural gateway to those travelling through the landscape and across the river on Port Wakefield Road. The river is ephemeral with limited flow in the summer months.

To the west of the site, there are some glimpsed views of the coast in and around Windamere Estate. The man made levy banks to the salt pans limit the views across the horizontal landscape.

The Site

The dominant landscape character is defined by horticultural practices. The visual character of the site is bounded by the Gawler River corridor to the north. The river corridor provides a dense vegetation buffer, preventing more expansive views to the north or from the north of the proposed site.

The site is denude of visually significant vegetation and has been intensively eroded by horticultural and grazing practices. The landform is flat with the exception of Thompson Creek which represents a dryland swale showing signs of erosion and infill from neighbouring farming practices.

Windamere Estate is adjacent to the site to the west. Windamere has a rural residential dwelling and olive grove. Similarly a property on Buckland Road which bounds the south eastern side of the side has associated olive groves.

4. Potential Visual Effects

(Refer to Appendix B for map of photographic survey Waypoint locations)

Waypoint 001

Travelling to the north along Port Wakefield Road the proposal will not cause any visual intrusion until the intersection of Park Road. At the intersection of Park Road and Port Wakefield Road the existing linear infrastructure of the road corridor and transmission lines provide a scaled reference to urban development. A residential dwelling and orchard are present to the north- west of the intersection. The transmission line aligned to Park Road is described as an 11kv line with vertical scale of approximately 6-10 metres (Figure 6). The pylons form a repetitive visual element to the road corridor. The proposal includes replacement of the 11kv and co-location to a 66kv aligned to the southern verge of Park Road. It is predicted that this will provide a proportionate increase in the visual affects along this road corridor, however this will be contained to a local visual effect. The proposed 66kv transmission line will be twice the vertical scale of the existing pylons. (Refer to Appendix C & D for transmission line alignment and photomontage)

Figure 6 View to the west of Park Rd and Port Wakefield Rd intersection

Two existing transmission lines are aligned parallel to the east of Port Wakefield Road. The scale of the 66kv dominates the skyline with the 11kv line forming a more proportionate scale to scattered vegetation within the verge. The vertical scale is supplement to post top road lighting which is predominantly located adjacent to road intersections.

From this viewpoint future residential areas will not be seen due to the existing orchard of irrigated fruit trees to the property boundary screening views towards the north. The horticultural practice (Lewis Horticulture) extends to the west with associated packing sheds and greenhouses for approximately 500 metres.

Figure 7 Transmission lines to the east of Port Wakefield Rd parallel to the road corridor.

To the south of Park Road is the State Shooting Park which is fenced and planted with dense plantings of mallee species to the road verge. There will be limited views of the proposal from the shooting park as the range is predominantly in a north south orientation. Furthermore, to the north of Park Road there is some localised earth mounding which provides a screen to views further north towards the site (Figure 8).

Adjacent to the State Shooting Park is an isolated telecommunication tower which provides a vertical visual element and landmark within the local landscape zone, from distances of 1-2km to the north (Figure 9). The tower provides reference to an urban context.

Figure 8 Left hand side is the State Shooting Park; to the left is localised earth mounding preventing views towards the site.

Figure 9 View of telecommunication tower from just west of Waypoint 001.

Waypoint 002

Towards the intersection of Park Road and Tozer Road views are more expansive. In particular, views to the north are across low lying, heavily grazed landscapes with scattered farming equipment and built form associated to horticultural practices (Figure 10). The Gawler River is a dominant visual element to the distant background, forming the extent of the field of view. The foreground to mid ground landscape (0-3km) is uniform in character with limited visual interest. The amenity value would be classified as low. From this viewpoint the proposal will considerably alter the rural/grazed landscape character to an urban context. The master plan illustrates the extension of the MOSS vegetation corridor to the south west of the site. The open space will be intertwined with mixed use precincts. Depending on the extent of landscape vegetation implemented in the scheme the visual amenity may be improved.

Figure 10 Views to the north with localised earthworks adjacent to Park Road.

Waypoint 003

This viewpoint is located further north of Waypoint 002 along Buckland Road. Buckland Road forms a boundary to the site. The view represents the character of the landscape from the residential dwelling (Figure 11). The view towards the site will be significantly altered by the proposals urban elements. The current view is described as a uniform dry land scene with limited vertical scale to the foreground within the paddocks to the west. The presence of some scattered mallee scrub and eroded swale and mounding to the verge of Buckland Road does provide some screening, however the landscape amenity value would be considered low (Figure 12).

Figure 11 Residential dwelling on Buckland Road.

Figure 12 View towards the west from the residence.

Waypoint 004

The visual effect from this viewpoint is similar to Waypoint 003. The landscape to the south of the site is uniform and heavily degraded with limited value. Views to the south east from the site are towards the State Shooting Park, telecommunication tower and the Adelaide Hills to the background (Figure 13).

Figure 13 Views from the site across arable land towards the State Shooting Park

Waypoint 005

Views from within the southern quadrant of the site represent the heavily degraded agricultural landscape with expansive views. Introduced plant species and saltbush occupy a percentage of the groundcover treatments. The industrial fabric of Port Adelaide is a distant backdrop. The landscape value would be classified as low (Figure 14). The proposal's master plan illustrates an open space vegetated corridor within this location which would provide an improvement to the amenity of the landscape, with the additional benefit of filtering views towards the urban fabric.

Figure 14 Views from within the site towards the south west.

Waypoint 006

Further to the west is Waypoint 006. This viewpoint is located at the western corner of the site and provides views towards the Gulf St Vincent. The visual character is similar to the surrounding degraded land use; however there are some definitive variances with the salt pans and ocean to the background (Figure 15). The presence of water bodies improves the visual quality of the landscape views in this direction. The proposal will have a slight to moderate effect on this view, with the urban residential form encasing and screening views. However the proposal will mainly be located to the north-west which will separate the visual receptor and coastal view from the dominance of the proposed urban context. The transitional zone between the new urban areas and the salt pans will be an important consideration in the management of this existing view.

Figure 15 Views towards the Gulf St Vincent.

Waypoint 007

This viewpoint is located to the north east of the site at the intersection of Port Wakefield Road and Port Gawler Road. The view towards the site is screened by the dense vegetation corridor associated to the Gawler River. There will be limited to no visual effects associated with the proposal from this location. The landscape character of this locality possesses slightly more aesthetic value due to the degree of existing remnant vegetation and layered visual complexity which provide a sense of mystery. The scattered Eucalypts to paddocks in the foreground is offset with the Gawler River vegetation belt to the background. The retention of the Gawler River vegetation corridor will provide a significant screen between the proposal and locations to the north east, preventing any potential visual effects from this location (Figure 16).

Figure 16 Views towards the site from the intersection of Port Wakefield Rd and Port Gawler Rd.

Figure 17 Views towards the site with intensively harvested land to the foreground.

Waypoint 008

Further to the east of Port Gawler is Waypoint 008. This viewpoint is characterised by low lying saltbush and samphire and water bodies with the Gawler River a distant backdrop. Views to the north of this viewpoint are of salt pans which represent a low lying water body with man made levy banks (Figure 18). Buckland Park Lake provides a visual reference to the adjacent salt pans. There will be no visual impact to the character of this locality. Buckland Park Lake represents a wetland of visual interest. This landscape character zone provides a medium to high level of amenity. The natural forms of the water bodies, coupled with the presence of wildlife provides scenic amenity (Figure 19). Due to the extent and density of vegetation associated to the water bodies and Gawler River, the proposal will have no visual impact from this locality.

Figure 18 Views of salt pans to the north

Figure 19 Views towards the site which won't be visible due to the vegetation associated to the Gawler River

Waypoint 009

The viewpoint is located at the entrance to the Port Gawler Conservation Park. The landscape character towards the site is the same as Waypoint 008. Adjacent to the south of this viewpoint is a coastal stretch of mangroves which provide a dense canopy structure containing views to the local estuaries. This area is of environmental significance. There will be no visual effects of the proposal from this area.

Waypoint 010

This viewpoint is located on Port Wakefield Rd with views into the site. The existing character is open with extensive horticulture. The character in this locality will dramatically change with the creation of the district centre included in the proposals master plan (Figure 20). Furthermore, it is proposed that a major intersection upgrade will be required to the north, creating a new visual element. An existing substation is located adjacent to the intersection location and is screened to a degree by roadside vegetation (Figure 21).

Figure 20 View towards proposed district centre location.

Figure 21 Views to the north along Port Wakefield Rd. The substation is located to the right.

Waypoint 011

The Gawler River corridor is a significant visual element in the regional landscape. It traverses across the landscape in an east westerly direction forming the northern boundary to the site. The river corridor is characterised by large remnant Eucalypt trees which provide a high level of amenity. The width of the corridor varies but is an average of 20-30m. The river is ephemeral and at the time of the field assessment there, was no water flowing. The river itself is described as a steeply incised land form which has signs of erosion. The corridors understorey is heavily infested with weeds. The natural aesthetic value of this area is significant to the local amenity. Port Wakefield Rd crosses over the Gawler River creating a visual gateway to the site. Consequently views of the proposal will only be witnessed from the south of the river. The proposal includes retention of the Gawler River corridor, and its progressive rehabilitation will contribute to an improvement of the regions visual amenity.

Figure 22 View from the north along the river corridor towards the proposed site.

Waypoint 12

To the north of Virginia is a cluster of rural residential dwellings with associated horticultural practices. The dwellings are typically of masonry construction with open views to surrounding horticultural land (Figure 23 & 24). Port Wakefield Road forms a dominant visual element with the frequency of traffic creating a dynamic effect. From this viewpoint there will be some moderate visual effects created by urban development to the north east of the proposal.

Figure 23 Typical view towards the site from rural/ residential dwellings

Figure 24 Rural residential dwelling vernacular with views orientated towards the site.

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Waypoint 13

Views within the township of Virginia are contained along Old Port Wakefield Road which represents a small commercial/ retail precinct. The streetscape is described by avenue planting of trees and on street parallel parking, traffic management devices and services such as an 11kv transmission line which creates an urban context (Figure 25).There will be no visual effects of the proposal from this locality.

Figure 25 Virginia commercial/ retail precinct

Waypoint 14

The northern urban fringe of Virginia is characterised by a school, community centre and associated recreational open space (oval and tennis courts). This area is screened to the north and west by a dense shelter belt planting of Pinus species. Further to the north views become more panoramic across irrigated horticultural land (Figure 26). The site is located approximately 1.5km to the north east. Views towards the site will be glimpsed with foreground to mid ground vegetation filtering and screening.

Figure 26 Views across horticultural practices towards the site.

5. Conclusions

The Buckland Park proposal represents a significant change to the existing land use. The dominant character of the landscape is horticultural and grazing practices, the amenity of which is relatively low.

The uniformity and intensity of the horticulture degrades the visual landscape. Expansive views to the south limit a sense of scale and visual interest. The lack of topographic variance also attributes to the lack of visual attraction.

Existing road corridors (Port Wakefield Rd) and the proposed expressway (NEXY), introduce infrastructural elements and visual corridors which are transient by nature. As a result the landscape is predominantly viewed through the eyes of a moving occupant.

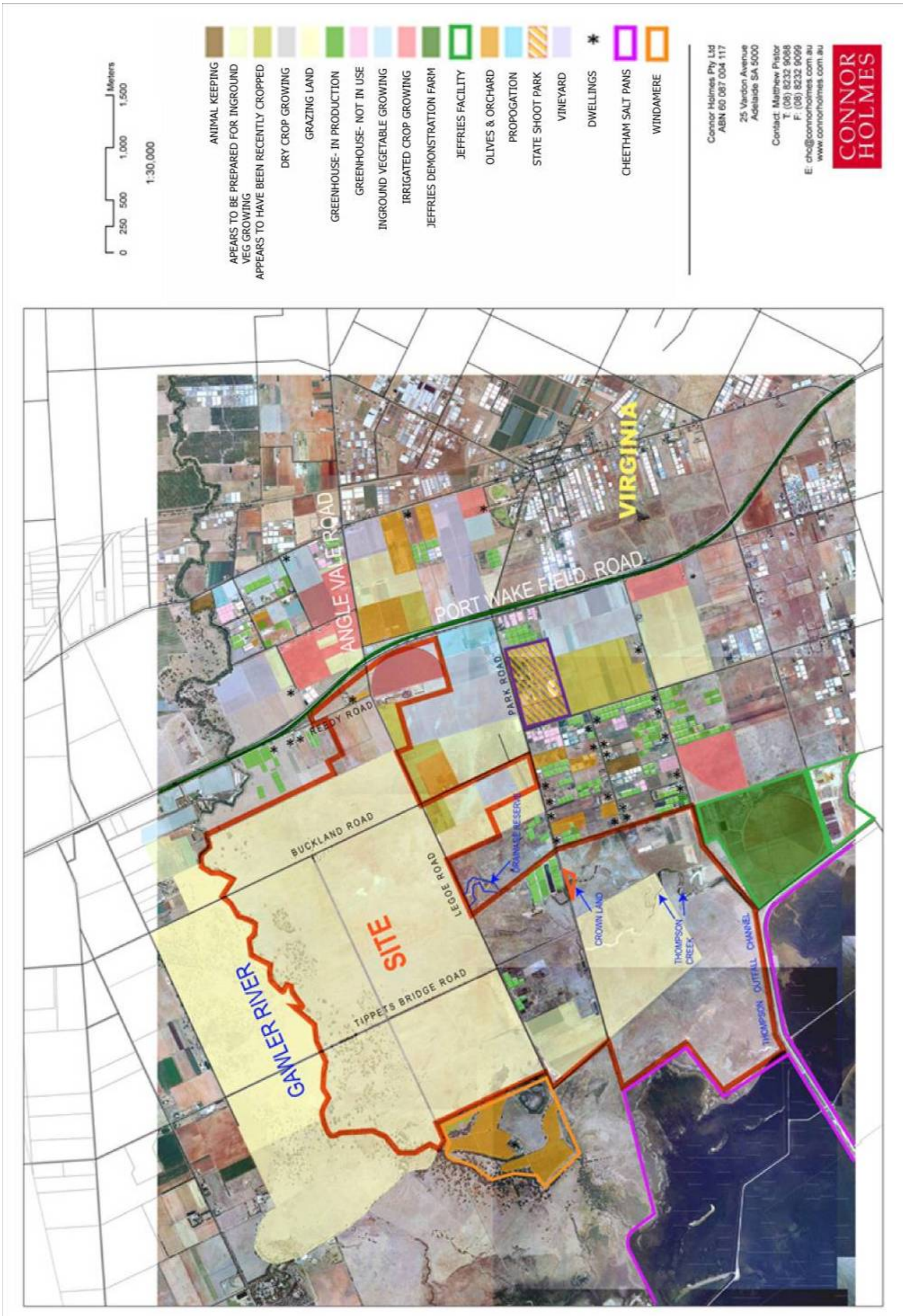
Urban populations are located approximately 2-3km to the east at Virginia, a small township orientated around a small main street retail, commercial precinct and intensive horticultural practices to the east and west. There will be limited visual effect or character change to the township of Virginia. There will be moderate effect to the northern urban fringe with isolated rural residential dwellings observing a degree of change associated to the proposal.

The major visual element in the landscape region is the Gawler River corridor. This distinctive element provides a shelter belt of vegetation to the northern boundary of the site. Its retention and rehabilitation as part of the proposal will provide screening between the proposal and viewpoints to the north.

Views of the proposal will principally be short distant and from the south to south west, indicating that the extent of the visual effect is limited to a contained viewshed. Consequently the visual effect of the proposal would be seen by a narrow percent of the local community with no identified significant views adversely affected.

Appendices

Appendix A:
Existing Landuse plan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APPEARS TO HAVE BEEN RECENTLY CROPPED
DRY CROP GROWING
GRAZING LAND
GREENHOUSE- IN PRODUCTION
GREENHOUSE- NOT IN USE
INGROUND VEGETABLE GROWING
IRRIGATED CROP GROWING
JEFFRIES DEMONSTRATION FARM
JEFFRIES FACILITY
OLIVES & ORCHARD
PROPOGATION
STATE SHOOT PARK
VINEYARD
DWELLINGS
CHEETHAM SALT PANS
WINDAMERE
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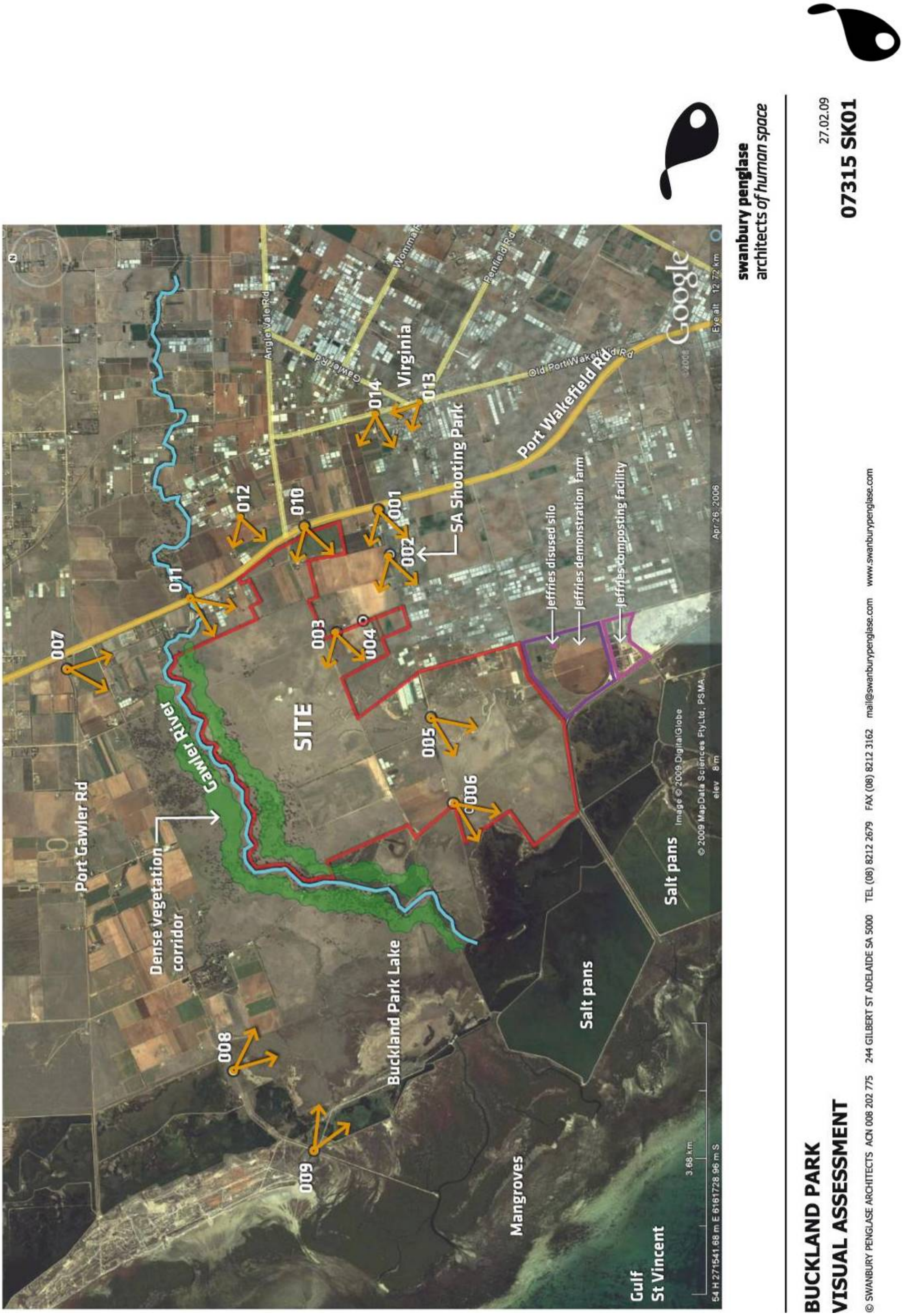
F: (08) 8232 9099
E: chc@connorholmes.com.au
www.connorholmes.com.au
CONNOR HOLMES
VIRGINIA
ANGLE VALE ROAD
PORT WAKE FIELD ROAD
PARK ROAD
REEDY ROAD
BUCKLAND ROAD
LEGOE ROAD
SITE
GAWLER RIVER
TIPPETS BRIDGE ROAD
CROWN LAND
THOMPSON CREEK
THOMPSON OUTFALL CHANNEL

Appendix B:
Photographic Survey


BUCKLAND PARK
VISUAL ASSESSMENT
swanbury penglase
architects of human space
27.02.09
07315 SK01
© SWANBURY PENGLASE ARCHITECTS ACN 008 202 775 244 GILBERT ST ADELAIDE SA 5000 TEL (08) 8212 2679 FAX (08) 8212 3162 mail@swanburypenglase.com www.swanburypenglase.com
SITE
Gawler River
Dense vegetation corridor
Port Gawler Rd
Port Wakefield Rd
Old Port Wakefield Rd
Virginia
SA Shooting Park
Jeffries disused silo
Jeffries demonstration farm
Jeffries composting facility
Buckland Park Lake
Salt pans
Salt pans
Mangroves
Gulf St Vincent
Angle Vale Rd
Gawler Rd
Penfield Rd
001
002
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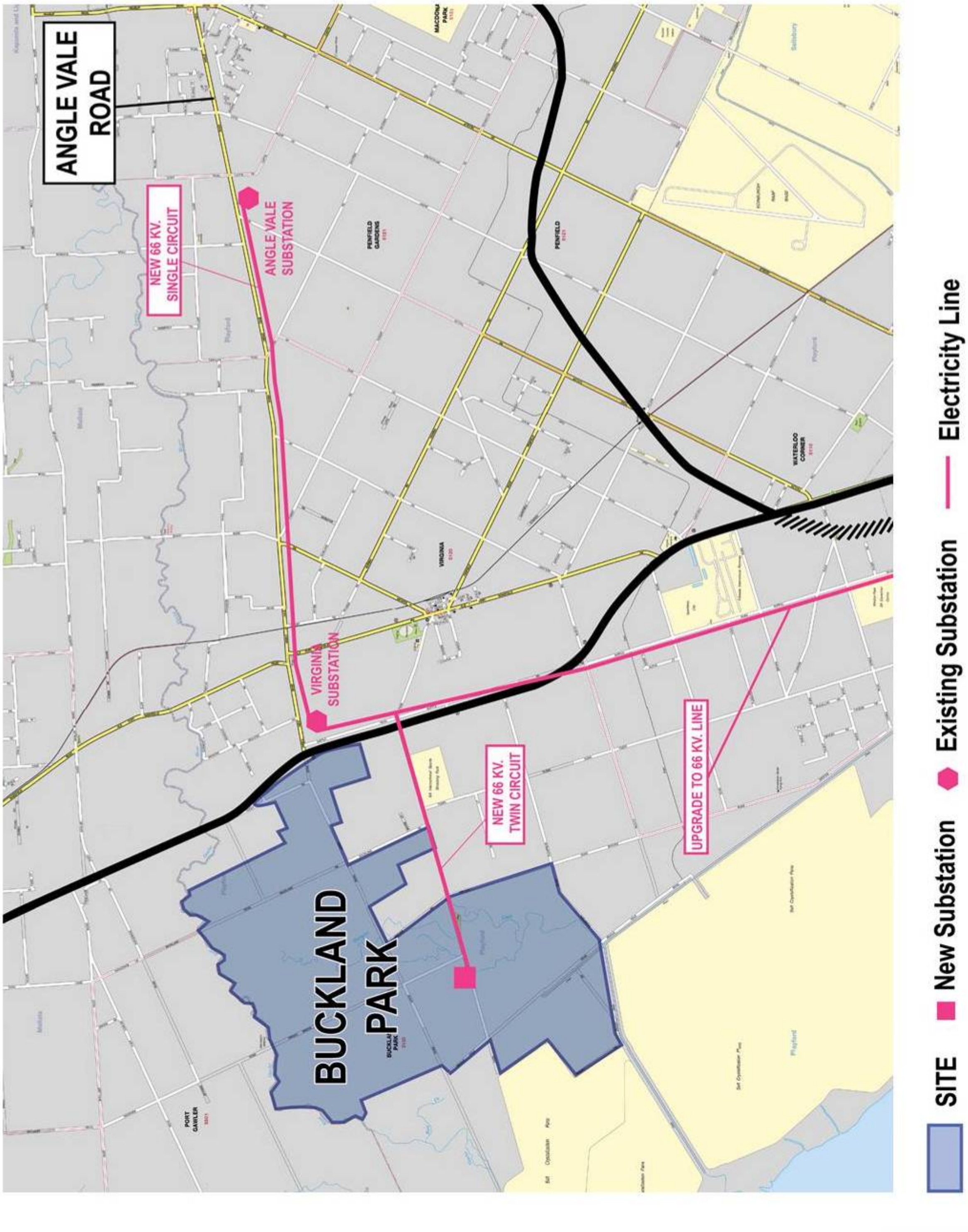
Google

Appendix C:
Transmission line alignment


ANGLE VALE ROAD
NEW 66 KV. SINGLE CIRCUIT
ANGLE VALE SUBSTATION
PENFIELD GARDENS
PENFIELD
WATERLOO CORNER
VIRGINIA
VIRGINIA SUBSTATION
NEW 66 KV. TWIN CIRCUIT
UPGRADE TO 66 KV. LINE
BUCKLAND PARK
PORT GAWLER
SITE
New Substation
Existing Substation
Electricity Line

Appendix D:
Photomontage of proposed transmission line

VIEW TO THE WEST ALONG PARK ROAD AT INTERSECTION OF PORT WAKEFIELD ROAD

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PROPOSED TRANSMISSION LINE
EXISTING CONDITIONS

03.03.2009
07315 SK02

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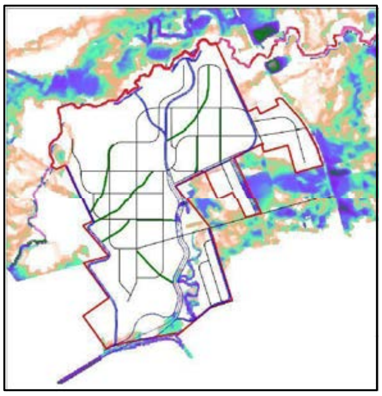
03.03.2009
07315 SK03

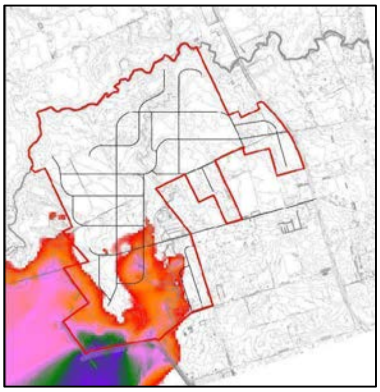
PROPOSED TRANSMISSION LINE
ARTIST'S IMPRESSION

BUCKLAND PARK PROPOSAL

STORMWATER MANAGEMENT
WATER, WASTEWATER AND RECYCLED WATER



TECHNICAL PAPER



prepared for

Walker Corporation

MARCH 2009

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W&G

WALLBRIDGE & GILBERT

Consulting Engineers

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ISSUE REGISTER				
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FIGURES

1. INTRODUCTION

1.1 Background

The Buckland Park proposal is a joint venture between the Walker Corporation and Daycorp. It comprises approximately 12,000 residential allotments, a number of commercial and industrial precincts, three permanent neighbourhood centres, one district centre, both primary and high schools, local shopping areas and employment opportunities. Figure 1.1 shows the Masterplan layout of the proposal.

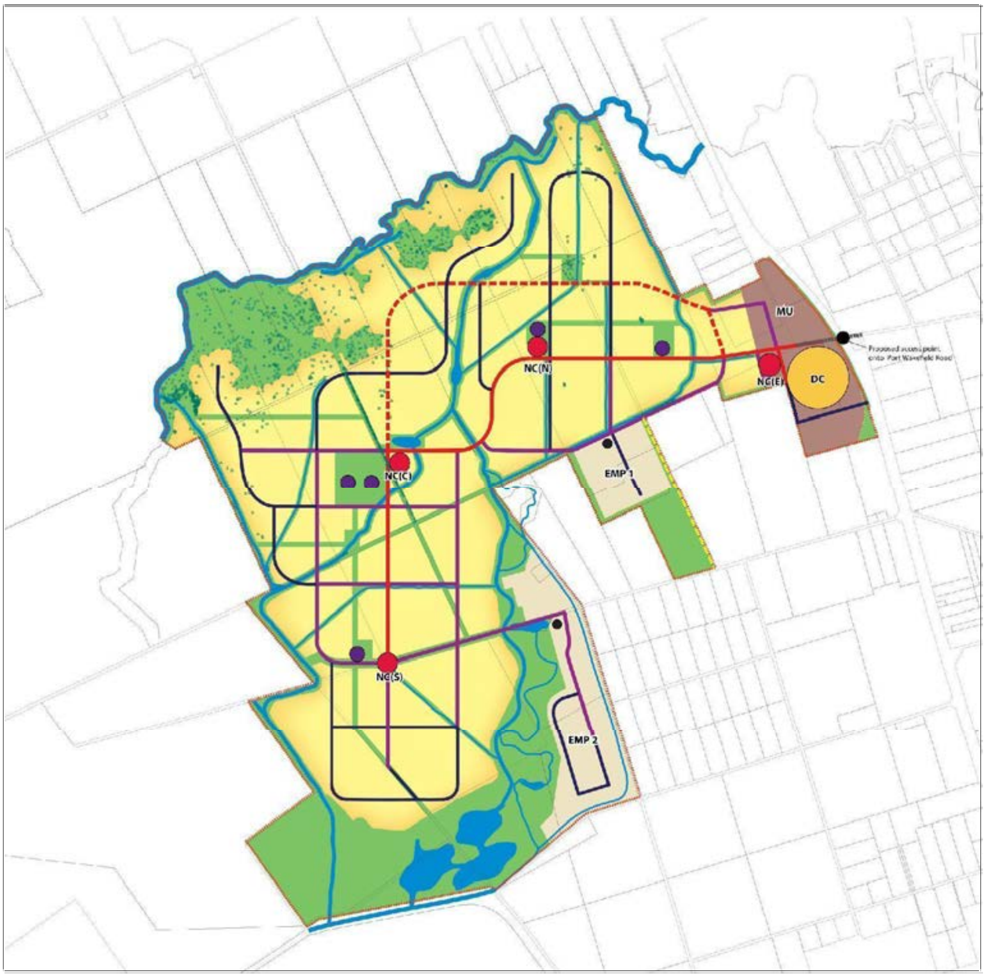


Figure 1.1 - Buckland Park proposal Masterplan

Construction of the proposal will be staged over a 25 year period, with approximately 480 houses constructed per year. The provision of infrastructure (such as the stormwater, potable water and waste water) will also be staged, and constructed as demand requires it. Therefore, capital costs associated with implementation of infrastructure will be progressive over the 25 year construction period.

Figure 1.2 shows the current Buckland Park proposal staging plan.

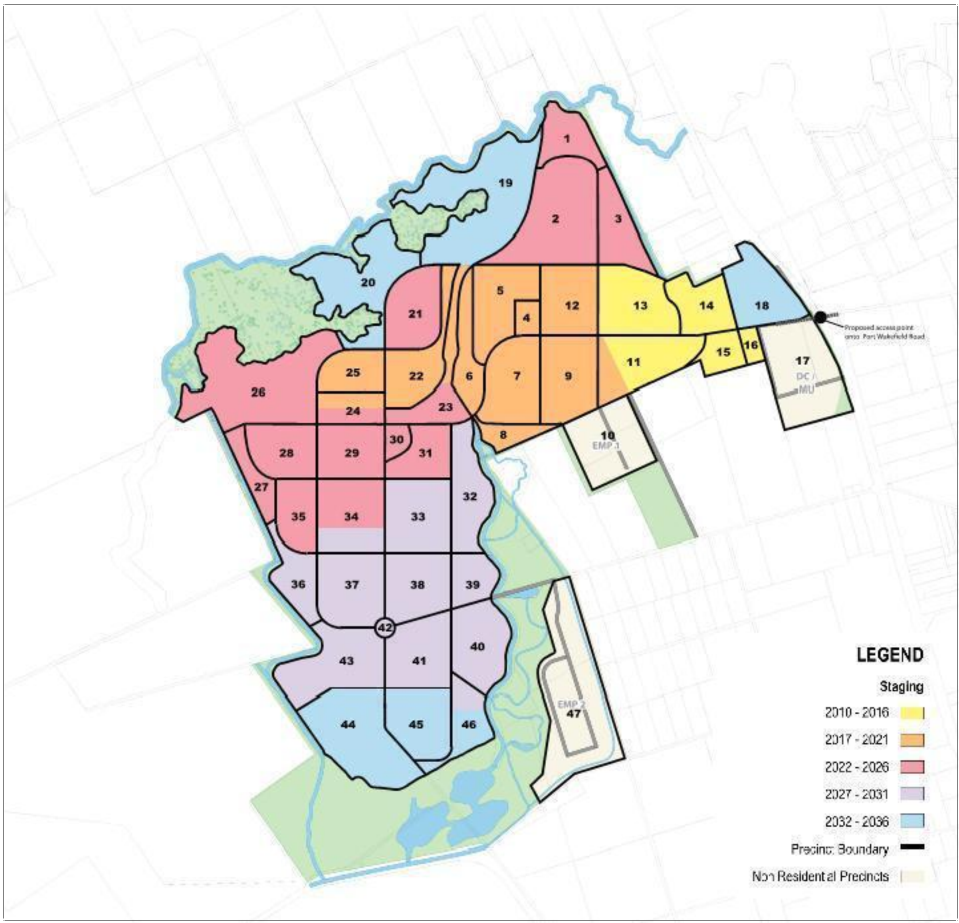


Figure 1.2 - Buckland Park proposal staging plan

The Buckland Park site is within the City of Playford Council area and according to the Council's Development Plan, the site is predominately zoned Horticultural West. Horticultural West permits horticultural production that contributes to the economy of the Council area.

As a result of the area's horticultural character, the Buckland Park currently has no major water or sewer trunk services available, however recycled water is currently supplied to the residents for irrigation and horticultural purposes via the WRSV (Western Reticulation Systems Virginia) pipeline.

1.2 Site Description

The Buckland Park site covers an approximate area of 1,308 hectares. The site is situated approximately 32km north of the Adelaide CBD, bounded by Gawler River to the north, Cheetham salt fields to the south, Port Wakefield Road to the east (see Figure 1.3 for the locality plan). The Buckland Park site is approximately 2.7 kilometres inland of the Gulf St Vincent coastline and it is for this reason it is not considered to be a coastal site.

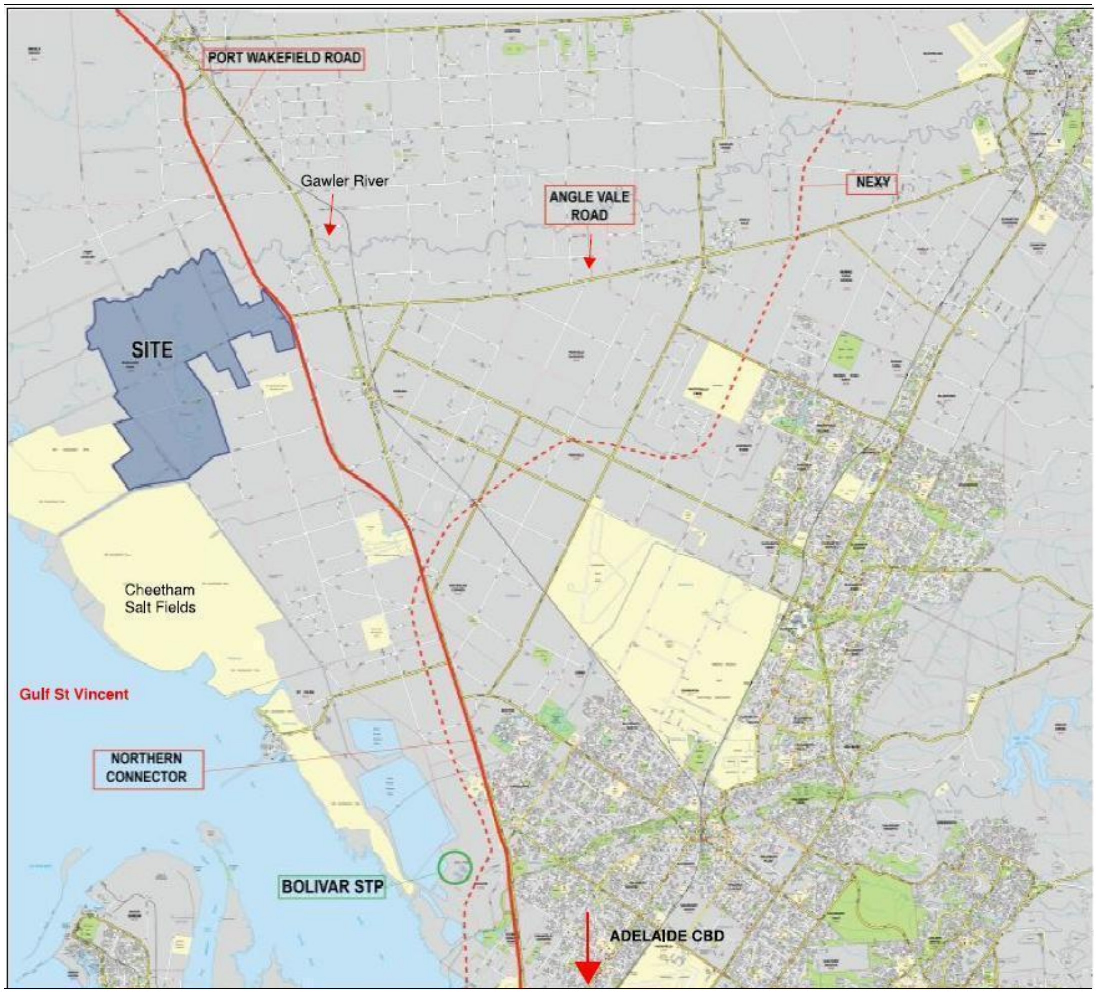


Figure 1.3 - Locality Plan

The topography of the site is relatively flat with an approximately fall of 0.2% across the site from east to west. The site also lies within the Gawler River flood plain. Figure 1.4 shows the site location in relation to the surrounding community.

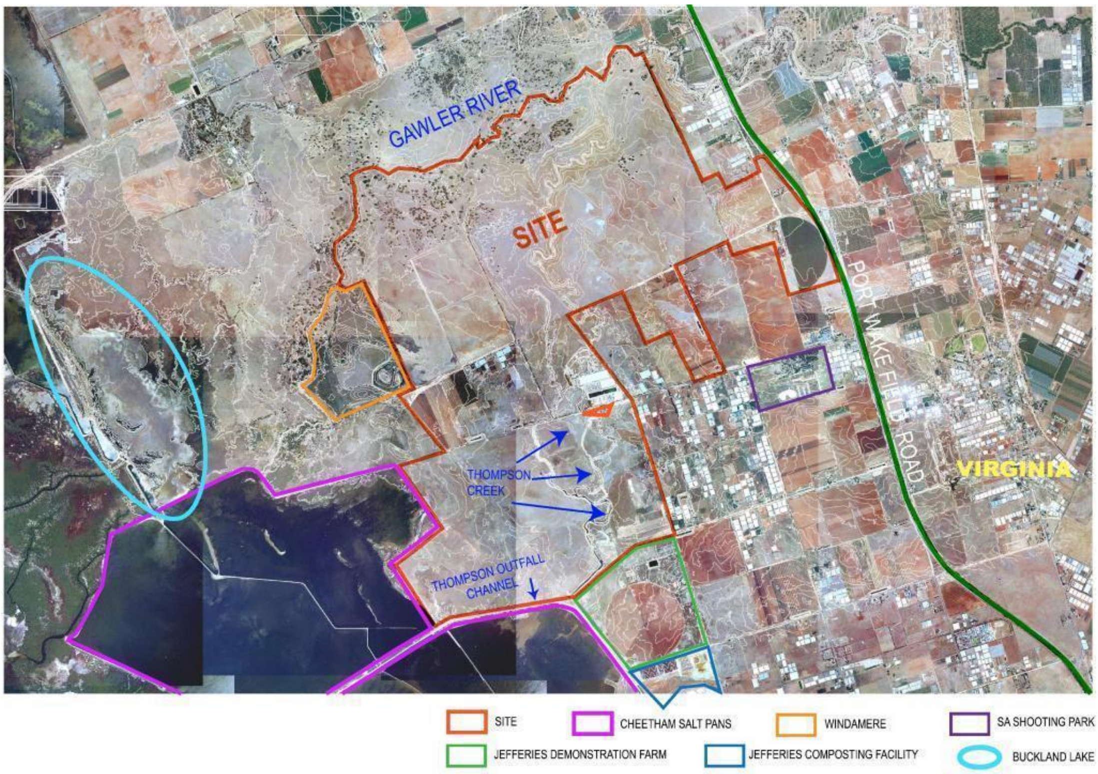


Figure 1.4 - Site boundary in context of surroundings

As a part of the initial site investigations ground water mapping was undertaken by Resource and Environmental Management (Reference 7). This mapping indicated that the depth to ground water within the site ranges from 0.2 metres to 7 metres below the natural surface level. It can be seen in Figure 1.5 that approximately 75% of the site has a depth to ground water of approximately 3 metres below the surface level.

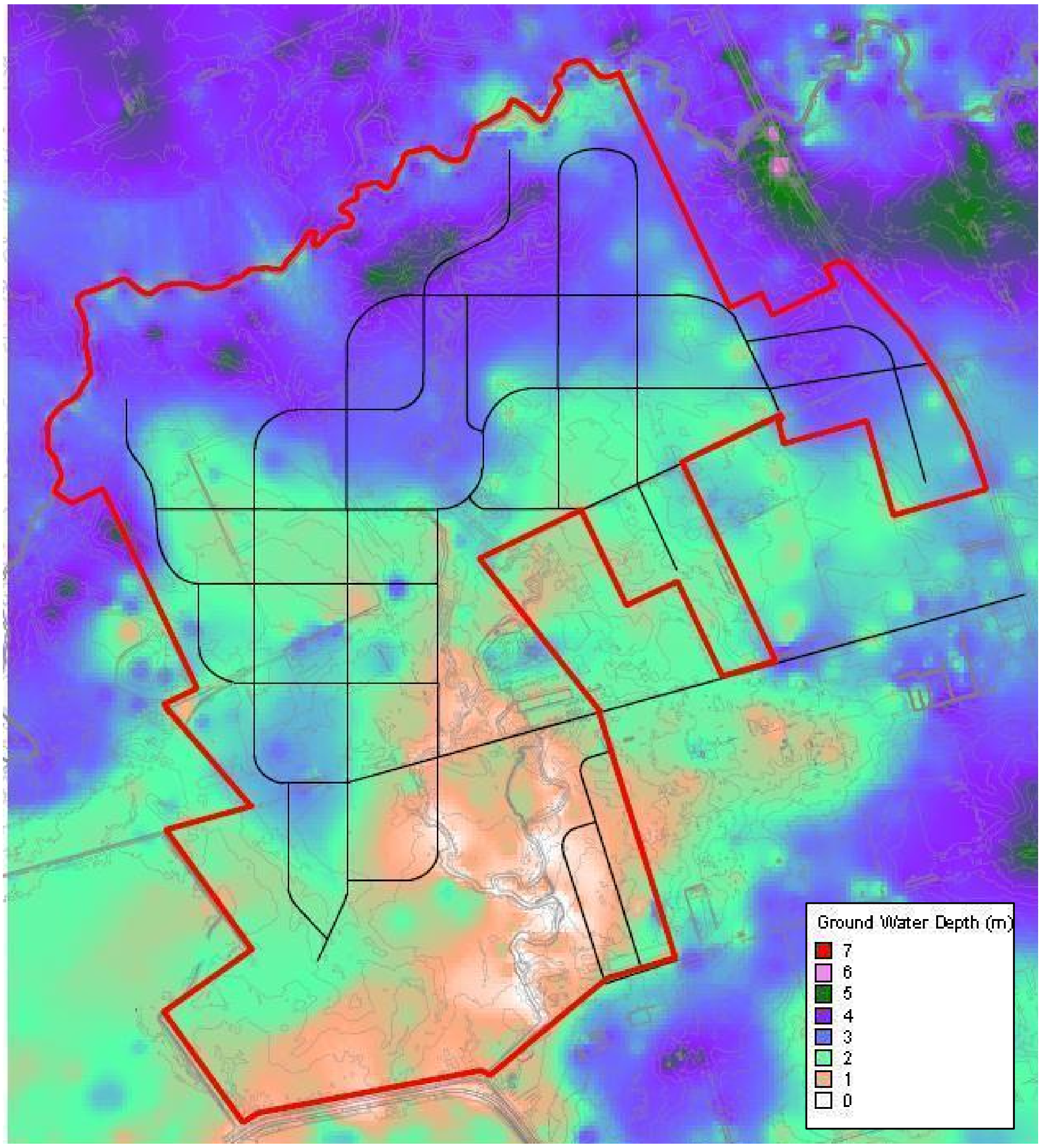


Figure 1.5 - Depth to Groundwater

Site investigations by both Golder Associates (Reference 5) and REM (Resource and Environmental Management, reference 7) revealed the ground water in the Buckland Park area is highly saline, with the salinity ranging from 1000ppm to 5000ppm Total Dissolved Solids (TDS). These investigations also indicated that some portions of the site are affected by Acid Sulphate Soils (ASS).

1.3 Water Management Aims

This technical paper outlines the formulation of the following concepts as they relate to the Buckland Park proposal:

- Stormwater capture, treatment and reuse (minor flow management)
- Stormwater Management (major flow management)
- Sewerage reticulation systems
- Potable water supply
- Flood protection from Gawler River
- Opportunities for recycling of wastewater and stormwater

These concepts will be discussed in relation to site conditions and how they influence the recommendations for water infrastructure and the layout of the proposal's Masterplan – particularly the location and configuration of stormwater management facilities.

The EIS Guidelines that will be addressed in this report are outlined in Appendix A.

2. STORMWATER

2.1 Introduction

The current method of stormwater management within the Buckland Park site relies on a system of natural open creek lines and roadside open drains and culverts to move the stormwater runoff through the catchment and discharge it to the ocean via the Thompson Outfall Channel.

The Buckland Park site generally drains away from the Gawler River in a south westerly direction towards the Thompson Outfall Channel. The Gawler River is situated within the Northern section of the Buckland Park site and is a perched river system. As the banks of the Gawler River are higher than the adjacent floodplain, stormwater runoff from the Buckland Park site will not drain to the Gawler River nor to the Buckland Park Lake System as they are both effectively located upstream of the Buckland Park proposal site.

Figure 2.1 shows the site levels in metres to Australian Height Datum (AHD) and shows that the site falls away from the Gawler River towards the Thompson Outfall Channel.

Section 2 of this report will focus primarily on minor and major internal stormwater flow management whilst water quality and the management of external flood water flows will be addressed in Sections 3 and 4 respectively.

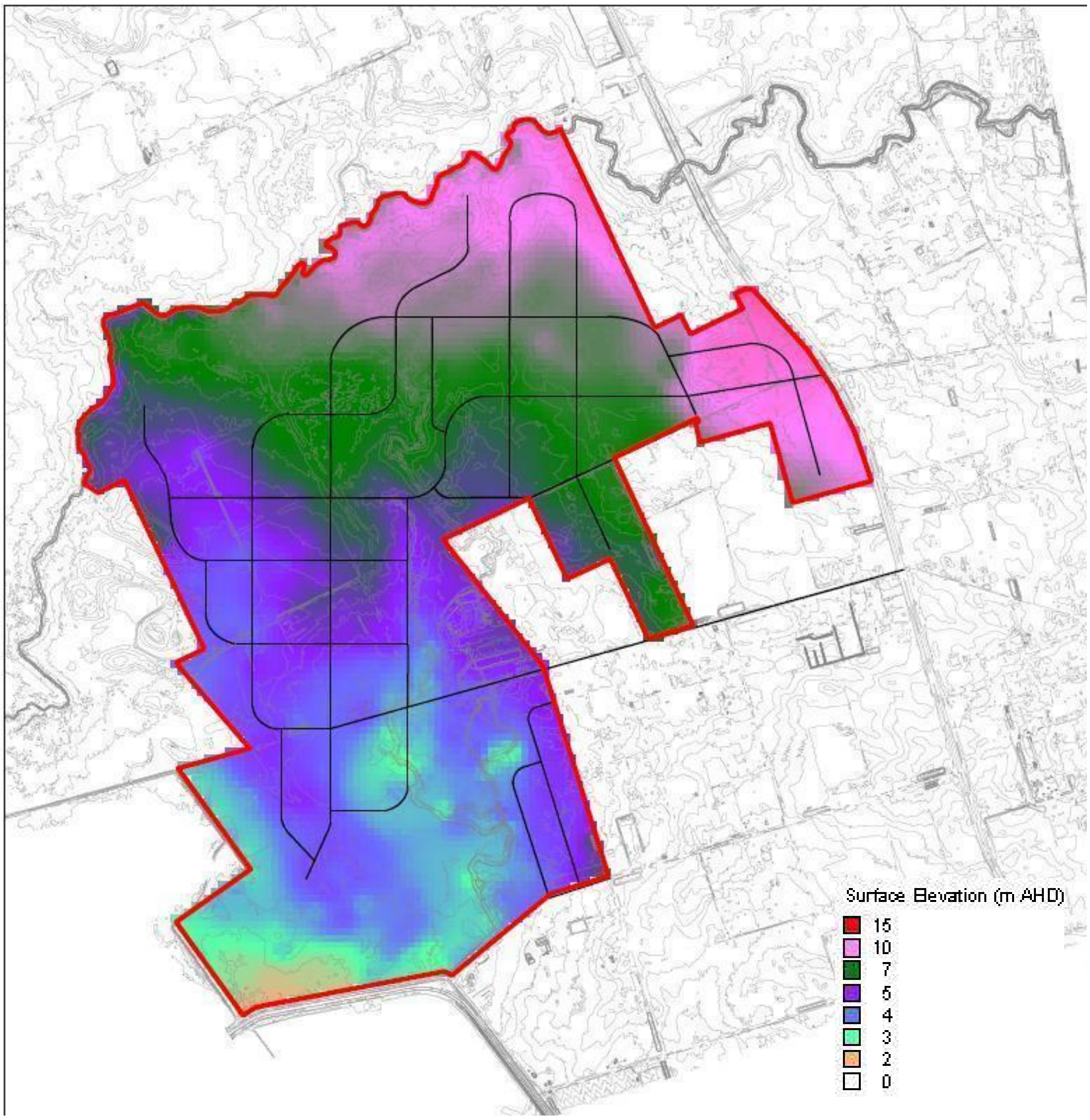


Figure 2.1 – Existing Site levels

2.2 Pre-Development Site Conditions

Currently stormwater infrastructure in the Buckland Park area is limited. The majority of the stormwater flows are carried by a system of natural creek lines, culverts and open drains that run along the road side and discharge to the Thompson Outfall Channel (see Figure 2.2 for stormwater infrastructure layout).

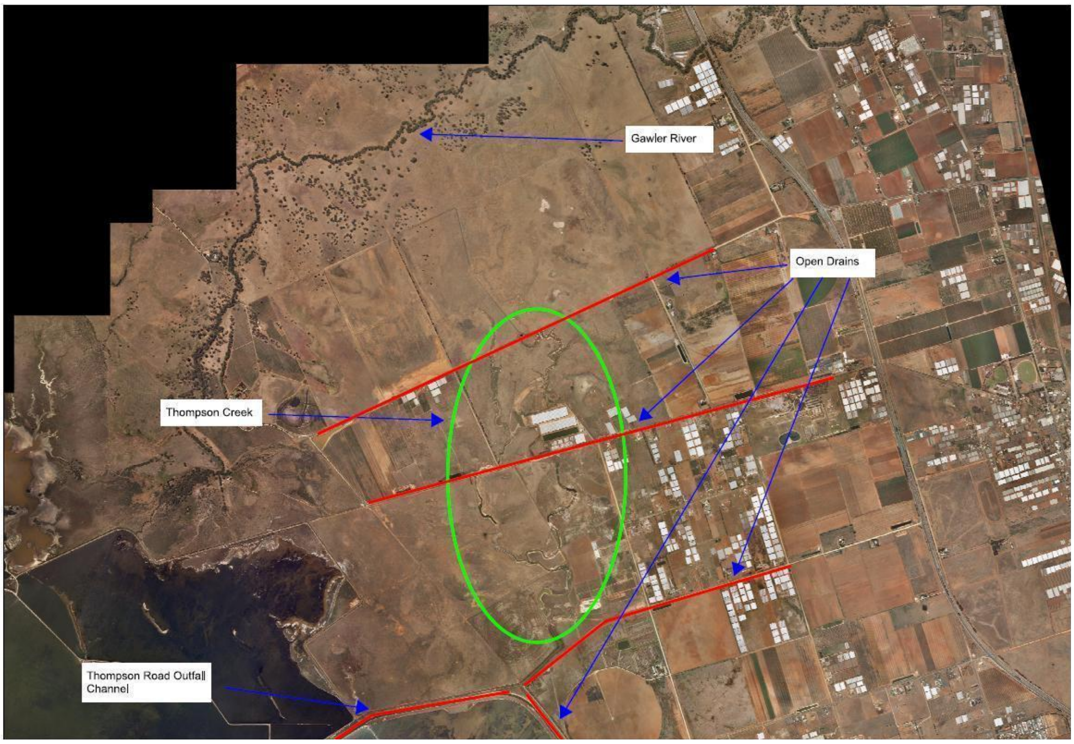


Figure 2.2 – Existing Stormwater Infrastructure

The Thompson Outfall Channel is a large earth channel that extends from the western most end of Thompson Road and discharges into Gulf St Vincent.

Thompson Creek is a natural creek which runs through the centre of the Buckland Park site (see Figure 2.2). The catchment that contributes to Thompson Creek extends west from Port Wakefield Road, between Thompson Road and the Gawler River.

2.2.1 *Thompson Outfall Channel*

Thompson Outfall Channel extends from the western most end of Thompson Road in Buckland Park and runs parallel with the SA Water Bolivar effluent discharge channel (see Figure 2.2 for location). The drain is earth lined with a varying trapezoidal cross section.

Thompson Outfall Channel receives stormwater runoff from a large catchment of approximately 85km^2 known as the Western Virginia Catchment. This catchment lies within the bounds of Gawler River to the north, Andrews Road, Munno Para Downs in the east, St Kilda Road to the south and the Salt crystallization pans to the west. The outfall channel discharges directly to Gulf St Vincent and the capacity of the channel will be affected by tide levels.

It is a requirement of the City of Playford Council's Development Plan that all new projects make an allowance for rises in sea level when designing stormwater outlets that discharge to the sea. *The Port Adelaide Seawater Stormwater Flooding study (Reference 11)* undertook a detailed assessment of tidal and rainfall records to determine if there was a relationship between tides and storms. The study determined there was no direct correlation, and formulated a series of criteria for combined storm and tide events based on likely probability. Port Adelaide Enfield Council adopts the following when assessing the drainage strategies for projects:

- 1 in 100 year ARI storm with a corresponding long term Mean High Water Springs (MHWS) tide.
- 1 in 1 year ARI storm, with a long term 1 in 100 year tide event

Taking into account predicted long term sea level rise at the downstream end of the Thompson Outfall Channel, an outlet tailwater level of 1.95m AHD has been adopted. This level was determined as follows:

- Mean High Water Springs (MHWS) level = 0.95m AHD
- Expected sea level rise (2100) = 1.0m (taken from Council's Development Plan)

Mean High Water Springs is a level that is the average of all the twice daily high tides in spring.

In order to determine the capacity of the Thompson Outfall Channel a HEC-RAS computer model was setup. HEC-RAS is a software package that uses one dimensional hydraulic calculations to analyse flows in natural or constructed channels.

The parameters used in the analysis include the following:

- Mannings n = 0.04
- Downstream water level = 1.95m AHD (as indicated previously)
- Length 2.6km

From the analysis it was determined that the maximum capacity of the outfall channel is approximately 28 to 30m^3/s assuming the existing degraded levee on the northern banks is reinstated to a level similar to the dividing levee to the Bolivar Outfall channel which is set at approximately RL 3m AHD.

2.2.2 *Thompson Creek*

Thompson Creek is a naturally occurring creek that runs directly through the centre of the site (see Figure 2.2 for location).

The creek currently meanders through the site with a number of branching tributaries and terminates at Thompson Road were it connects into the Thompson Outfall Channel.

2.2.3 *Stormwater Drainage Infrastructure*

At present the stormwater infrastructure within the site is limited, with the stormwater runoff from the undeveloped site being carried through the catchment area via a system of road side open drains and culverts (see Figure 2.2 for details) that terminate at the Thompson Road outfall channel.

The exact capacity of the current stormwater drainage system is not known, but is expected to be limited.

2.2.4 *Gawler River*

The Gawler River is a perched waterway that runs along the northern most boundary of the site.

The river is situated upstream of the site and the banks of the river are raised so they are higher than the surrounding floodplain as shown in Figure 2.1. As such the Gawler River receives no contribution of stormwater runoff from the Buckland Park site.

The site will however experience flood events from water breaking the banks of the Gawler River. This is discussed in detail in section 5 of this report.

2.3 Post-Development Stormwater Management

Once the proposal is complete, the Buckland Park catchment will produce a significantly larger volume of stormwater runoff than it would currently given its undeveloped state. Therefore, to capture and discharge the runoff to Gulf St Vincent, whilst considering and managing the environmental impacts of the increased flows, a more structured stormwater management system will be required.

In order to meet the Council's criteria that peak stormwater flows discharged from the Buckland Park proposal must not exceed the pre-developed discharge rate, and considering the relatively limited capacity of the Thompson Outfall Channel, onsite detention will be required within the proposal's Masterplan.

In order to model the estimated peak flows from the developed site a DRAINS model was created.

DRAINS is a software package used for designing and analysing urban stormwater drainage systems. DRAINS uses hydraulic and hydrologic calculations to simulate rainfall events on catchment areas. From this it then calculates the resultant flows, velocities, and hydraulic grade lines that are produced by the rainfall events.

In order to effectively convey and capture the stormwater runoff created by the proposal a number of different techniques will be used. These techniques include the following:

- A network of concrete pipes to collect local drainage from rooves and roadways
- A network of linear drainage reserves to convey larger flows that will provide a dual use for water quality treatment
- A detention basin to reduce the peak outflow from the proposal

A single large detention basin in the south western corner of the site was considered appropriate, as the low lying nature of the land in this area makes it unsuitable for residential purposes.

2.3.1 Stormwater Modelling

The analysis required the setup of two separate models within the DRAINS software package, one defining the pre-development catchment areas and one defining the post-development catchment areas.

A number of hydrologic parameters need to be established in order to undertake the DRAINS analysis, particularly in regards to estimating runoff from pervious areas. These assumptions were constant for both the undeveloped and developed site and include the following:

- Soil Type = 2 (Moderate infiltration rates and Moderately well drained)
- Antecedent Moisture Content (AMC) = 3
- Grassed initial loss = 40mm
- Paved initial loss = 2mm
- Supplementary paved initial loss = 2mm

Rainfall data is also required to be entered into the model. In this situation rainfall intensities for the Light Region situated slightly north of Buckland Park was considered to be the closest and most accurate representation of rainfall at Buckland Park. Recent reports prepared by the CSIRO suggest that in the future Climate Change could increase the intensities of storms experienced in South Australia by up to 4 to 5 % higher by 2050 (*Reference 4*). In order to take some account for climate change the rainfall intensity from Australian Rainfall and Runoff were increased by a factor of 15% to allow for some further potential increases in predictions through to 2100. This was achieved in the model by specifying a rainfall multiplier factor of 1.15.

Table 2.1 shows a comparison between the undeveloped and developed stormwater peak runoff volumes for both the 100 year ARI and 1 year ARI storm events and also the increased flows attributed to accounting for climate change.

Table 2.1- Peak flow rates for the developed and undeveloped site conditions

	Undeveloped (m^3/s)	Developed (m^3/s)	Developed with Climate Change Allowance (m^3/s)
1 year ARI	4	22	25
100 year ARI	10	82	92

The runoff from the developed catchment in a 100 year ARI storm is approximately $82m^3/s$ greater than the undeveloped peak flow rate. In accordance with Council's requirements this flow will be detained within the site to curtail the peak so that it does not exceed the undeveloped flow rate of $10m^3/s$.

2.3.2 Pipe Network

A network of concrete pipes will be used to collect the stormwater runoff from the developed catchment area including the commercial and residential areas as well as from the roadways and other impervious surfaces. Following collection the pipe network will discharge at intermittent locations into a network of major linear drainage reserves as shown in Figure 2.3.

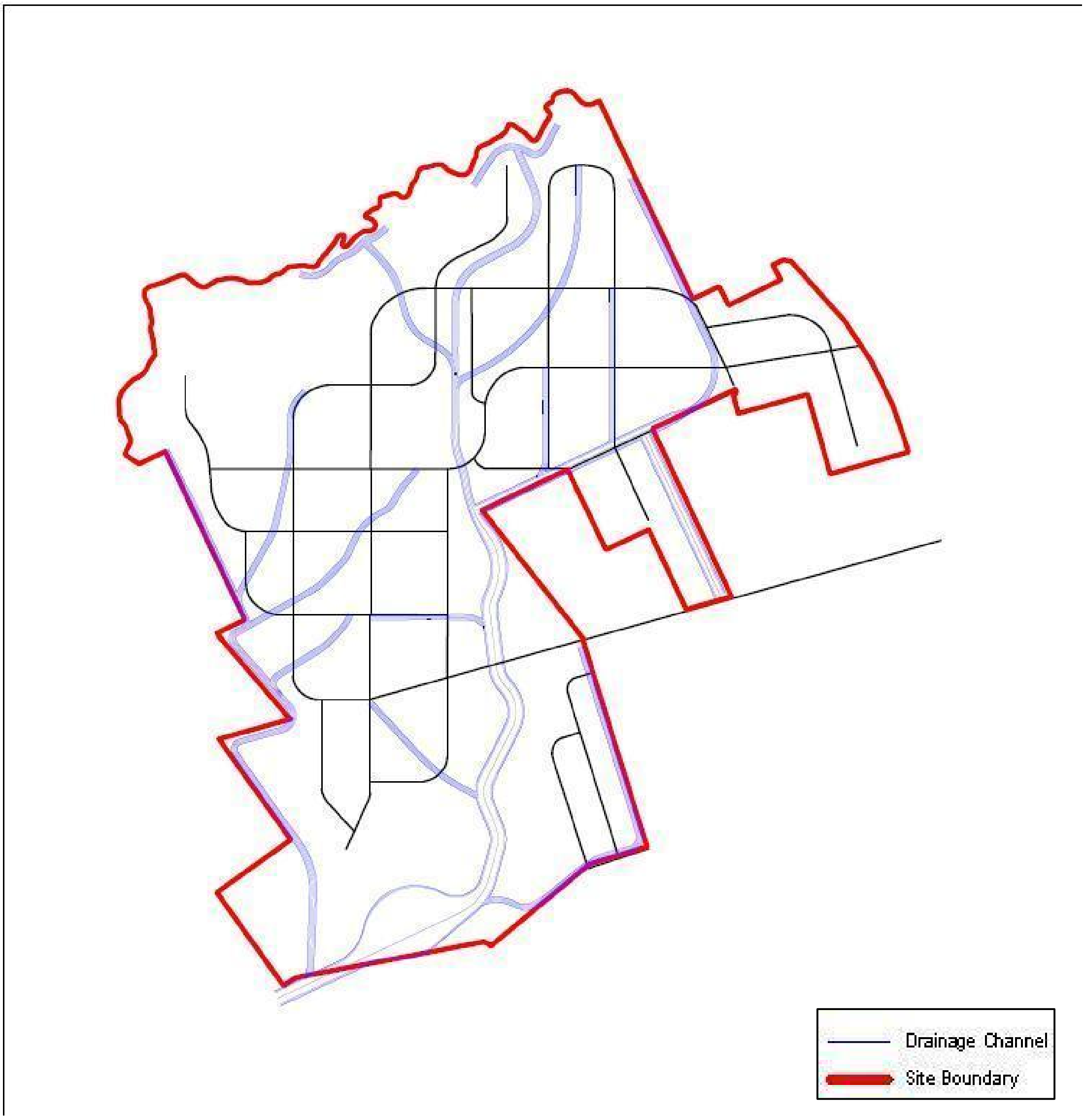


Figure 2.3 – Proposed Lineal Open Drainage System

2.3.3 *Linear Drainage Reserves*

Linear drainage reserves will be placed within the Masterplan to convey the peak stormwater flows through the site to the Thompson Outfall Channel. These drains are positioned within the site to take advantage of the natural slope of the land.

The preliminary sizing of these drainage reserves was on the basis that it becomes more practical and cost effective to capture and pass 1 in 100 year ARI flows within open channels, when these flows begin to exceed the capacity of the combined street and drainage system. This is considered to be when flows reach levels of the order of approximately $5m^3/s$. From calculations it has been estimated that a catchment area of approximately 50 hectares would be required to produce this magnitude of peak flow in a 100 year storm event. Figure 2.3 shows the proposed locations of the drainage reserves.

The concept design for the linear channels includes a low flow channel that will accommodate up to a 1 in 1 year ARI flow and an upper portion that will accommodate a 1 in 100 year ARI peak flow. The low flow channel aims to collect minor flows and minimise scour across the base of the channel, and will confine the low flows to provide for better water quality treatment.

The assumptions that were made in the design process include the following:

- Mannings n= 0.04
- Peak storm event for the 1 year ARI peak storm duration is 60 minutes
- Peak storm event for the 100 year ARI peak storm duration is 30 minutes
- Average channel slope of 0.05%

The channel sizes presented are indicative sizes only. The channels will need to be individually designed during the detailed design process when the catchment area contributing to each drain can be more confidently determined, however it is considered that the extent of the network as shown will be required due to the size of the proposal. The network of drainage channels also provide for flood protection from the Gawler River, which will be discussed further in Section 5.

Due to the length and depth of the proposed drainage channels a significant amount of excavation will need to be undertaken and therefore a significant amount of excavated material will be produced. This excavated material will be used within the site to fill lower areas of the site, to provide shape for road drainage on the flatter areas of the site and also to provide flood protection.

2.3.4 *Detention Basin*

The pre-development peak flow rate was calculated to be approximately 10m^3/s, where as the post-development peak 100 year ARI flow rate was found to be 92m^3/s based on the allowance for Climate Change. The proposed detention basin will be located in the south western corner of the site and will reduce the peak flows from the site to a maximum of 10m^3/s.

Using the DRAINS model it was determined a basin of the order of 250,000m^3 would be required to attenuate the 1 in 100 year ARI peak flows to a maximum outflow of 10m^3/s, with the critical duration storm the 90 minute event.

This location for the detention basin was chosen for the following reasons:

- Lowest point on the site
- Low possibility of encountering acid sulphate soils (see ASS report)
- Limited development potential of this area as the site elevations are low.

This onsite detention basin will not only provide flood mitigation applications it may also provide potential to capture and store minor stormwater flows for harvesting purposes.

3. WATER QUALITY

3.1 Introduction

A Water Sensitive Urban Design (WSUD) approach will be adopted at both a Masterplan and a detailed design level. The basis of the WSUD for the proposal as a whole has been set in the stormwater management system designed for the Masterplan. In terms of stormwater management, this places an emphasis on stormwater treatment, peak flow mitigation, harvesting and reuse, while also ensuring that such practices adopt the multi-objective approach to stormwater management.

The multi-objective approach includes features such as:

- Detain and slow the conveyance of stormwater through the site
- Harvest and use stormwater as an alternative source of water to reduce the reliance on potable and ground water supplies
- Use vegetation and landscaping to filter and treat stormwater
- Integrate the stormwater management into the landscaping
- Water efficient landscaping and the use of local indigenous vegetation species
- Protection of the water related environments and their associated values
- Protection and enhancement of recreational, social, and cultural values
- Improved biodiversity, ecological and habitat outcomes
- Community education and demonstration.

Overall the proposal will incorporate the following stormwater management features:

- Capture, treatment and reuse of stormwater runoff at the allotment level, and at the site level
- Treatment of stormwater via wetlands, bio-filtration beds / rain gardens, and vegetated swales
- Management of the major storm events up to the 1 in 100 year Average Recurrence Interval (ARI) as discussed in Section 2.

This report will focus on the areas of WSUD required at the macro Masterplan level, noting the intention is also to include WSUD features throughout the proposal at the detailed precinct level.

Some examples of typical WSUD features that might be incorporated throughout the proposal are shown in the following images.

Rain Garden / Bio-filtration bed

Biofiltration systems

Infiltration / wetland pond

Rainwater Retention tank (above ground)

Vegetated Swale

Currently stormwater runoff from the site is not treated prior to discharging via the Thompson Outfall Channel.

A secondary recycled water source is crucial in order to meet the predicted water demand for all new projects given the impacts of climate change and drought, stormwater runoff provides a very important source of potentially reusable water.

The stormwater runoff from Buckland Park will need to be treated to achieve the South Australian Environmental Protection Authority (SAEPA) – Environment Protection Water Quality Policy 2003, guidelines, on the basis the water will either be discharged to the marine environment or to the aquifer for storage.

It is recognised by the Institute of Engineers Australia (refer Reference 6) that treatment of up to a 1 in 3 month storm event, is equivalent to treatment of 93% of the annual runoff. It is not considered practical to capture and treat water for events greater than a 1 in 1 year ARI. For water quality treatment, a design treatment event between a 1 in 3 month and a 1 in 1 year ARI event is normally adopted.

A MUSIC (Model for Urban Stormwater Improvement Conceptualisation) model was established to assist in developing the proposed water quality treatment strategy to achieve the SA EPA Water Quality Policy Guidelines.

3.2 Aquifer Storage and Recovery Potential

The Aquifer Storage and Recovery Potential at Buckland Park has been assessed by REM in their report *Aquifer Storage and Recovery Potential for Buckland Park, (Reference 7).* REM has advised the T2 aquifer has the potential to accept up to 50ML/a of water without pressurising the aquifer. Pressuring the aquifer would potentially result in increased storage potential, however, it would significantly impact on all existing bores connected to the T2 aquifer, requiring the bore heads to be sealed, and pumps changed to suit the new aquifer pressure.

There are a currently 287 recorded local bores that could be affected by pressurising the aquifer and it is therefore concluded planning should exclude this option.

For the purposes of assessing the ASR potential of the site, it has been assumed a maximum of 50ML/a of treated water can be discharged to the local T2 aquifer, compared to the potential to capture up to 2000ML/a of annual runoff.

The ASR potential is therefore very limited in terms of its ability to be a reliable source of secondary water supply, unless above ground storages with floating covers are considered which have proven to be very costly, and would add significantly to the cost of water. SA Water advised that sufficient recycled water will be made available from Bolivar for the recycled water supply for the entire proposal. On this basis it is likely that the 50ML/a of ASR potential will be used to provide recycled water for irrigation of some parks, and to top up wetland water bodies.

As there is limited ASR potential on the site, and a limited ability to construct wetlands in portions of the proposal site due to the high groundwater level, it is recommended that residents be encouraged to install rainwater tanks. This can be implemented through design guidelines.

3.3 Stormwater Treatment Strategy

In order to determine the level of water treatment required to meet the SA EPA guidelines a preliminary treatment strategy was prepared. The strategy employs the use of large lineal treatment swales and wetlands to promote natural water treatment processes to occur as the flows move through the catchment area.

A MUSIC model was setup to evaluate the effectiveness of these treatment strategies.

It can be seen in the stormwater layout that trash racks, swales and 2 wetlands are proposed to treat the stormwater prior to its reuse, or discharge.

3.3.1 Water Quality Criteria

There are a number of guidelines and standards that can be used to assess the outcomes of a water quality strategy. The following two were used in this investigation:

1. South Australian Environmental Protection Authority (SAEPA) EPP Water Quality Policy (2003) for discharge to a marine environment.

   This policy provides standard concentration levels that pollutants should not exceed if they are to be able to be safely discharged into a marine environment.

   EPP Water Quality Criteria:

   4 Total Suspended Solids = 10 mg/L

   5 Total Phosphorus = 0.5 mg/L

   6 Total Nitrogen = 5 mg/L

   7 Gross Pollutants were not specified therefore 100% removal was adopted

2. CSIRO Best Practices Environmental Management Guideline

   This guideline was published in the CSIRO publication “Urban Stormwater, Best Practice Environmental Management Guidelines” and it provides a guide as to the minimum percentage pollutant removal a treatment strategy should achieve.

   CSIRO Reduction Parameters:

   - Total Suspended Solids = 80%
   - Total Phosphorus = 45%
   - Total Nitrogen = 45%
   - Gross Pollutants = 100%.

3.3.2 MUSIC Modelling

MUSIC is a software model which predicts the performance of stormwater quality improvement systems by simulating the quantity and quality of runoff produced by catchments and assessing the effectiveness of down stream treatment points to reduce pollutant loads. The treatment methods used in this treatment strategy include:

- Gross Pollutant Traps (GPT's)/Trash racks
- Swales
- Wetlands
- Ponds

There are a number of pollutants which can be present in stormwater runoff. Within the MUSIC model only the following are analysed:

- Total Nitrogen
- Total Phosphorus
- Total Suspended Solids
- Gross pollutants

Other pollutants are expected to be present in the runoff prior to treatment, it is known however that fine particulate pollutants attach themselves to other particulate pollutants such as Total Phosphorus (TP) and Suspended Solids (SS). MUSIC therefore assumes that by targeting pollutants such as TP and SS it will also be treating other pollutants.

Figure 3.1 shows how the stormwater strategy has been arranged within the MUSIC model. It can be seen that each sub-catchment is connected to a GPT/Trash rack and a swale prior to entering either a wetland or a capture basin.

This layout is not a true representation of how the system will operate, but was an altered version constructed to suit the capacity of the modelling program.

The MUSIC model requires the input of local rainfall data to generate realistic surface runoff volumes. For this analysis 5 years of rainfall data from the Edinburgh RAAF base was used. This data was thought to provide a reasonable representation of the possible rainfall in the Buckland Park area.

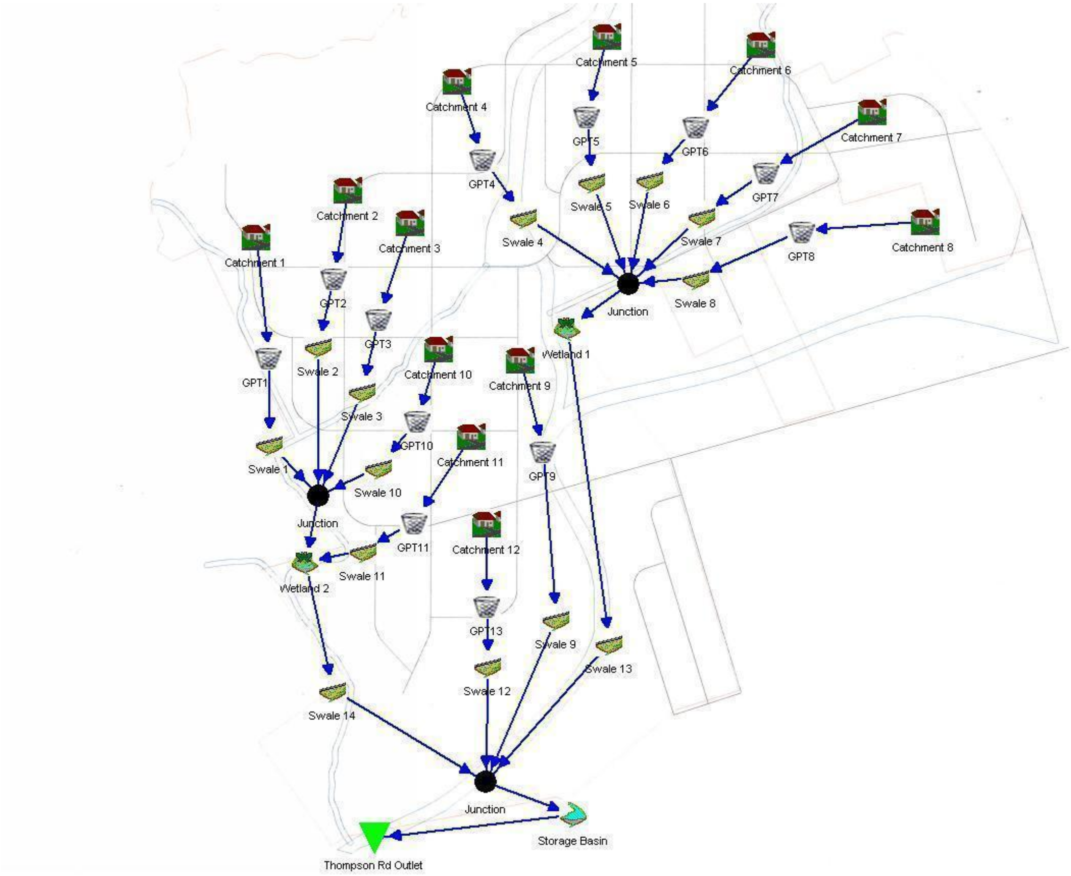


Figure 3.1 - MUSIC Model Layout

In order to run the model a number of assumptions needed to be made. These assumptions included the following:

- Impervious Storage = 2 mm
- Pervious Soil Storage = 40 mm
- Pervious Field Storage = 30 mm

These figures have been altered from the default parameters automatically setup in the MUSIC model and are typical for catchments in South Australia.

Given the limited availability for ASR potential on site, and due to the relatively high water tables at the south western end of the site, it is proposed that only two wetland systems would be able to be constructed in the higher areas of the site where the groundwater is deeper, and the risk of groundwater intrusion into the wetland is minimised.

3.3.3 *Water Quality Results*

Table 3.1 and 3.2 show the results that were determined by the MUSIC model. These results have been compared to both the SA EPA water quality policy standards for discharge to marine environments and also to the CSIRO best practices guidelines.

Table 3.1- Water quality results compared to SA EPA policy

	Pollutant Type	Total Phosphorus (mg/L)	Total Nitrogen (mg/L)	Total Suspended Solids (mg/L)	Gross Pollutants (Kg/6 minutes)
	Target Value mg/L	**0.5**	**5**	**10**	**Not Specified**
Catchment Identifier	**1**	0.011	0.122	1.15	0.00
	2	0.0053	0.058	0.569	0.00
	3	0.0093	0.105	1.00	0.00
	4	0.0114	0.132	1.32	0.00
	5	0.0117	0.132	1.26	0.00
	6	0.0078	0.086	0.836	0.00
	7	0.0101	0.114	1.09	0.00
	8	0.0078	0.0865	0.84	0.00
	9	0.0102	0.115	1.0	0.00
	10	0.00797	0.0889	0.859	0.00
	11	0.00921	0.116	1.02	0.00
	12	0.0127	0.147	1.37	0.00
	Wetland 1	0.00427	0.0708	0.447	0.00
	Wetland 2	0.00402	0.0679	0.418	0.00
	Outlet Channel	0.00345	0.0468	0.457	0.00

Table 3.2- Water quality results compared to CSIRO guideline

	Pollutant Type	Total Phosphorus (mg/L)	Total Nitrogen (mg/L)	Total Suspended Solids (mg/L)	Gross Pollutants (Kg/6 minutes)
	Target Percentage Reduction	**45%**	**45%**	**80%**	**70%**
Catchment Identifier	**1**	89.6	91.3	90.3	100
	2	94.7	95.6	95.2	100
	3	90.5	91.9	91.2	100
	4	89.1	90.5	88.8	100
	5	88.2	89.9	88.9	100
	6	92.0	93.4	92.6	100
	7	90.1	91.6	90.6	100
	8	92.2	93.4	92.6	100
	9	90.4	91.8	90.8	100
	10	91.9	93.2	92.4	100
	11	90.4	90.9	90.8	100
	12	88.3	89.9	88.8	100
	Wetland 1	63.5	46.8	64.8	100
	Wetland 2	64.4	48.6	66.0	100
	Outlet Channel	96.3	96.5	96.0	100

From analysis it can be seen the system performs well when compared to the limits outlined by the SA EPA policy and the CSIRO guidelines. This indicates the water quality management strategy will perform adequately under the simulated conditions.

The analysis indicates the water quality discharging from the site is suitable for discharge to marine environments and water discharging from the two wetlands would meet the requirements for discharge to the aquifer.

3.4 Water Quality Impacts

Subject to final agreement with City of Playford Council, it is intended up to 80% of annual runoff will be captured for reuse both within the proposal and also external to the site. This is discussed further in Section 6. The proposal is therefore expected to have a minimal effect on increasing the frequency of flows discharging to the Thompson Outfall Channel.

The overall stormwater management regime intends to replicate the existing hydrology as far as practically possible, with the exception that in stormwater events in excess of say a 1 year Average Recurrence Interval (ARI) flow result in increased volumes of water being discharged to Thompson Outfall Channel. The net effect is expected to be approximately a 20% increase in annual runoff from the Buckland Park site compared to the existing conditions. It should be noted that Buckland Park is approximately 1,308Ha of the 8,500Ha Western Virginia catchment which discharges to the Thompson Outfall Channel. Therefore the net overall increase in runoff for the entire catchment is expected to represent about 3% to 5% of the overall volume. The 20% increase in runoff from the proposal is due to the combined effect of not practically being able to capture the highest of the peak flows on an annual basis.

3.4.1 *Buckland Park Lake System*

The flows from the Buckland Park site will not connect to the Buckland Park Lake system, hence the proposal will have no impact on the Buckland Park lake system.

3.4.2 *Cheetham's Salts*

The intake to the Cheetham Salts pans is at Middle Beach, approximately 11km north of the Thompson Outfall Channel.

The water quality discharging from the site was shown through the MUSIC modelling to meet the SA EPA Water Quality Policy requirements for discharge to marine environments. In addition it was estimated up to 80% of the annual runoff will be captured and reused within and external to the site, hence the net increase in stormwater discharging to the marine environment is relatively minor and is not expected to have any impact on Cheetham Salt pans.

4. FLOOD PROTECTION FROM GAWLER RIVER

4.1 Introduction

The Buckland Park site is currently subject to flooding during a 20 year ARI event via a breakout from the Gawler River. Refer to the *Floodplain Mapping for the Gawler River – Technical Report 2008, prepared by Water Technology and Australian Water Environments* (Reference 1). Appendix B contains the Gawler River Flood Plain Maps.

The lower reaches of the Gawler River through Virginia and Buckland Park is an example of a 'perched' river, as its banks are higher than the surrounding floodplain. When water breaks the banks of the Gawler River in these areas, water flows away from the Gawler River as opposed to being contained in a low lying floodplain. There are a number of breakouts that enter the site as shown in Figure 4.1.

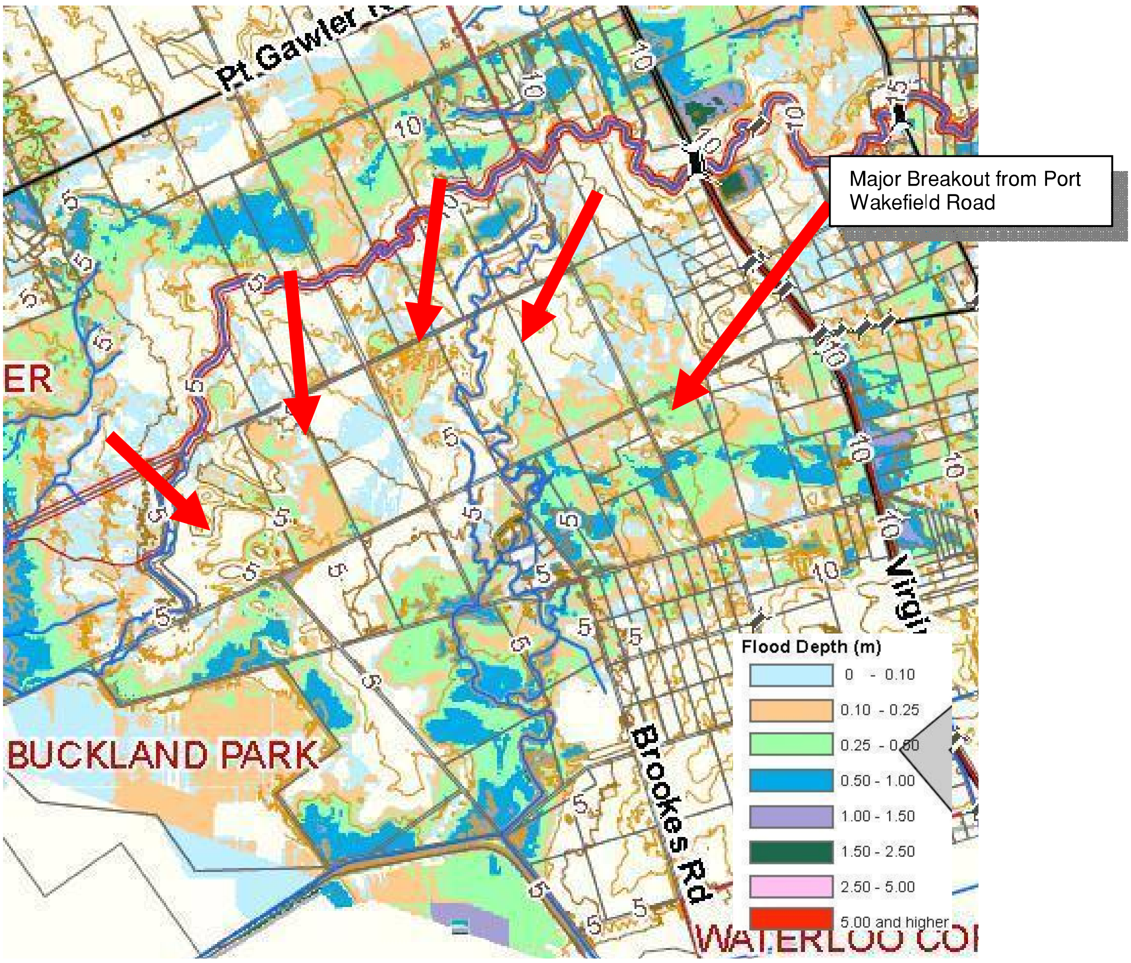


Figure 4.1 - Extract from 100 year ARI Floodplain Map from AWE/Water Technologies Floodplain Report

The flows are relatively shallow in nature and in terms of Flood Hazard as defined by the Australian Government SCARM 2000, Floodplain Management in Australia, Best Management Practices and Principles, the flood hazards are primarily in the low to medium category as they are relatively shallow and the flow velocities are low.

The largest breakout from the Gawler River approaches the site from the east via Port Wakefield Road and in the 100 year ARI event, is in excess of $100m^3/s$. The other breakouts are relatively minor, however, they do pose some risk to the site and need to be managed. Figure 4.2 shows in greater detail the predicted extent of flooding within the site in the 100 year ARI event.

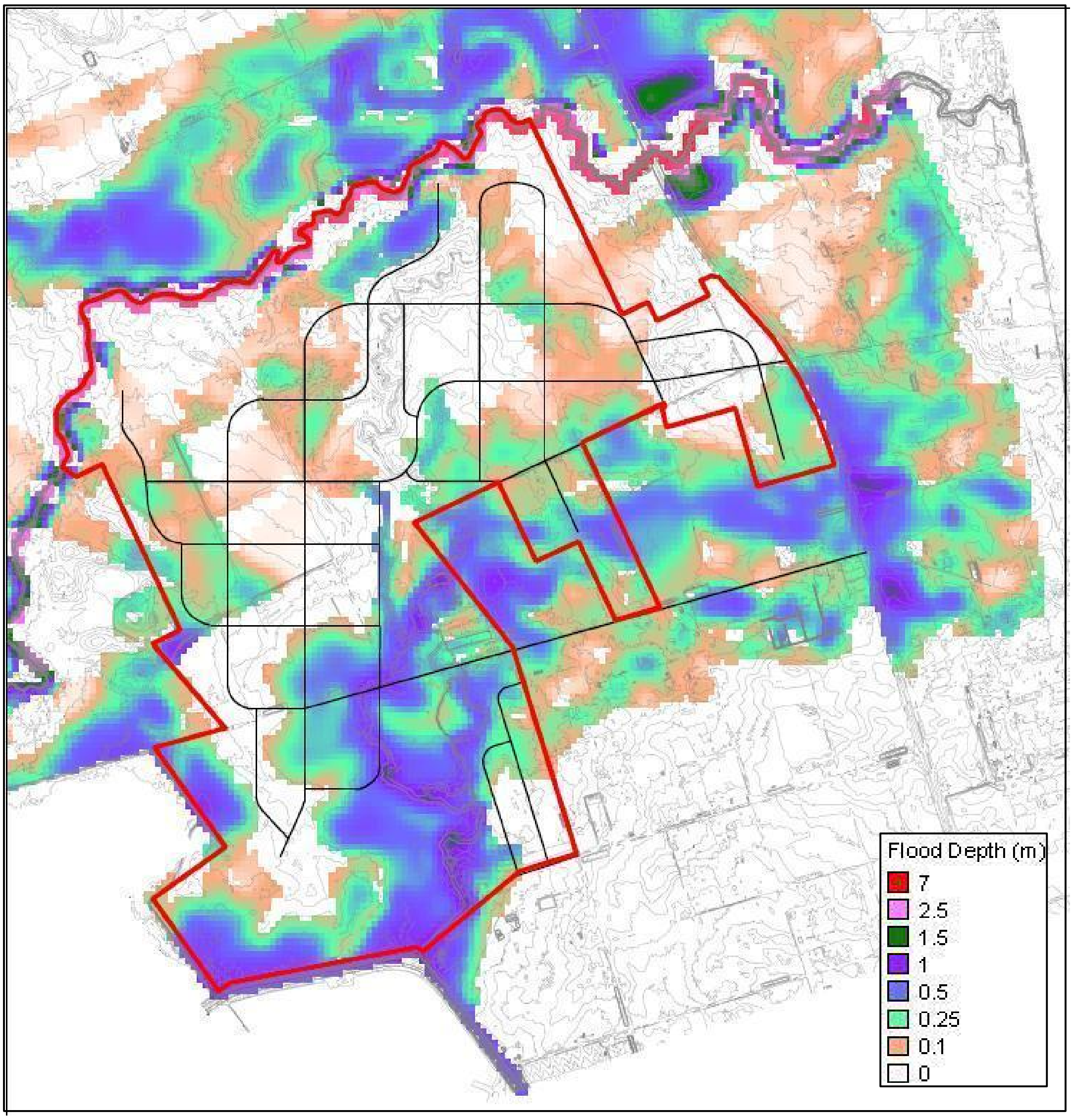


Figure 4.2 - 100 year ARI Gawler River Floodplain as it relates to the Buckland Park site

4.2 Flood Management Strategy

The flood management strategy proposed for the site involves of a series of flood channels.

The use of levees was initially trialed, particularly against the banks of the Gawler River, however, it was found that introducing levees to control breakouts often forced breakouts in other areas. Similarly, the introduction of a levee system often diverts flood flows to other areas, potentially adversely impacting adjoining properties.

It should be noted currently when the 100 year ARI breakout flows leave the southwestern boundary of the site, they overtop the Thompson Outfall Channel into the Cheetham salt crystallisation pans, and into the Bolivar Outfall channel.

As this would currently occur in a 100 year ARI flood event, and to alter this situation would require significant works outside of the site boundaries, the flood mitigation strategy allows this to continue to occur in the future as it would do now, and provides protective works within the site.

The proposed major drainage channel system proposed for Buckland Park is shown in Figure 4.3. The system consists of a number of major drains through the site to capture the breakout flows from the Gawler River. It should be noted that a flood event that would produce a breakout in the Gawler River is a long duration storm event, peaking after some 20 to 30 hours. Refer *Hydrological Study of the Gawler River Catchment* (Reference 2).

The critical storm durations for the internal drainage system are of the order of 30 to 60 minutes. Therefore the drainage system within Buckland Park would not need to accommodate a coincident peak flood event from the Gawler River and from within the site, hence, significant sections of the proposed major drainage system have been designed to provide a dual purpose.

The drains are relatively flat, particularly the main capture drain which is as flat as 0.05% in some areas. The drains have been kept relatively shallow, up to a maximum of 2.0m, to keep the invert as high as possible to keep the risk of groundwater intrusion to a minimum.

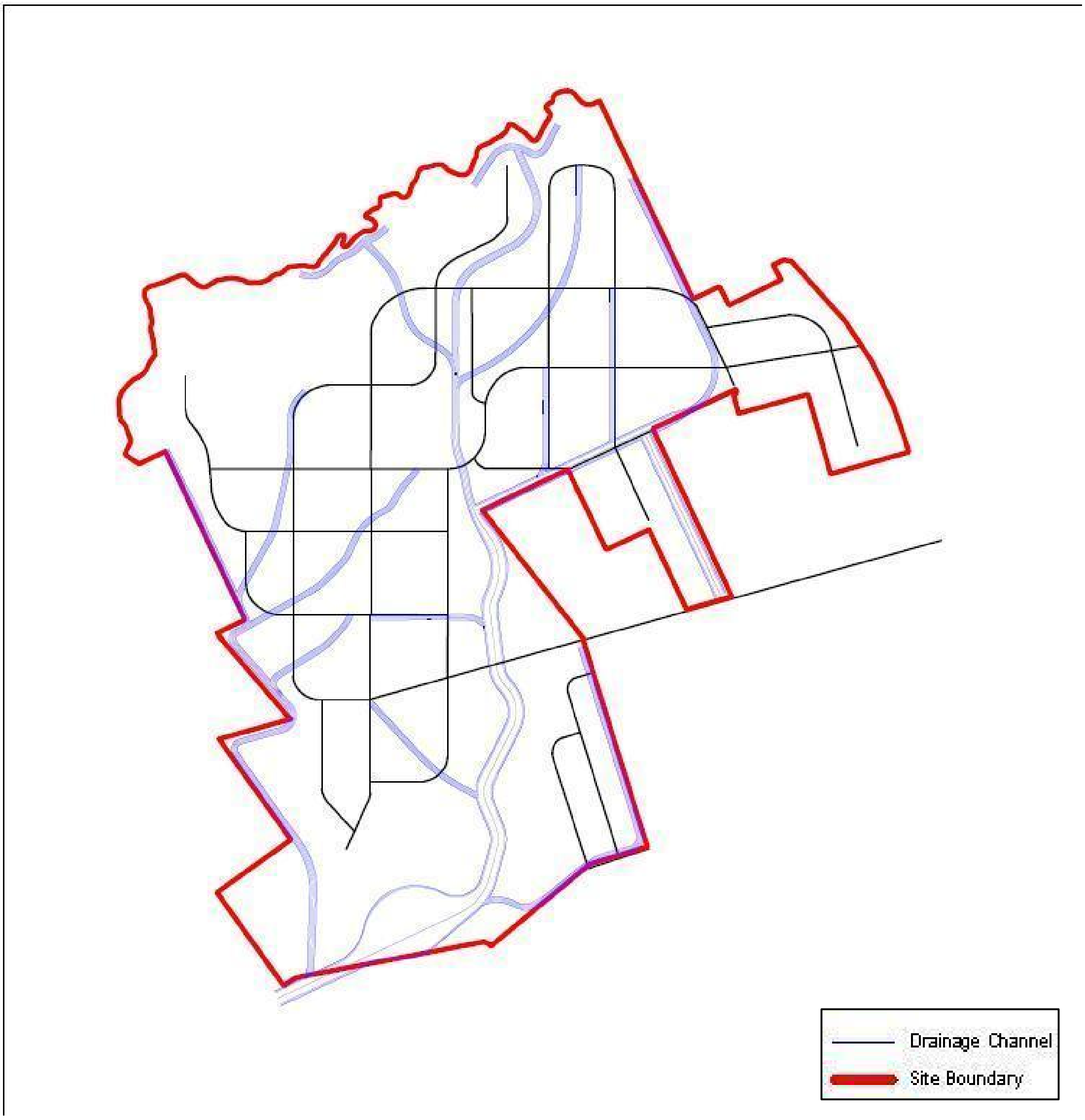


Figure 4.3 - Proposed Buckland Park Major Drainage System

4.3 Modelling

The modelling of the flood performance from breakouts from the Gawler River has been undertaken by Water Technologies under the supervision of Australian Water Environments (AWE) as the consultants for the Gawler River Floodplain Mapping Project.

The modelling has been undertaken using the two dimensional floodplain model MIKE 21, using the modelling assumptions adopted and agreed for that study.

A series of trials have been carried out which have led to the preferred solution for the proposal.

4.4 Results

Figure 4.4 presents the results of a 100 year ARI event on the Gawler River.

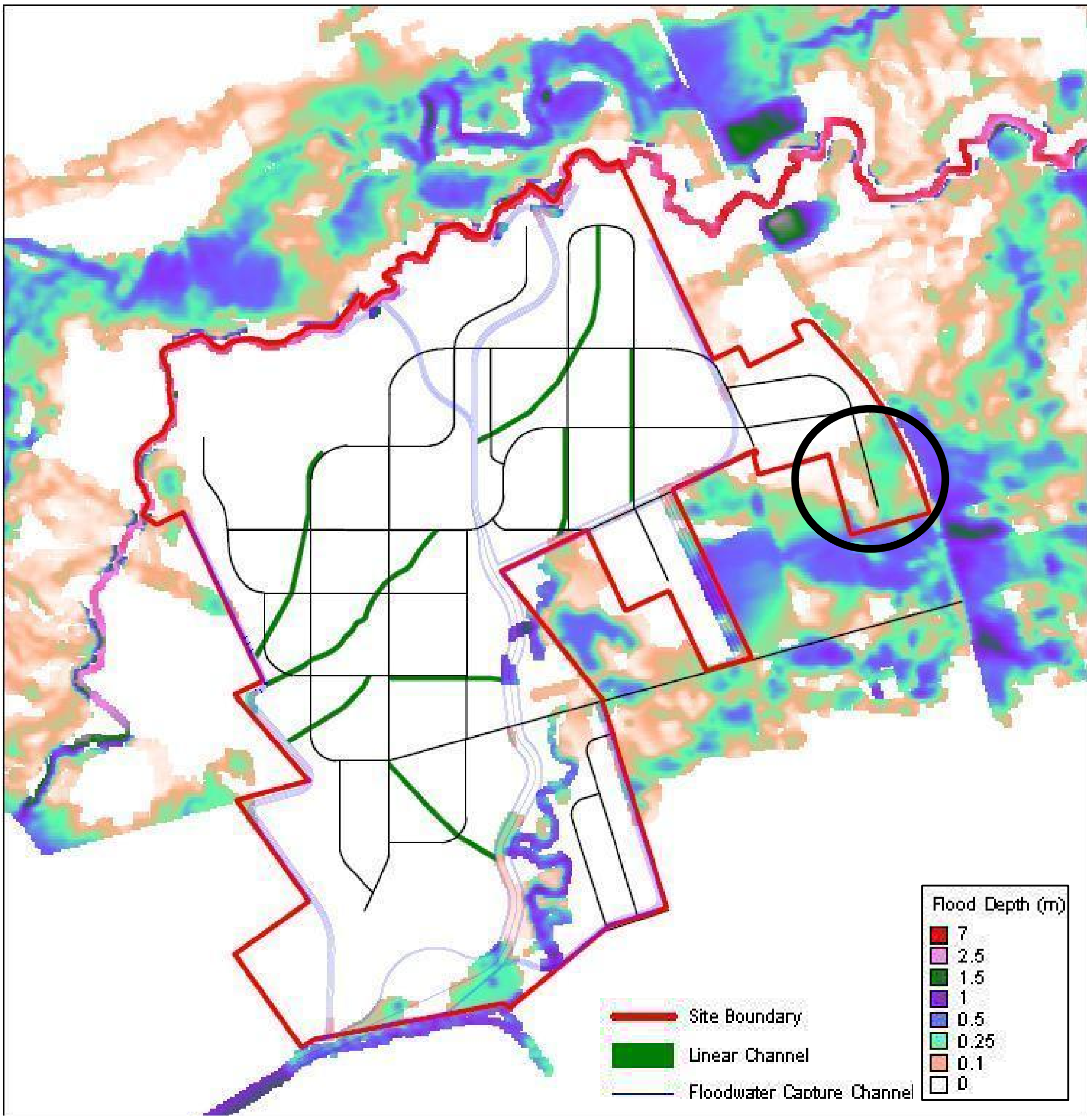


Figure 4.4 - 100 year ARI event in Gawler River with proposed Flood Protection Channels

The modelling shows that the proposed open channel system has the capacity to capture and pass the 100 year ARI Gawler River breakouts through the site, the exception is the proposed District Centre and Mixed Use precinct adjacent Port Wakefield Road which has been highlighted in Figure 4.4.

This area will not drain northward because of its topography. In order to provide 100 year ARI flood protection to this area, a trial was modeled where the area was filled and a 20m wide overflow path adjacent Port Wakefield Road was used to channel the low flows.

The results are shown in Figure 4.5.

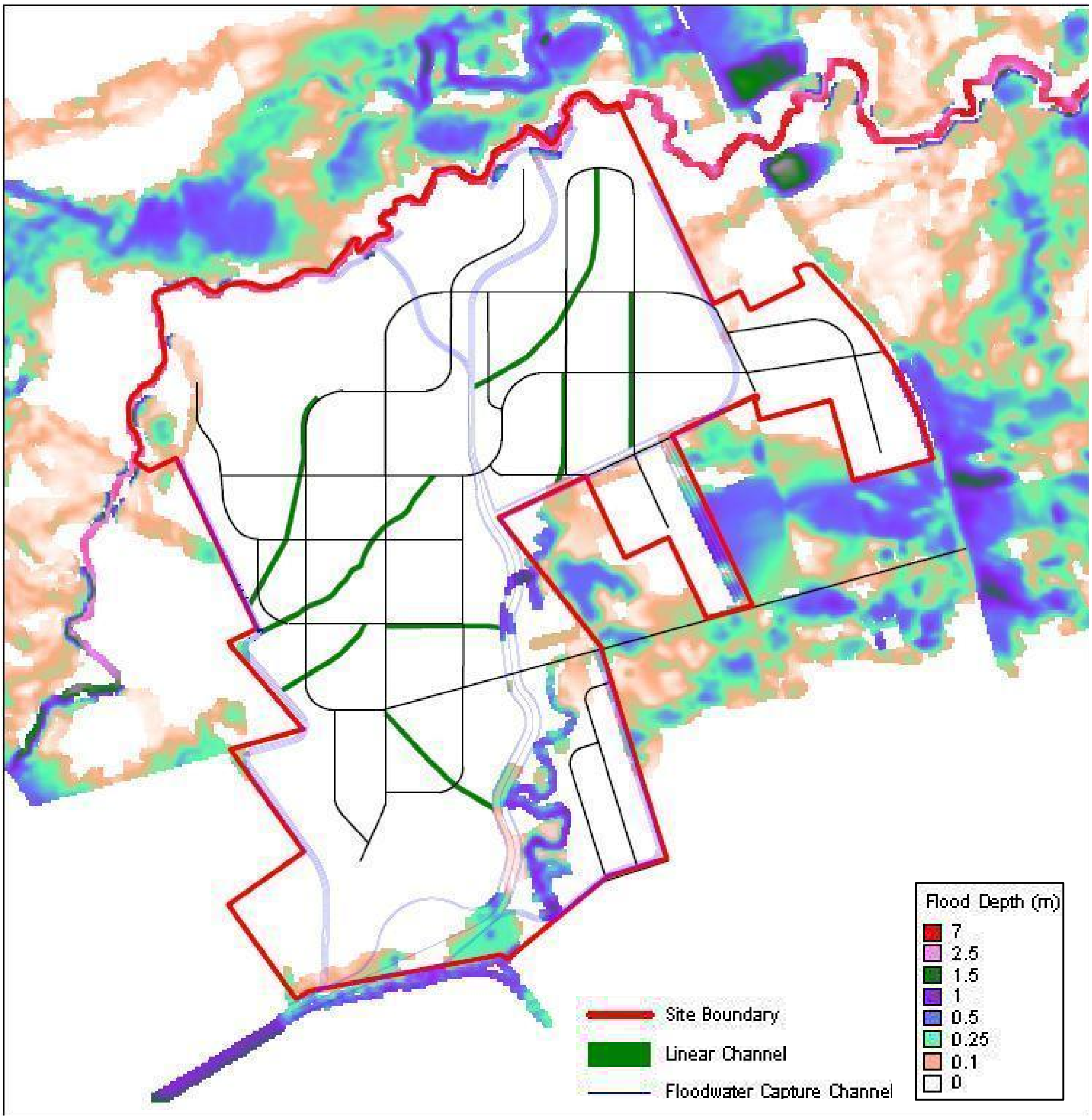


Figure 4.5 - 100 year ARI event in Gawler River with proposed Flood Protection Channels and fill in a section of the Proposed District Centre and Mixed Use precinct.

Figure 4.5 demonstrates that filling this site adequately passes the breakout flow that crosses Port Wakefield Road around the District Centre site.

Filling of an area can adversely impact on flood levels on adjoining properties. A comparison between the predicted water surface elevations from the no fill scenario and the proposed fill scenarios as shown in Figures 4.4 and 4.5 has been prepared as is shown in Figure 4.6.

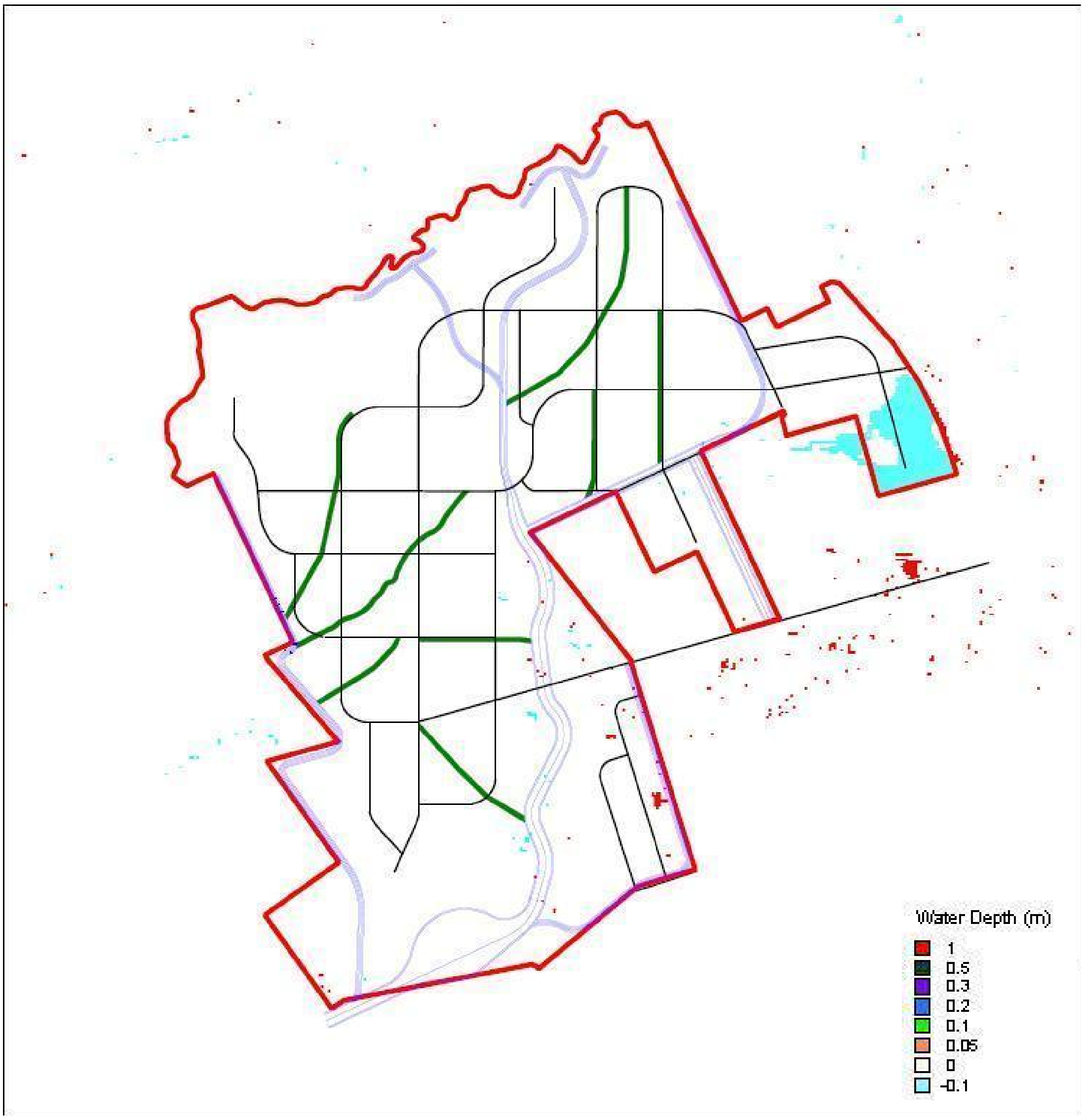


Figure 4.6 - Predicted difference in 100 year ARI Flood elevations with and without the proposed fill to the District Centre and Mixed Use precinct.

Figure 4.6 shows that upstream of Port Wakefield Road, there is no discernible difference in flood levels between the 'filled' District Centre and Mixed Use precinct option and the no filled option. The areas shown in red, represent areas where the two water surface levels do not overlap and are really representative of calculation differences between the two models resulting in minor differences in flood extents.

It is believed the difference is due to there being no data in one model and some data in the other, hence producing an error when the difference in the flood surfaces are calculated.

4.5 Impacts of blockage in the Gawler River

The potential for a blockage to occur on the Gawler River, and the resulting impacts this would have on flooding in Buckland Park has been considered.

In the 2005 flood event in the Gawler River, a fallen tree contributed significantly to the flooding, primarily by causing a break in a levee on the banks of the River (Personal Communication with AWE, November 2008).

Consideration included the potential flood impacts of an obstruction in the Gawler River, between Port Wakefield Road and the site's western boundary. A channel blockage factor of 25% was considered a reasonable upper limit. A 25% blockage was trialed at a number of locations, however, no additional breakouts were predicted, as the section of Gawler River downstream of Port Wakefield Road has greater capacity than sections upstream, and water will break the banks of the Gawler River at locations indicated in AWE mapping, resulting in flows less than the capacity of the Gawler River in the channel downstream of Port Wakefield Road.

Figure 4.7 and 4.8 show the predicted 100 year ARI floodplain in Buckland Park created by placing 25% blockages at two locations on the Gawler River, downstream of Port Wakefield Road.

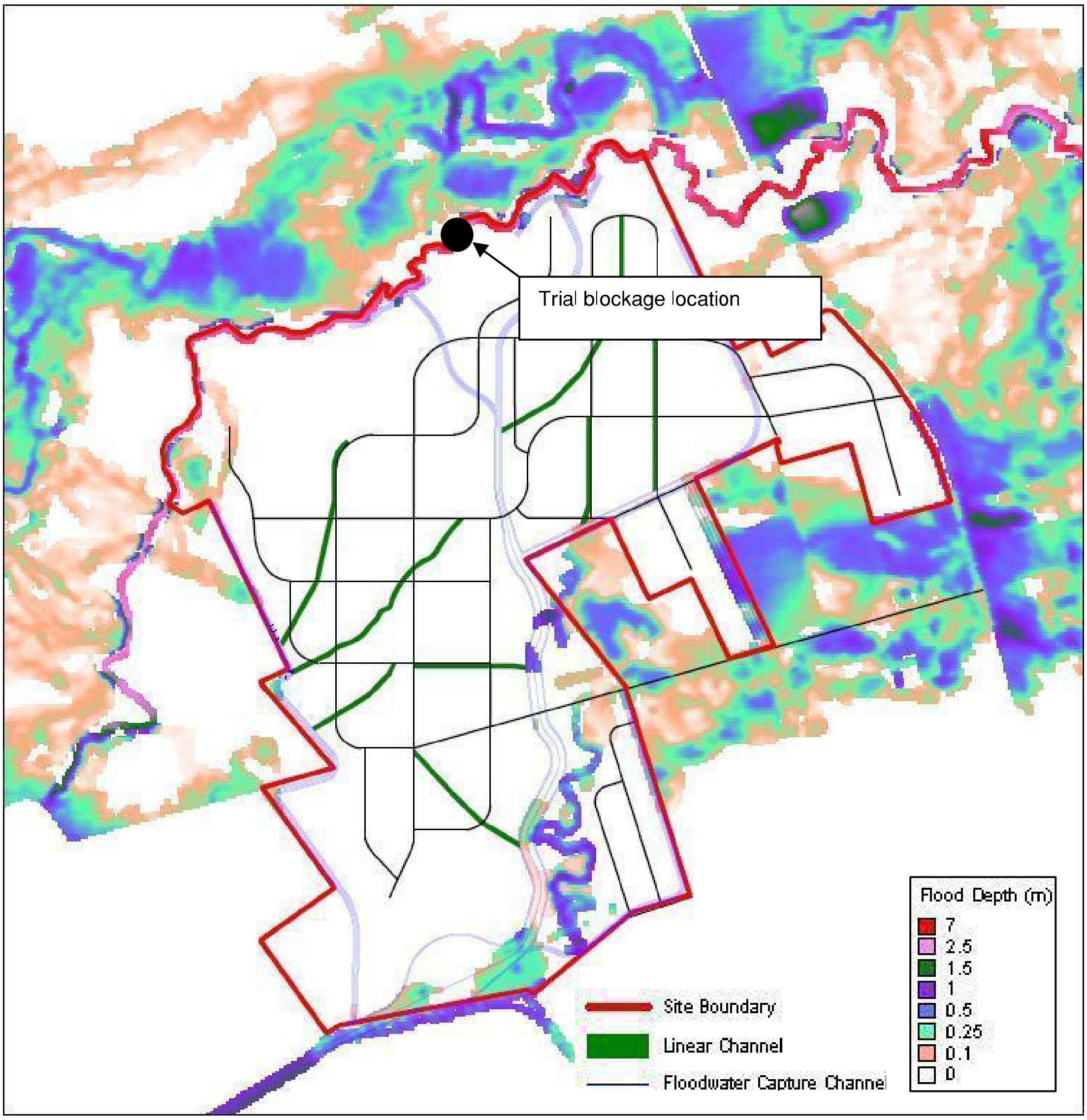


Figure 4.7 - 100 year ARI floodplain with a 25 percent blockage of Gawler River at Location 1

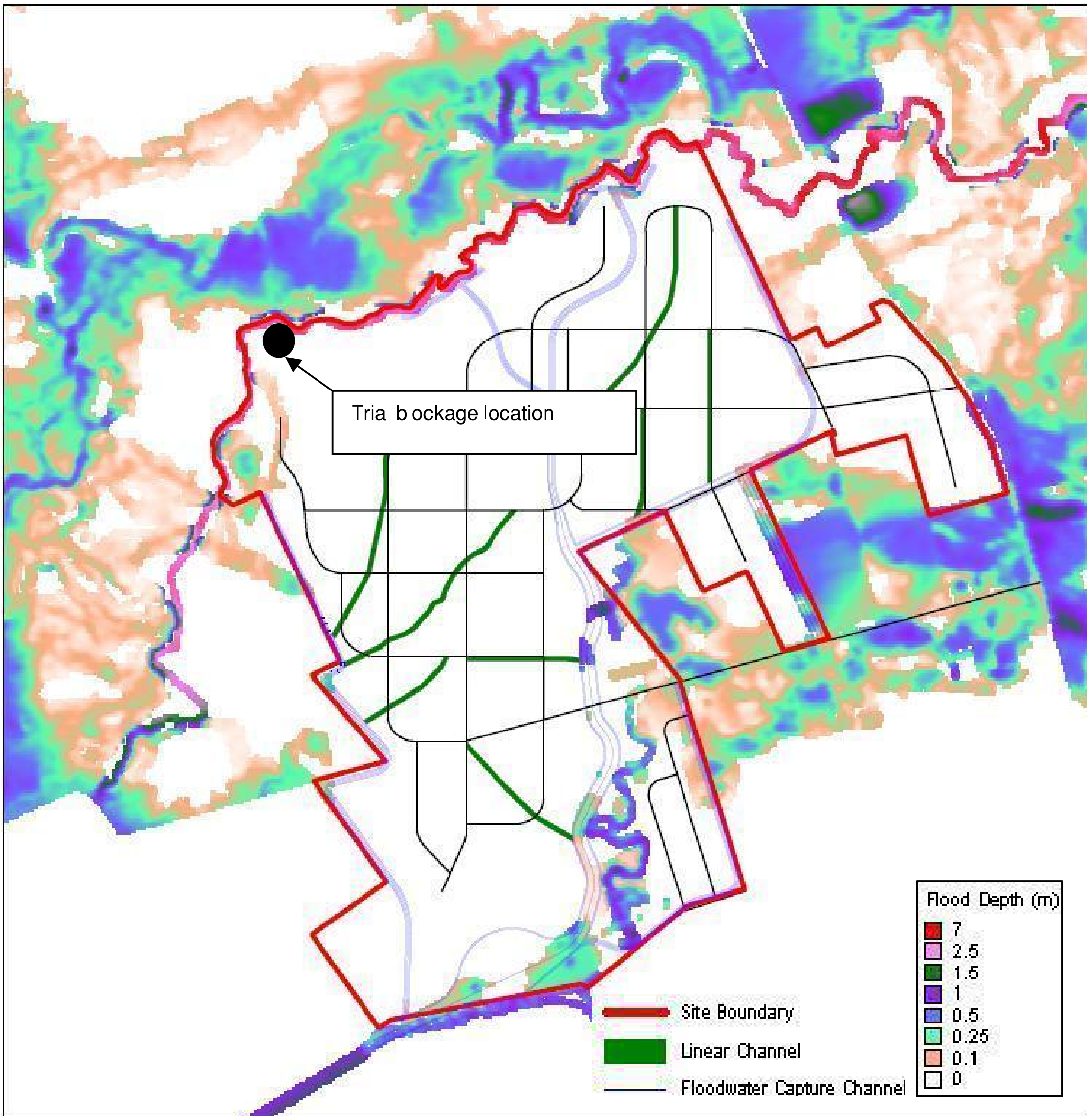


Figure 4.8 - 100 year ARI floodplain with a 25 percent blockage of Gawler River at Location 2

The modeling indicates that the risk of a blockage occurring in the Gawler River downstream of Port Wakefield Road has little to no impact on an increase in flood risk in the 100 year ARI event.

5. WASTE WATER

5.1 Introduction

Currently within the Buckland Park area there is no formal system for the collection and disposal of waste water.

New waste water infrastructure will therefore be required to serve the proposal.

SA Water have advised (Reference 9) that a new rising main will be required from the site to deliver sewage directly to the Bolivar Wastewater Treatment Plant, located approximately 14km south of the site.

In order to determine the most efficient method of waste water collection system for this proposal the following network types were considered:

- Vacuum
- Pressure
- Gravity
  - Septic Tank Effluent Disposal System (STEDS)
  - Full Sewer

These four sewerage schemes were assessed based on their cost effectiveness, and the suitability of their design characteristics for the environmental conditions on site.

The environmental conditions within the Buckland Park site that could significantly impact on the suitability of the use of a particular sewerage system include the following:

- High ground water level
- Highly saline ground water
- Acid sulphate soils

Based on the preliminary costing and the expected site environmental conditions a vacuum system was recommended for the Buckland Park proposal see the Network Options Report (W&G, August 2008) in Appendix C.

5.2 Environmental Conditions

Site specific environmental conditions are instrumental in determining the suitability of a sewer system. The selection of an environmentally suitable sewer system could significantly reduce the risk of cost escalations during construction, reduce ongoing running costs and increase constructability.

5.2.1 High Ground Water

The majority of the site has a depth to water table of less than 3 metres. To minimise the length of drain constructed below the groundwater table the maximum drain depth was set to 3 metres. In order to keep the pipes as shallow as possible pump stations would need to be installed at regular intervals.

From analysis it was determined for a gravity system approximately 35 pump stations would be required to keep the pipe invert level within 3 metres of the surface level. Even with this large number of pump stations, as much as 75% of the gravity drains would still be installed within the ground water zone, this is prior to considering the impacts of long term sea level rise on groundwater levels. Figure 5.1 shows a depth to water table plan for the site highlighting all areas where the groundwater is less than 3m below the surface. This map is based on recent site mapping undertaken by REM.

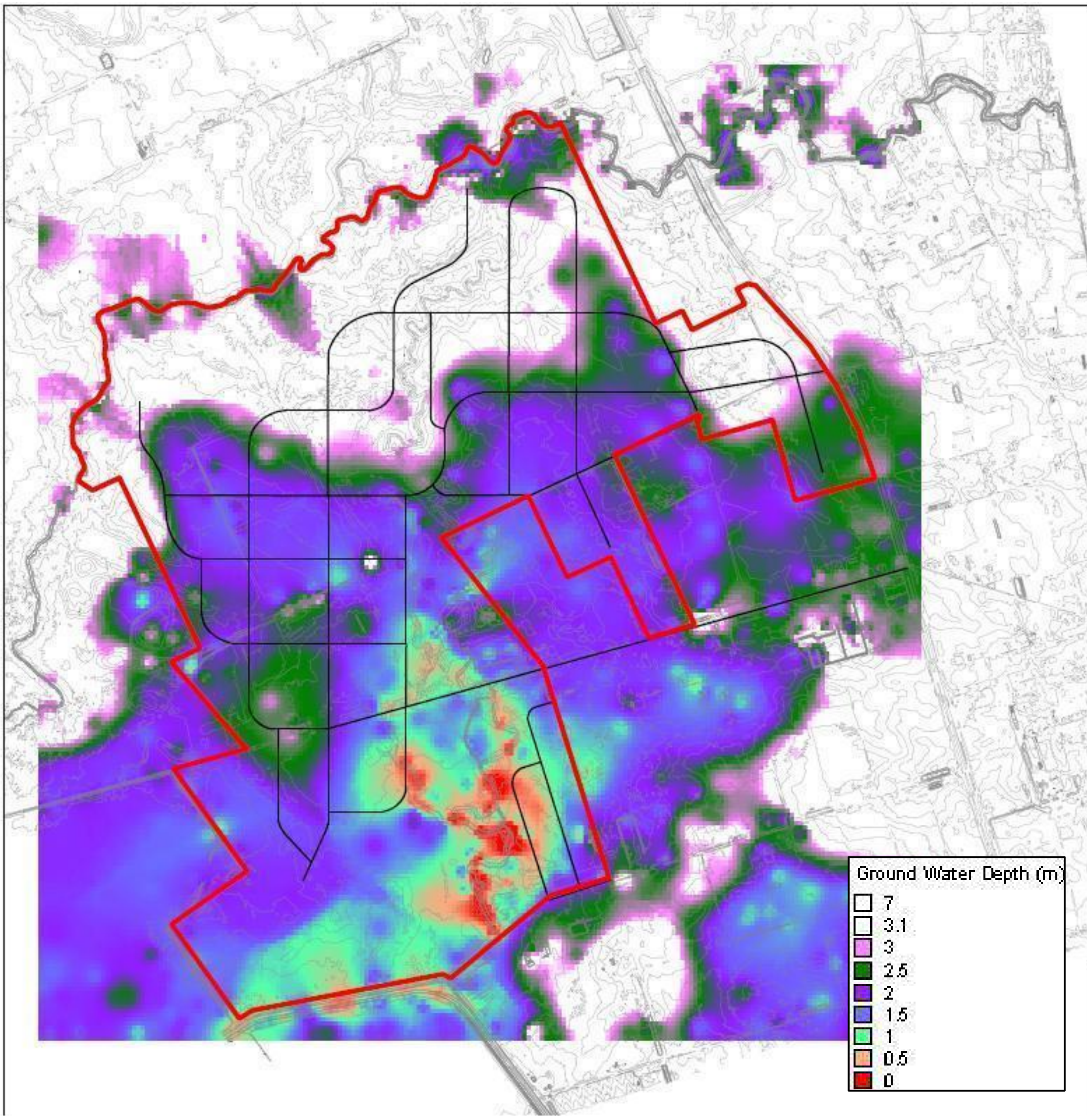


Figure 5.1 - Depth to Groundwater within 3m of existing surface level.

It should be noted that seasonal fluctuations of up to 1 metre could be experienced based on the advice from the REM report (Reference 10). This could see as much as 95% of the gravity drain being below the standing groundwater level.

Constructing a gravity system within the ground water table could potentially result in water infiltration at manholes, pump stations and any breaks or cracks in the pipe work. STED systems also have potential for ground water ingress at septic tanks.

The drains for a vacuum system are generally installed between a depth of 1.2m and 1.5m. It is estimated that for a vacuum system only 10% of vacuum drains would be installed within the water table.

Figure 5.2 indicates the area of the site that the depth to ground water is less than 1.5m

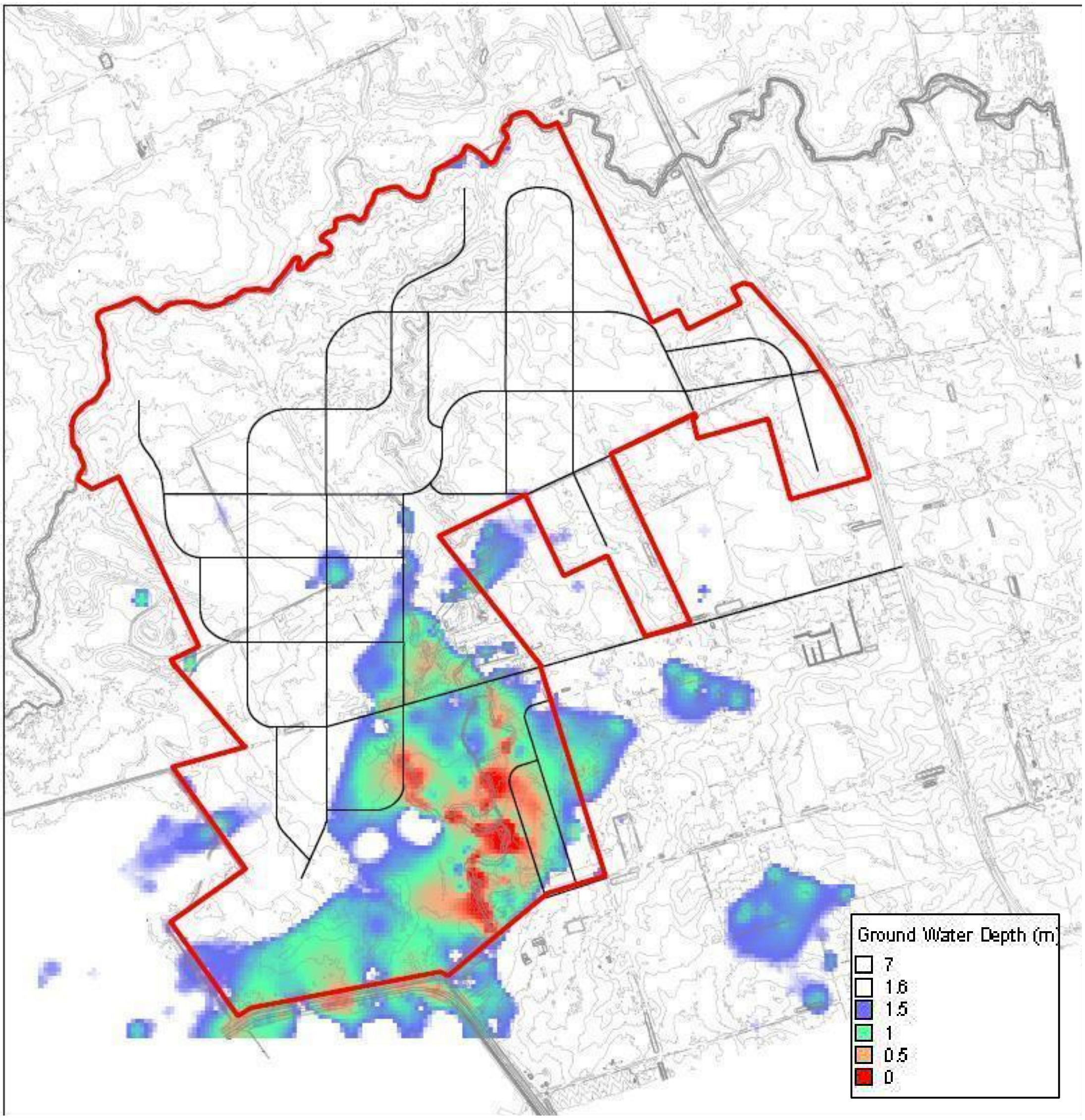


Figure 5.2 - Depth to Groundwater within 1.5m of existing surface level.

It should be noted some of the areas within the proposed urban areas shown here as being within 1.5 of groundwater, will be filled to provide for adequate protection from long term sea level rise.

5.2.2 *Salinity*

Ingress of saline ground water into the waste water pipe network could cause the salinity of the waste water to increase and highly saline waste water can impact on the effectiveness of the operation of the WWTP at Bolivar. Increased salinity could also impact on the potential number of reuse applications for the treated effluent.

The ground water within the Buckland Park site is expected to have salinity in the order of 1000ppm to 5000ppm (TDS).

The salinity of typical treated waste water schemes in South Australia is between 800ppm and 1000ppm (TDS). This would mean relatively small volumes of ingress could significantly impact on producing treated waste water of an acceptable salinity level.

The Buckland Park proposal places a high priority on the potential to reuse the treated waste water, therefore the potential for ingress of saline groundwater into the waste water management system was a significant factor in selecting the most appropriate method of waste water management.

5.2.3 *Acid Sulphate Soils*

It has been confirmed by Golders Associates (Reference 5) that sections of the Buckland Park site have the potential to encounter acid sulphate soils below the ground water level (see Figure 5.3 for potential acid sulphate soil locations)

If Acid Sulphate Soils (ASS) are encountered within trenches, the soil will need to be treated prior to the installation of any infrastructure, therefore causing construction costs to increase.

Precautions will need to be taken to prevent ingress of leachate from ASS getting into the trenches and being transported around the site. Both vacuum and pressure systems will minimise leachate ingress due to the relatively shallow depth of drains. Gravity drains also drain for long distances at a constant downward grade which facilitates the transport of leachate (if encountered). Both the vacuum and pressure sewerage drains are not required to constantly grade downward, this in itself would minimise the spread of ASS leachate should it be encountered.

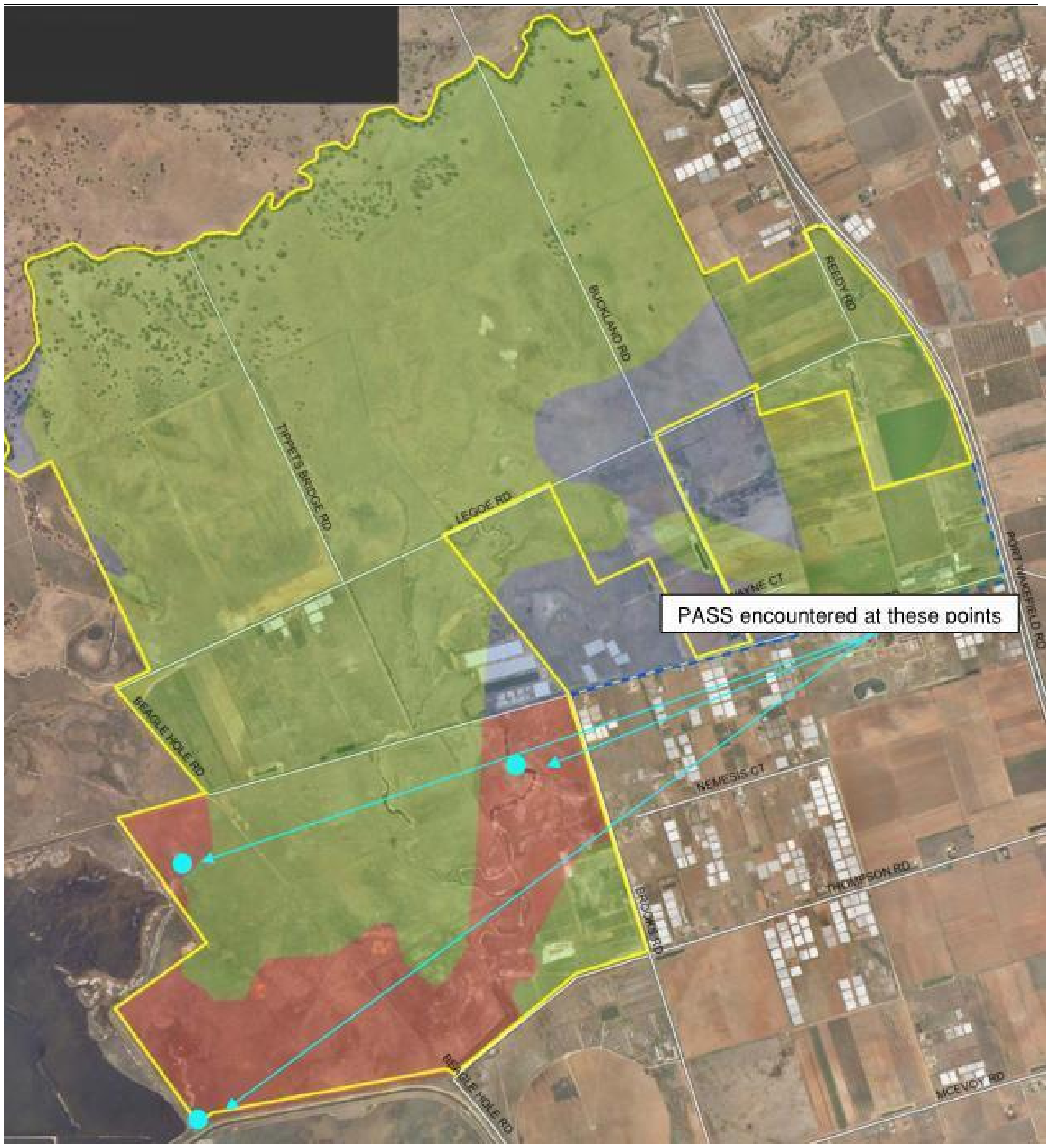


Figure 5.3 - Potential acid sulphate soil locations.

5.3 Recommended Waste Water Management System

From Wallbridge & Gilbert's analysis in Appendix C it was determined that the most suitable form of communal waste management system for Buckland Park is a vacuum system.

The reasons for recommending this option include:

- Lower estimated capital cost and all of life costs
- Reduced potential impacts of salinity on the reuse applications
- Lesser impact of peak wet weather flows on the WWTP and pump stations
- Lesser potential for long term ground water ingress
- Reduced risk of system failure due to groundwater ingress
- Lower pumping costs associated with limited groundwater ingress
- Approximately 75% of drains in a gravity system would be installed below the current ground water levels, even with the installation of 35 pumping stations

5.4 Methods for Disposal of Waste Water

In order to determine the most feasible method for treating and disposing of Buckland Park's waste water a number of scenarios were considered.

The main scenarios that were considered are shown in the table below:

Scenario	Interim	Ultimate
1	Onsite WWTP with 5000 Person capacity	450mm pipe to pump waste water to Bolivar WWTP
2	225mm pipe to pump waste water to Bolivar WWTP	450mm pipe to pump waste water to Bolivar WWTP
3	150mm pipe to pump waste water to Bolivar WWTP	450mm pipe to pump waste water to Bolivar WWTP
4	33,000 person capacity onsite WWTP	

The above scenarios include opportunities for the disposal method to be staged in order to cater for:

- Initial capital cost reduction
- Waste water flow production.

The treatment of effluent in an onsite WWTP has been considered and discounted for the following reasons:

- Buffer areas around the Plant will require a large area within the site, which may be more efficiently used for urban purposes.
- There are environmental constraints associated with areas that do not have urban potential, which preclude a WWTP. For example, significant flora, high ground water and potential acid sulphate soils.
- A new facility may be more costly to construct than augmentation at an existing WWTP facility.

The preferred method for disposal of the effluent generated by the completed Buckland Park proposal is pumping the effluent via a 450mm PVC rising main to the Bolivar WWTP.

The Bolivar WWTP is located approximately 14 kilometres south of the Buckland Park site. This represents a considerable pumping distance and will result in large friction losses and potentially long travel times.

In the proposal's early stages the effluent flow rates generated will be significantly smaller than the flows that will be generated by the completed proposal. Therefore, if the 450mm pumping main required for the completed proposal was used in the early stages it would lead to a reduction in flow velocity within the pumping main. This reduction in flow velocity could potentially cause the pumping main to slime up, and will increase the travel time taken for the waste water to reach the Bolivar WWTP.

SA Water advised (Pers Comm Lewis, G, SA Water, November 2008) that long travel times will cause the raw waste water to become septic and will promote the production of hydrogen sulphide. Hydrogen Sulphide production is highly undesirable and will have a significant impact on the efficiency of the operation of the Bolivar WWTP, therefore staging the pumping main to cater for the magnitude of waste water production and subsequent flow velocity is critical.

The travel times expected at each of the proposal's stages have been calculated and can be seen in Table 5.3.

These calculations were based on a number of assumptions including:

- Number of persons per allotment = 2.8
- Peak flow rate = 17.5 L/person/hour
- Approximately 480 homes in the first year of construction
- Total head of 120 metres

Table 5.3 Pumping Main Detention Times

Pumping Main Size	Maximum Number of Persons	No. of Allotments	Flow (L/s)	Travel Time	Notes
150 mm	1,350	480	6.5	10 hours 34 minutes	First Stage of Proposal
225 mm (poly)	1,350	480	6.5	15 hours 44 minutes	First Stage of Proposal
150 mm	4,100	1,470	20	3 hours 26 minutes	Peak Pipe Capacity
225 mm (poly)	7,800	2,800	38	3 hours 56 minutes	Peak Pipe Capacity
450 mm	4,120	1,470	20	30 hours 56 minutes	150mm Change Over Point
450 mm	7,820	2,800	38	16 hours 17 minutes	225mm Change Over Point
450 mm	33,000	12,000	160	3 hours 53 minutes	Ultimate Population

During the proposal's initial stages of the waste water flows generated will be considerably smaller than the capacity of the 150mm and 250mm pumping mains (approximately 6.5L/s), therefore the travel time taken for waste water to reach the Bolivar WWTP will initially be increased. As more stages are constructed and occupied, these travel times will decrease.

From calculations it was determined that at 120m of head pressure, the capacity of the 150mm and 225mm pumping mains are 20L/s and 38L/s respectively. Using these calculated pumping main capacities, the population at which the 450mm pumping main will need to be commissioned was determined. For the 150mm pumping main this point occurs at a population of 4,120 people or 1,470 allotments, whilst for the 225mm pumping main this occurs at 7,820 people or 2,800 allotments.

When comparing the cost and suitability of the 150mm and 225mm pumping mains it is envisaged the 150mm main will be the most cost effective option, however, once the capacity of the 150mm main is reached, and the 450mm main is commissioned, the reduced flow volume and velocity in the 450mm main will cause a significant travel time increase to approximately 31 hours, which is approximately 15 hours longer than the travel time at the 225mm pumping main change over point.

As the 150mm pumping main has a reduced waste water flow capacity, the operational life of the pipe will be considerably reduced in comparison to the 225mm pumping main.

The occurrence of these long travel times was discussed with an SA Water representative (Pers Comm Cesca, J, CH2MHILL, November 2008) and it was established that these travel times are unavoidable and as such the production of hydrogen sulphide within the pumping main is expected. In order to reduce the septicity of the waste water and therefore the hydrogen sulphide level significant head works will be required prior to the waste water entering the existing Bolivar WWTP treatment train.

6. WATER SUPPLY

6.1 Introduction

Under the City of Playford Council's Development Plan Buckland Park is zoned as Horticulture West. This zone means that the Buckland Park site is predominantly undeveloped farm land with a small demand for potable water supply, therefore a limited amount of SA Water infrastructure was installed in the area.

Upon completion, the Buckland Park proposal will comprise approximately 12,000 allotments. A proposal of this scale will create a large demand for potable water in a previously undeveloped area.

In order to provide a reliable source of potable water, major infrastructure works will be required. SA Water outlined a number of potential potable water supply options can be considered for the proposal (see Appendix D). These options include potential for short term water supply from existing infrastructure during the initial stages of construction and occupation. This will reduce initial capital costs and will also potentially provide the site with a long term backup potable water source.

Water restrictions, and the ever increasing need to conserve water resources, have made recycled water use for applications that do not require drinking quality water a necessity. Recycled water is sourced from waste water treatment systems and stormwater runoff, and is increasingly being used for non potable applications within industry and also in new residential communities.

Within the proposal recycled water should be used for non potable applications such as garden watering and toilet flushing in order to reduce the proposals demand for potable water.

Figure 6.1 shows a schematic drawing of the overall water strategies that will be discussed.

Appendix D contains SA Water's assessment of the water supply options available to the Buckland Park proposal.

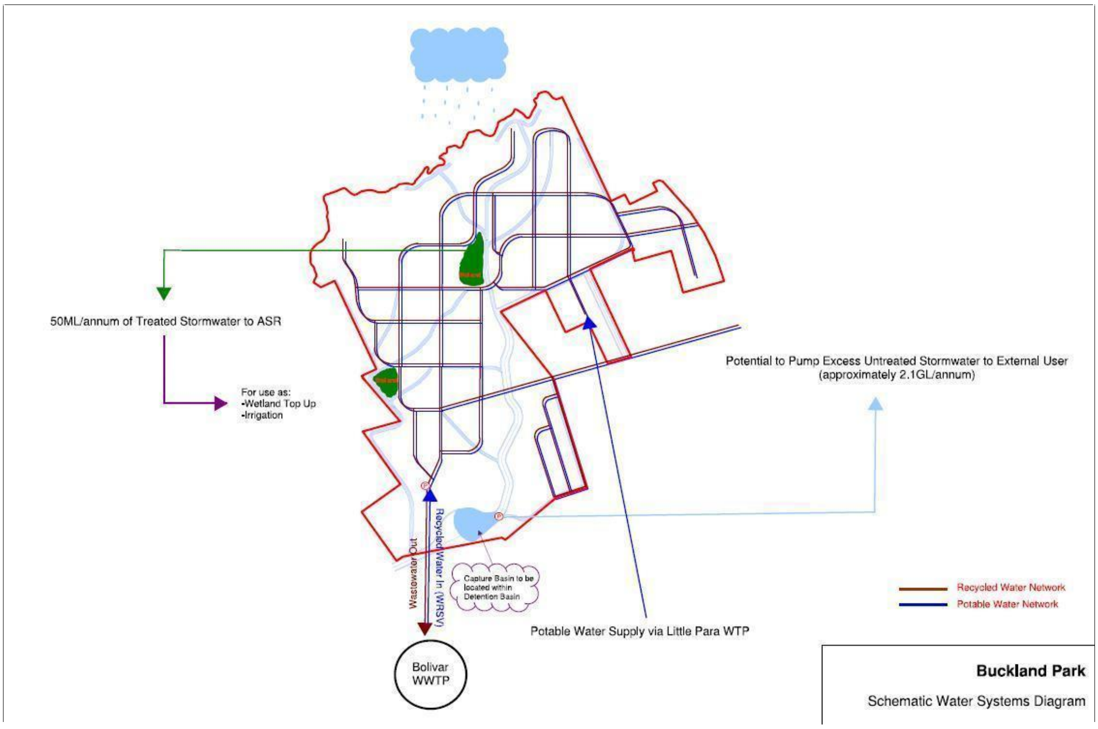


Figure 6.1 Buckland Park Water and Recycled Water Supply Schematic

6.2 Water Demand

The Buckland Park proposal will utilise both recycled and potable water to meet its total water demand. This water delivery system is commonly referred to as a dual pipe system, with one set of pipes carrying recycled water and the other carrying potable water into each allotment.

Using a dual pipe system to meet the water demand within new residential areas has been adopted in South Australia for a number of projects, with Mawson Lakes being the largest example.

Mawson Lakes is located in the northern suburbs of South Australia, approximately 16.5 kilometres south east of the Buckland Park site. Recycled water is used in Mawson Lakes for toilet flushing, and watering of gardens, whilst potable water is used in the kitchen, bathroom and laundry.

The average annual water usage figures for allotments within Mawson Lakes were obtained from SA Water (Pers Comm, Feronas, P, SA Water, May 2008) and are as follows:

- Potable Water 140 kL/service/annum
- Non Potable Water 160 kL/service/annum

Using these figures as a guide, the expected annual demand for potable and non potable water for the proposal was calculated. These figures are shown in table 6.1.

Table 6.1 – Annual Water Demand

	Annual Demand (GL/annum)
Potable Water	1.7*
Recycled Water	1.9**

Note: *This figure is purely based on residential use and therefore does not include an allowance for any water used for emergency services, increased industrial and commercial use etc.

**This value does not allow for irrigation of open spaces, maintenance of ornamental lakes etc.

6.3 Potable Water Supply

In order to supply the Buckland Park proposal with potable water, a suitable water supply source was identified.

SA Water considered two potential water supply sources to serve the Buckland Park proposal, they include the Barossa WTP (Water Treatment Plant) and the Little Para WTP (see Appendix D).

The Little Para WTP was considered to be the best option for supplying a reliable potable water source for the proposal. Barossa WTP was discarded as a water supply option, as the plant does not have sufficient capacity to meet the proposal's ultimate demand. Also, further residential proposals have been foreseen within Gawler and its surrounding areas and these proposals will most likely be supplied by the Barossa WTP.

Little Para WTP is located approximately 20 kilometres south east of the site. In order to service the proposal a number of pipes will need to be installed to provide connections between the site and the existing infrastructure.

Figure 6.2 graphically represents the long and short term potable water supply options available to Buckland Park.

6.3.1 Short Term Potable Water Supply Options

Construction and occupation of the proposal will be staged over a period of approximately 25 years. During the initial years, the demand for potable water will be significantly smaller than the predicted ultimate demand for completed and occupied proposal.

SA Water outlined two short term options to supply potable water to the proposal's initial stages (see Appendix D). These options have limited capacity and will only be able to supply up to a maximum of 3,000 services. Utilising one of the two short term options will reduce initial capital cost. The full capacity system will then be installed as demand grows.

Both options are viable for short term potable water supply to the proposal's initial stage. Cost comparisons will need to be done prior to the commencement of Stage 1's construction in order to determine which option is the most economically viable for the proposal in the short term.

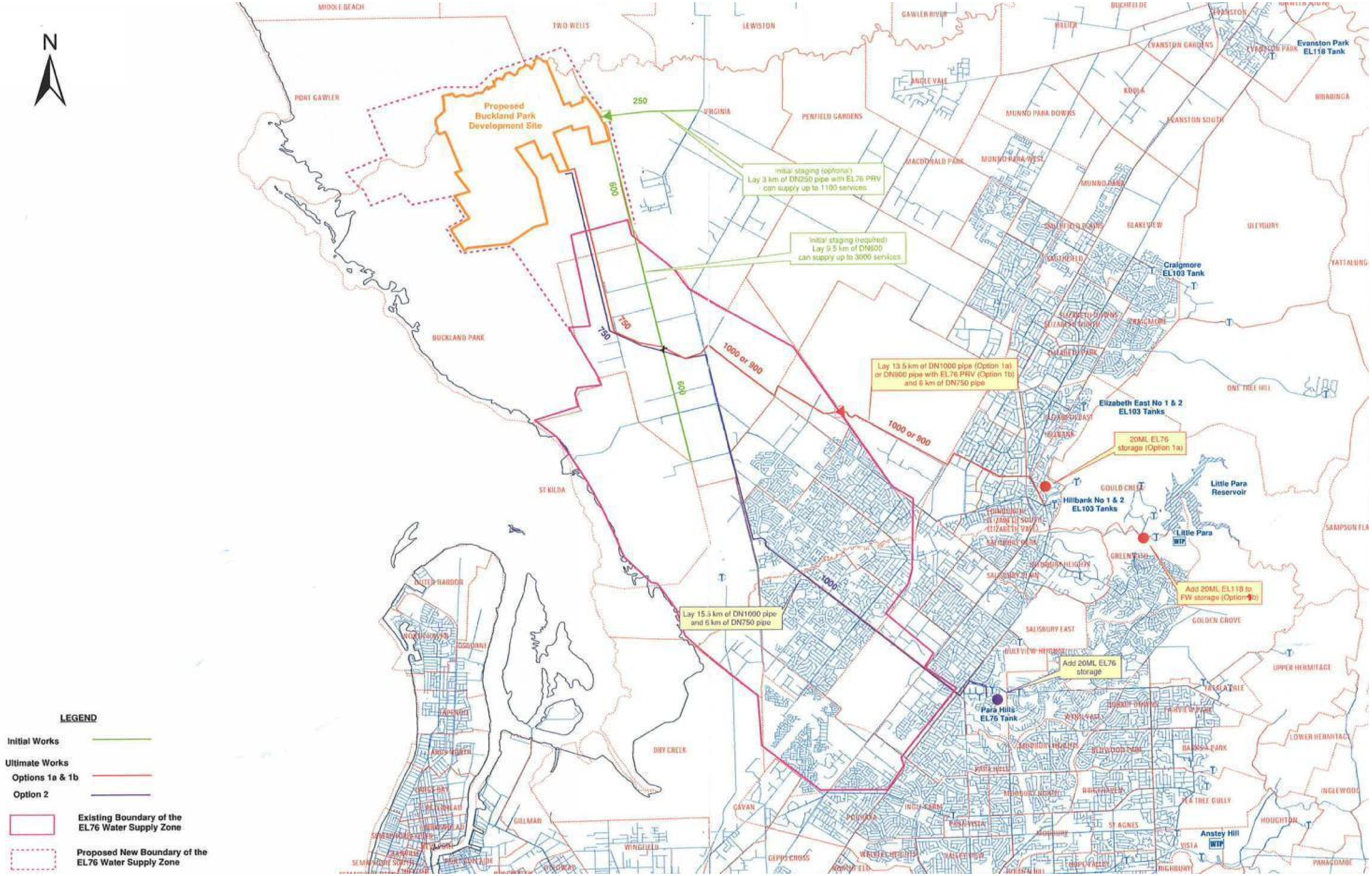


Figure 6.1 SA Water Potential Potable Water Supply Options Diagram

6.3.1.1 Option 1

Currently there is a 450mm diameter DICL (ductile iron concrete lined) main that supplies potable water to the Virginia Area. This main is located at the corner of Roberts Road and Angle Vale Road in Virginia (shown in Figure 6.2) and has enough spare capacity to supply approximately 1,100 allotments.

In order to utilise this main it is proposed a 250mm diameter main covering approximately 3 kilometres will connect the current 450mm main into the Buckland Park site. At present the 450mm DICL main provides potable water to the Virginia and Two Wells townships, therefore any other residential proposals in their vicinity would decrease the capacity for the 450mm main to provide potable water to the Buckland Park proposal.

6.3.1.2 Option 2

Currently a 450mm diameter water main exists within Undo Road, Waterloo Corner as can be seen in Figure 6.2. This main was installed in 2000 and was used to provide water to the Bolivar WWTP. Due to improvements at Bolivar WWTP, potable water from this 450mm main is no longer required and the main is redundant and could therefore form part of the Buckland Park's potable water infrastructure.

The estimated spare capacity available from this main is approximately 3,000 services.

SA Water advised once the capacity of this main is surpassed and it is once again made redundant this main would be an essential requirement as a back up potable water supply for the completed and occupied proposal. SA Water also advised that this main has the potential to supply enough potable water to the completed proposal to cover the loss of a main feeder main for maintenance or mishaps such as bursts (see Appendix D).

In order to deliver potable water from the main, between Undo Road and the site approximately 10 kilometres of 600mm diameter water main would need to be laid.

6.3.2 *Long Term Potable Water Supply Options*

At completion the Buckland Park proposal will potentially have 12,000 allotments demanding water from the potable water supply network. This number of allotments will present a significant demand on the potable water supply network. Since there is a limited amount of infrastructure in the vicinity of the site with the capacity to supply such volumes of water major infrastructure will need to be constructed and some existing infrastructure will need to be upgraded.

SA Water outlined three options to supply the completed proposal with the predicted ultimate potable water demand. All three options require drawing potable water from the Little Para Water Treatment Plant which is located approximately 20 kilometres south east of the site.

SA Water has considered the eventuality of further projects within the greater Buckland Park and Waterloo Corner areas, as a consequence of changes to the zoning of the area in the City of Playford and the City of Salisbury Council's Development Plans. SA Water therefore upsized the potable water supply options to provide enough capacity to meet all foreseeable demand increase. It was estimated that in addition to the Buckland Park proposal a further 11,000 service connections could be created in the area in years to come. This takes the total estimated required capacity of the delivery system to 23,000 service connections. The infrastructure was designed to meet the following demand criteria:

- Sufficient capacity to supply 70ML/day, and
- Instantaneous peak demand of 1500L/s.

The potable water supply options are presented in Sections 6.3.2.1 to 6.3.2.3 below, and are represented graphically in Figure 6.2.

SA Water concluded the site is capable of being supplied with potable water in an efficient and staged manner to coincided with the staged construction of the proposal.

Additional design work and cost analysis will be required to determine which of the options is considered to be the most suitable.

6.3.2.1 *Option 1a – Supply via Hillbank EL76 Storages*

This supply option requires the construction of a 20ML storage tank at the corner of Black Top Road and Bungarra Street in Hillbank. The storage is to be located at an approximate elevation level (EL) of 76m AHD and will be fed by water drawn from the Little Para WTP.

This option will require the acquisition of land in order to build the storage tank in the required location.

In order to deliver water from this storage tank to the Buckland Park site13.5 kilometres of 1000mm diameter main will be laid in an existing easement that runs along Hogarth Road, Edinburgh Road, Wyatt Road, Mill Road and Curnow Road. Following this a further 6 kilometres of 750mm diameter main will be required along Curnow Road and Tozer Road.

6.3.2.2 *Option 1b – Supply via Little Para EL118 Storages*

This supply option requires the addition of a 20ML storage tank at the Little Para WTP. The elevation level (EL) at the Little Para WTP is 118m AHD.

This supply option will have a pipe network that follows the same path as Option 1a, however the diameter of the pipe located within the existing easement along Hogarth Road, Edinburgh Road, Wyatt Road, Mill Road and Curnow Roads is reduced from 1000mm to 900 mm.

The maximum pressure head allowed in SA Water distribution networks for domestic services is 90m. As the ground elevations at the Buckland Park site range from between 3m AHD and 11m AHD, and the elevation of the supplying storage tank is 118m AHD, the pressure head in the pipe network will need to be reduced. This will be achieved by the installation of a pressure release valve (PRV). This valve will be located in Wyatt Street, Direk and will have an elevation set to 76m AHD.

6.3.2.3 *Option 2 – Supply via Para Hills EL76 Storage Tank*

This supply option requires the addition of a 20ML storage tank located at the Para Hills EL76 storage site. At present the Para Hills storage site is too small to accommodate further storage requirements. Another storage site will be aquired in a close proximity to the existing location for the new storage.

In order to supply potable water from the Para Hills storage location 15 kilometres of 1000mm diameter water main will need to be laid along Kings Road, Port Wakefield Road and Curnow Road. The main will then reduce in diameter to 750mm and continue along Curnow Road and Tozer Road and connect into the Buckland Park site.

SA Water have indicated the capacity of the infrastructure that provides potable water to the Para Hills EL76 storages and the Para Hills EL103 storage tanks may not be sufficient to supply the entire demand generated by the predicted growth in the area. However SA Water determined the Para Hills EL103 storage tanks could be supplemented from the Anstey Hill WTP. This change in operation may require some infrastructure upgrade works.

6.4 Recycled Water Supply

To ensure potable water supply sustainability, the use of recycled water for all applications which do not require drinking water quality water is becoming more and more common in residential, industrial and commercial projects.

Typically the incentive for consumers to use recycled water is its cost. Recycled water is cheaper than potable water as it commonly does not require the same high level of treatment that potable water does.

Recycled water can be used for most applications where humans do not have direct contact with the water, such as:

- Toilet flushing
- Garden watering
- Car washing, and
- Irrigation.

Using recycled water for the above applications will significantly reduce the use of potable water. Table 6.1 shows an annual reduction in residential potable water usage of 1.9 GL/annum could be expected by utilising recycled water within Buckland Park for all applications which do not require water of drinking water quality standard. This is based on residential water use experienced at Mawson Lakes.

6.4.1 *Recycled Water Sources*

Sources of recycled water available to the Buckland Park proposal include:

- Treated waste water delivered from the Bolivar Waste Water Treatment Plant via the Western Reticulation Systems Virginia (WRSV) pipeline or a new pipeline direct from the Bolivar WWTP.
- Stormwater runoff

The salinity of WRSV water is an average of 1200ppm, this is considered on the high side, but is suitable for irrigation.

The main difficulties impacting on the ability to develop a large scale stormwater collection and ASR system the Buckland Park include; the limited capacity of the local aquifer to accept treated stormwater and also high groundwater levels within the site limiting the locations in which water treatment wetlands can be established.

SA Water have advised they expect sufficient treated wastewater will be made available from the Bolivar WWTP to supply the full non potable needs of the proposal (Pers Comm Harris, G, SA Water, November 2008).

Options for capturing stormwater and pumping to other locations within the City of Playford for treatment, storage and then returning to the site have been explored. The most suitable location is 10 kilometres west of the Buckland Park site and would therefore require installation of 20 kilometres of new pipe.

No other potential users for the water have been identified, but it is expected over the longer term users for this water will be found. Horticulture business in the region may be one suitable user (Pers Comm, Redmond, M, Virginia Horticulture Centre, September 2008). A scheme to supply additional water to the WRSV scheme could be considered, or to provide additional non potable water supplies to the Greater Edinburgh Parks proposal.

6.4.2 Stormwater Capture and Treatment for Recycled Water Use

It is proposed to capture, treat, store and reuse stormwater up to the 50ML/a limit set by the aquifer storage and recovery potential in the area. This water would be used for irrigation of reserves within the site, and to top up the wetland water bodies.

For the remainder of the stormwater runoff it is proposed to develop a ‘capture’ basin within the proposed detention basin, which would be set up to capture the volume of say a 1 in 3 month to 1 in

6 month flow, with the ability to pump the water off site for use by another party, such as the City of Playford, or City of Salisbury.

In order to be able to use stormwater as a source of recycled water, it will need to be captured and treated to meet the SA EPA water quality guidelines prior to use. It is estimated the capture basin will require a volume of approximately 100,000m^3 or 100ML. It is anticipated it will be located in the upper sections of the to southern detention basin, where the groundwater levels are deeper.

A schematic diagram of the potable and recycled water strategy for Buckland Park is shown in Figure 6.1.

7. SEA LEVEL RISE AND MINIMUM SITE LEVELS

7.1 City of Playford Development Plan

The City of Playford's Development Plan suggests an allowance of 0.3m in Sea Level Rise to 2050 and a further 0.7m of sea level rise to 2100.

7.2 Coastal Protection Board

The current figures advised the required minimum Site Level (SL) and Finished Floor Level (FFL) to prevent coastal flooding for design to 2050 and 2100, as outlined in Table 7.1.

Table 7.1. Minimum Site Levels (Coastal Protection Board SA, 2008)

	2050	2100
Minimum SL (m AHD)	3.30m AHD	3.30m AHD+0.7m = 4.0m AHD
Minimum FFL m AHD)	3.55m AHD	3.55m AHD+0.7m = 4.25m AHD

Figure 7.1 shows the extent of existing land within the site that is less than the recommended Coastal Protection Board 2100 site level of 4.0m AHD.

Areas within the proposed residential and commercial zones identified on the Masterplan that have a ground level below 4.0m AHD will be filled to achieve this minimum requirement. Further fill above this level will be required on site in order to create fall on the land and to achieve drainage and minimum road grades.

Although the proposal is located several kilometres from the Gulf St Vincent, the site is linked to the Gulf via the Thompson Outfall Channel and would therefore be subject to tidal surge.

7.3 Recommendation

The recommended minimum site level is therefore 4.0m AHD with minimum floor levels of 4.25m AHD. It should be noted however, that due to the need to create falls across the site to drain the road system that the majority of properties will have site levels well in excess of the recommended minimum level.

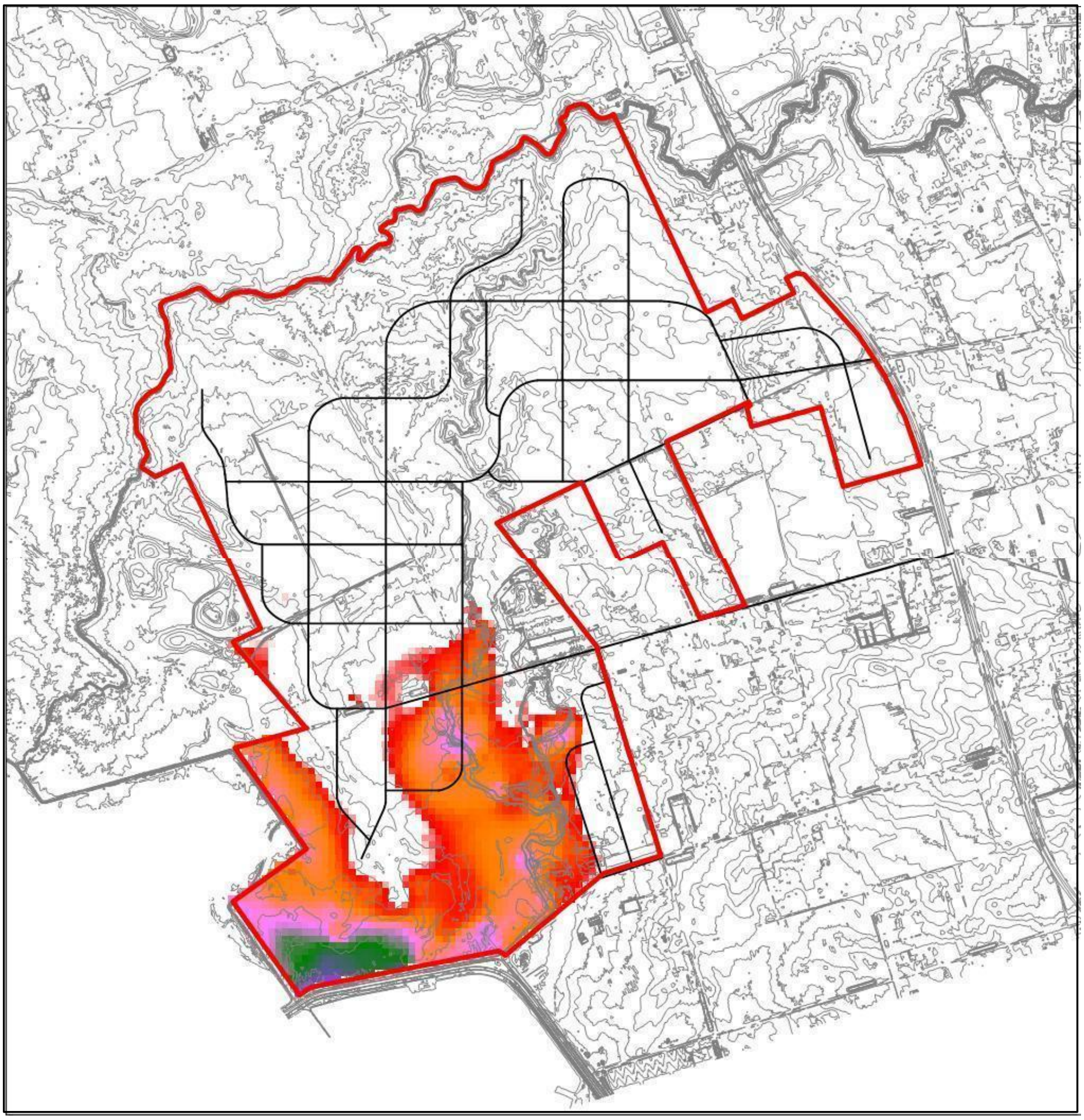


Figure 7.1 - Extent of Existing Site less than 4.0m AHD.

8. STAGE 1

8.1 Introduction

Stage 1 of the Buckland Park proposal is programmed to begin construction in 2009. This stage of the proposal will contain 624 dwellings and will cover an approximate area of 62.4 hectares.

Stage 1 will be located at the north eastern side of the overall Buckland Park proposal. Figure 8.1 shows the location of Stage 1 in relation to the Gawler River and Port Wakefield Road.

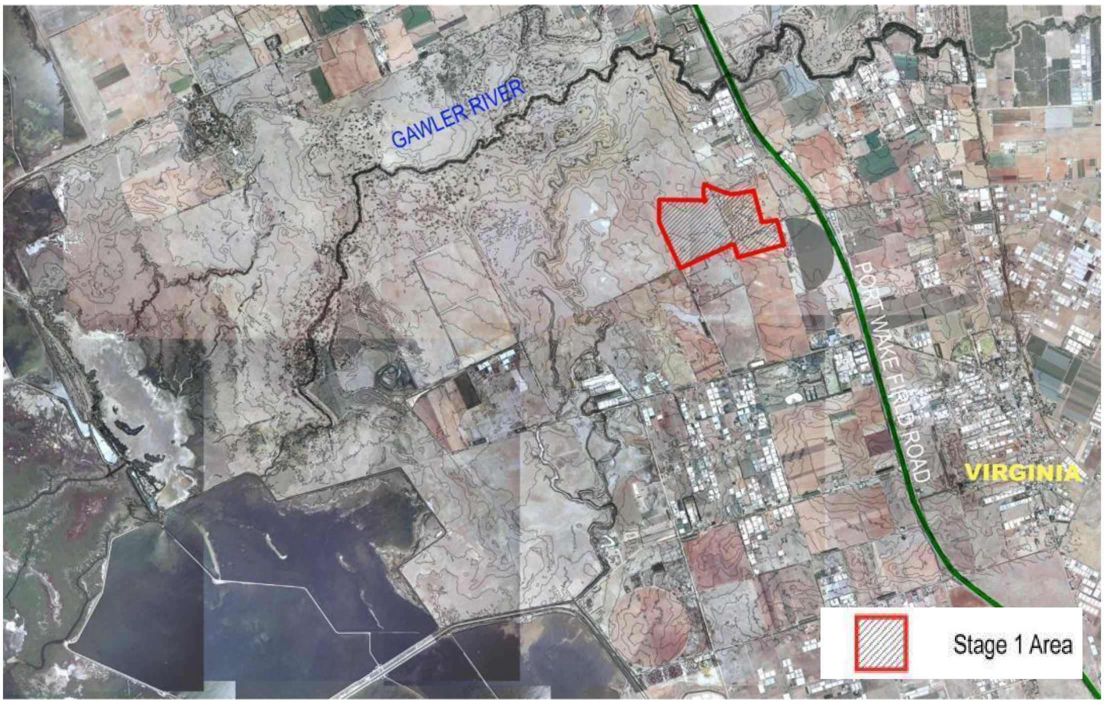


Figure 8.1 - Stage 1 Location

Measures to manage the stormwater created by Stage 1 of the proposal will be outlined in Section 8.2.

Staging of the waste water and potable water infrastructure in order to cater for Stage 1 of the proposal will be in accordance with Sections 5 and 6 of this report.

Figure 8.2 shows the allotment layout and proposed open drainage areas of the Stage 1 proposal.

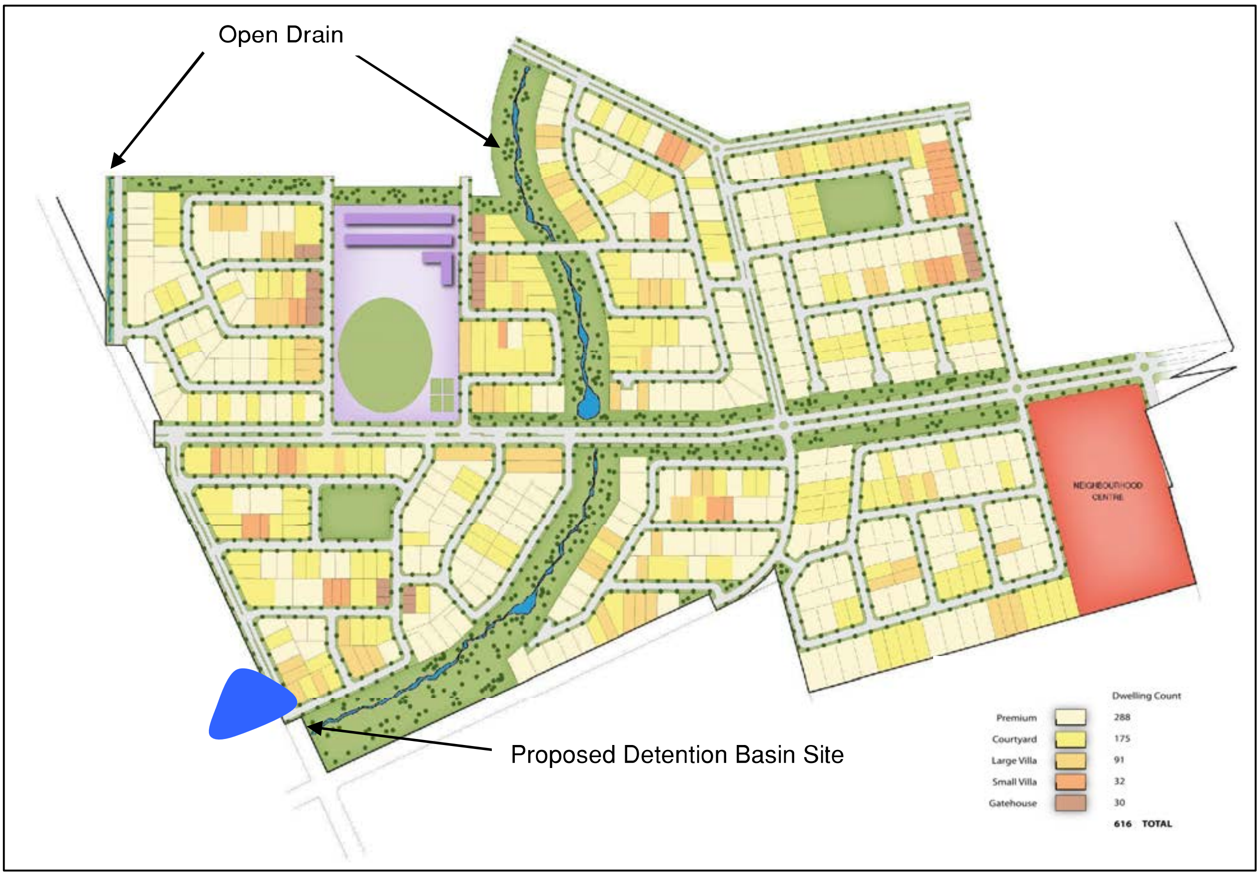


Figure 8.2 - Stage 1 Layout

8.2 Stormwater Management

In accordance with the stormwater management guidelines outlined in Section 2 of this report, the aim of the stormwater management plan for Stage 1 of the proposal is to reduce the peak flow of water from the site so it does not exceed the pre-developed flow rate.

Similar to the stormwater management plan for the overall proposal the stormwater runoff produced by Stage 1 will be channelized into large open drains with the peak flows being detained within a temporary detention basin.

It is proposed that the detention basin will be located at the downstream end of the main open drain (Figure 8.2 shows the approximate location).

The open channels that will be used to channelise the stormwater flow through Stage 1 will form an important part of the overall stormwater management system for the overall proposal and therefore will be sized in accordance with Section 2.3.3 of this report.

Stormwater runoff from Stage 1 will discharge from the detention basin into an open drain that will carry it to Thompson Creek where the water will discharge to Gulf St Vincent via Thompson Outfall Channel.

Figure 8.3 shows the proposed stormwater management layout to manage the runoff created by Stage 1 of the proposal.

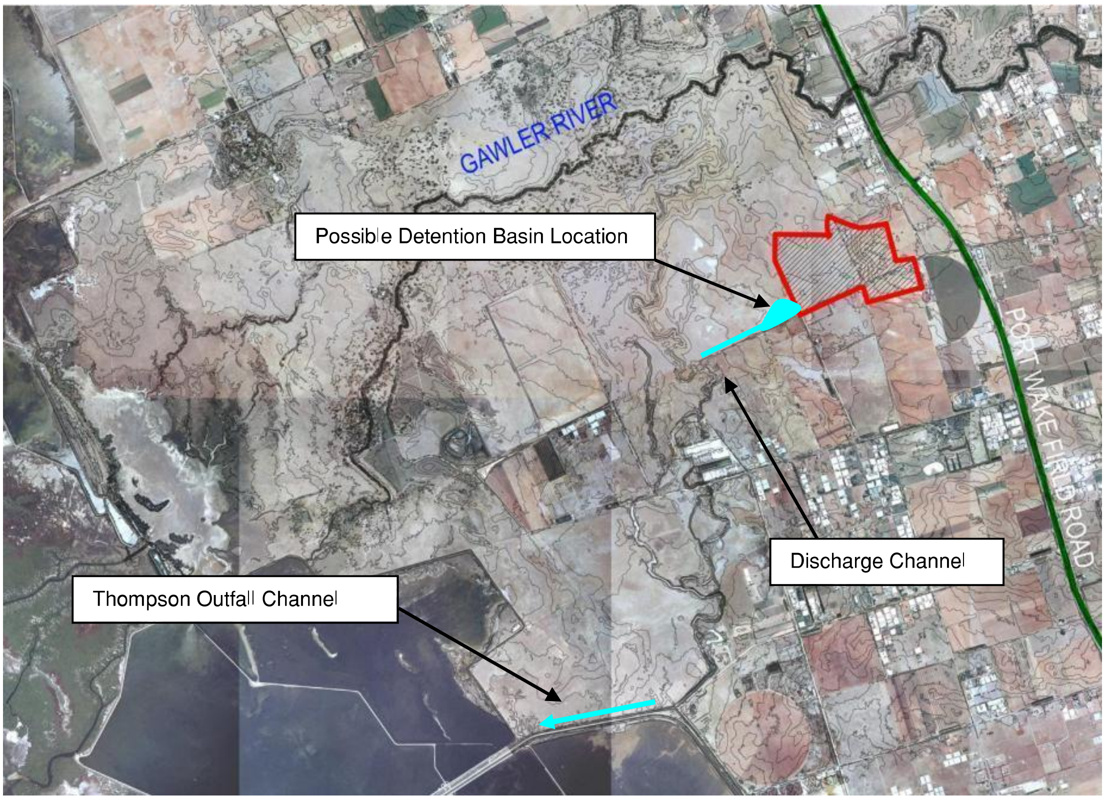


Figure 8.3 - Stage 1 stormwater management layout

8.2.1 Allowable Outflow

From calculations the peak 100 year ARI flows for both the pre-developed and post-developed site conditions were determined and can be seen in Table 8.1

Table 8.1 Stage 1 stormwater runoff peak flow rates

	Pre-developed	Post-developed
100 year ARI	0.8 m^3/s	3.7 m^3/s

From Table 8.1 it can be seen that the maximum allowable outflow from the developed site is 0.8m^3/s.

8.2.2 Detention Basin

From analysis it was determined that in order to limit the outflow from Stage 1 of the Buckland Park proposal to a rate of 0.8m^3/s a temporary 16,000m^3 detention basin would be required.

This detention basin would be located at the outlet of the main drainage channels from Stage 1 and will not only provide flood mitigation applications it may also provide a potential to capture and store stormwater for recycled water applications.

8.2.3 Outflow channel

Outflow from the detention basin will be carried via an open drain to the existing Thompson Creek. As indicated previously the peak outflow rate will be 0.8m^3/s.

Figure 8.3 shows the approximate location of the outflow channel.

8.2.4 Gawler River Flood Protection

In order to provide suitable flood protection from the Gawler River for Stage 1 of the Proposal, sections of the proposed major drainage system as discussed in Section 4 will need to be constructed. The extent of the drainage system required is shown in Figure 8.4.

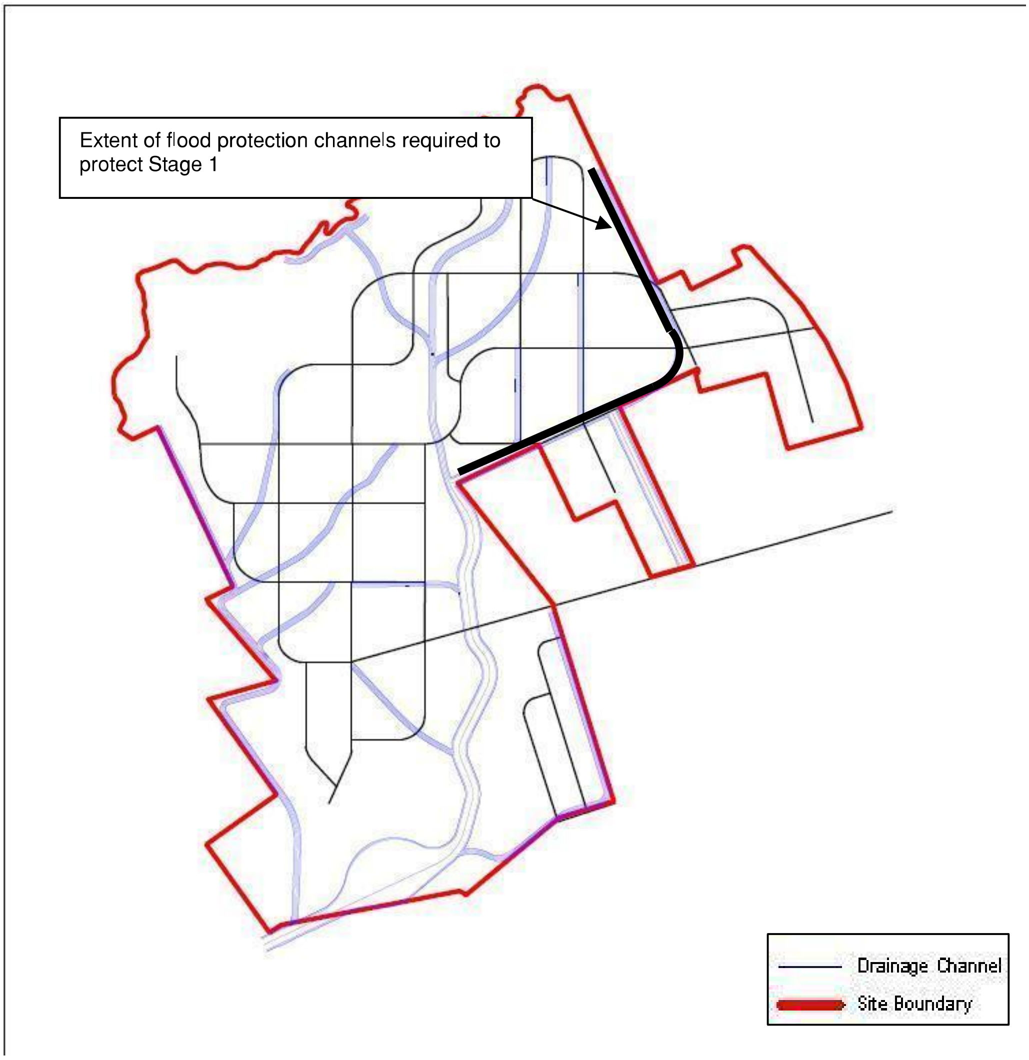


Figure 8.4 - Stage 1 – Flood Mitigation Channel Requirements

9. SUMMARY

The following is a brief summary of the outcomes of this study.

9.1 Stormwater Management

- A Water Sensitive Urban Design approach will be applied across the entire site and is incorporated in the Masterplan.
- At least two significant wetlands will be developed on the higher sections of the site
- Shallow groundwater levels confine the construction of wetland and water bodies to the higher areas of the site.
- A series of lineal stormwater management corridors will be constructed to manage minor stormwater flow water quality treatment and for the passage of major flows from the site. These are incorporated in the Masterplan.
- A series of major channels will also act as capture channels to intercept flood water 'breakouts' from the Gawler River and provide protection for the 100 year ARI flood. These are incorporated in the Masterplan.
- Site level collection of stormwater for reuse will be adopted where practical.
- An on site detention basin of approximately 250,000m^3 is required to reduce the peak flows from the site to acceptable levels. This is incorporated in the Masterplan at the southern end of the site
- ASR potential on the site is limited to 50ML/a which is significantly less than the estimated annual runoff.
- An on site ASR scheme will be designed to make use of the 50ML/a storage and reuse potential of the site with water treated through the two constructed wetlands.

9.2 Wastewater

- A vaccum sewer scheme is proposed to accommodate the shallow groundwater levels across the site.
- All wastewater will be pumped to the Bolivar Wastewater Treatment Plant.
- An interim rising main to Bolivar will be required until the proposal approaches its full potential. The detention times in the pipeline will be long, and therefore the wastewater in the line will turn septic, requiring additional treatment at the Bolivar Wastewater Treatment Plant, either before entering the Plant, or through additional treatment within the Plant.
- The ultimate rising main to Bolivar is likely to be a 450mm pipe, approximately 14km long.

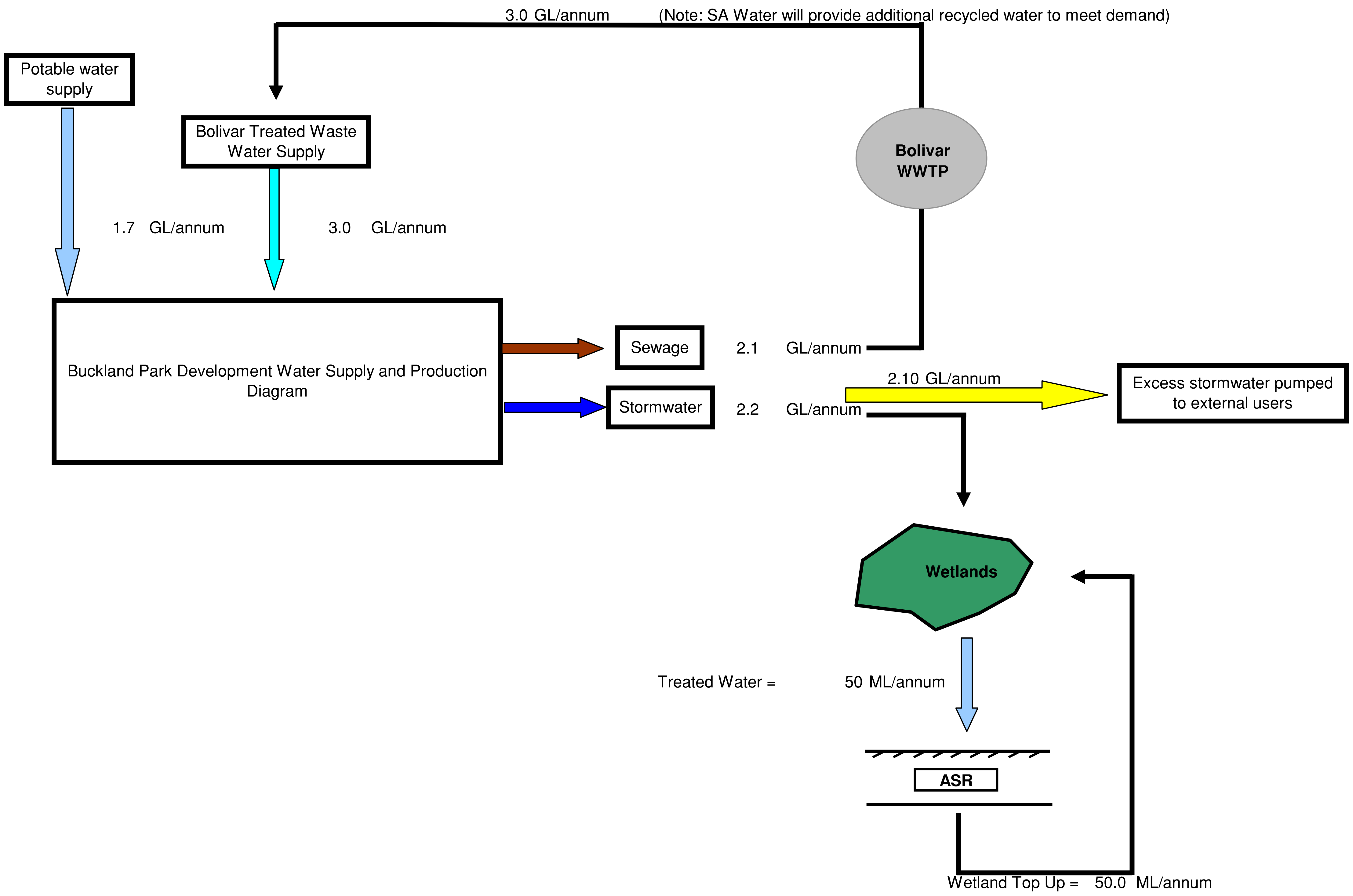
9.3 Potable Water

- Potable water supply to the site will come from the Little Para Water Treatment Plant.
- Short term options have been proposed by SA Water that can supply up to 3,000 services.
- The ultimate scheme will require a new supply main from the Little Para system, and SA Water have proposed 3 viable alternatives.

9.4 Recycled Water

- A third pipe system will be provided throughout the site to supply recycled water to each allotment.
- SA Water indicated they will be able to supply sufficient recycled water to service the proposal's needs, provided a new rising main is constructed from the Bolivar Wastewater Treatment Plant to the site. There is insufficient capacity in the existing WRSV network to supply the site.
- Up to 50ML/a of stormwater will be captured, treated and reused within the site making full use of the limited potential available.
- The stormwater system will be designed to provide suitable capture facilities to harvest stormwater for use external to the site
- The Proponents will continue to work with Council, the Natural Resource Management Board and the surrounding horticultural industries including WRSV to identify external uses for the stormwater.

Figure 9.1 provides a summary of the proposed method of managing all water entering and leaving the Buckland Park Site.



Buckland Park

Figure 9.1

Schematic Water Systems Diagram

10. GLOSARY OF TERMS

AHD = Above height datum

AMC = Antecedent moisture content

ARI = Average recurrence interval

ASS = Acid sulphate soil

EL = Elevation level

FFL= Finished floor level

GL = Giga litres

GPT = Gross pollutant trap

GRC = Glass reinforced concrete

HEC-RAS = Hydrologic Engineering Centre river analysis system

LGA = Local government association

MHWS = Mean high water springs

ML = Mega litre

ML/a = Megalitres per annum

MUSIC = Model for urban stormwater improvement conceptualisation

PASS = Potential acid sulphate soil

ppm = Parts per million

PRV = Pressure release valve

RO = Reverse osmosis

SCADA = Supervisory control and data acquisition

SL = Surface level

STED = Septic tank effluent disposal

TDS = Total dissolved solids

TP = Total phosphorus

TSS = Total suspended solids

WRSV = Western reticulation scheme Virginia

WTP = Water treatment plant

WWTP = Waste water treatment plant

11. REFERENCES

1. Australian Water Environments, *Floodplain Mapping for the Gawler River-Technical Report*, prepared for the Gawler River Floodplain Management Authority, February 2008

2. DTEI Hydrologic *Study of the Gawler River Catchment* 2007

3. Connell Wagner, *Coastal influences and climate change considerations for Buckland Park proposal*, prepared for Walker Coporation Pty Ltd, November 2008

4. CSIRO, *Climate Change in Australia,* prepared for the Department of the Environment and Water Resources, October 2007

5. Golder Associates, *Preliminary ASS Investigation, Buckland Park, South Australia*, prepared for the Walker Corporation Pty Ltd, November 2008

6. IE Aust, T, Wong, *Australian Rainfall and Runoff Quality- A guide to water sensitive urban design*, 2006

7. Resource and Environmental Management, *Aquifer Storage and Recovery Potential for Buckland Park*, prepared for the Walker Corporation Pty Ltd, February 2008

8. SA Environment Protection (Water Quality) Policy 2003 – Schedule 2

9. SA Water, *Memorandum: Ultimate water supply for the Buckland Park/Waterloo Corner Area,* prepared by Paul Feronas for Wallbridge & Gilbert, September 2008

10. Sinclair Knight Merz, *Groundwater investigation – Buckland Park proposal*, prepared for Walker Corporation, November 2008

11. Tonkin Consulting, *Port Adelaide Seawater Stormwater Flooding Study*, prepared for the City of Playford Council, October 2005

12. Tonkin Consulting, *Western Catchment - Stormwater Master Plan*, prepared for the City of Playford Council, April 2008

APPENDIX A

EIS GUIDELINES

3.1.1 Determine the flood potential for the area, including flood plain mapping for a 1 in 100year ARI storm, as a result of the restriction of the floodplain in the vicinity of the proposed development and taking into account the construction of a dam on the North Para River.

Section 4

3.1.2 Outline the requirements for the likely location of water, sewerage, stormwater management infrastructure.

Section 2, 4, 5, 6

3.1.3 Describe the approach to water sustainability, including ways in which mains water supply use can be minimised or supplemented and opportunities for reducing and recycling water, particularly stormwater and waste water from the Virginia Pipeline through Water Sensitive Urban Design (WSUD).

Section 6

3.1.4 Identify opportunities for the reuse of grey water.

Section 6

3.1.5 Detail measures to minimise impacts and to protect the Gawler River and coastal environments during both the construction phase and on an ongoing basis.

Section 2

3.1.6 Identify the impact of possible erosion, subsidence or inundation as a result of flooding arising from construction on this low lying part of the coast.

Section 1.2

3.1.7 Describe the connection to water supply for the proposed development, the required upgrading or provision of pipelines and the implications for water sources, include information on the quantity of potable water required.

Section 6

3.1.8 Describe the proposed method of dealing with wastewaters.

Section 5 and 6

3.1.9 Describe measures to protect, maintain and monitor suitable water quality in waterways.

Section 3

4.2.11 Outline measures to prevent soil, fertilizers, herbicides and pesticides derived from residential allotments and open space reserves from entering the waterways.

Section 3

4.2.12 Identify the potential effects as a result of stormwater runoff on the St Kilda-Chapman Creek and Barker Inlet-St Kilda Aquatic Reserves (nursery areas) ecosystem and fish breeding grounds.

Section 1.2 and Section 3

4.2.13 Identify the potential effects of the proposal on the adjacent salt operations (intake water quality issues) such as storm water discharge, nutrients management, sewage management, waste management, water pollution from littering and illegal dumping, oil and fuel spill management, wash down and toxic seepage.

Section 3

4.2.19 Describe the proposal of excavated materials for the proposed waterways.

Section 2 and 7

4.2.20 Describe how the proposal will comply with the coastal flooding policy outlined in the Development Plan.

Section 7

4.2.24 Describe any special engineering requirements for infrastructure due to the expected high water table in this area including the costs of developing and maintaining infrastructure for saline and acid sulphate soils, seasonal variations in height and groundwater rise due to sea level rise.

Section 5 and 7

4.3.5 Describe the requirements of the sea level rise policies in the Development Plan and how these would be achieved in undertaking this proposed development.

Section 7

4.3.7 Describe any impacts on the neighbouring Port Gawler Conservation Park, adjacent Crown land and the Buckland Park Lake System.

Section 3

4.3.8 Outline the potential effects of climate change from a risk management perspective, including adaptive management strategies.

Section 2 and 7

4.3.31 Describe the likely effects on marine organisms and seagrasses, in the context of runoff from the proposed development into the river and out to sea potentially reducing the salinity and increasing nutrients, suspended sediments and pollutants, particularly heavy metals.

4.7.1 Describe the condition and capacity of existing trunk infrastructure and the likely impacts of the development on that capacity.

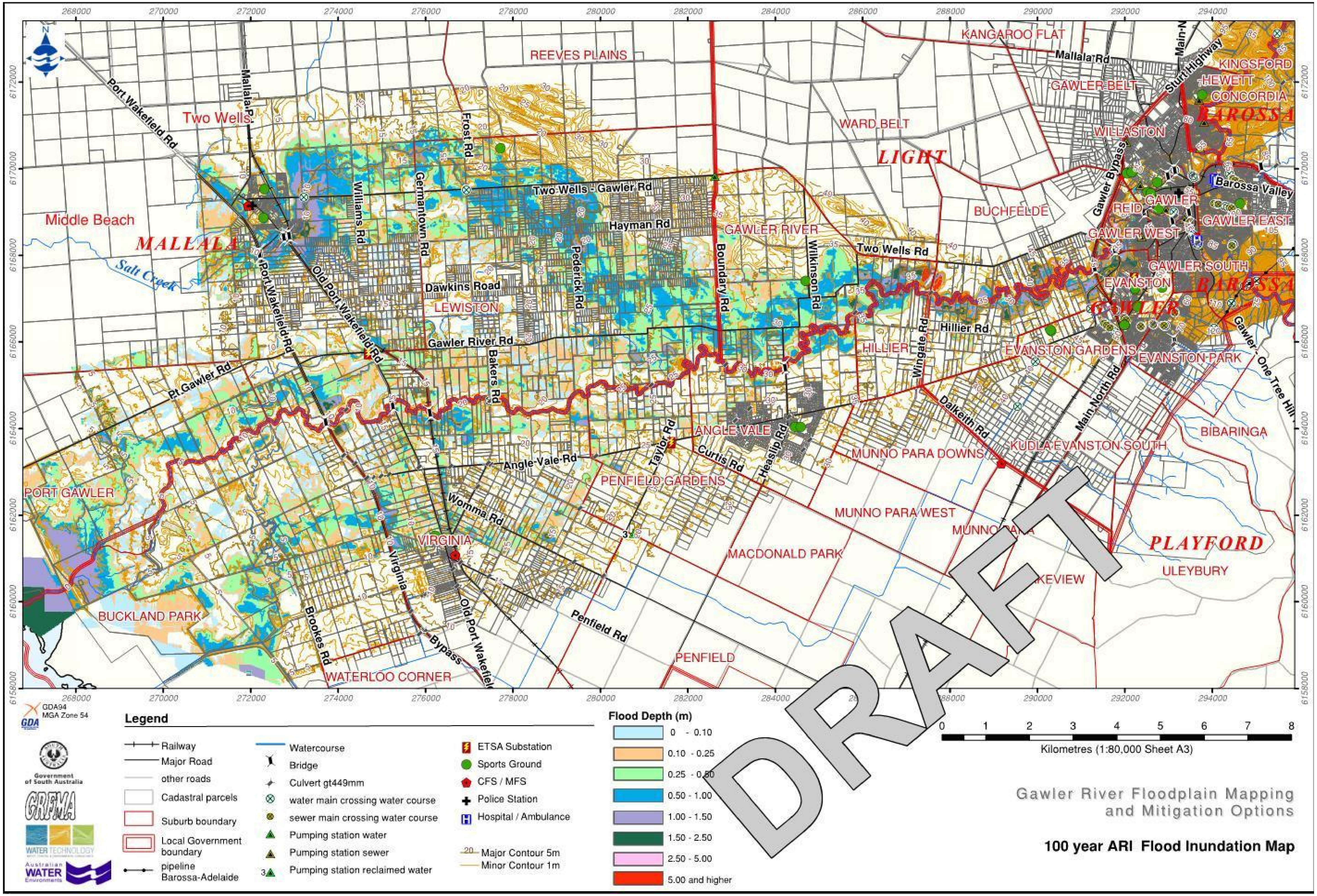
Section 6

4.11.6 Describe how the proposal would comply with the requirements under the Environment Protection Act, 1993 and the Adelaide Dolphin Sanctuary Act, 2005 and the duty of care under these Acts.

Section 3

APPENDIX B

Gawler River Flood Plain Maps



KANGAROO FLAT
REEVES PLAINS
Mallala Rd
KINGSFORD
HEWETT
CONCORDIA
BAROSSA
Sturt Highway
GAWLER BELT
Port Wakefield Rd
Two Wells
WARD BELT
WILLASTON
LIGHT
Gawler Bypass
Barossa Valley
Two Wells - Gawler Rd
Middle Beach
BUCHFELDE
REID
GAWLER
GAWLER EAST
Hayman Rd
GAWLER RIVER
GAWLER WEST
MALLALA
Two Wells Rd
Salt Creek
GAWLER SOUTH
Dawkins Road
EVANSTON
LEWISTON
GAWLER
Hillier Rd
Gawler River Rd
HILLIER
EVANSTON GARDENS
EVANSTON PARK
Pt Gawler Rd
Main North Rd
Gawler - One Tree Hill
Dalkeith Rd
ANGLE VALE
BIBARINGA
Taylor Rd
Heaslip Rd
KUDLA EVANSTON SOUTH
Curtis Rd
MUNNO PARA DOWNS
Angle Vale Rd
PENFIELD GARDENS
PORT GAWLER
Womma Rd
MUNNO PARA WEST
PLAYFORD
VIRGINIA
MACDONALD PARK
ULEYBURY
BUCKLAND PARK
Penfield Rd
Brookes Rd
Virginia Bypass
Old Port Wakefield Rd
PENFIELD
WATERLOO CORNER
Mallala Rd
Frost Rd
Williams Rd
Germantown Rd
Pederick Rd
Boundary Rd
Wilkinson Rd
Wingate Rd
Bakers Rd
Old Port Wakefield Rd
DRAFT
GDA94
MGA Zone 54
Legend
Railway
Major Road
other roads
Cadastral parcels
Suburb boundary
Local Government boundary
pipeline Barossa-Adelaide
Watercourse
Bridge
Culvert gt449mm
water main crossing water course
sewer main crossing water course
Pumping station water
Pumping station sewer
Pumping station reclaimed water
ETSA Substation
Sports Ground
CFS / MFS
Police Station
Hospital / Ambulance
Major Contour 5m
Minor Contour 1m
Flood Depth (m)
0 - 0.10
0.10 - 0.25
0.25 - 0.50
0.50 - 1.00
1.00 - 1.50
1.50 - 2.50
2.50 - 5.00
5.00 and higher
0 1 2 3 4 5 6 7 8
Kilometres (1:80,000 Sheet A3)
Government of South Australia
GRFMA
WATER TECHNOLOGY
Australian WATER Environments
Gawler River Floodplain Mapping and Mitigation Options
100 year ARI Flood Inundation Map

APPENDIX C

Wallbridge and Gilbert Assessment of Waste Water Treatment Methods

BUCKLAND PARK
WASTEWATER COLLECTION SYSTEMS

NETWORK OPTIONS ASSESSMENT

prepared for

WALKER CORPORATION

by

WALLBRIDGE & GILBERT
Consulting Engineers

NOVEMBER 2008

REV E

Job No: C080163

CONTENTS

EXECUTIVE SUMMARY

Wallbridge & Gilbert (W&G) were engaged by the Walker Corporation to undertake a first order assessment of the most economically and technologically suitable form of communal collection system for domestic wastewater within the Buckland Park proposal.

Gravity drainage systems are commonly thought to be the most economically viable wastewater management systems. However, issues such as a high water table, acid sulphate soils and high salinity levels within the groundwater at Buckland Park mean that the cost to build a gravity system could escalate, and there would be an increased potential for groundwater ingress into the system. These factors prompted the need to investigate the viability of vacuum and pressure systems.

This report assesses the applicability of the following four collection systems:

- Gravity
  - Septic Tank Effluent Disposal System (STEDS)
  - Full Sewer
- Pressure
- Vacuum

A general technical description of the characteristics of each scheme as well as a summary of the advantages and disadvantages is enclosed within this report.

First order cost estimates for each of the systems have been presented with the all of life costs derived using the LGA's CWMS (Community Waste Management System) all of life cost model.

The latest groundwater mapping indicates that the depth to ground water across the site varies from 0.2m to 7m below the current surface level. In the order of 60% of the proposal site has a ground water depth of less than 2m from the surface level. Seasonal water level fluctuations in the order of 0.5m to 1m could be expected.

The key impacts that the high ground water table, acid sulphate soils and saline ground water conditions have on the suitability of a waste management system include:

- Increased construction costs for deeper drains, manholes and pump stations
- Increased risk of cost escalation during the construction phase especially if construction is undertaken in years when the seasonal variation in groundwater is higher than current measurements
- Increased OHS&W risks associated with construction of the drains (this adds to the cost for mitigation but also to the potential of an accident)
- Increased risk of system failure from overflow due to ground water intrusion into the wastewater management network.

- Increased running costs associated with pumping and treatment systems
- Increase in capital costs to cater for emergency storage or increased pump sizes to cater for peak wet weather flows
- Greater potential for a higher salinity within treated effluent, therefore limiting potential reuse applications
- Increases the risk of future settlement of reinstated trenches due to difficulties in achieving compaction.
- Potential to create a greater trench footprint due to collapsing trenches during construction.
- Risk of creating acidic soil conditions due to construction in acid sulphate soils, also creating the potential to transport leachate along the trench spreading the extent of the potential impacts.

Table E1 (on page 3) summarises the capital and all of life cost estimates for the various collection options assessed. These costs are for comparative purposes only and have been based on indicative layouts. Cost estimates of the preferred option would be produced after a preliminary design has been completed.

The following assumptions need to be considered when reading the table:

1) The gravity sewer concept is based on a maximum drain depth of 3m. This results in the order of 35 pump stations being required to service the proposal.
2) Vacuum sewer is based on 3 vacuum stations and an average of 5 connections per valve pit.
3) It has been assumed that the capital costs for scheme installation are expended in year 1. In practice this will not be the case but the costings are for comparative purposes only and are not intended as an absolute measure of the all of life costs.
4) The costs do not include treatment or disposal, they relate to the collection network only.
5) The all of life costs shown in the summary table do not include an allowance for increased operational costs due to ground water ingress, as the impact is difficult to estimate.
6) The costs of installation and maintenance of property pumps has been included in the pressure system. This cost is often excluded from cost estimates for schemes in South Australia as traditionally these costs have been met by the individual land owner, however W&G believe that if a true cost comparison is to be made between the schemes then these costs should be included.

Table E1 – Summary of Comparative costs

Effluent		
Discount Rate	Capital Cost	All of Life Cost
4%	$78,100,000	$100,900,000
Sewer		
Discount Rate	Capital Cost	All of Life Cost
4%	$41,800,000	$58,400,000
Pressure		
Discount Rate	Capital Cost	All of Life Cost
4%	$132,700,000	$248,000,000
Vacuum		
Discount Rate	Capital Cost	All of Life Cost
4%	$37,900,000	$55,300,000

Recommended Collection System for Buckland Park

W&G recommend that design development be based on a vacuum sewerage system.

The reasons for recommending this option include:

- The lower estimated capital cost and all of life costs
- The reduced potential impacts of salinity on the reuse applications
- Lesser impact of peak wet weather flows on the WWTP and pump stations
- Lesser potential for long term ground water ingress
- Reduced potential for system overflow at the pump stations during peak wet weather events or power outages
- Reduced risk of system failure due to groundwater ingress
- Lower pumping costs associated with limited groundwater ingress (which is not captured in Table 5.1.1)
- Reduced operational requirements in a major power failure scenario
- Approximately 75% of drains in a gravity system would be installed below the current ground water levels, even with the installation of 35 pumping stations
- Aeration of the sewage through the collection network will have a positive impact on the WWTP operation.

1. INTRODUCTION

Wallbridge & Gilbert (W&G) were engaged by the Walker Corporation to undertake an assessment to determine the most appropriate wastewater collection system for the Buckland Park proposal.

It is currently envisaged that the Buckland Park proposal will ultimately consist of 12,000 properties with a likely ultimate population of up to 33,000 persons.

This report summarises the general characteristics of the following four collection systems:

- Gravity
  - Septic Tank Effluent Disposal System (STEDS)
  - Full Sewer
- Pressure
- Vacuum

It outlines the suitability of each of the systems as applicable to Buckland Park, as well as comparing estimates of the capital and all of life costs that could be expected for each of the systems.

Section 3 and 4 of this report have been included as background knowledge for those who are not familiar with collection technologies and provide a general description of each of the systems and generic advantages and disadvantages of each.

2. PURPOSE

The purpose of this report is to:

- To enable comparison of the various collection system options available
- Inform the utility owner of the operational implications of each individual system inclusive of the impacts on future reuse applications
- Outline comparative all of life costs for operation of the schemes
- Recommend the most suitable option to adopt for design development.

3. GENERAL DESCRIPTION OF SCHEMES

Gravity

Gravity sewer systems are the oldest and most commonly used form of collection system utilised in South Australia.

There are two basic forms of gravity systems employed in South Australia. Generically these are full sewer (also known as conventional sewerage) and Septic Tank Effluent Disposal Schemes (STEDS).

A gravity system collects wastewater from all properties via gravity and as such the connection point has to be deep enough to drain the site. In steep terrain where land slopes away from the main drains, this can result in deep excavations for individual property owners.

Gravity systems grade downhill from the top of the catchment to the lowest point. A pump station is generally located at this point to pump the wastewater to a treatment facility, either directly or indirectly via other catchments.

The system consists of a network of main drains and individual property connections. An Inspection Point (IP) is located at all property boundaries, with the property owner being responsible for plumbing within the property and the authority for all drains downstream of the connection IP. The main drains may be in public land such as road reserves or within easements through private property.

At all significant changes of direction and regular spacings along straight runs, flushing points are installed. Flushing points take the form of maintenance holes or access chambers for full sewer systems but can be IP's (also known as risers) for STEDS.

Pump stations are used at low points in the catchment to lift the effluent to the treatment plant or to ensure the depth of the gravity drains is minimised. Placement of pumping stations is at the discretion of the designer and is dependent on the local conditions, which may limit the viability of installing deep gravity drains.

The major difference between the two gravity systems is that a full sewerage system transfers all wastewater from the property including solids, whereas the STED schemes utilise a septic tank at each individual residence to capture the solids and only transfer the effluent to the collection system.

This difference has resulted in STED schemes having smaller pipes laid at lesser grades. While the prior removal of solids significantly reduces the number of maintenance holes or access shafts required. This generally results in the collection network for a STED scheme being shallower and having a lower capital cost to install especially in existing communities where all properties have septic tanks operating. STED schemes require a septic tank pump out program to desludge each tank on a four yearly cycle.

Pressure

Pressure sewerage schemes are becoming more widely adopted in South Australia, particularly over the past 8 years. Each property is fitted with a storage tank. In South Australia, this tank is required to provide 600 L of emergency storage for a residential domestic dwelling. The pump chamber is placed directly inline with the house's plumbing and hence receives all wastewater from the dwelling (inclusive of solids). A typical pressure system layout for a residential property is shown in Figure 3.1

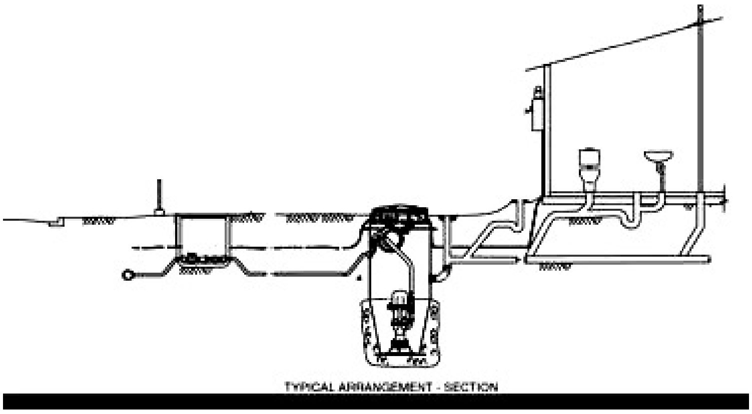


Figure 3.1 Pressure system layout

Diagram obtained from Environmental Systems Limited

For the pressure sewerage systems, a single grinder or cutter pump is installed in the pump sump to pump the wastewater from the property to the network. The network of drains may either deliver directly to a treatment facility or may pump to a main pumping station, which then transfers the wastewater to the treatment facility. Generally, where the treatment site is either elevated or a long distance from the network (i.e. high pumping heads) a transfer pumping station will be required. Over the past few years there have been significant developments in domestic pump units and several are now capable of duties approaching 50m head. A package system has recently been released to the market which is capable of pumping against a 60m head.

Each property connection consists of a 32mm connection line from the pump chamber to the main drain. A valve pit is to be located at each property boundary containing isolation valves and a non return valve.

Pressure systems have traditionally utilised centrifugal submersible pumps, but the introduction of more sophisticated control systems have resulted in positive displacement pumps also now being suitable for this application.

Pressure systems allow for the use of smaller bore drains than gravity systems and can be laid at shallower depths, as they do not require a minimum downhill grade and can be laid to the contour of the land.

Most of the pump supply companies in South Australia now market a package system suitable for installation in domestic situations. The quality and capability of each of the systems varies and needs to be assessed for the particular application.

Pump selection is a critical component of the design of a pressure network. Utilising pumps with performance curves that differ from that of the design can adversely impact on the system performance. Ensuring that the pumps specified in the design are actually installed requires vigilant monitoring and control. Most land owners will substitute the specified pump for cheaper alternatives if the installation is not monitored and strict controls placed on pump installation.

The reticulation network in a pressure system generally remains full of wastewater. Each time an individual property pumps into the system it forces wastewater in at the top end of the catchment and consequently out of the system at the outlet end. In large networks significant volumes of wastewater can be retained within the pipe network for long periods of time.

The period of time the wastewater remains in the network depends on the volume of the pipes within it and the volume of wastewater being pumped into it. The biochemical reaction occurring in the sewage/effluent quickly uses all available oxygen in the process. Once this occurs, anoxic or even anaerobic conditions are established, which causes septicity to occur, a by product of this process is hydrogen sulphide which is highly corrosive, toxic and at low concentrations has an unpleasant odour.

The potential for hydrogen sulphide generation within the systems will impact on the system design. The location of air valves need to be considered carefully so as not to position them in areas likely to be sensitive to odours. Head works at the treatment plant need to be designed to cater for the higher

Hydrogen sulphide load as it is highly corrosive. The gas can also be highly toxic, so safety of operators needs to be considered in the design. In addition to this the treatment process itself needs to account for the septic conditions particularly when calculating oxygen demands.

Vacuum

In a vacuum system, houses gravity feed to a chamber, usually located in the road reserve. Inside this chamber there is a level sensor, which activates the opening of the valve. The pressure in the pipeline is lower than that in the pit and the contents of the pit are effectively "sucked out". The valve then closes to allow the network to maintain its vacuum. A significant volume of air is "sucked" into the line along with the wastewater. The wastewater slug that results from the valve opening and emptying the chamber soon disintegrates and flows via gravity to a low point in the system, where it reforms. Subsequent flows of air push the wastewater through the system to the vacuum/pump station.

Figure 3.2 shows the generic layout of a vacuum scheme

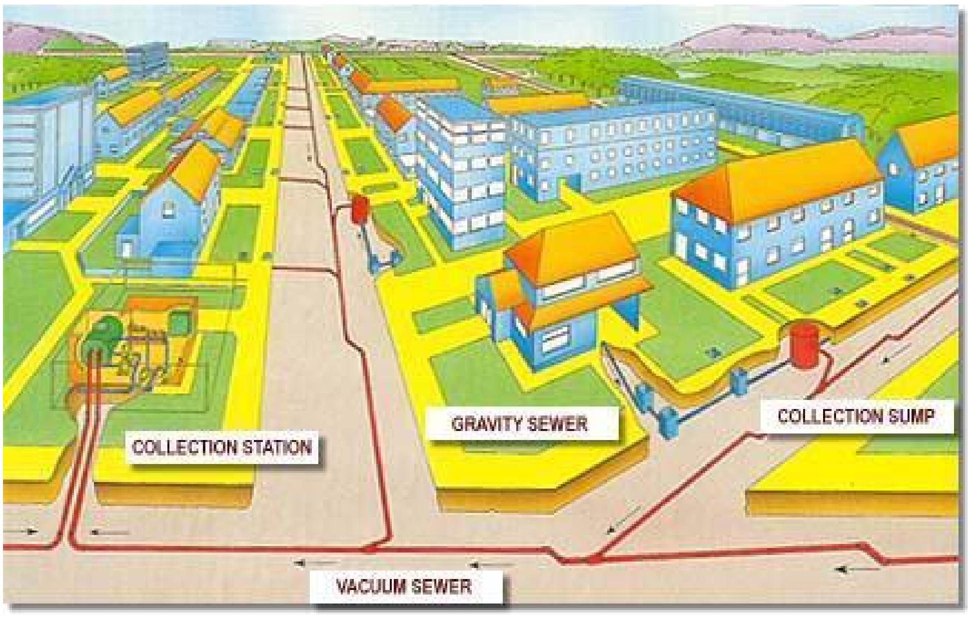


Fig 3.2 Typical Scheme Layout

Diagram provided by Flovac Pty Ltd

At the main pump station there are two types of pumps. One is used to create and maintain the vacuum in the pipe network, and the other is a conventional pump, which transfers the wastewater from the pump station to the treatment facility.

The chambers located outside the residential properties are generally service between 1 and 10 connections. The chambers vent via an 80-100mm vent located within each property. Unlike pressure or STEDS, vacuum systems do not require infrastructure other than the vent and drains on each individual property.

Care needs to be taken when situating the vents if the site is in a flood prone area. They will allow infiltration into the system if inundated.

The vacuum network is designed with a saw-tooth system, which allows a shallow depth to be maintained. Figure 3.3 outlines a typical detail for a property connection. It also outlines the saw-tooth arrangement for the main drains.

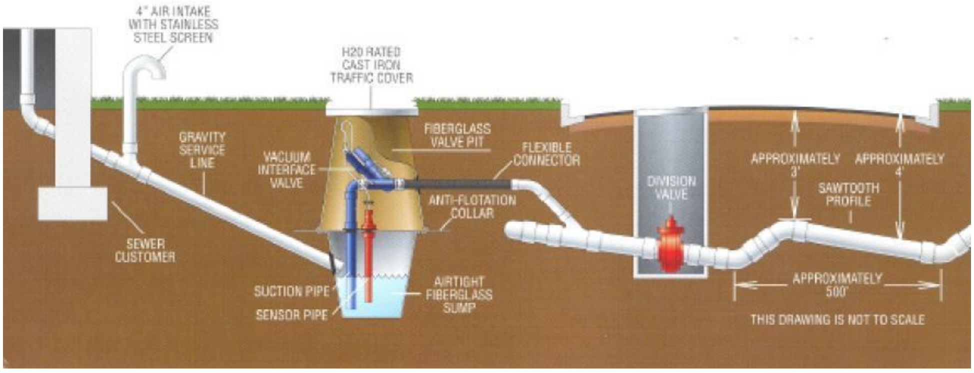


Figure 3.3 Saw-tooth Design

Diagram from Eurobodalla Shire Council Community fact sheet

The introduction of air each time the valve opens and the velocity of the wastewater within the network, acts to aerate the sewage and reduce the potential for odour generation otherwise resulting from the creation of septic conditions.

Vacuum pumps generally operate continuously to maintain the required pressure differential in the system. In times of low flow the pumps turn off and a vacuum vessel maintains the pressure differential in the system.

The vacuum pump stations have a high capital cost, which tends to result in the vacuum systems having a high unit connection cost, where the number of connections is low.

4. GENERAL COMPARISON OF AVAILABLE COLLECTION NETWORKS

4.1 SUITABILITY OF THE COMMUNITY WASTEWATER MANAGEMENT SYSTEMS

The decision to select a pressure or gravity system is dependent on a number of factors but the key issues include:

- The terrain and ground conditions
- Number of connections within the system
- The level of skills within authority's operations personnel and/or contract administrators.

No individual system is generally "better" than the others, as the functionality of each system will vary from site to site. The following guidelines can be used to select the most appropriate and economical option.

Gravity

Suited to;

- Gently sloping terrain towards one side of the site
- Areas with good excavation conditions
- Reasonably dense housing (i.e. not sparsely spaced blocks)
- Remote areas where system response times are likely to be long
- Areas with a high probability of prolonged power failure.

Pressure

Suited to:

- Areas where excavation conditions are difficult
- Areas with high ground water
- Sites that are elongated such as those that follow coastlines or rivers
- Areas with sparsely located houses
- Areas with significantly undulating terrain
- Areas that require large lifts from individual properties
- Hilly areas (vacuum lift is restricted to about 6m)
- Areas where construction impact needs to be minimised
- Where significant land acquisition would be required to install gravity drains

Vacuum

Suited to:

- Areas where excavation is difficult
- Areas of high ground water
- Proposals with over 100 connections
- Gently undulating sites
- Sites that are elongated such as those that follow coastlines or rivers

4.2 GENERIC ADVANTAGES AND DISADVANTAGES

There are a number of advantages and disadvantages of each of the waste collection alternatives. These are outlined below:

Gravity

Advantages

- There are limited maintenance issues for property owners (STEDS do require maintenance of the septic tank)
- Access to individual properties is not necessarily required by the authority (STEDS may require access depending on the pump out arrangements in place for septic tanks)
- The system is simple with very few mechanical parts or valves that may result in choke points.
- Power failure does not result in total system shutdown. Emergency response in such circumstances requires response to only a few key locations such as pump stations. This can be achieved by a trailer mounted diesel pump or a generator.
- Systems have minimal electrical requirements.
- Most civil contractors are able to install a gravity sewerage scheme.

Disadvantages

- Tracking infiltration or illegal stormwater discharges is difficult.
- Network isolation for maintenance purposes is more difficult.
- Drains tend to be deeper, making access for maintenance or replacement difficult. It also increases the construction costs, particularly when adverse ground conditions exist.
- Internal plumbing for individual properties may require deep excavation.
- Ground water ingress potential is higher than for either pressure or vacuum.
- Wastewater egress from the system is almost untraceable.

- System may not be appropriate to accept effluent and full sewer. Full sewer would accept effluent connections but STEDS drains may not accept full sewer.
- Stormwater ingress can significantly increase peak flows, which may cause system capacities to be exceeded (particularly at the pump stations or treatment plants).
- Deep excavation can cause considerable damage to nearby structures, as can the removal of rock by percussion.
- Pump stations have 9m or 12m vent stacks and may also have pump sheds that can have an adverse visual impact.
- Odour may be generated at pump stations in low flow situations as the wastewater may sit in the pump station for some time, which may result in septicity.
- System upgrades can be costly as gravity flow through a system is limited by the capacity of the pipe. Pressure and vacuum systems are a little more flexible as the system pressures can be increased to increase flow capacity.
- A larger working corridor is required for construction of the drains. Where access is required through sensitive areas or private property then gravity systems will require the largest construction corridor and hence cause the greatest damage during construction.
- Construction tolerances on the main drain are relatively small especially in schemes constructed on flat ground (due to being at flat grades 0.15% to 0.4% minimum grade)
- Septic tanks are located on the property for a STEDS which impacts on the space available for building on the allotment. Therefore larger minimum allotment sizes are required, reducing the efficiency of land use.

Pressure

Advantages

- Pipelines are shallower than for gravity and can follow the terrain.
- Pipelines are a smaller bore than for gravity.
- Drainage network is cheaper to install.
- Greater tolerance in levels and alignment can be accepted than for the other two systems.
- Being a pressure system, groundwater ingress into the system is highly unlikely (due to the pressure in the pipe being higher than the external water pressure) other than at main pump stations or on the individuals' property.
- Tracking of illegal connections can be facilitated by requiring hour run meters or flow meters and checking volumes.
- System is easily adaptable from effluent to full sewer, as long as the treatment facility has the sludge handling facilities.

- Most pump manufacturers in South Australia produce a pressure pump unit, so there is a good choice of supply.
- Avoiding services during construction is straight forward.
- Due to using a smaller bore pipe and being at a minimal depth the construction corridor is smaller than for other systems and the damage caused by installation is minimised.

Disadvantages

- Pumps are required for each individual property.
- The question of who owns and maintains the pumps needs to be addressed. If the owner maintains the pump then the likelihood of malfunction due to poor maintenance is increased. If the authority maintains the pump then the issue of access to infrastructure arises.
- If pump unit installation is not controlled (types of pumps) can impact negatively on the operation of the system.
- The system can not operate in the event of a power failure. The scheme then relies on individual on-site storage. Hence extended power failure is difficult to mitigate, since every allotment would need to be pumped out by portable pumps and disposal units.
- Leakage of effluent from the system can be difficult to trace or detect.
- The area for buildings on each allotment is restricted by mandatory setback distances.
- Design is significantly more complex than for gravity.
- Air valves are required throughout the scheme. This can result in odour within residential areas. Air valves also tend to be prone to leakage which results in small releases of effluent to the environment.
- The onus is on the land owner to detect faults and either fix or report the fault depending on what ownership model is adopted.
- Pump sumps are located on each allotment which limits the area available for buildings. Therefore larger allotments are required, reducing the efficiency of land use.
- There are more mechanical and electrical components within the system which will result in a more rigorous maintenance regime being required.
- Each individual property owner is paying the power bill for the pumps. This is a hidden community cost which artificially deflates the comparable cost of this system.

Vacuum

Advantages

- Pipeline construction can be kept at a minimum depth, saving excavation costs. Generally these mains will be deeper and larger than for pressure systems but shallower than for gravity. This helps reduce water ingress.
- Generally there will be fewer pump stations than for a gravity system.
- Eliminates the need for maintenance holes, reducing costs compared to conventional sewerage and reducing ground water ingress.
- The system is easily adaptable from effluent to full sewer as long as the treatment facility has the sludge handling facilities.
- Property owners do not need to maintain infrastructure, as is the case with conventional sewerage. With pressure schemes they have a pump and sump, STEDS they have a septic tank.
- The risk of egress of effluent to the environment is less than any other scheme due to the low pressures in the mains.
- The potential for ingress of stormwater is reduced. Suppliers have indicated that the system can tell due to the loss of vacuum if water is getting into the system. The system has the potential to track illegal stormwater discharges depending on the level of monitoring equipment installed.
- The mixture of air and wastewater in the system maintains wastewater in an aerobic state, reducing the potential for odour and providing a small level of pre-treatment before it is delivered to the WWTP. This reduction in septicity also reduces the potential for corrosion.

Disadvantages

- Stormwater ingress can occur upstream of the vacuum chambers.
- A vent is required on the individual property so there is a potential for odour in the event that effluent remains in the chamber for some time.
- Should the vacuum pumps fail then the whole system will become inactive. There is some limited storage at the vacuum chambers.
- Suppliers have indicated that it is possible to track leaks in the system. However, this is done via an elimination process and could be time consuming.
- Because individual connections are via gravity then deep connections within each property may be required. This is the same as for gravity. Pressure systems do not present this difficulty.
- Design costs are significant as design is significantly more complex than for a gravity system.
- Adherence to tolerances is very important, making construction standards and supervision very important.

- There are limited suppliers of vacuum systems.
- There are more mechanical components within the system (compared to gravity) which will result in a more rigorous maintenance regime being required.
- System requires more vigorous monitoring than a gravity system, to ensure vacuum pressures are maintained. This is likely to require a SCADA system for this monitoring to be effective.

5. SITE SPECIFIC CONDITIONS AND ISSUES AT BUCKLAND PARK

The following conditions and issues at the Buckland Park site will influence the selection of an appropriate collection network.

High Ground Water Levels

The majority of the site has a depth to water table of less than 3 metres. To minimise the length of drain constructed below the groundwater table level the maximum drain depth was set to 3m by installing pump stations. To achieve this, approximately 35 pump stations would be required to service the proposal. Even with this number of pump stations up to 75% of the gravity drains would be installed within the water table. Appendix A shows a depth to water table plan for the site highlighting all areas where the groundwater is less than 3m below the surface. This map is based on recent site mapping undertaken by Golder and Associates. It should be noted that seasonal fluctuations of up to 1m could be experienced. This would result in the majority of gravity drain being below the standing groundwater level.

Constructing a gravity system within the ground water table could potentially result in water infiltration at manholes, pump stations and any breaks or cracks in the pipe work. STED systems also have potential for ground water ingress at septic tanks.

Sewer systems generally have more manholes in the system than STEDS and the drain depths are greater due to the larger minimum grade required for sewer systems so the risk of infiltration is increased.

The drains for vacuum systems are generally installed between a depth of 1.2m and 1.5m. Appendix B indicates the area of the site that the depth to ground water is less than 1.5m. It is estimated that for a vacuum system only 10% of vacuum drains would be installed within the water table.

The maximum number of houses connected to each valve pit should be set to minimise the depth of the vacuum pits. The cost estimate in this report has assumed an average of 5 connections per pit, however, when detailed design is undertaken up to 8 houses may be able to connect and still keep the pits above the standing water table level. It is likely that some of these pits will need to be installed below the current groundwater levels.

With a pressure system almost all the drains will be above the ground water level which will minimise construction costs. Since the drains are pressurised it is unlikely that ingress would occur in any case as the pressure in the pipe network is likely to prevent infiltration.

It is likely however that a fair percentage of the domestic pumping units will be installed within the ground water table, which does introduce the potential for ground water ingress. If GRC pumping units are used then precautions will be required to prevent flotation of the pump chambers.

Salinity

Ingress of saline ground water into the waste management network causes the salinity of the waste water to increase and highly saline waste water can impact on the effectiveness of the WWTP operation. It will also impact on the potential number of reuse applications that the treated effluent may be used for.

The ground water within the Buckland Park site has salinity in the order of 3000ppm to 5000ppm (TDS).

This would mean that relatively small volumes of ingress could have a significant impact on the salinity of the waste water.

The salinity of typical treated waste water schemes in South Australia is between 800ppm and 1000ppm (TDS). Anecdotal information from the Virginia region indicates that soil salinity in the area is of concern to the local growers. As such if salinity of the treated water increases much above the typical values then the applications for reuse may be limited.

Within the Buckland Park proposal a high priority is placed on the potential to reuse the treated waste water, therefore the potential for ingress of saline groundwater into the waste water management system is likely to be a significant factor in selecting the most appropriate method of waste water management.

Salinity can be managed in a number of ways:

- Reduce the potential for it entering the system (by implementing a vacuum or pressure system)
- Shandy the treated water with mains or harvested stormwater.
- Install a desalinisation (RO) plant. This is likely to increase capital cost by $300,000 to $400,000 and running costs by $40,000 to $50,000 per annum.
- Do not reuse the water and dispose via evaporation (not a desirable option).

Acid Sulphate Soils

It has been confirmed within a report prepared by Golders Associates (November 2008) that sections of the Buckland Park site have the potential to encounter acid sulphate soils below the ground water level.

Construction within these zones is likely to occur if installation of a gravity waste management system is to be implemented.

If Acid Sulphate Soils (ASS) are encountered the soil will need to be treated prior to the installation of any infrastructure, therefore causing the construction cost to increase.

Precautions will need to be taken to prevent ingress of leachate from ASS getting into the trenches and being transported around the site. Both vacuum and pressure systems will minimise this due to the relatively shallow depth of drains. Gravity drains also drain for long distances at a constant downward grade which facilitates the transport of leachate (if encountered). Both the vacuum and pressure sewerage drains are not required to constantly grade downward, this in itself would minimise the spread of ASS leachate should it be encountered.

Resource Availability

When selecting a scheme the resource availability and skill levels within the region need to be considered.

The gravity options will have the lowest site maintenance requirements and also require the lowest level of system familiarisation.

This needs to be carefully considered when selecting the most appropriate system for the Buckland Park proposal.

Technology

The gravity options are the oldest form of collection system and their operation is generally understood.

Pressure technology uses conventional pumps and as such there is a wide variety of suppliers and a considerable availability of skilled labour to service the pumps, however with the increased number of mechanical and electrical components the potential for faults is increased.

Vacuum is not a commonly utilised technology in SA with only 3 schemes currently known to W&G being:

- Hindmarsh Island Marina
- Waterfall Gully
- A marina project within the Murray Bridge Council area.

The Alexandrina Council are about to install a significant scheme to expand the area serviced by its STEDS network at Goolwa. There is also a vacuum system currently being constructed at Port Wakefield.

This technology however is widely used in Western Australia particularly and also in some of the eastern states.

From all reports and the research undertaken by W&G these systems are proving to be reliable if designed and operated appropriately.

6. COST COMPARISON

Table 5.1.1 provides a summary of the capital and all of life costs that are associated with each of the different wastewater management systems. These costs have been calculated taking into account a discount rate of 4 percent. The cost comparison has been based on estimates completed on capital and running costs produced by W&G through experience and industry knowledge using rates based on similar recently completed projects. These estimates have then been entered into the LGA's all of life cost model to obtain the all of life cost per connection, for each of the options.

These cost comparisons have been based on servicing the projected total population of 33,000 as outlined previously.

Table 6.1.1 Summary of costs from LGA cost evaluation spreadsheet

	Effluent	
Discount Rate	Capital Cost	All of Life Cost
4%	$78,100,000	$100,900,000*
	Sewer	
Discount Rate	Capital Cost	All of Life Cost
4%	$41,800,000	$58,700,000*
	Pressure	
Discount Rate	Capital Cost	All of Life Cost
4%	$132,700,000	$248,000,000
	Vacuum	
Discount Rate	Capital Cost	All of Life Cost
4%	$37,900,000	$55,300,000

- *This does note take into account additional pumping costs to cater for groundwater ingress*
- *It also does not account for additional costs to manage salinity for any reuse applications*
- *The impact of staging the proposal has not been taken into account in the all of life cost comparison.*

The gravity sewer concept has been based on a maximum drain depth of 3m, resulting in the need for 35 pumping stations and 75% of the drains laid in the water table.

The vacuum sewer cost has been based on an average of 5 houses being serviced by each vacuum pit and the scheme requiring 3 vacuum pumping stations.

From the above summary it can be seen that a vacuum system will require the lowest all of life cost and capital cost out of all four of the options considered.

It should be noted that the two gravity options will have the greatest risk/potential for cost escalations during construction due to unfavourable ground conditions.

Given these cost estimates have been produced at the proposal's concept design stage a number of assumptions have been made.

The accuracy limits of the cost model would suggest that the all of life costs for the options outlined above with less than a 10% differential could be considered to be of comparable value and should not totally influence the decision for the selection of the most appropriate scheme. In this instance for the purpose of comparison it can be assumed that the gravity sewer and the vacuum systems are of the same order of cost and as such other factors should determine which system is adopted.

7. RECOMMENDATION

W&G recommend that design development be based on a vacuum sewerage system.

The reasons for recommending this option include:

- The lower estimated capital cost and all of life costs
- The reduced potential impacts of salinity on the reuse applications
- Lesser impact of peak wet weather flows on the WWTP and pump stations
- Lesser potential for long term ground water ingress
- Reduced potential for system overflow from the pump stations during peak wet weather events or power outages
- Reduced risk of system failure due to groundwater ingress
- Lower pumping costs associated with groundwater ingress (which is not captured in Table 5.1.1)
- Reduced operational requirements in a major power failure scenario
- It is estimated that approximately 75% of drains in a gravity system would be installed below the current ground water levels, even with the installation of 35 pumping stations
- Aeration of sewage through the collection network will have a positive impact on the WWTP operation.

We recognise vacuum sewer systems are a new technology in South Australia, and they are likely to require additional resources for maintenance, than a gravity scheme. We also recognise that specialist skills are required to operate the system.

We believe that these issues can be mitigated by:

- Ensuring the construction contract allows for significant training and support after the scheme is installed.
- The economies of scale offered by a proposal of this scale justify creation of a maintenance team with specialist training.
- Ensuring spare parts are provided as part of the supply contract, and keeping the valves on hand so they can simply be swapped in the field, and the valves later repaired in the workshop.

Salinity is critical for future reuse applications within the proposal and therefore all practical measures should be taken to prevent, or at least minimise, the potential for groundwater ingress.

8. REFERENCES

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EPA# 600979010 National Conference on Less Costly Wastewater Treatment Systems for Small Communities

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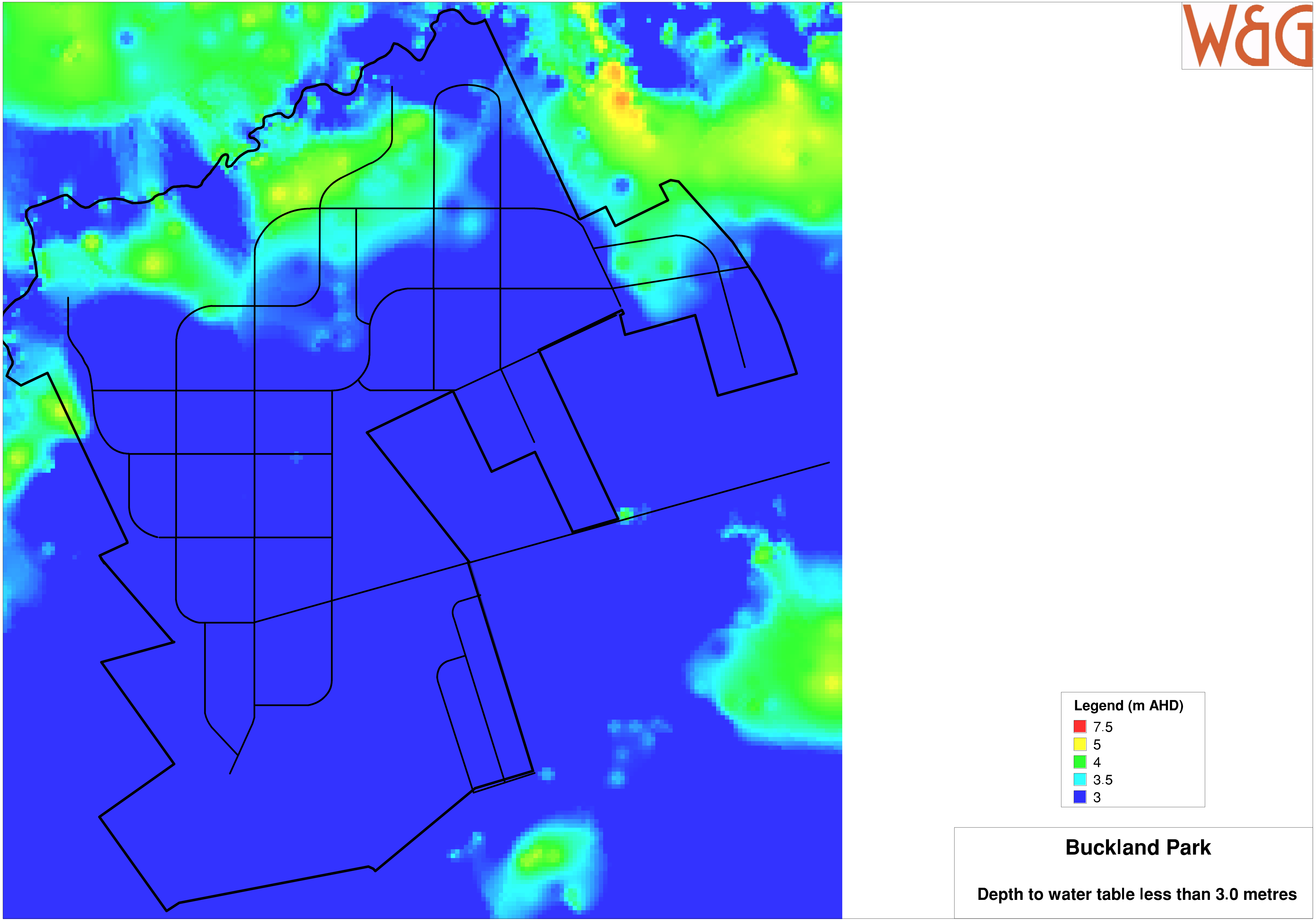
APPENDIX A

PLAN SHOWING DEPTH TO WATER TABLE LESS THAN 3 METRES

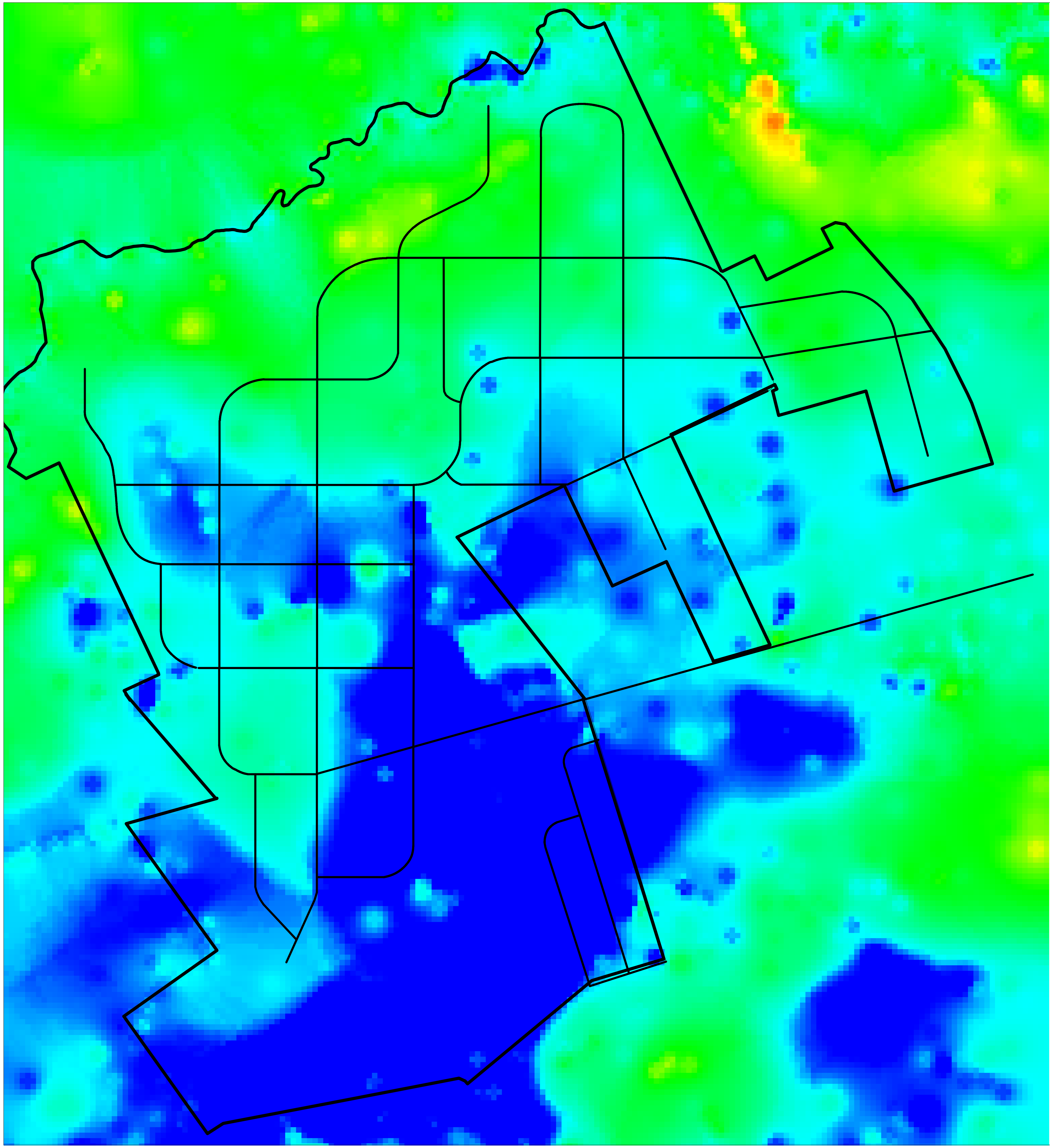


Buckland Park

Depth to water table less than 3.0 metres

APPENDIX B

PLAN SHOWING DEPTH TO WATER TABLE LESS THAN 1.5 METRES



Legend (m AHD)

- 7.5
- 5
- 4
- 2
- 1.5

Buckland Park

Depth to water table less than 1.5 metres

APPENDIX D

SA Water Consideration of Water Supply Options

Memorandum

SA Water 01/01595

To: Manager Customer Connections
(Attention: Gerry Harris)

From: Manager Systems Planning

CC: Principal Engineer Networks Design

Date: 18 September 2008

Re: Ultimate water supply for the Buckland Park/Waterloo Corner Area

1 EXISTING WATER SUPPLY

There is no SA Water water supply infrastructure available at the proposed development site. The site contours vary from EL2 to EL10, but no developed lots will be below EL4.

The site is between Two Wells and Virginia and on the western side of the Port Wakefield Road. Virginia is mostly supplied by the DN450 DICL main in Roberts Road, with Two Wells and surrounding areas partly supplied by this main. Water is supplied from the Craigmore EL103 Tank, which in turn is supplied from the Barossa Trunk Main. The DN450 DICL main is about 3 kilometres from the site.

The water supply to the immediate south of the site has only small mains which supply rural and rural living lots. These mains are within the EL76 water supply zone, but are boosted at peak times to maintain adequate pressures.

The nearest large main is a DN450 main in Undo Road, Waterloo Corner. This main was laid in 2000 to assist the effluent reuse scheme from Bolivar WWTP by reducing peaks in salinity at Bolivar. However since the commissioning of a separate high salinity treatment plant, this DN450 main is now redundant and has spare capacity. This main is 9.5 kilometres from the site.

The EL76 water supply zone is supplied from the Little Para WTP via Hillbank EL103 Tanks and an EL76 PRV in Commercial Road, Elizabeth South and Para Hills EL103 and EL76 Tanks. The Para Hills EL103 Tanks can also be supplied from Anstey Hill WTP at off peak times.

2 DEMANDS

The proposed development could be a trigger for further rezoning and similar development of vacant land that is also currently zoned rural living in both the Buckland Park and Waterloo Corner areas. It is assumed that this could yield another 11,000 allotments for a total of 23,000 services.

As a comparison the existing EL76 water supply zone, which includes the Mawson Lakes, would have a similar area of urban development area and population density to the Buckland Park/Waterloo Corner area when developed. This zone currently has about 25,000 services and a peak demand of 65 ML/day.

A cost sharing arrangement could be negotiated with the developer given that the options for an ultimate water supply scheme as below are upsized to meet a greater demand than this development will require. However the developer will be responsible for all internal mains and service connections and any other works associated with the provision of a water supply to the development.

3 FUTURE WATER SUPPLY

4.1 Pressure Zone

Because the ground levels will vary from about EL4 to EL10, the better option is to extend the EL76 water supply zone. Pressures will not exceed SA Water maximum pressures for domestic services of 90 metres head. Also pressure fluctuations on a peak day may be more manageable with a lower pressure supply, given that the site is quite some distance from an adequate water supply source.

4.2 Water Supply Options

There are two potential water supply sources. These are Barossa WTP via the Barossa Trunk Main and Little Para WTP.

Earlier consideration for the Barossa WTP option has been examined. This option has been discarded, however, for the following reasons. Although slightly closer to the site, it is found that the Barossa Trunk Main does not have enough capacity to meet the above ultimate demand and will need upgrading. Up to 4.5 kilometres of DN750 main would need to be duplicated to the between the Gawler township offtakes and the existing Evanston Park EL118 break pressure tank.

Also Gawler and surrounding areas, including Blakeview, Munno Para West and Penfield in the City of Playford, are identified for future housing developments. These developments would most likely be supplied from the Barossa WTP. Some flexibility exists to supply the Elizabeth East EL103 Tanks from Little Para WTP with current infrastructure, a transfer of about 20 ML/day, but to transfer water further north to Craigmore EL103 Tank say would require expensive upgrades.

Also with the future inclusion of the Adelaide Desalination Plant and a north-south transfer main, infrastructure closer to this infrastructure will allow more flexibility to be able to supply a greater area to fully utilise this new water supply source without additional upgrades. The Little Para WTP and the associated water supply systems provide this flexibility.

4.3 Staging

As an interim water supply, a three kilometre DN250 main extension from the existing DN450 DICL main at the corner of Roberts and Angle Vale Road is an option. Network analysis shows that this main has enough current spare capacity to supply about 1100 services. But as the Two Wells/Virginia water supply develops, this main would be unavailable to supply the proposed development and other alternate water supplies will be required. However, the main could be utilised in future as a back up at times of emergency.

A 1DN600 main extension of about 10 kilometres from an existing DN450 main in Undo Road, Waterloo Corner is an alternate source. A network analysis shows that this main could supply 3000 services. This main is an essential requirement for the ultimate development as a back up supply to the ultimate scheme. Further network analysis shows that this main could supply up to 33% of the ultimate demand and should cover the loss of the main feeder main due to scheduled maintenance or most other unscheduled events, such as bursts.

Beyond 3000 services, the development will require major upgrades. These upgrades will need to be from major water supply sources quite some distance from the site. Logistically, this will require laying large mains. Additional storages will also be required to balance the demand and provide adequate security to supply.

Option 1a – Supply from new Hillbank EL76 storages via Little Para WTP

1. 20 ML EL76 storage (or staged as 2No 10 ML storages) at the corner of Black Top Road and Bungarra Street - site to be purchased-

2. New inlet control valves in suitable enclosure

3. Lay 13.5 kilometres of DN1000 main in existing easement, Hogarth, Edinburgh, Wyatt, Mill and Curnow Roads

4. Lay 6 kilometres of DN750 main in Curnow and Tozer Roads

Option 1b – Supply from Little Para EL118 Filtered Water Storage (at Little Para WTP)

1. Add 20 ML EL118 storage at Little Para WTP (or stage as 2No 10 ML storages)

2. Lay 13.5 kilometres of DN900 main in existing easement, Hogarth, Edinburgh, Wyatt, Mill and Curnow Roads

3. Lay 6 kilometres of DN750 main in Curnow and Tozer Roads

4. Install a PRV set, set to EL76, in Wyatt Road, Direk

Option 2 – Supply from Para Hills EL76 Tank via Little Para WTP

1. Add 20 ML EL76 storage near existing Para Hills EL76 Tank (or staged as 2No 10 ML storages) – existing site too small, new site required.

2. Lay 15.5 kilometres of DN1000 main in Kings, Port Wakefield Curnow Roads

3. Lay 6 kilometres of DN750 main in Curnow and Tozer Roads

4. Combined Para Hills EL76 storages to be supplied from Little Para WTP, with Para Hills EL103 Tanks to be supplied from Anstey Hill – may require additional works for this change in operation.

SUMMARY AND RECOMMENDATIONS

1. Walker Corporation Pty Ltd plan to develop 12,000 homes on the proposed development site of 1,300 hectares. Initially 500 lots will be developed, with the remainder being developed over a 25 year timeframe from 2013 – a development rate of 460 lots per annum is assumed.

2. Although zoned rural living in the City of Playford Development Plan, the development has been given major project status by the State Government.

3. The proposed development will be supplied by expanding EL76 water supply zone due to ground elevations varying from EL2m to EL10 for the proposed site. This zone is currently supplied from the Little Para WTP.

4. Some staging of the water supply can be undertaken as follows -:

    - an interim supply from a DN450 main in Roberts Road, Virginia with a three kilometre DN250 mains extension could supply 1,100 services

    - about 10 kilometres of DN600 from a DN450 main in Undo Road could supply 3,000 services – this main is required as a backup to the ultimate scheme.

5. For ultimate development (ie for the whole of the Buckland Park/Waterloo Corner area of up to 23,000 services), the above water supply options are designed to supply 70 ML/day, with an instantaneous peak demand of 1,500 L/s.

6. There are three options for the ultimate water supply scheme as above.

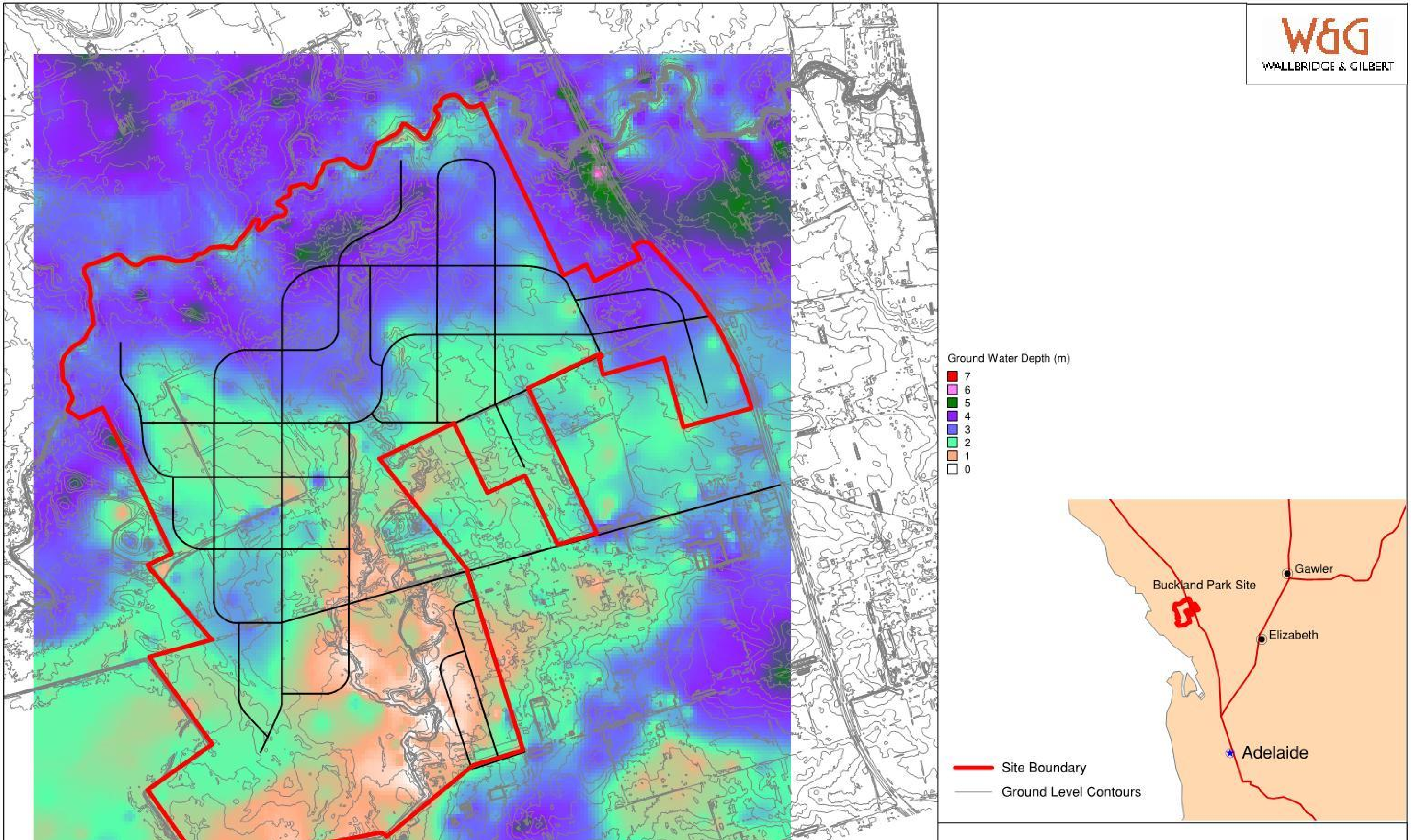
7. It is recommended that cost comparisons be undertaken to ascertain which of the three options is more feasible for the ultimate water supply to the Buckland Park/Waterloo Corner area, including the proposed development site at Buckland Park submitted by Walker Corporation Pty Ltd

8. Some cost sharing with the developer, Walker Corporation Pty Ltd, could be negotiated because the ultimate scheme has been designed with other beneficiaries.

Paul Feronas

APPENDIX E

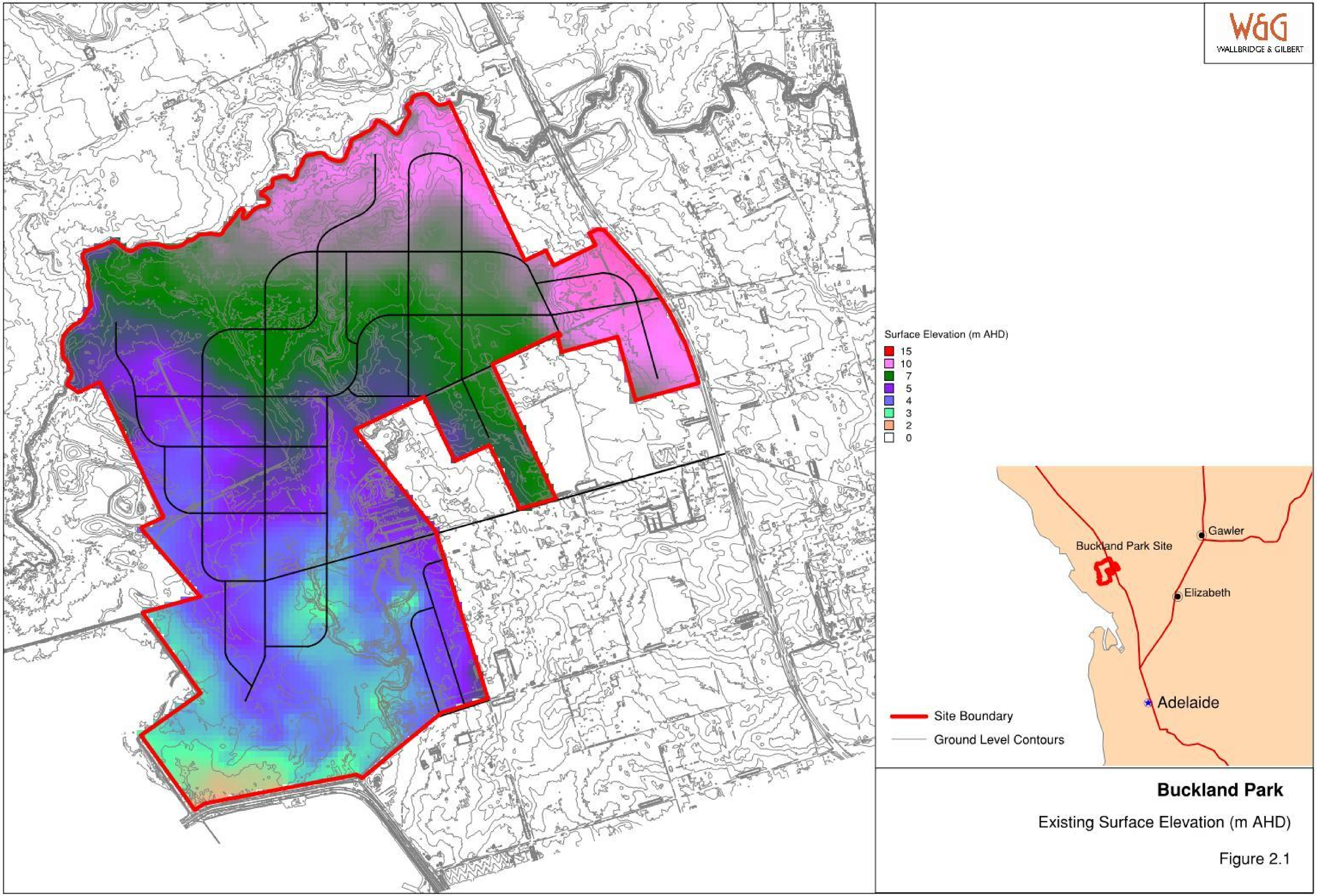
Figures



Buckland Park

Figure 1.5

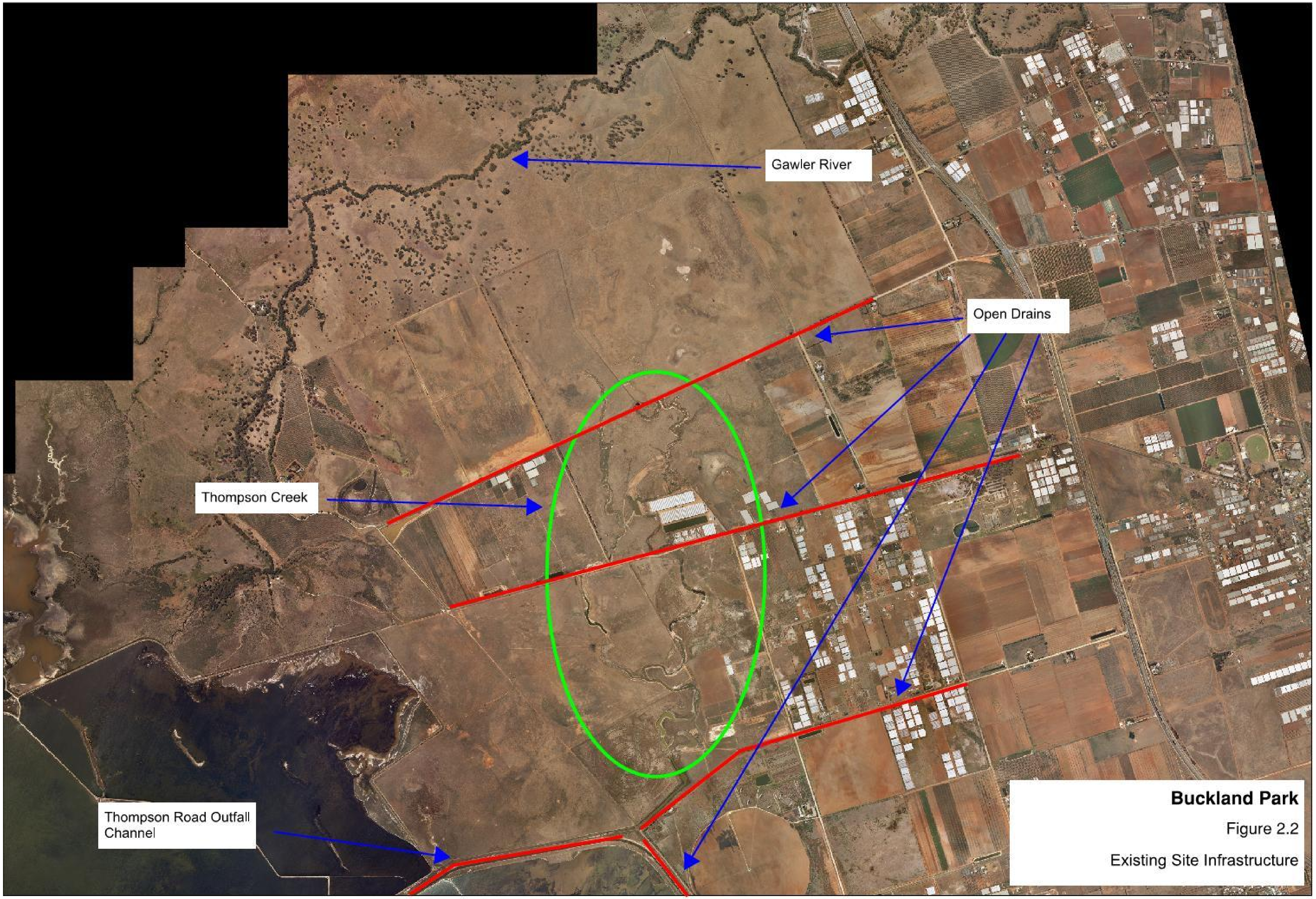
Depth to Groundwater



Buckland Park

Existing Surface Elevation (m AHD)

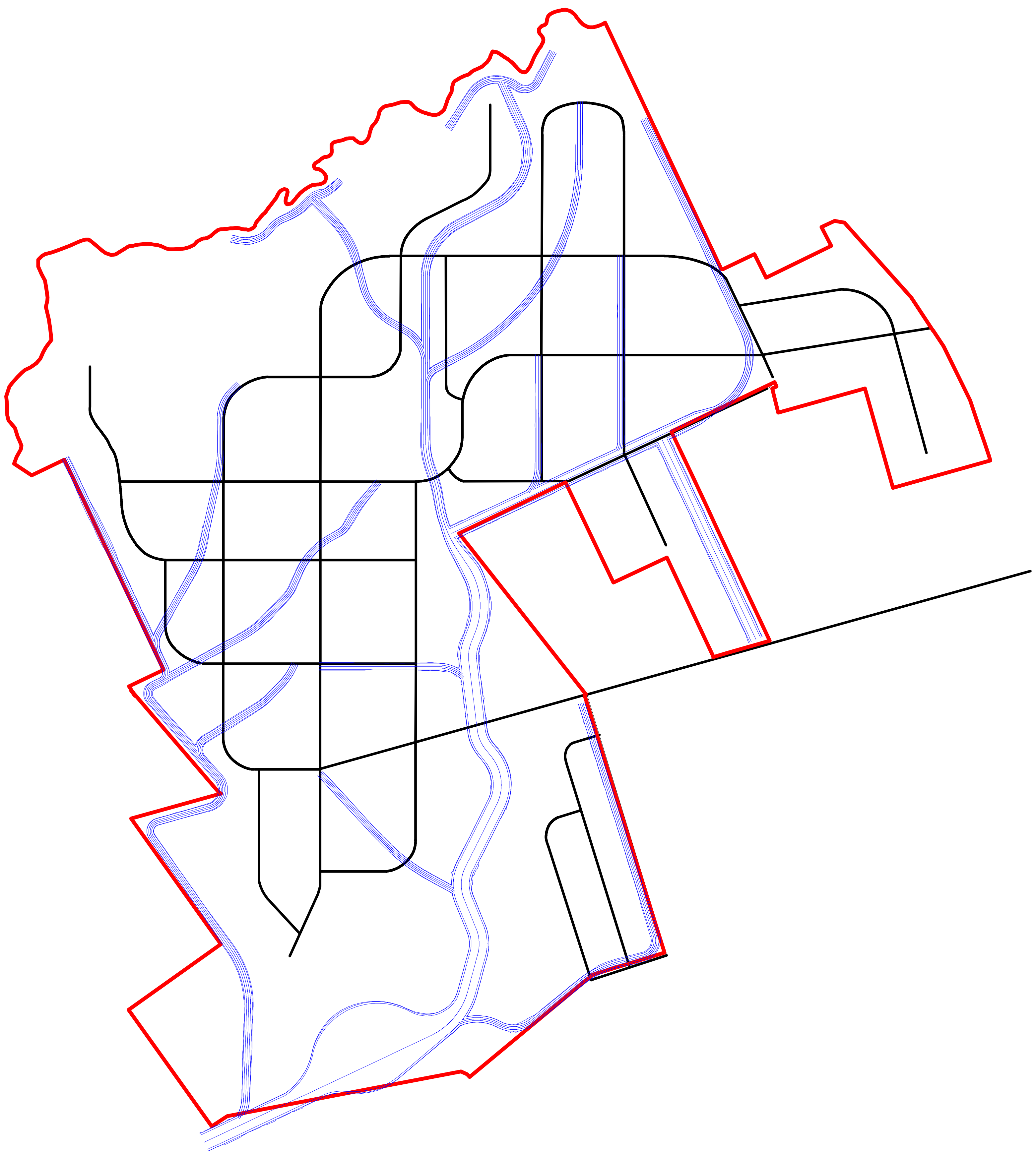
Figure 2.1

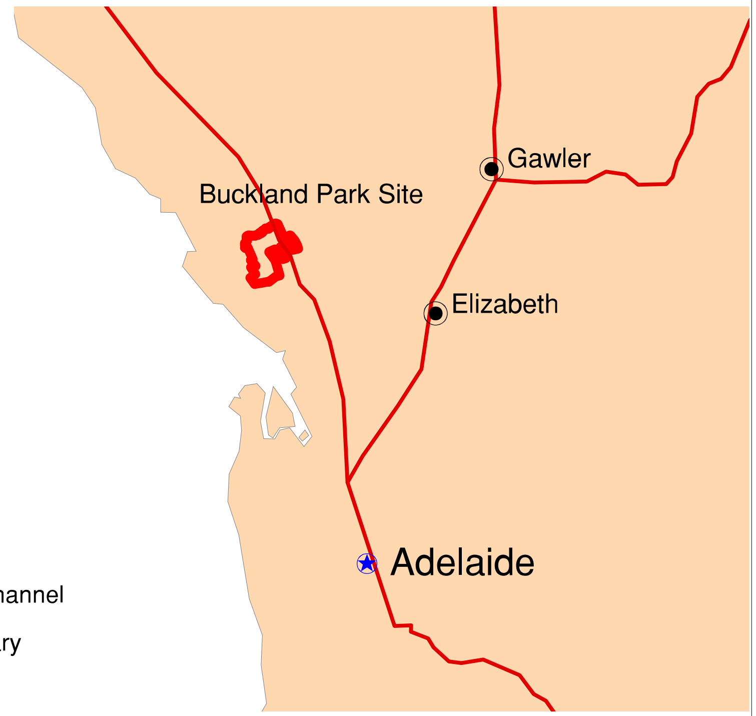


Buckland Park

Figure 2.2

Existing Site Infrastructure





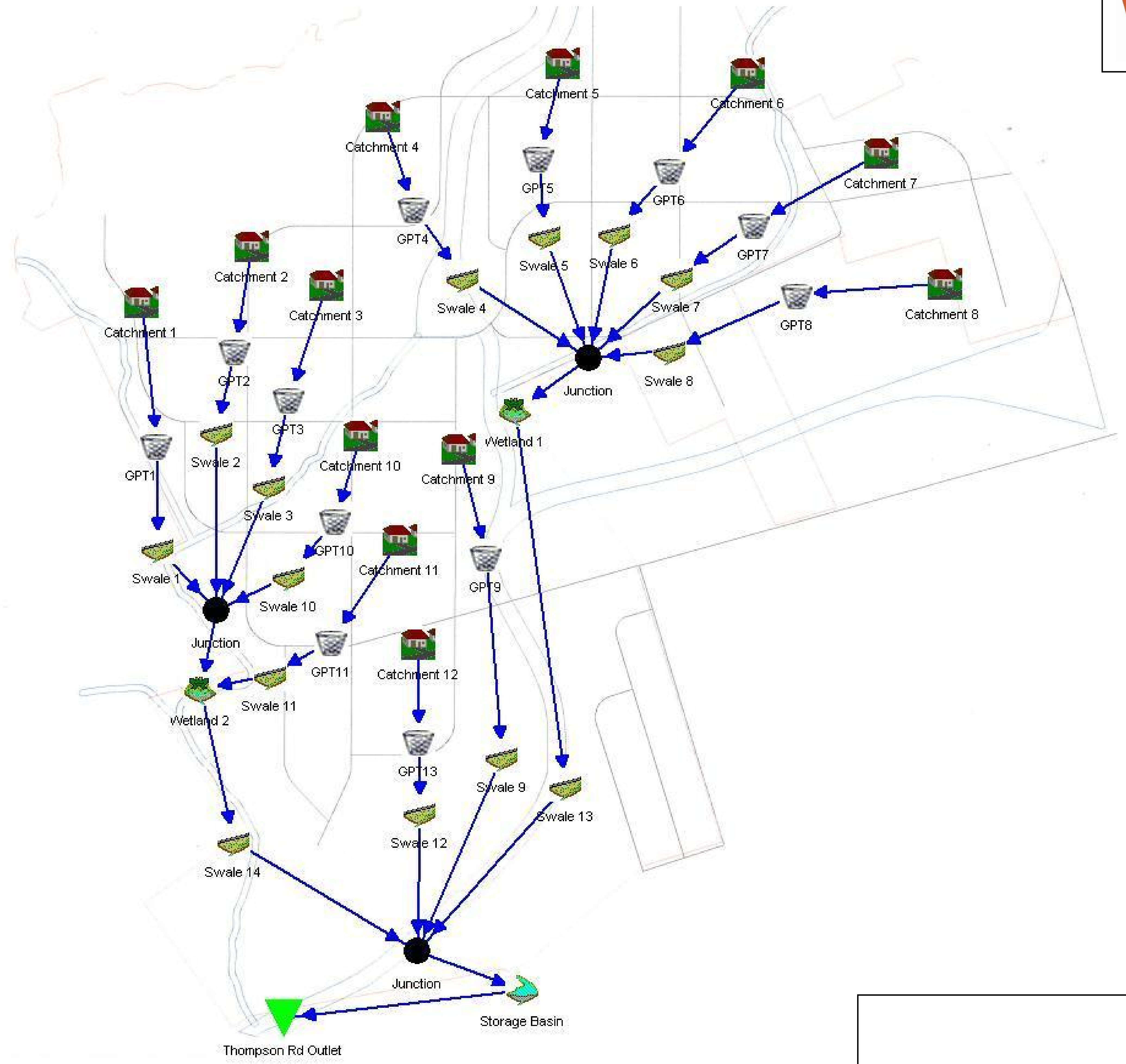
Drainage Channel
Site Boundary

W&G
WALLBRIDGE & GILBERT

Buckland Park

Drainage Channel Layout

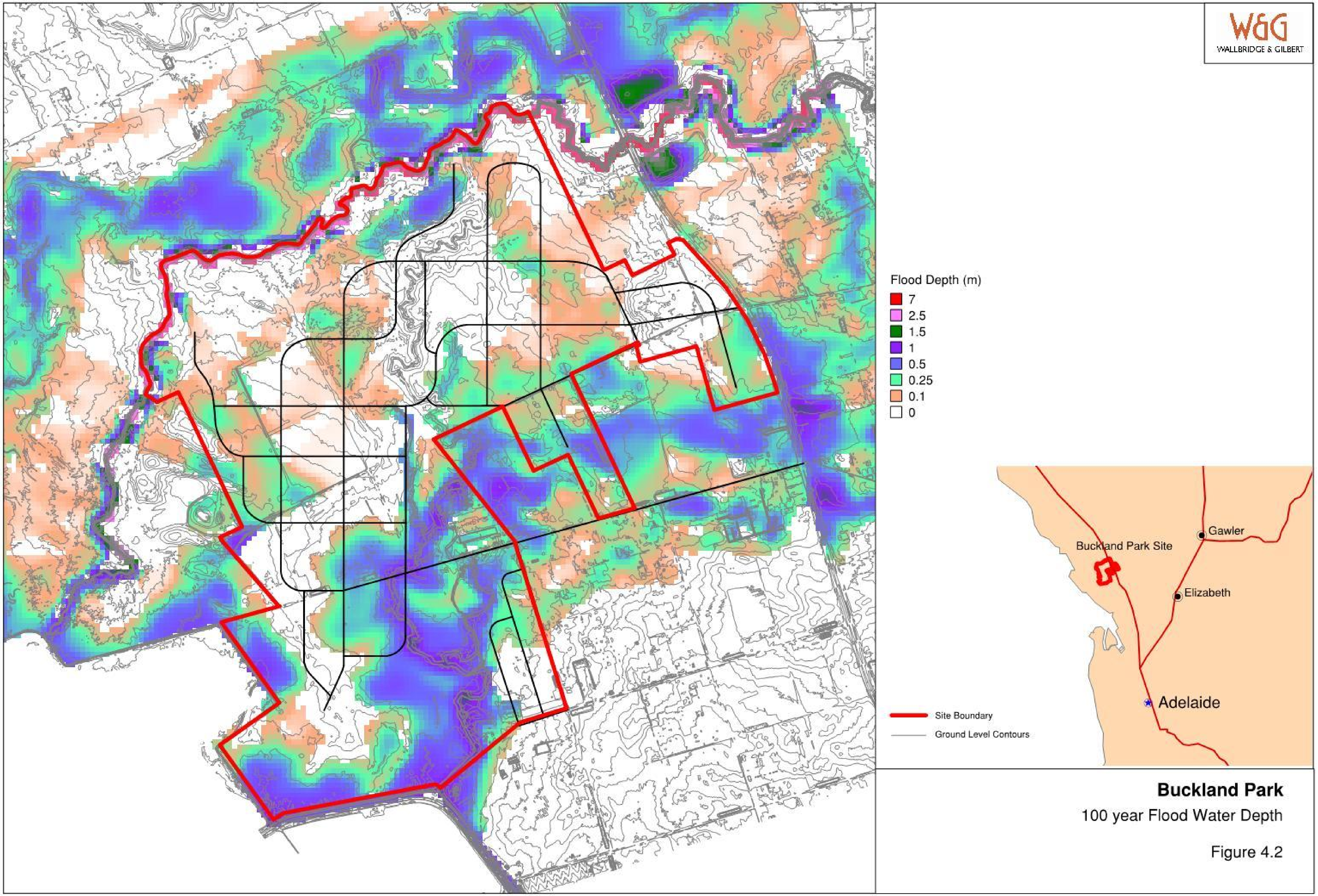
Figure 2.3



Buckland Park

Figure 3.1

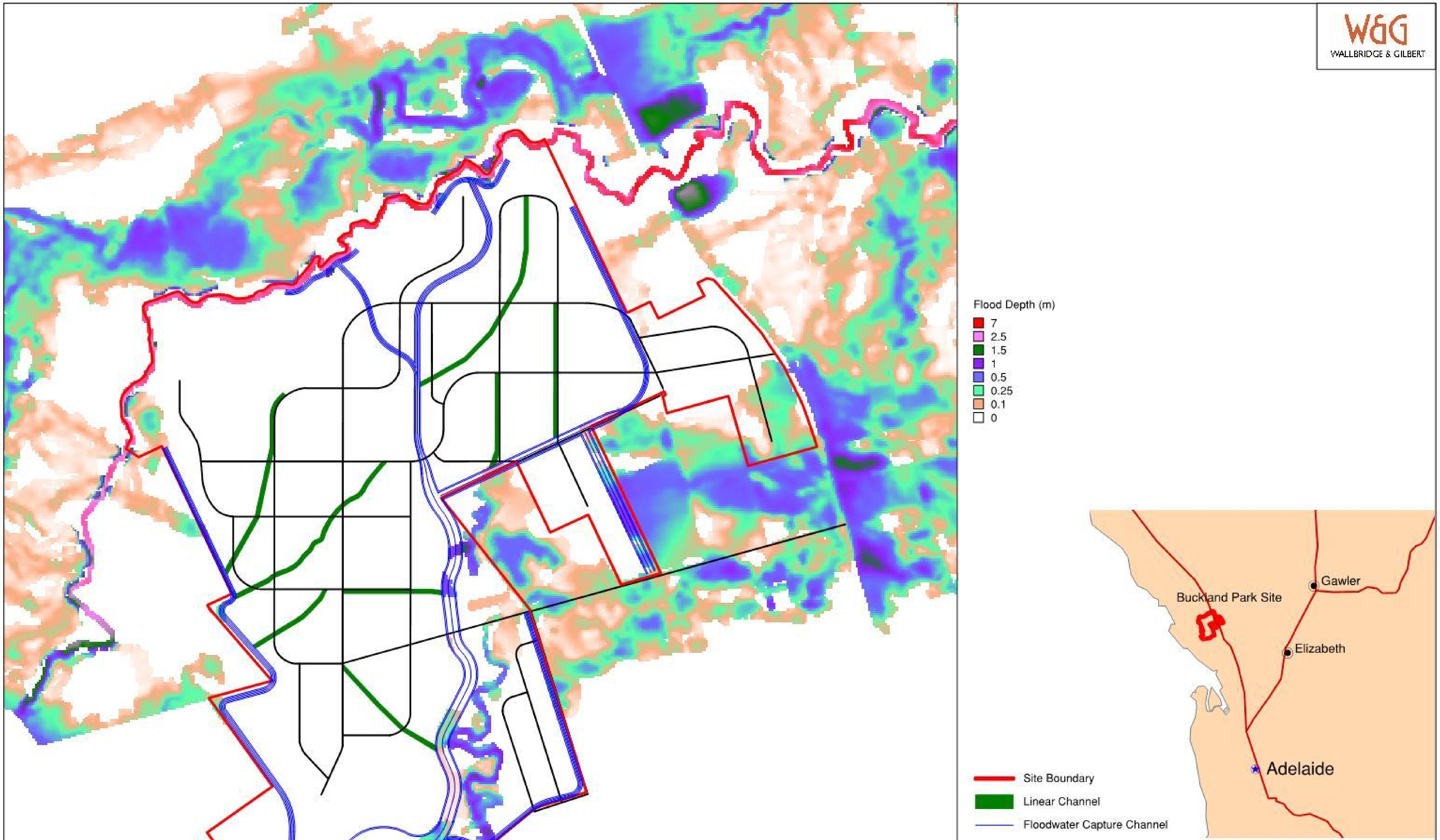
MUSIC model Layout



Buckland Park

100 year Flood Water Depth

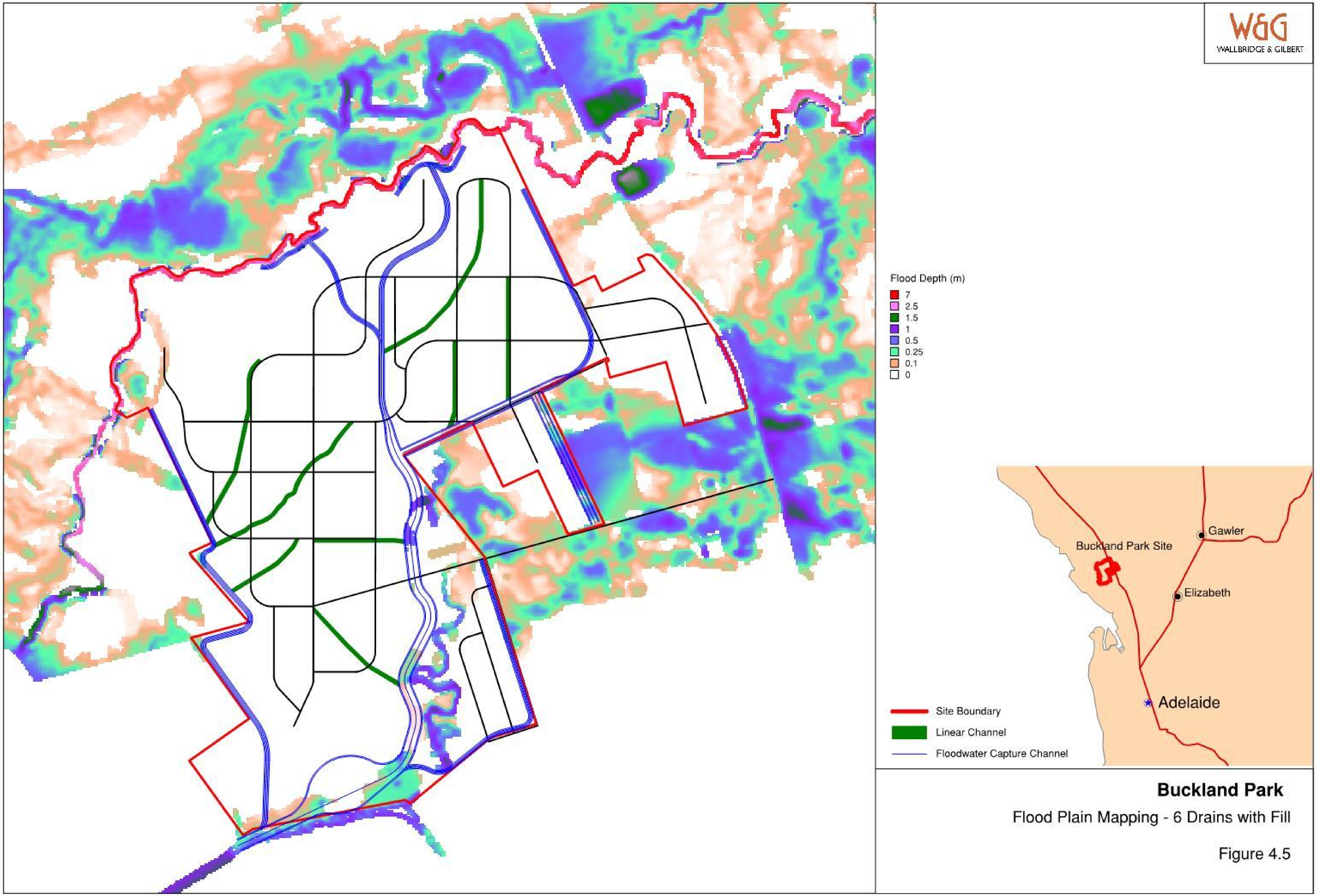
Figure 4.2



Buckland Park

Flood Plain Mapping - 6 Drains No Fill

Figure 4.4



Buckland Park

Flood Plain Mapping - 6 Drains with Fill

Figure 4.5

WALLBRIDGE & GILBERT

Water Depth (m)

- 1
- 0.5
- 0.3
- 0.2
- 0.1
- 0.05
- 0
- -0.1

Note: A negative value indicates a flood reduction to natural surface level

- Site Boundary
- Linear Channel
- Floodwater Capture Channel

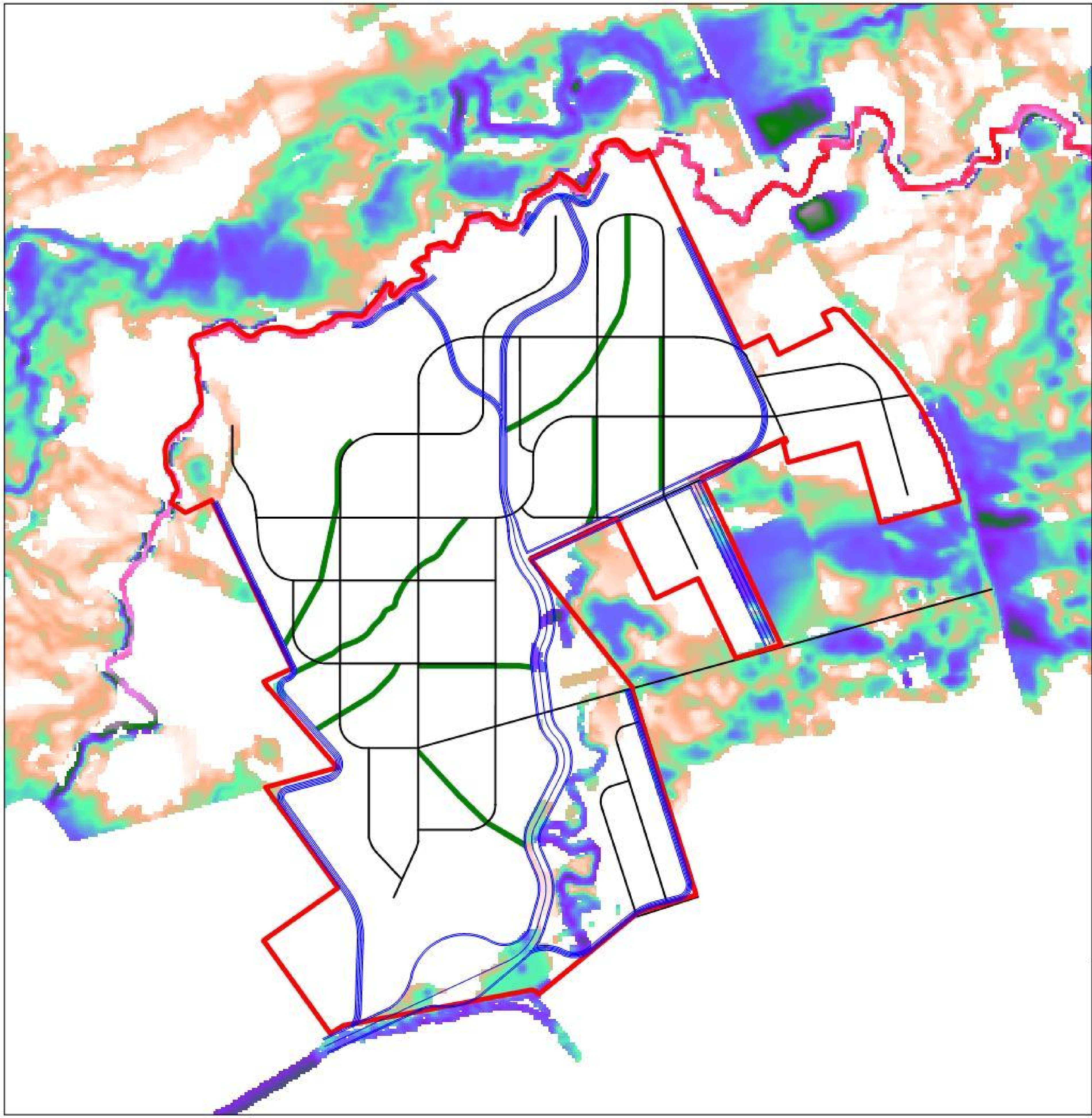
Buckland Park

Flood Plain Mapping

Difference in water surface level between with fill and without fill

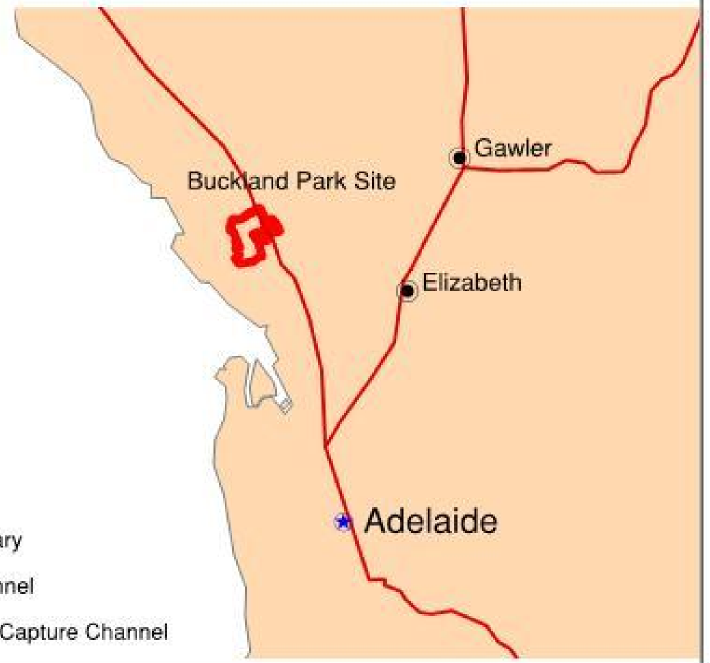
Figure 4.6

WALLBRIDGE & GILBERT



Flood Depth (m)

- 7
- 2.5
- 1.5
- 1
- 0.5
- 0.25
- 0.1
- 0



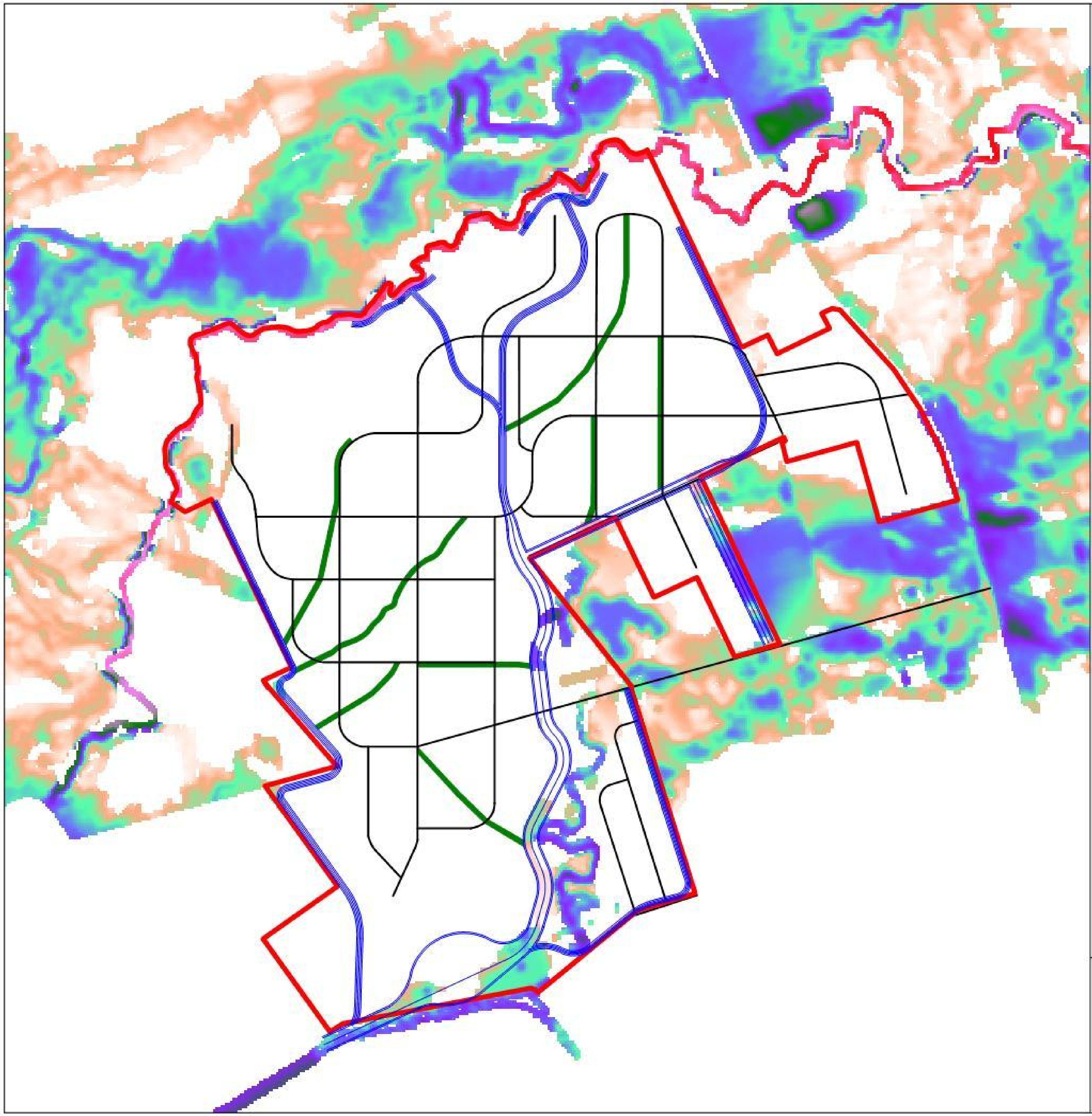
- Site Boundary
- Linear Channel
- Floodwater Capture Channel

Buckland Park

Flood Plain Mapping

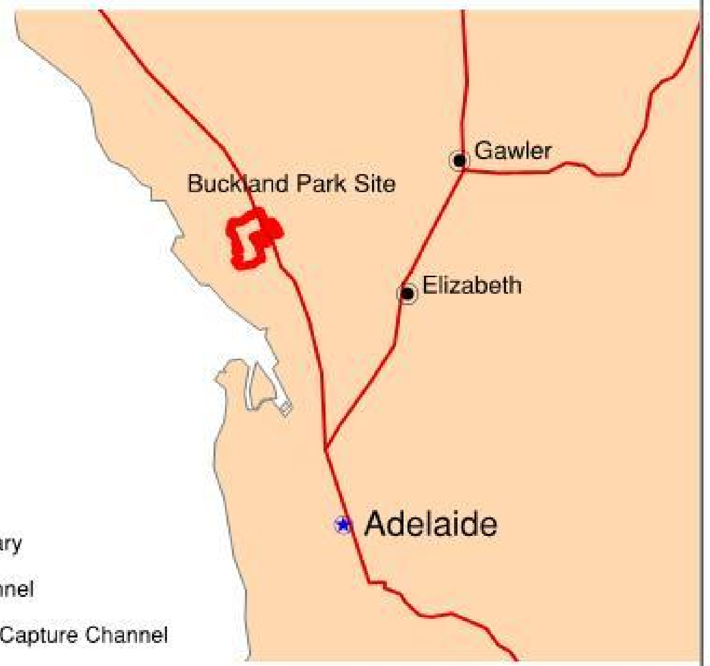
6 Drains with fill and blockage at location 1

Figure 4.7



W&G
WALLBRIDGE & GILBERT

Flood Depth (m)
- 7
- 2.5
- 1.5
- 1
- 0.5
- 0.25
- 0.1
- 0



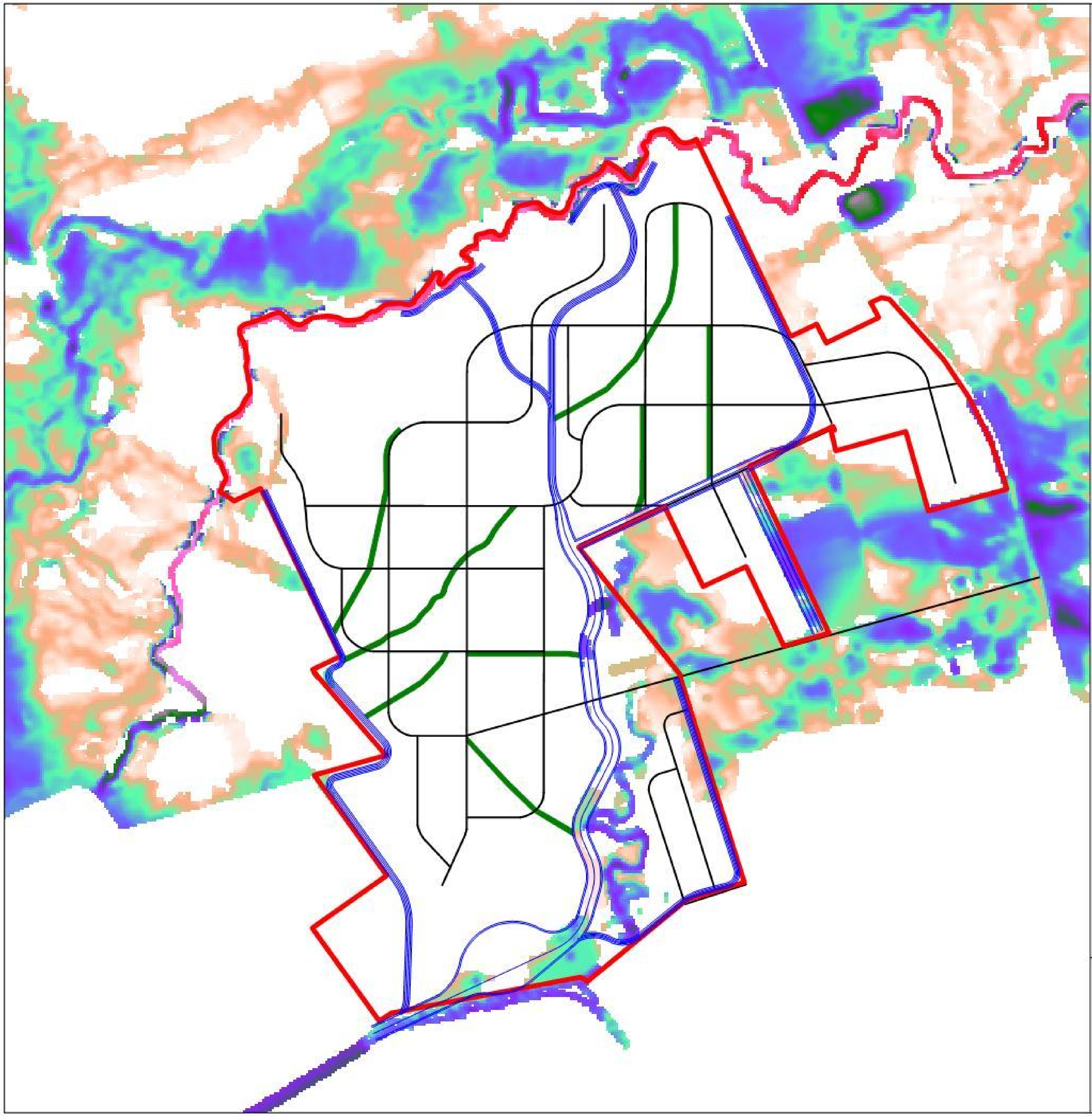
Site Boundary
Linear Channel
Floodwater Capture Channel

Buckland Park

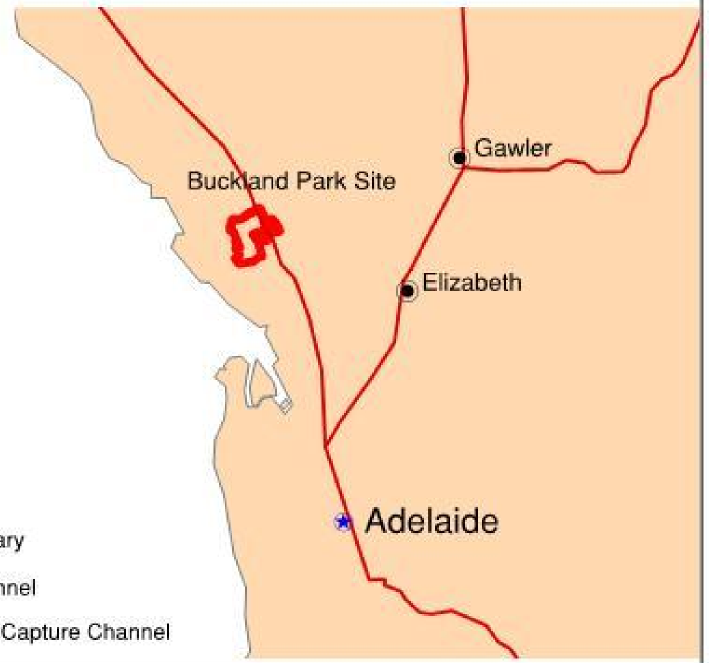
Flood Plain Mapping

6 Drains with fill and blockage at location 1

Figure 4.7



Flood Depth (m)
- 7
- 2.5
- 1.5
- 1
- 0.5
- 0.25
- 0.1
- 0



Site Boundary

Linear Channel

Floodwater Capture Channel

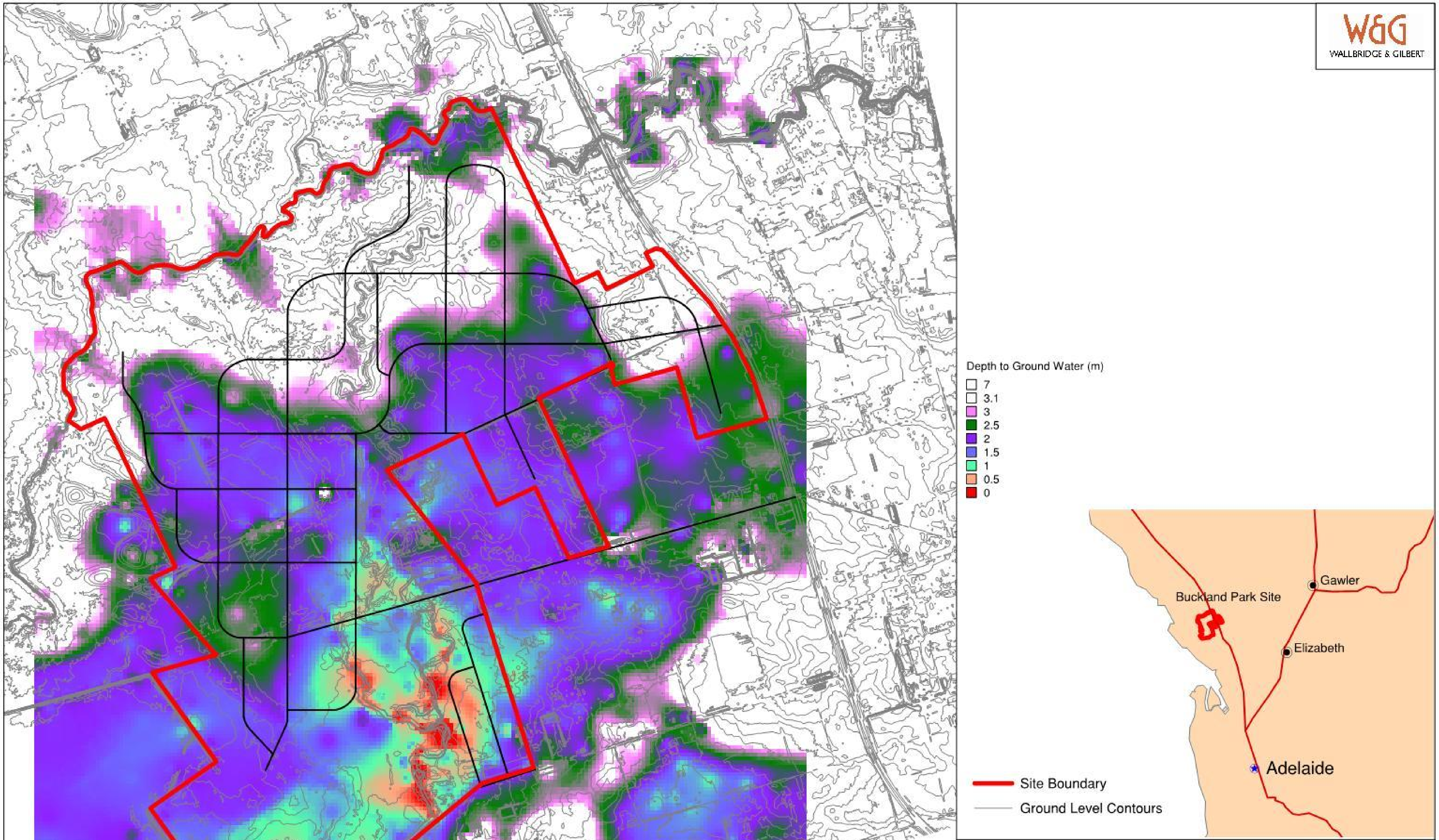
WALLBRIDGE & GILBERT

Buckland Park

Flood Plain Mapping

6 Drains with fill and blockage at location 2

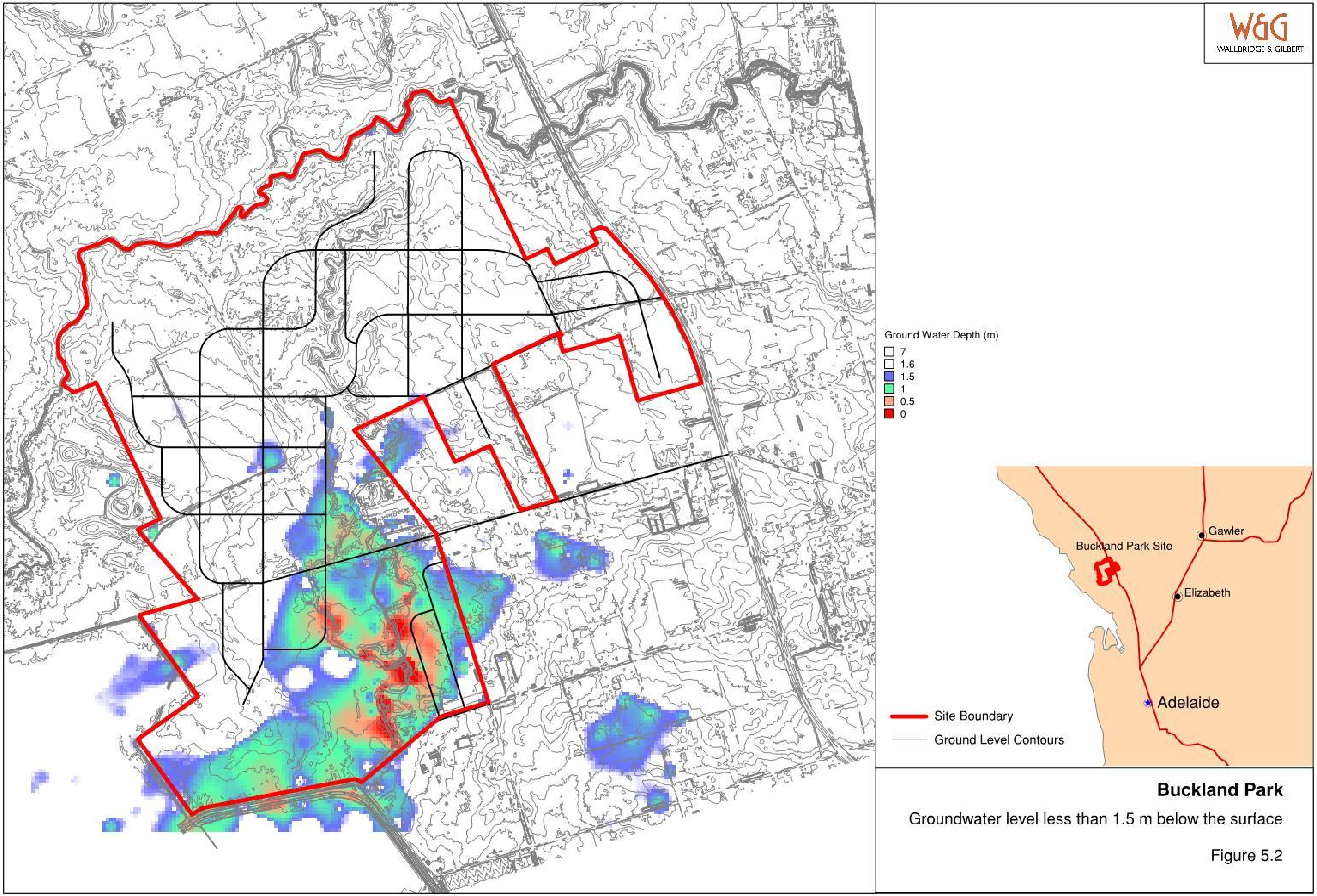
Figure 4.8



Buckland Park

Groundwater level less than 3.0 m below the surface

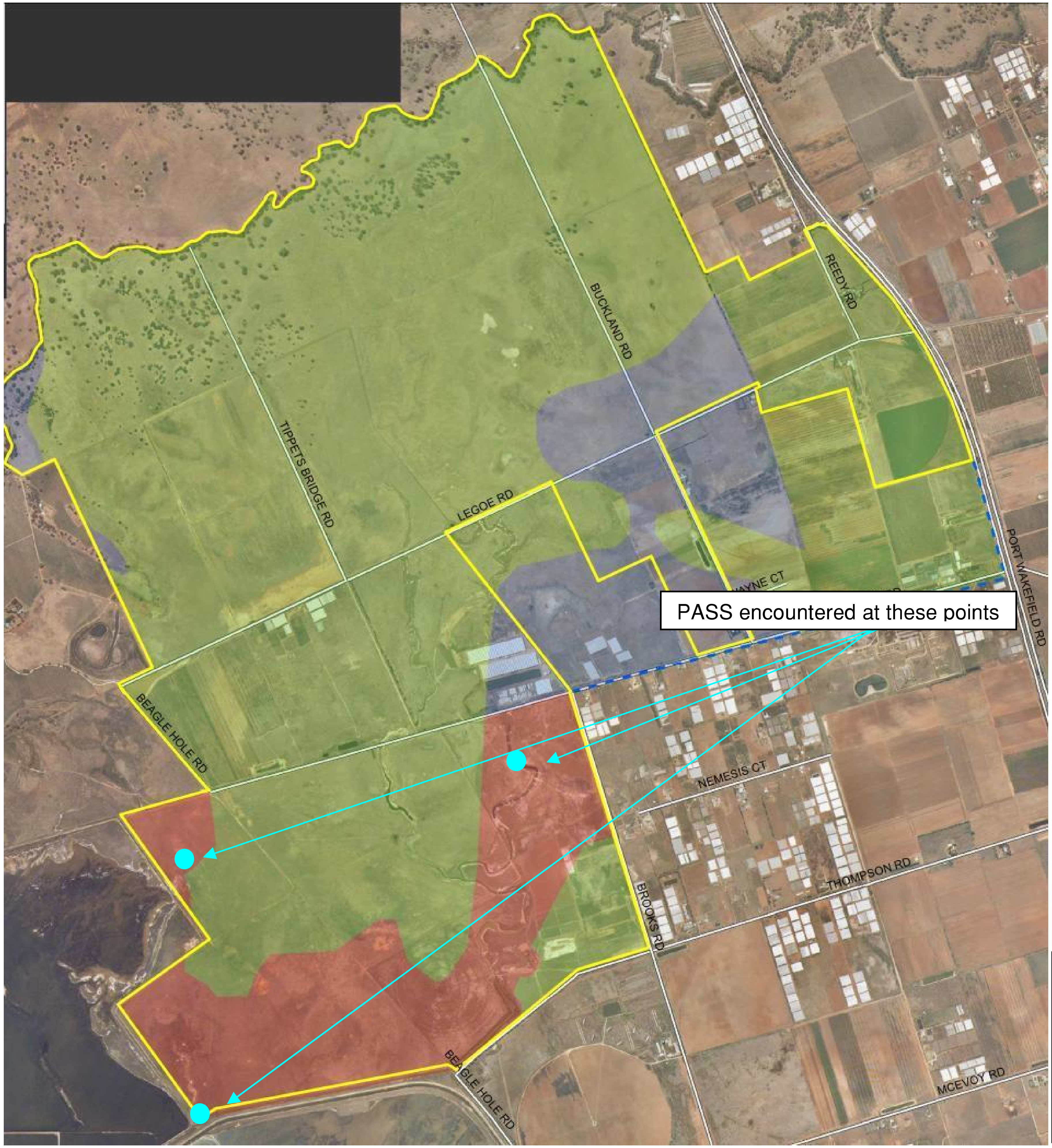
Figure 5.1



Buckland Park

Groundwater level less than 1.5 m below the surface

Figure 5.2



BUCKLAND PARK COUNTRY TOWNSHIP

RISK OF ENCOUNTERING
ACID SULPHATE SOILS SECTORS

Legend

High Risk of Encountering ASS

Medium Risk of Encountering ASS

Low Risk of Encountering ASS

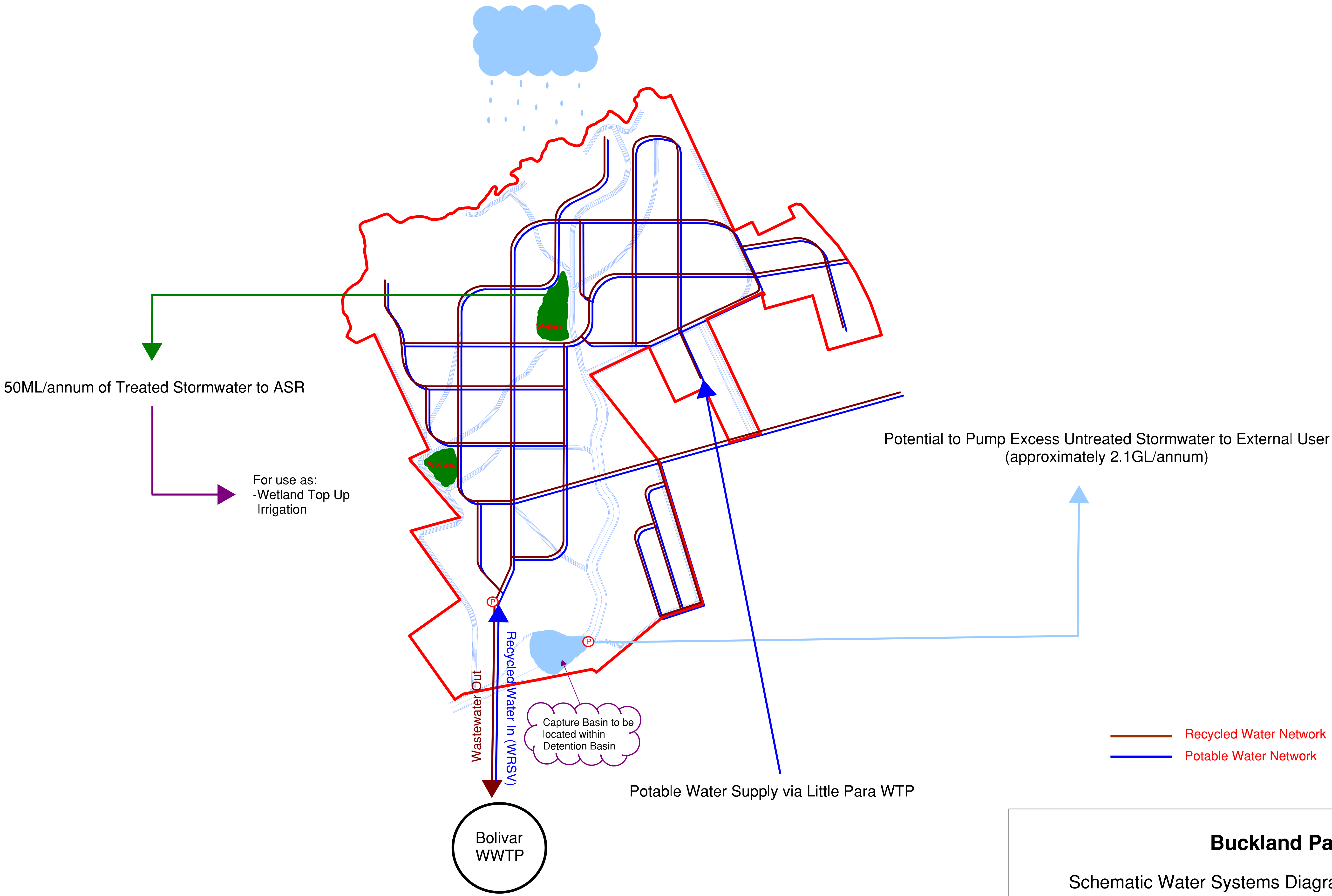
Site Boundary

Road

Buckland Park

Risk of encountering Acid Sulphate Soils

Figure 5.3



Buckland Park

Schematic Water Systems Diagram

Government of South Australia

SA Water

W&G WALLBRIDGE & GILBERT

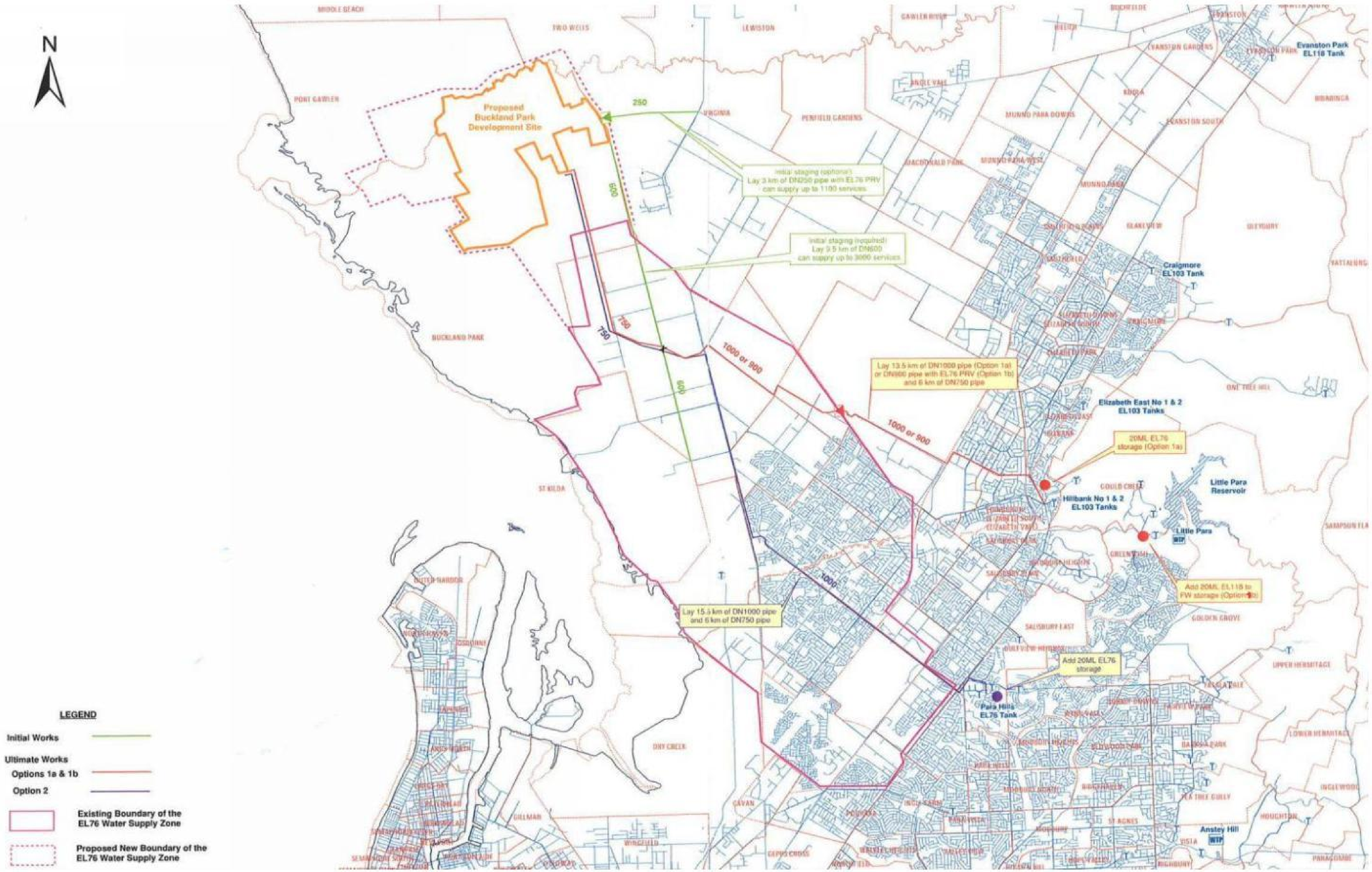
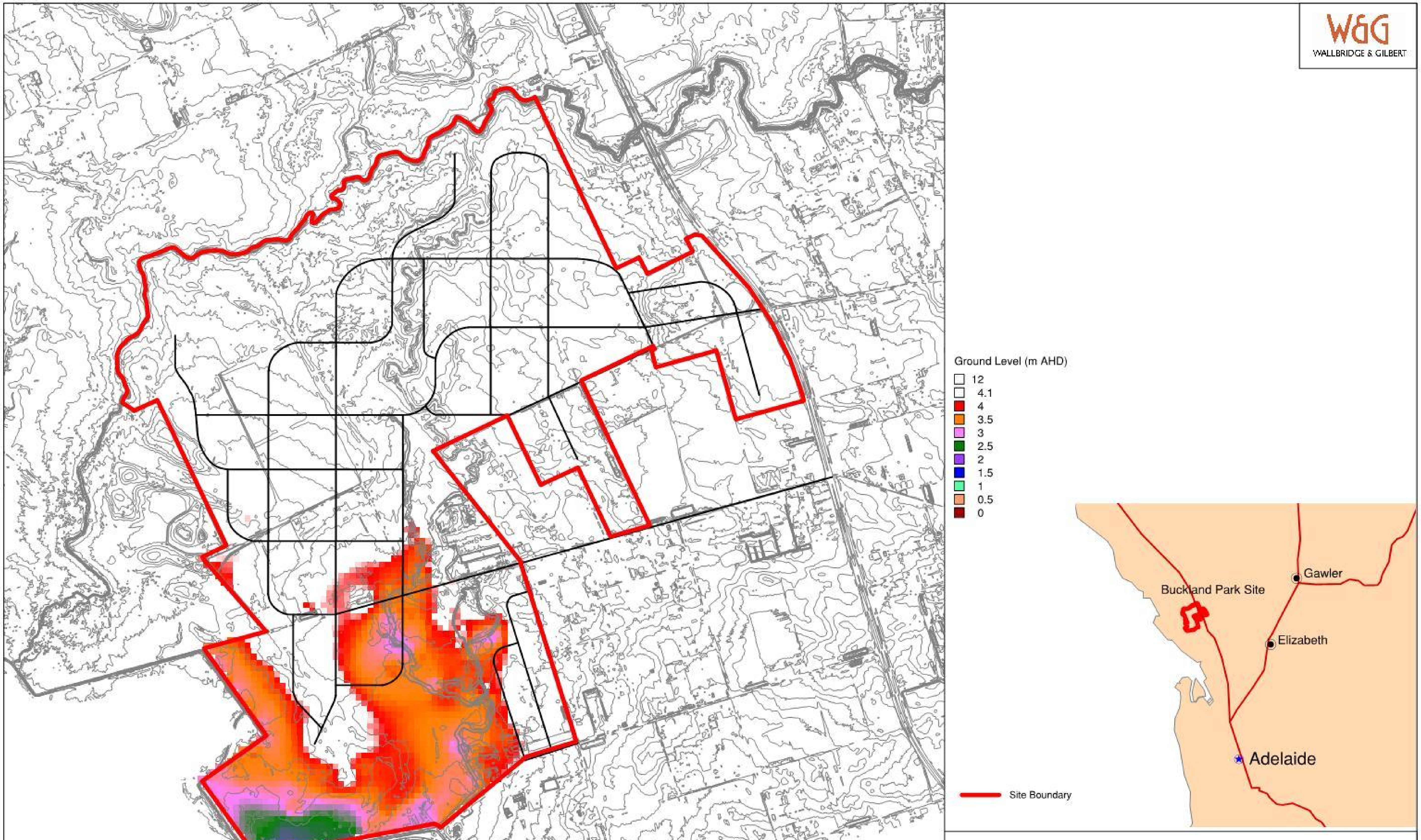


Figure 6.2 SA Water potential potable water supply options diagram



Buckland Park

Extent of site less than 4.0m AHD

Figure 7.1