Government of **Western Australia**
Department of **Water**

Jandakot drainage and water management plan Peel main drain catchment

Drainage and water management plan no. 3

Looking after all our water needs

Jandakot drainage and water management plan

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Disclaimer

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Summary

This *Jandakot drainage and water management plan* forms a key part of the Department of Water's urban drainage initiative. The focus of this initiative is the preparation of water management plans to help address water issues in proposed development areas.

This plan presents the Department of Water's guide for developers and stakeholders to help development proceed (particularly in relation to stormwater management issues). It has been prepared with reference to the *Jandakot structure plan*, approved by the Western Australian Planning Commission in August 2007 as relating to the Peel main drain catchment.

Key sections of this report containing information critical to development of the Jandakot structure plan area are:

Section 4 — Protection of environmental assets

There are a number of significant wetlands within the Jandakot structure plan area. In this section information is provided which will enable developers and stakeholders to ensure that changes to the existing hydrological regime of these wetlands is minimised.

Section 6 — Stormwater management

Figure ES1 provides an overview of the arterial drainage scheme that is proposed for the Jandakot structure plan area and which forms a major part of this drainage and water management plan – addressing stormwater quantity management. In addition, recommendations and key design criteria for stormwater quality management are detailed.

Section 7 — Groundwater management

In this section a regional-scale modelled groundwater level is established and advice for developers and stakeholders for managing groundwater quantity and quality within the Peel main drain catchment area is provided.

Section 9 — Implementation

This report presents monitoring requirements for local water management strategies and an implementation action plan.

All water management strategies, local structure plans, local planning scheme amendments and subdivision plans prepared for areas of proposed new development must demonstrate compliance with the strategies, objectives and design criteria detailed in this document.

Checklist for developers (see Appendix C)

This checklist provides a summary of items to be addressed by developers in preparing local water management strategies for assessment by the Town of Kwinana when an application for a local structure plan is lodged.

The checklist must be completed and signed by a suitably qualified professional and submitted to the Town of Kwinana with the local water management strategy for assessment when an application for a local structure plan is lodged.

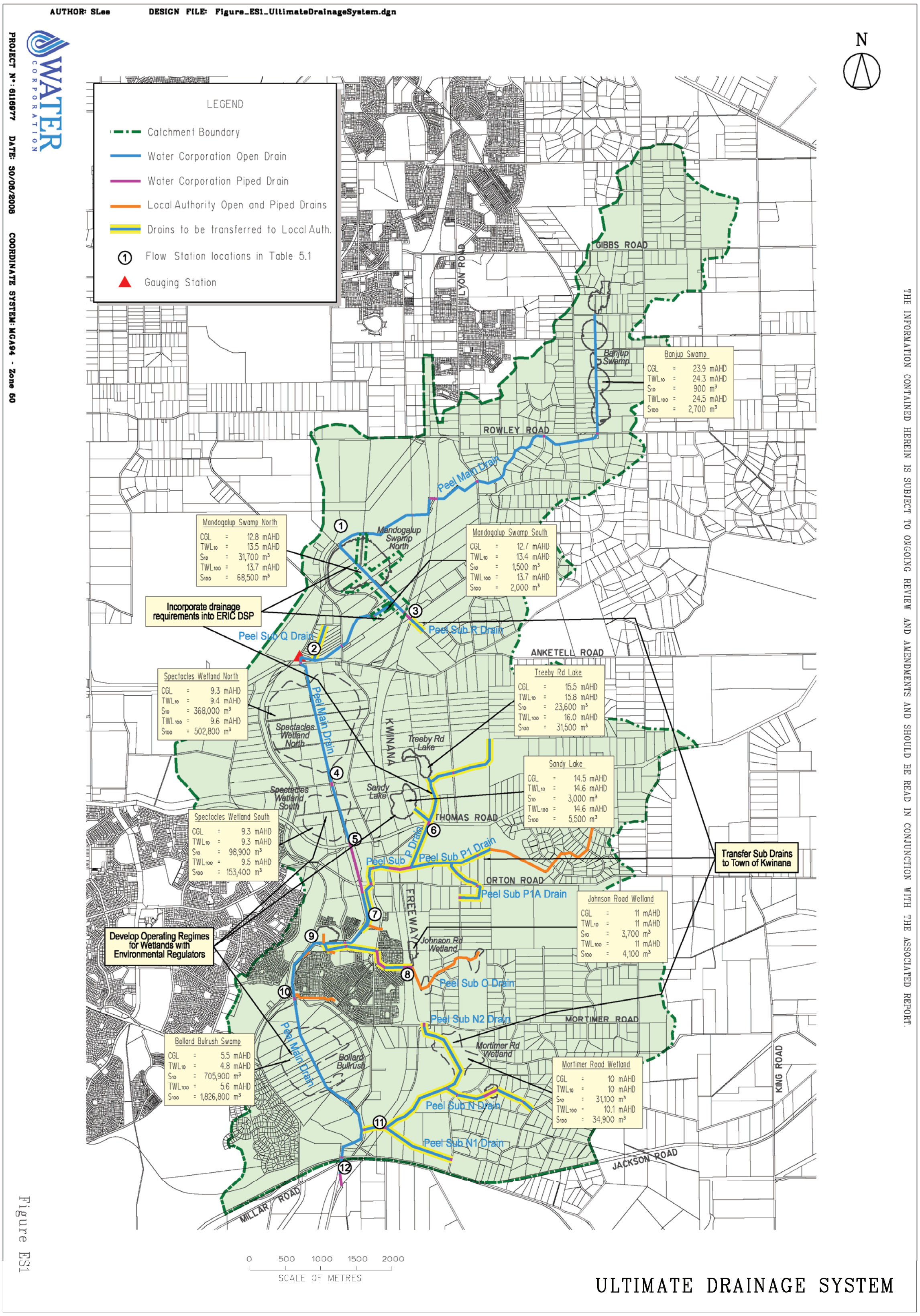

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Figure ES1 Ultimate drainage system

1 Introduction

The *Jandakot structure plan* (WAPC, 2007) provides a guide to subdivision and development/redevelopment of the Jandakot area, while protecting the Jandakot underground water pollution control area, addressing the environmental constraints within the area, and reflecting the area's expedient location within the growing south-west corridor of Perth.

This *Jandakot drainage and water management plan* provides a guide for developers and stakeholders to enable development to proceed, particularly with regards to stormwater management issues.

A number of key investigations have been undertaken in the Jandakot locality. It is the aim of this drainage and water management plan to incorporate information from these studies and present design criteria and management strategies that will enable the Department of Water to facilitate the future planning of development and to provide a framework for more site-specific water management criteria within the area. This will support the implementation of the *Jandakot structure plan* (WAPC, 2007) including providing protection to public drinking water source areas to ensure water quality remains of a good, safe quality.

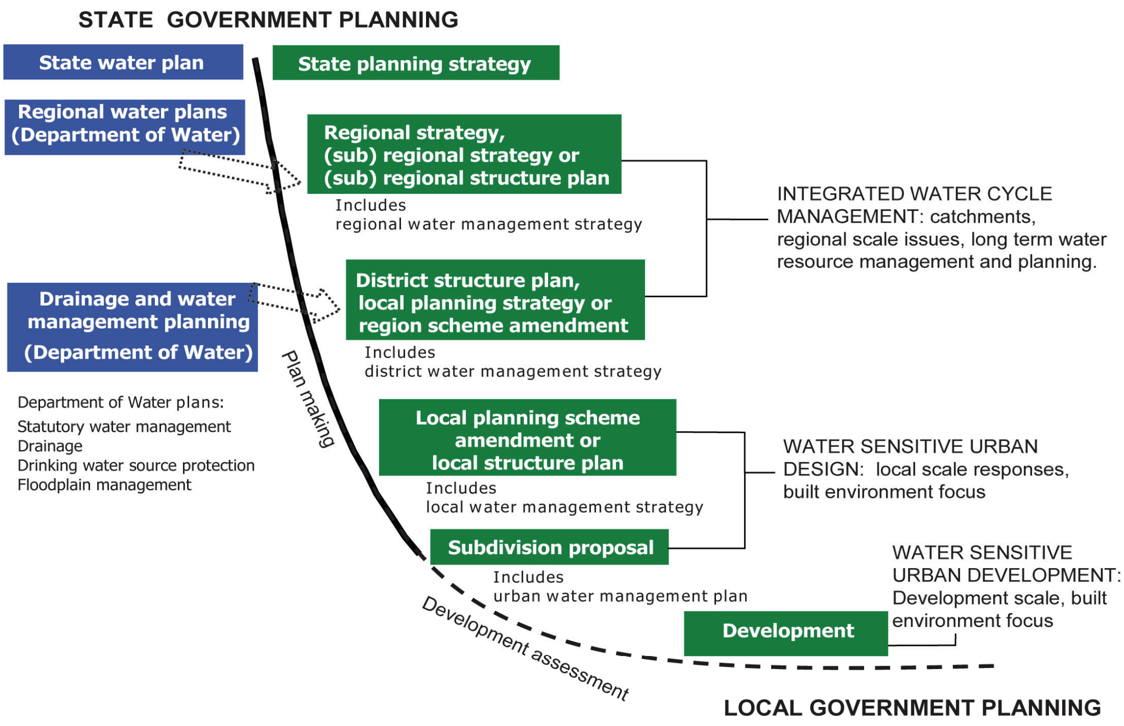
Total water cycle management, also referred to as integrated water cycle management, 'recognises that water supply, stormwater and sewage services are interrelated components of catchment systems, and therefore must be dealt with using a holistic water management approach that reflects the principles of ecological sustainability' (Department of Water, 2004, *Stormwater management manual for Western Australia*, Ch. 2, p. 14).

The scope of the drainage and water management plan is to cover aspects of total water cycle management, including:

- protection of significant environmental assets within the structure plan area, including meeting their water requirements, managing potential impacts from development and protecting their cultural value
- alternative water supply options, opportunities for conservation and demand management measures, and wastewater management
- surface runoff, including both peak event (flood) management and the application of water sensitive urban design principles to frequent events
- groundwater, including the impact of urbanisation, variation in climate, installation of drainage to manage groundwater levels, potential impacts on the environment and the potential to use groundwater as a resource
- water quality management, which includes source control of pollution inputs by catchment management, acid sulfate soil management, control of contaminated discharges from industrial areas and management of nutrient exports from surface runoff and groundwater through structural measures.

The planning and provision of sewerage services is a Water Corporation function and so is not included within this drainage and water management plan. Water management strategies and plans at subsequent stages of the planning process should identify the planned sewage disposal strategy for the subject area.

The position of drainage and water management plans within the state government planning framework is defined in *Better urban water management* (WAPC, 2008) and outlined in diagram 1 below.



Note: The above diagram depicts the optimal process. In situations where there is existing zoning and a lack of guiding information, a flexible approach to implementation may be required. This is at the discretion of the Western Australian Planning Commission on advice of the Department of Water.

Diagram 1 Planning framework integrating drainage planning with land planning processes (WAPC 2008)

This document presents the proposed arterial drainage scheme for the Jandakot district structure plan area in accordance with the responsibilities for drainage planning assigned to the Department of Water by the state government.

1.1 Planning background

A number of strategies, policies and plans have been undertaken that relate either directly or indirectly to the use, transport and protection of water within the Jandakot area. Many of these, for example *Bush forever* (WAPC, 2000), are broad-reaching studies applicable to areas of the Perth Metropolitan or Western Australian regions outside of the study area of this drainage and water management plan. While their influence is recognised in the formation of this plan, the following discussion is restricted to planning background relating specifically to the Jandakot area.

Jandakot land use and water management strategy (1995)

In 1995, the Western Australia Planning Commission sought to protect and manage groundwater resources for drinking water supply and environmental factors associated with the Jandakot underground water pollution control area through the *Jandakot land use and water management strategy*. Key features of the strategy included establishing the Jandakot Botanic Park, designation of rural areas, a moratorium on vegetation clearing and detailed assessment on the development of urban areas.

Statement of planning policy No. 6: Jandakot groundwater protection policy (1999) (now State planning policy No 2.3)

The Western Australian Planning Commission has adopted the *Statement of planning policy No. 6: Jandakot groundwater protection policy* (1999), which contains a list of allowable land uses within the Jandakot area in order to protect the Jandakot groundwater source. The policy also establishes a number of objectives to be considered when assessing development applications within the groundwater recharge zone, including protecting vegetation, placing limits on contaminant sources and consideration of drainage impacts on the Peel–Harvey Estuary. This policy is now referred to as *State planning policy No 2.3.*

Environmental protection (Peel–Harvey coastal catchment) policy (1992)

The *Environmental protection (Peel–Harvey coastal catchment) policy* (1992) sets out the environmental quality objectives for the Peel–Harvey estuary which, if achieved, will rehabilitate the estuary and protect it from further degradation. These objectives are reinforced through the *Water quality improvement plan for the rivers and estuary of the Peel–Harvey system* (2008) which has established that the current target for phosphorous entering the estuary is being exceeded by 90 per cent.

State planning policy No 2.1: Peel–Harvey coastal plain catchment (1992)

The *State planning policy No 2.1: Peel–Harvey coastal plain catchment* (1992) is the main government policy mechanism to implement the Peel–Harvey environmental protection policy and the targets included in the *Water quality improvement plan for the rivers and estuary of the Peel–Harvey system* (2008).

Jandakot structure plan (2007)

As previously discussed, the Western Australia Planning Commission published the draft *Jandakot structure plan* in 2001 following recognition of increasing pressure for development within the Jandakot area that may not necessarily comply with the aims of the *Jandakot land use and water management strategy* (WAPC, 1995). The *Jandakot structure plan* as shown in Figure 2.5a provides guidance for development within Jandakot, including discussion of potential development areas, community facilities, conservation and *Bush forever* sites, transport networks and neighbourhood structure. Also included in the document are a number of strategies for implementing the plan, including rezoning recommendations. Following advertising and consideration of submissions, the *Jandakot structure plan* was approved by the Western Australia Planning Commission in August 2007.

Framework for developing the Jandakot water resources management strategy (2004)

One of the key outcomes of the *Jandakot structure plan* (WAPC, 2007) was the preparation of a water resources management strategy for the Jandakot area, which Parsons Brinkerhoff was engaged to undertake. During the preparation process, it became apparent to Parsons Brinkerhoff that there was insufficient data available on water resources to deliver a water resources management strategy that would meet the rigorous standards of the key government stakeholders; hence, the completed document became a *Framework for developing the Jandakot water resources management strategy* (2004). The framework focuses primarily on water quality issues, summarises the available information on water bodies within the Jandakot area, proposes water quality objectives for immediate use in stormwater management, and makes recommendations regarding future water quality monitoring plans.

Eastern residential intensification concept (2005)

In 2005, the Town of Kwinana released a draft district structure plan (*Eastern residential intensification concept*) for the section of the Jandakot structure plan area located within the Town of Kwinana as shown in Figure 2.5b in appendix B.

The document defines a broad framework by which urban subdivision and development can occur. At this stage, the concept has not been finalised because of insufficient land allocation for stormwater drainage purpose, as well as other land-use planning considerations.

1.2 Previous studies

The following documents provide information about constraints and opportunities related to the drainage and water management plan area and have been compiled from documentation written in conjunction with the *Jandakot structure plan* (WAPC, 2007) and relating to the Peel main drain catchment.

Snapshot survey of the Serpentine, Murray and Harvey catchments of the Peel-Harvey estuary (2002 and 2004)

The Marine and Freshwater Research Laboratory within the Institute of Environmental Science at Murdoch University conducted a 'snapshot' investigation of total nitrogen, total phosphorus and electrical conductivity within the surface waters of the Serpentine, Murray and Harvey catchments in September 2002 and September 2004, for the Waters and Rivers Commission/Department of Environment. Eighteen sample sites were located within the Jandakot drainage and water management plan area. Results of these studies are discussed in Section 2.6.

Groundwater modelling to assess effects of climatic variations, and planned urban development (2006)

In 2006, Rockwater was commissioned by the Water Corporation to conduct groundwater assessment and modelling to quantify changes in groundwater levels as a result of urban development in the Jandakot district structure plan area and the Peel main drain catchment area. The results are discussed in Section 2.7.

Modelling water level criteria for the development of urban drainage and water management strategy within the Peel Main Drain catchment (2007)

The Department of Water commissioned URS in 2007 to expand upon the Rockwater study, providing a proposed methodology for water table and drainage management in the Peel main drain catchment. Specifically this involved developing water level maps, water level criteria and drainage and wetland modelling.

Ecological water requirements of selected wetlands within the Peel Main Drain catchment (2007)

Ecoscape (Australia) has conducted a study of the ecological water requirements of six priority wetlands in the Jandakot structure plan area for the Department of Water. The wetlands selected were Spectacles wetland north, Spectacles wetland south, Sandy Lake, Johnson Road, Mortimer Road and Bollard Bulrush Swamp. The vegetation characteristics of each wetland were assessed by transects and plot surveys. Ecological water requirements were then determined for each wetland based on available literature, datasets and knowledge of ecosystems and species requirements. The results of the study were used in the determination of controlled groundwater levels in the study area.

2 Pre-development environment

Documents referred to for background information include:

- *Jandakot district structure plan* (WAPC, 2007)
- *Framework for developing the Jandakot water resources management strategy* (Parsons Brinkerhoff, 2004)
- *Planning bulletin No. 64* (WAPC, 2003)
- Swan coastal geomorphic wetland mapping.

2.1 Study area

The study area of the *Jandakot drainage and water management plan* is shown in Figure 2.1 in Appendix B, is approximately 59 km^2, or just over half of the total Peel main drain catchment area, and is located between Millar Road and Rowley Road, approximately 40 km south of Perth, and 5 to 10 km east of Cockburn Sound. The area includes the localities of Mandogalup, Casuarina, Wellard, Anketell, Wandi, Bertram, Oldbury and The Spectacles wetlands. The study area lies partially within the *Jandakot structure plan* (WAPC, 2007) area in the Town of Kwinana.

The Jandakot structure plan area is approximately 1450 hectares and is bound by Rowley Road and the underground water pollution control area to the north, Birrega drain to the east, Jackson and Millar roads to the south and Mandogalup Road, McLaughlan Road, Colchester Avenue, the railway line and Wellard Road to the west.

Existing land use within the study area is shown in Appendix B is predominantly rural and there is a significant amount of conservation and wetland area. A number of development constraints are located in the north-west area comprising Mandogalup and Anketell, including Alcoa's residue disposal area, sand and mineral extraction, powerlines, gas pipelines, poultry farms, wetlands and the Kwinana Freeway. Powerlines, poultry farms and mushroom farming present development constraints within the south-west area of Wellard and Casuarina, while development within the south-east area of Oldbury is constrained by poultry farms and extractive industries.

2.2 Topography and geology

The topography and geology of the study area is presented in Figure 2.2 in Appendix B.

Three physiographic subdivisions intersect the area: the Spearwood dunes in the west; the Bassendean dunes in the east; and the Pinjarra plain in the south-east, south of the Perth–Kwinana railway line. Topographically, the Spearwood dunes rise to an elevation of about 15 to 50 m AHD, the Bassendean dunes to about 15 to 25 m AHD and the Pinjarra plain to about 5 to 10 m AHD.

The study area is characterised by clayey alluvium of the Pinjarra plain, undulating eolian sand plains of the Bassendean dune system and slightly calcareous eolian sand of the Spearwood dune system.

Lakes, wetlands and swamps within the area are the only topographical features requiring special management or presenting developmental constraints, as there are no terrain features such as steep slopes or major river crossings (WAPC, 2001). The lakes, wetlands and swamps are formed in interdunal swales of the Bassendean dune system, intercarrier depressions between the Spearwood dune and the Bassendean dune systems, and within the Spearwood dune system.

2.3 Soils

The dominant soils of the study area are pale deep sands of the Bassendean dune system, which are generally leached, grey siliceous sands, possibly becoming pale yellow in the dune sequences (WAPC, 2001). In the eastern side of the study area these sands are underlain by clayey soils of the Guildford Formation, while to the west there are areas of peaty or sandy silts associated with swamp deposits, and significant regions of pale brown, yellow or orange Karrakatta or Cottesloe sands formed through the weathering of Tamala limestone. Although the silts and Tamala limestone-formed soils may have significant abilities to absorb nutrients, soils within the Jandakot area typically have low nutrient absorption potential (Parsons Brinkerhoff, 2004).

Those soils associated with higher nutrient absorption ability have historically been developed for intensive horticulture, resulting in the soils receiving extremely high fertiliser inputs. These inputs coupled with the ability of the soils to retain nutrients has likely resulted in very high concentrations of phosphorus in the soil profiles of these areas, in suburbs such as Mandogalup and Anketell. Parsons Brinkerhoff (2004) also report that nitrate-N concentrations in excess of 10 mg/L are commonly found in shallow groundwater beneath horticultural properties, with high concentrations of nitrate-N being more likely under properties on Spearwood and Karrakatta sands.

Parsons Brinkerhoff conducted soil nutrient analysis as part of the *Framework for developing the Jandakot water resources management strategy* (Parsons Brinkerhoff, 2004) with the aim of assessing the potential for the release of phosphorus during earthworks or subdivisional construction. Twenty-seven sample sites were selected within the proposed Oakford Village in Casuarina just east of the Kwinana Freeway and an area in Mandogalup and Anketell adjacent to the Kwinana Freeway.

Phosphorus retention index, bicarbonate extractable phosphorus, total phosphorus and the estimate of phosphorus in soil solution were determined for the seven samples that were considered likely to have significant phosphorus retention capacity.

Four of the samples were of yellow-orange sands, which were found to have low-moderate phosphorus retention index values and low concentrations of bicarbonate extractable phosphorus and total phosphorous. The phosphorus in soil solution concentrations for these samples was 0.02 mg/L or less, indicative of exposure to small phosphorus inputs.

Two of the remaining three samples of black clayey coffee rock sands had very high phosphorus retention index values, and high to very high bicarbonate extractable phosphorus and total phosphorus concentrations, indicative of exposure to significant phosphorus inputs. Parsons Brinkerhoff states that it is likely that such material could present a risk of phosphorus release if disturbed, and recommends a more extensive soil analysis regime be undertaken.

Acid sulfate soils

The Western Australian Planning Commission's *Planning Bulletin No. 64* (2003), which is based upon a review of existing geomorphological, geological and hydrological information, indicates that the soils in the Jandakot area may be broadly classified as having moderate to low risk of actual acid sulfate soils or potential acid sulfate soils occurring generally at depths of >3 m. Limited areas in the east of the study area are classified as having low to no risk of actual acid sulfate soils or potential acid sulfate soils occurring generally at depths of >3 m.

As shown in Figure 2.3 in Appendix B there are also scattered areas at high risk of actual acid sulfate soils or potential acid sulfate soils <3 m from the surface. These areas are generally associated with wetland sites. High risk areas will require an acid sulfate soil management plan to be prepared in accordance with the strict amelioration standards set out in *Planning bulletin 64* (WAPC, 2003) if development is to occur at these locations.

2.4 Environmental assets and water-dependent ecosystems

Environmental assets and water-dependent ecosystems are presented in Figure 2.6 in Appendix B.

Bush forever sites

There are 10 *Bush forever* sites within the Jandakot study area. *Bush forever* sites 393, 268, 269, 272 and 349 are located down the western region of the study area and form part of a regionally contiguous bushland/wetland linkage.

Wattleup Lake and adjacent bushland lies in the north-western corner of the study area. The 18.9 ha area is *Bush forever* site 393, and contains 12.3 ha of lake covered by the *Environmental protection (Swan coastal plain wetlands) policy* (EPA, 2004).

Mandogalup Road bushland, *Bush forever* site 268, also lies in the north-western region of the study area, and is a 95.9 ha area of bushland containing endemic flora in excellent condition, and Quenda (Southern Brown Bandicoot – see photo), a significant mammal species.

The Spectacles wetland system lies to the south of Mandogalup bushland in the mid-west of the study area. Given the significance of this system it is discussed separately below.

Bush forever site 270, containing the western extent of Sandy Lake and adjacent bushland, lies immediately east of the Spectacles wetlands. 5.4 ha of the 201.4 ha site contains Environmental protection policy lakes; while there are 127.6 ha of conservation category wetland. Significant flora species *Aotus cordifolia* and *Dielsia stenostachya*, an important mammal species Quenda and six significant species of bird have been identified within the bushland. The most vulnerable of the dominant/key species recorded by Ecoscape (2007) on the Sandy Lake transect was *Banksia littoralis*.

Just south of the Spectacles wetlands, over Thomas Road, lies *Bush forever* site 272, known as Sicklemore Road bushland. The 84.6 ha area contains 2.4 ha of conservation category and resource enhancement wetland, and three species of significant flora (*Diuris micrantha, Caladenia huegelii and Aponogeton hexatepalus*).

The south-western corner of the study area contains a small fragment of Leda and adjacent bushland, *Bush forever* site 349. The entire site encompasses 959.8 ha and contains a number of wetlands although none are within the Jandakot study area. Approximately 60 species of bird, a significant mammal species (Western Brush Wallaby) and important flora (*Glischrocaryon aureum*) are found within the area.

Banksia Road nature reserve, *Bush forever* site 353, lies within the southern rural region of the study area. The 32.3 hectares contain 1.9 ha of Environmental protection policy lake and conservation category wetland, five important species of bird and endemic vegetation in excellent condition, including the flora species *Boronia crenulata* and *Gyrostemon subnudus*.

Bush forever site 273, which contains the majority of Casuarina Prison bushland, lies within the southern rural region of the study area. Of the 116.9 ha site, 1.3 ha consists of conservation and resource enhancement wetland. Greater than 90 per cent of the vegetation within the bushland is categorised as being in excellent to pristine condition, and the four significant flora species *Lysinema elegans, Burchardia bairdiae, Drosera gigantea* subsp. *geniculata* and *Hensmania turbinate* and important mammal species Quenda are located within the bushland.

Portions of *Bush forever* sites 347 and 348 are located within the north-eastern region of the study area. *Bush forever* site 347 is known as the Wandi Nature Reserve and Anketell Road bushland, and is a 412.3 ha site containing a number of Environmental protection policy lakes and conservation wetlands. Important flora species *Eucalyptus todtiana*, *Brachyloma preissii* and *Dielsia stenostachya* have been located within the site. It also provides habitat for the Quenda and the significant bird species of Scarlet Robin, Grey Shrike-thrush, Western Thornbill, Splendid Fairy Wren (see photo) and Grey Currawong.

Bush forever site 348 is known as Modong Nature Reserve and includes adjacent bushland. The 242 ha site contains 111.9 ha of Environmental protection policy lakes and conservation category wetland. Over 90 per cent of the vegetation in the site is categorised as excellent to pristine, with the significant flora species Stylidium mimeticum, Macarthuria apetala, Evandra pauciflora, Hensmania turbinate and Burchardia bairdii identified. The site also provides habitat to the mammal species Quenda, Grey Kangaroo (see photo) and Western Brush Wallaby, the significant reptile species legless lizards (Lined Skink, Swamp Skink, Black Monitor and Rosenberg's Monitor) and a good assemblage of insectivorous and nectarivorous birds.


Mack S., 2006,
Western Grey Kangaroo

The Spectacles wetlands

To the south of Mandogalup Bushland, in the mid-west of the study area lies the most important *Bush forever* and Environmental protection policy lake in the Jandakot area. The Spectacles wetlands, consisting of Spectacles north and Spectacles south, are Environmental protection policy lakes, are part of the Beeliar Regional Park, are listed on the *Directory of important wetlands in Australia* (Environment Australia, 2001) and lie within *Bush forever* site 269. The 349 ha area contains significant flora *Dodonaea hackettiana*, a number of significant mammal and reptile species and provides an important waterfowl breeding site.

A comprehensive hydrogeological and nutrient balance investigation was undertaken by the Waters and Rivers Commission in 1997 (Shams, 1997), with key findings as follows.

- The northern extent of the Peel main drain entering the wetlands is often not hydraulically connected to groundwater due to clayey sediments.
- While the general flow direction of groundwater is west-south west, a small groundwater mound created by the Kwinana wastewater treatment plant to the west of the wetlands was thought to cause the groundwater locally to flow east. This was, in turn, thought to transport contaminants from the Kwinana wastewater treatment plant to Spectacles north, though subsequent hydrological investigations reported that infiltrating effluent at the Kwinana wastewater treatment plant does not reach the wetlands (Woodward Clyde, 2000).
- The Peel main drain contributes approximately 48 per cent of the water entering the Spectacles, while the remainder is from groundwater.

Bushland condition scores, using the *Bush forever* scale, were given to Spectacles north and Spectacles south as part of the ecological water requirements study conducted by Ecoscape (2007). Vegetation within the four survey plots of Spectacles north were rated excellent to pristine, while the six survey plots of Spectacles south were rated good to pristine. The most vulnerable of the dominant/key wetland species recorded by Ecoscape on the Spectacles north and south transects were *Baumea articulata* and *Juncus pallidus* respectively.

Other priority wetlands

As presented in Figure 2.6 in Appendix B, there are a number of wetlands within the study area that do not lie within *Bush forever* sites. The majority of these sites are located in the rural southern region of the area. Many of these sites were not included within the *Bush forever* list as they were identified as being able to be protected through other planning and environmental mechanisms, specifically as protected wetlands (WAPC, 2002).

The largest of these areas is Bollard Bulrush Swamp, which is bounded by Bertram, Johnson, Millar and Wellard Roads. The most vulnerable of the dominant/key species recorded by Ecoscape (2007) on the Bollard Bulrush Swamp transect was *Melaleuca rhaphiophylla*.

Johnson Road and Mortimer Road wetlands were also identified by Ecoscape, yet are not included in the *Bush forever* list. The most vulnerable of the dominant/key species recorded on the Johnson Road and Mortimer Road transects were *Meeboldina scarinosa* and *Baumea articulata* respectively.

Possible impacts of drainage from the study area upon the Peel Inlet–Harvey Estuary must also be considered given that surface water from the study area drains south to the Serpentine River that in turn discharges into this system. The Peel Inlet–Harvey Estuary is contained within the Peel–Yalgorup system, a listed Ramsar wetlands site.

2.5 Social considerations

The *Aboriginal Heritage Act* was introduced in Western Australia in 1972. The Act recognises Aboriginal peoples' strong relationships with the land, which goes back many thousands of years.

The Act provides automatic protection for all places and objects in Western Australia that are important to Aboriginal people because of connections to their culture. These places and objects are referred to as Aboriginal sites.

The Department of Indigenous Affairs maintains a register of known Aboriginal sites as a record of places and objects of significance to which the Act applies. The presence of an Aboriginal site places restrictions on what can be done to the land. Anyone who wants to use land for research, development or any other cause, must investigate whether there is an Aboriginal site on the land.

The Minister for Indigenous Affairs is responsible for the administration of the Act. Under the Act it is an offence for anyone to; excavate, damage, destroy, conceal or in any way alter an Aboriginal site without the Minister's permission. The Department of Indigenous Affairs assists the Minister in the administration of the Act.

The Department of Indigenous Affairs has previously identified several sites of Indigenous significance in the Jandakot study area. The larger of these sites relate to Mandogalup Swamp and the Spectacles wetlands. There are also a number of smaller sites of Indigenous significance that relate to smaller water bodies and sites of Indigenous artefacts.

The locations of these sites are identified in Figure 2.6 in Appendix B.

Any government agency, organisation or individual who is the proponent for strategic or statutory planning documents or construction of individual developments or engaged in any ground-disturbing activities should seek advice from the Department of Indigenous Affairs regarding requirements and obligations under the *Aboriginal Heritage Act 1972*, and any other investigations that may be required. This may include but not be limited to:

- consultation with relevant Aboriginal people about the proposal in general, or areas that may be subject to physical alteration
- undertaking an Aboriginal heritage survey or investigation, or predictive modelling for any specific location to identify unregistered sites
- development of a full inventory of heritage values.

If in subsequent stages of planning it is proposed to modify or impact on any water resource, proponents must ensure that they undertake the appropriate actions in regard to sites of Aboriginal significance in accordance with sections 17 and 18 of the Act.

Water and waterways (including rivers, pools, wells, soaks and estuaries) hold an important place in the spiritual and mythological realm for Aboriginal people. Water is also significant to Aboriginal people as a crucial survival factor for people living traditional lifestyles. Proponents should ideally consider opportunities to address and include heritage management principles in their proposals that go beyond the scope of the Act.

2.6 Surface water

As stated in the *Jandakot structure plan* (WAPC, 2007), surface water only exists in the study area as wetlands and as artificial or modified drainage lines. There are no rivers, creeks or marine areas.

Surface water quantity

The Peel main drain is a rural drain that extends predominantly from north to south, and forms a regional drainage network. The system runs through many wetlands and other low-lying areas. The modelled existing drainage system which included the Peel sub drains and some local government authority drains is shown in Figure 4.1 in Appendix B.

Longitudinal section drawings of the main drainage routes within the catchment are presented in Figure 4.2a to 4.5c (existing system) and Figure 5.2a to 5.5c (post-development system) in Appendix B. Flows and water levels during the 10-year average recurrence interval and 100-year average recurrence interval storm events are summarised in Tables 2.1 and 2.2.

Table 2.1 Existing system flows and water levels-hydraulic modelling InfoWorks CS

	Location	Peak flows (m^3/s)		Peak levels (m AHD)	
		10-year ARI	100-year ARI	10-year ARI	100-year ARI
1	Peel main drain upstream of Mandogalup Swamp	0.71	1.23	15.9	16.1
2	Peel main drain at Hope Valley flow gauging station, upstream of Spectacles north wetland	1.06	1.49	11.9	12.0
3	Peel Sub R drain downstream of Kwinana Freeway	0.32	0.52	13.2	13.4
4	Culvert between Spectacles north and Spectacles south wetlands	0.69	1.45	9.3	9.4
5	Peel main drain culvert under Thomas Road exiting Spectacles south wetland	0.62	1.49	9.2	9.3
6	Peel Sub P drain downstream of culverts under Thomas Road	0.21	0.38	15.7	15.9
7	Peel Sub P drain entering Peel main drain	1.03	1.56	9.9	10.0
8	Peel Sub O drain upstream of Kwinana Freeway	0.31	0.31	11.0	11.0
9	Peel Sub O drain entering Peel main drain	0.66	0.76	9.8	10.2

Location		Peak flows (m^3/s)		Peak levels (m AHD)	
		10-year ARI	100-year ARI	10-year ARI	100-year ARI
10	Peel main drain upstream of Bertram Road culvert (entering Bollard Bulrush)	2.27	3.66	7.8	8.1
11	Peel Sub N drain upstream of Johnson Road	0.74	1.11	4.9	6.9
12	Peel main drain upstream of the Millar Road bridge	4.21	4.76	4.7	5.6

Note: At Millar Road, the tailwater applied to the 100-year average recurrence interval event is higher than that applied to the 10-year average recurrence interval event due to the influence of the Serpentine River flood levels. This results in a peak flow for the 100 year event only slightly higher than the 10 year event at this location.

Table 2.2 Existing system wetland water levels

Wetland	Invert level (m AHD)	Maximum level (m AHD)			Maximum volume (m3)		
		Baseflow	10-year ARI	100-year ARI	Baseflow	10-year ARI	100-year ARI
Banjup Swamp	23.7	23.9	24.3	24.5	–	900	2,700
Mandogalup Swamp north	12.6	12.8	13.3	13.5	300	32,200	85,900
Mandogalup Swamp south	12.5	12.7	13.2	13.4	200	1,100	1,500
Spectacles wetland north	8.7	9.2	9.3	9.4	164,200	268,600	372,900
Spectacles wetland south	8.6	9.2	9.2	9.3	62,500	67,900	91,600
Treeby Road Lake	15	15.5	15.8	16.0	12,800	23,100	31,400
Sandy Lake	14.5	14.5	14.6	14.6	–	3,000	5,500
Johnson Road wetland	10.4	11	11.0	11.0	3,700	3,700	4,500
Mortimer Road wetland	7.5	10	10.0	10.1	28,500	30,100	34,100
Bollard Bulrush Swamp *	3.5	5.5	4.8	5.6	1,690,900	715,700	1,835,500

Note: In Bollard Bulrush Swamp the 10- and 100-year average recurrence interval event flood volumes are influenced by tailwater from the Serpentine River.

The wetland inundation is caused by a combination of direct runoff from the local catchment area and overland flooding from a wider catchment area via nearby drains; but is due mainly to elevated groundwater levels. The contribution of surface runoff to the inundation of wetlands is, however, relatively minor compared with the depth and extent of inundation due to high groundwater levels experienced each year, particularly during wet periods.

Water levels in Bollard Bulrush Swamp are strongly influenced by the tailwater conditions in the Serpentine River. During a flood, waters from the Serpentine River propagate up the Peel main drain and inundate the low-lying areas of Bollard Bulrush Swamp.

A number of subsidiary drains join the Peel main drain throughout the catchment and these sub drains vary widely in profile shape and function. Due to the undulating and sandy nature of the catchment, a number of small wetlands have been formed which help to compensate flows in the drainage system.

The main drainage system is capable of conveying the 100-year average recurrence interval event under existing development conditions. For the Peel sub drains the 10-year event is expected to result in localised flooding in the catchment, in particular along the Peel sub P drain.

The flow data record in the Peel main drain from 1976 to 2001 demonstrates peak flows of up to 2.5 m^3/s (although they are more commonly up to 0.20 m^3/s) resulting mainly from surface runoff. The flows decreased to zero in all years except 1982 (when the minimum flow was 0.002 m^3/s), generally ceasing in December or January and recommencing in April or May. Flows have ceased as early as November, and started again as late as June. Zero flow at the gauging station does not mean there has not been groundwater discharging to the drain and its tributaries. In winter, groundwater discharge is obscured by surface runoff, and in summer some of the discharge is lost by evaporation, transpiration and by pumping from the drains and their surrounds.

Surface water quality

The Peel main drain discharges to the Serpentine River that in turn discharges into the Peel Inlet, contained within the Peel–Yalgorup system, a listed Ramsar wetland site. The Peel main drain catchment is currently a major source of nutrients, as identified by a number of studies (Shams (1997), Freshwater Research Laboratory of Murdoch University (2003, 2005).

Total phosphorous, total nitrogen and electrical conductivity data collected by the Marine and Freshwater Research Laboratory of Murdoch University (2003, 2005) was compared to *Australian and New Zealand guidelines for fresh and marine water quality* (2000) trigger values for streams in south-west Western Australia. Results of the snapshot survey indicate that total phosphorous was high (>0.2 mg/L) in the east of the study area in both 2002 and 2004; medium (0.065–0.2 mg/L) to high in the north-west of the study area in 2002 and 2004; and low (<0.065 mg/L) in the south-west of the study area in 2002 and 2004.

Total nitrogen was generally medium (1.2–3 mg/L) across the study area in 2002 with the exception of the three sample sites in the south-west which were found to be low (<1.2 mg/L). While this trend was generally mimicked in 2004, three of the sites in the north-east of the study area exhibited high total nitrogen concentrations (>3 mg/L).

Electrical conductivity across the study site was low (<1.5 mS/cm) in both 2002 and 2004 for all sample sites except one in the south-west which had medium (1.5–4 mS/cm) electrical conductivity in 2002.

Shams (1997) calculated the approximate loading of nutrients on the Spectacles wetlands. Loading of total nitrogen was estimated to be 12 tonnes/year (of which 58% was from the Peel main drain and 42% from groundwater) while total phosphorus was 1.7 tonnes/year (of which 80% was from the Peel main drain and 20% from groundwater).

The long-term targets for nutrient concentrations in the Peel main drain are 1.0 mg/L total nitrogen and 0.1 mg/L total phosphorus (*Australian and New Zealand guidelines for fresh and marine water quality*, 2000). These targets have been developed with consideration of the following:

- surface water inputs dominate this nutrient balance
- there was a trend of increasing runoff into the wetlands from the Peel main drain during the late 1980s and early 1990s
- the proposed change in land use will significantly minimise the potential for ongoing groundwater pollution.

It is concluded by Parsons Brinkerhoff (2004) that the Spectacles wetlands play an important role in managing water quality within this catchment, having an impact on total nitrogen, total phosphorous and total suspended solids. However, the assimilative capacity of these wetlands is finite and therefore the focus of this drainage and water management plan in the vicinity of the Spectacles wetlands is on preventing future stormwater contamination (both in terms of pollutant loads and concentrations).

The *Water quality improvement plan for the rivers and estuary of the Peel–Harvey system* (EPA, 2008) has considered further the water quality of the Serpentine, Harvey and Murray catchments, specifically developing objectives for total phosphorous and indicating the percentage reduction required in each subcatchment to achieve the objectives. Recommendations from the *Water quality improvement plan for the rivers and estuary of the Peel–Harvey system* (EPA, 2008) have been incorporated into the water quality management strategies presented in section 6.3.

To meet the objective of no deterioration in water quality in the Peel main drain, then development will need to demonstrate that local stormwater management systems meet specific pollutant reduction design objectives which are presented in section 6.4 of this drainage and water management plan.

The Department of Water may recommend that treatment measures be included in the arterial drainage system. Where any treatment systems are installed, they must not reduce the hydraulic capacity of the arterial drainage system and must be compatible with the land uses of any multiple use corridors.

2.7 Groundwater

Groundwater flows

The Peel main drain and local sub drains were originally constructed to control regional winter groundwater levels. Direct and indirect (overland) connections exist between lakes/wetlands in the catchment and the drainage system. Drainage in the catchment is linked inextricably to groundwater. A number of swamps and wetlands exist in this area and are a reflection of the regional groundwater table.

The south-western part of the Jandakot mound flow system underlies most of the study area. The groundwater originates from rainfall and flows south-westwards towards the coast, with water levels falling from about 25 m AHD to 5 m AHD. The aquifer varies in thickness from about 35 m in the east to about 20 m in the depression between the Spearwood and Bassendean dunes in which the major wetlands occur.

Rockwater (2006) found that groundwater through flow is intercepted by wetlands in the area, particularly the Spectacles wetlands and Bollard Bulrush Swamp, and the Peel main drain. Groundwater levels are also affected by private and commercial bores in the area, recharge from drainage off the Kwinana Freeway, leakage from the Alcoa residue disposal areas and infiltration from the Water Corporation's Kwinana wastewater treatment plant.

Modelling using very wet conditions (1920s rainfall) resulted in the water table being above ground level over roughly a quarter of the study area at the end of winter. Two development scenarios were run for average rainfall conditions, with and without subsurface drains, set at peak pre-development groundwater levels in an average rainfall period.

The modelling study (Rockwater, 2006) investigated changes to groundwater levels in the Jandakot structure plan area and the Peel main drain catchment that would result from urban development.

Rockwater (2006) discusses the seasonal variability of groundwater levels in the catchment stating that the average groundwater fluctuations in the catchment are generally in the range 1.2 to 2 metres, increasing to 2 to 2.5 metres near drains.

The results of groundwater modelling (Rockwater, 2006) also showed that during wet years (e.g. 1915–31) the area inundated by shallow groundwater is substantially greater than the area predicted to be inundated by surface runoff resulting from the 10-year or 100-year average recurrence interval rainfall event.

Figure 3.2 in Appendix B shows the variability in groundwater levels between a dry and wet cycle. The differences are particularly pronounced in the Spectacles wetlands and Mandogalup Swamps.

Peak water levels at the Spectacles wetlands were predicted to increase 0.11 m in summer and 0.16 m in winter for conventional development, and only 0.02 m in winter for the subsurface drainage scenario. Minor changes to groundwater levels compared to pre-development conditions were predicted to occur in the other wetlands of the study area.

Flows in the Peel main drain and other drains depend largely on winter surface runoff, though baseflow due to groundwater discharge was found to increase with urban development. Specifically, total peak groundwater flows to the drains in August were predicted to be 23 000 m^3/d greater for the developed case with subsurface drainage, while subsurface drainage controls peak groundwater levels.

Groundwater quality

Groundwater contamination is a potentially significant issue for the study area given the number of potential historical and current sources (e.g. market gardens, piggeries, chicken farms, pesticide storage areas and dairies) and some areas of known contamination. There is also the potential for contaminated groundwater to be drawn into sensitive wetlands such as the Spectacles wetlands, given the relatively rapid rate of groundwater flow into such wetlands.

In groundwater quality investigations (Shams, 1997) that were conducted around the Spectacles wetlands in the west of the area, nitrogen and phosphorus concentrations were found to be generally low in groundwater. However, some significant 'hot spots' were identified around sources such as market gardens and the Kwinana wastewater treatment plant. 'Hot spot' contamination of groundwater identified during Shams' (1997) study was estimated to reach the Spectacles wetlands in approximately 2010.

Water quality data from the Department of Water's water information network database demonstrates that groundwater in the area is generally fresh, with salinity less than 1 000 mg/L TDS. There are some higher salinities of up to 5 000 mg/L TDS near wetlands and in areas with a shallow water table where salts have been concentrated by evaporation and transpiration. Higher levels of salinity were also detected beneath and down gradient of the Alcoa residue disposal areas.

The water information network database contains few nitrogen measurements in the area, but those available indicate that total nitrogen concentrations in the groundwater range from less than 1 to 123.7 mg/L. Generally they are low to medium (<3 mg/L) but in some areas are elevated. For instance, water information network sites 12078898, 12078901 and 12078904 exhibit maximum total nitrogen concentrations of approximately 9 mg/L; water information network site 11812614 exhibits maximum total nitrogen of 74.5 mg/L; and water information network site 3048 exhibited total nitrogen of 123.7 mg/L in 1996.

Total phosphorus concentrations in the area range from 0.01 to 34.7 mg/L, are generally less than 0.5 mg/L, and follow a similar distribution to the total nitrogen concentrations. The 34.7 mg/L sample was taken at water information network site 3048, while water information network site 11812632 had a maximum total phosphorous concentration of 20.8 mg/L.

pH is generally in the range 5.2 to 7.3, although there is one bore alongside a drain south-east of the study area with a measured pH of 3.0 which may be indicative of acid sulfate soils at this location.

2.8 Jandakot underground water pollution control area

The study area intersects a significant proportion of the Jandakot underground water pollution control area (see Figure 2.6). The underground water pollution control area covers the Jandakot mound, which is used as a public drinking water supply. The boundaries of the underground water pollution control area are the same area that is covered by the *Jandakot land use and water management strategy*. The underground water pollution control area is proclaimed under the *Metropolitan Water Supply, Sewerage and Drainage Act 1909*. By-laws apply under this Act to prevent contamination of the water.

In addition, *State planning policy 2.3 Jandakot groundwater protection policy* (as discussed in section 1.1) and *State planning policy 2.7 public drinking water source policy* apply to the underground water pollution control area. These policies and the Department of Water's *Water quality protection note: Land use compatibility in public drinking water source areas* provide guidance on what land uses are considered acceptable within the underground water pollution control area. Development proposals within the part of the study area that intersects with the underground water pollution control area should be consistent with these policies.

3 Proposed development

3.1 Key elements of the structure plan

The *Jandakot structure plan* (WAPC, 2007) Figure 2.5a in Appendix B) recognises that the development potential of the study area is both enhanced and limited by a number of factors. Enhancing factors include its proximity to major transport infrastructure such as the Kwinana Freeway and Perth–Mandurah railway line. The proximity to the Town of Kwinana is a positive factor in that it provides a range of district level services to the area, but industrial land use within the area also limits the type, extent and timing of urban development, particularly within Mandogalup. Further limiting factors include the required protection of wetlands and *Bush forever* sites throughout the area, and environmental requirements relating to the export of nutrients to the Peel Inlet–Harvey Estuary.

Ultimately, the *Jandakot structure plan* proposes urban development along the Kwinana Freeway from Millar Road in the south to Rowley Road in the north, urban expansion of Kwinana, a small rural village in Oakford at the corner of Thomas and Nicholson Roads, and a reinforced rural character in the east of the study area. *Liveable neighbourhoods: edition 4* (WAPC, 2008) is the preferred development model for the study area. The small rural village at Oakford is proposed to consist of a cluster of neighbourhoods to provide rural lifestyle opportunities with a ’sense of connection to the countryside’ (WAPC, 2001 p. 69). It is recognised, however, that development at the Oakford site is currently constrained by the remoteness of sewerage infrastructure and the low-lying nature of much of the area.

Environmental protection policy lakes, conservation category wetlands, resource enhancement and multiple use wetlands are included within the *Jandakot structure plan* (WAPC, 2007) and they are subject to additional detailed investigation. It is expected that any wetlands not shown on the Jandakot structure plan as open space will be evaluated for their social and environmental value and protected, if appropriate, at the detailed planning stage. Multiple use corridors are also indicated within the plan as either linear open space or main drain alignments, with the expectation that subsequent detailed planning will realise their potential for conservation, drainage, nutrient stripping and open space uses. All *Bush forever* sites that fall within the study area have been excluded from the planning process and thus do not impact upon any of the proposed developments.

While main and other drains are shown in the *Jandakot structure plan* (WAPC, 2007) it is recognised that development within the study area will produce runoff rates and volumes in excess of the existing system capacity. This issue, along with the need for a comprehensive nutrient management strategy to address any potential adverse effects on the Peel Inlet–Harvey Estuary system, Jandakot groundwater mound and Environmental Management Areas, led to the development of the *Framework for developing the Jandakot water resources management strategy* (Parsons Brinkerhoff, 2004) and subsequently this drainage and water management plan.

The Eastern residential intensification concept Figure 2.5b in Appendix B) proposes five new urban cells namely Wellard East, Casuarina, Anketell, Wandi and Mandogalup in addition to existing development in Bertram. These developments would produce an additional 13 000 dwelling units and an additional population of 37 000 (*Eastern residential intensification concept*, 2005). The Eastern residential intensification concept does not provide sufficient land allocation for surface water management and is currently under review pending the outcomes of this and other studies.

There is currently no development proposed within the part of the study area that intersects with the underground water pollution control area. Any future proposals for development within this area should be consistent with all policies relating to the underground water pollution control area (as discussed in section 2.8).

4 Protection of environmental assets

The following strategies have been developed to protect and enhance the value of environmental assets in the study area.

Minimise changes to hydrology to prevent impacts on watercourses and wetlands

Changes in land use from rural to urban may lead to local increases in peak flows and volumes of runoff due to increases in the impervious area (Diagram 2 below). Large increases in peak flows and volumes have the potential to adversely impact on receiving environments by causing erosion and increasing the period of inundation of vegetation.

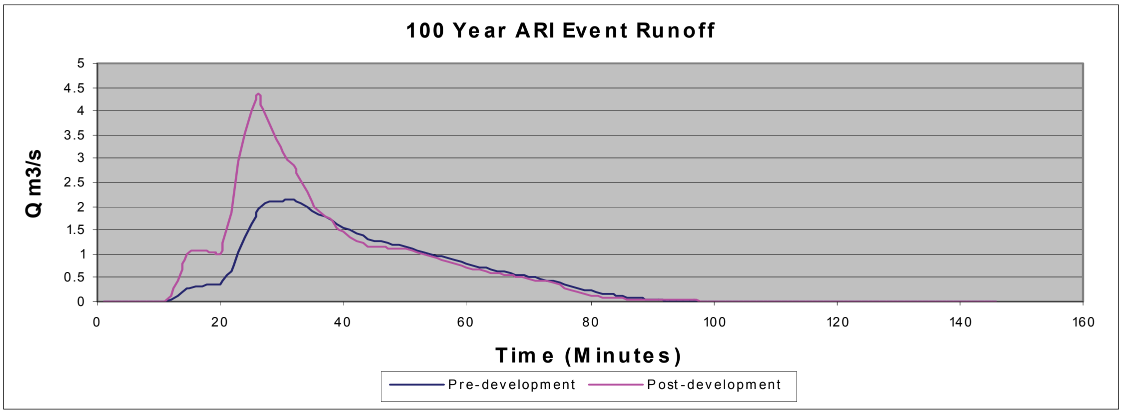


Diagram 2 Typical pre- and post-development runoff hydrograph comparison

Surface water management must ensure that urban development does not increase the peak flows discharging to receiving environments, although there may be increases in total runoff volumes (Diagram 3 below) provided that the assimilative capacity of the downstream environment can be demonstrated. Development must also ensure that watercourses and wetlands do not dry out due to over-abstraction of water resources or lowering of groundwater levels.

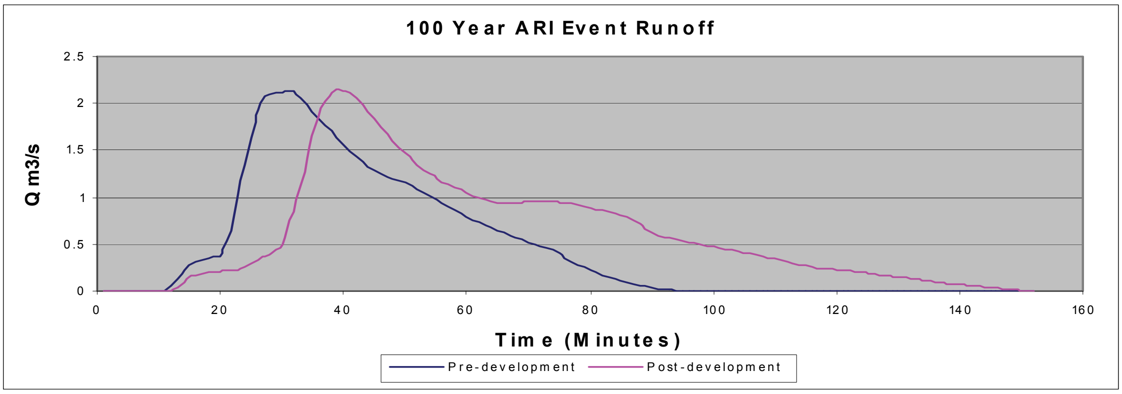


Diagram 3 Typical pre- and post-development runoff hydrograph comparison, with compensated post-development flows

Manage and restore watercourses and wetlands

There are numerous important conservation category wetlands within the study area (Figure 2.6 in Appendix B). The Environmental Protection Authority requires all conservation category wetlands to be protected and managed for conservation purposes and encourages protection of vegetated portions of resource enhancement wetlands. The Environmental Protection Authority also recommends the consideration of existing watercourses and inclusion of requirements for restoration, revegetation and reservation of an appropriate corridor width. Various guidelines are available for aspects of wetland and watercourse protection and restoration and are published by the Department of Water and the Department of Environment and Conservation.

The environmental water requirement study conducted by Ecoscape (2007) provides key information regarding the water regimes required to manage and restore six priority wetlands within the study area. The findings of the study are a key component of the groundwater management strategy, summarised in Table 4.1 and further discussed in section 7.1.

Table 4.1 Wetland ecological water requirements, as water level ranges, required to maintain current wetland species (Ecoscape 2007)

	Most vulnerable sp.		Least vulnerable sp.	Most vulnerable sp.	Preferred maximum (mAHD)
Wetland	**Upper max groundwater level (mAHD)**	**Lower max groundwater level (mAHD)**	**Lower max groundwater level (mAHD)**	**Upper min groundwater level (mAHD)**	**0.50 < Upper min.**
Spectacles north	8.62	8.16	7.00	10.11	9.61
Spectacles south	8.71	8.21	5.10	13.05	12.55
Sandy Lake	19.19	13.96	11.12	20.60	20.10
Johnson Road	10.27	10.09	8.04	15.02	14.52
Bollard Bulrush	4.11	1.99	0.67	5.99	5.49
Mortimer Road	9.13	8.25	6.15	10.62	10.12

The Peel main drain within wetlands is poorly maintained and is blocked by weeds. Maintenance schedules and operating regimes for Peel main drain within these wetlands need to be established by the Water Corporation upon advice from the Department of Water and the Department of Environment and Conservation.

Surface water modelling scenarios have been used to demonstrate that the existing wetland hydrological regimes, as previously presented in Table 2.2, can be maintained by ensuring that additional stormwater is retained in local compensation basins and post-development flows through the wetlands are kept to pre-development levels (see Table 4.2). The exceptions to this are the Spectacles wetlands which show a rise of 0.2 m. This increase is partially due to urbanisation of the area and increase in regional groundwater levels and to the loss of Mandogalup Swamp floodplain.

Table 4.2 Post-development system wetland water levels

Wetland	Invert level (m AHD)	Maximum level (m AHD)			Maximum volume (m3)		
		Baseflow	10-year ARI	100-year ARI	Baseflow	10-year ARI	100-year ARI
Banjup Swamp	23.7	23.9	24.3	24.5	–	900	2,700
Mandogalup Swamp north	12.6	12.8	13.5	13.7	300	31,700	68,500
Mandogalup Swamp south	12.5	12.7	13.4	13.7	200	1,500	2,000
Spectacles wetland north	8.7	9.3	9.4	9.6	247,768	368,000	502,800
Spectacles wetland south	8.6	9.3	9.3	9.5	93,832	98,900	153,400
Treeby Road Lake	15	15.5	15.8	16.0	12,800	23,600	31,500
Sandy Lake	14.5	14.5	14.6	14.6	–	3,000	5,500
Johnson Road wetland	10.4	11.0	11.0	11.0	3,700	3,700	4,100
Mortimer Road wetland	7.5	10	10.0	10.1	28,500	31,100	34,900
Bollard Bulrush Swamp	3.5	5.5	4.8	5.6	1,690,900	729,500	1,857,900

Note: In Bollard Bulrush Swamp the 10- and 100-year average recurrence interval event flood volumes are influenced by tailwater from the Serpentine River.

Assess and manage impacts on native flora and fauna


Dodonaea hackettiana Photos: D. Bright, I.R. Dixon & S.J. Patrick

As presented in Figure 2.6 in Appendix B, there are a number of declared rare and priority flora species within the study area, with one species shown below (CALM, 2003). Detailed flora and fauna assessments are required to be undertaken as part of more detailed levels of planning to ensure that development and subdivision is cognisant and sensitive to the protection of native flora and fauna. Specific details of requirements for the management and protection of flora and fauna are given in the *Draft local biodiversity strategy* (Town of Kwinana, 2007).

5 Water use efficiency and non-drinking water resources

Water conservation and efficiency are about reducing water consumption, making it available for higher value purposes and/or achieving greater productivity from the same amount of water.

In new developments, water use efficiency requires the urban form to minimise use and to achieve the highest value use of fit-for-purpose water. This means that water should be of a quality suitable for its intended final use. For example, in areas identified as suitable, garden bores provide a fit-for-purpose alternative to scheme water for garden use.

In the average household, 47 per cent of water is used outside the home. Gardens (private and public) and public open space areas should be 'waterwise' to minimise irrigation requirements. This includes the use of low water requirement plants and minimal turf areas. The use of scheme water for non-drinking purposes should be minimised.

Non-drinking scheme water is often used in applications outside buildings, commonly for maintenance of public open space and passive and active recreation areas. Demand has traditionally been met by groundwater resources.

The use of drinking water for purposes such as the irrigation of parks, household garden watering and toilet flushing should be an option of last resort. Development shall identify opportunities for the adoption of non-drinking water schemes where appropriate and cost-effective.

New developments should aim to achieve a target of less than 100 kilolitres per person per year (kL/person/year) for consumers within Perth.

In addition there is an aspirational target of not more than 40–60 kL/person/year for scheme water.

The *State water recycling strategy* (Department of the Premier and Cabinet and Department of Water, 2008) further identified the need for new housing developments to consider the use of alternative, fit-for-purpose, water supplies.

5.1 Water efficiency tools

Principles of efficient urban use

Ground and surface water resources are becoming fully allocated in some areas. To maintain current uses and allow further development, water must be used more efficiently or alternative sources developed.

Where appropriate:

1 reconsider the need for the water use
   - minimise irrigated areas or minimise irrigation
   - use fit-for-purpose water
2 consider non-drinking water (rainwater, greywater, treated wastewater, stormwater) for outside use (gardens and public open space)
   - consider non-drinking water indoor use (e.g. toilet flushing)
3 use all water efficiently
   - use water efficient appliances, devices and irrigation systems.

Water efficiency standards and labelling

Products that use water in the home are sold with a star rating similar to that used for energy products. The higher the star rating, the more water efficient the product is.

5-star plus: water use in houses

The *Water use in houses code* – stage one, applies to new homes approved for construction after 1 September 2007 (Department of Housing and Works, 2007). This provides for:

- limiting water use through efficient 3- or 4-star taps, shower and toilet fittings
- new swimming pools to be fitted with a pool blanket
- reducing energy waste by limiting the distance of taps from a hot water source.

Waterwise rebate

The government's Waterwise Rebate program was launched in 2003 to increase awareness of water efficient products in the community and to encourage water savings in homes. The program stimulated market innovation in water savings technology and encouraged the introduction of new product lines previously not available in the Western Australian market.

In 2008, the government assessed the suitability of continuing the program. The program was considered to have achieved its original objectives and was terminated as of 30 June 2009. The government will now focus on other programs to achieve improved water efficiency in the wider community.

Waterwise communities toolkit

To integrate and further develop options for household scale water conservation and recycling, an online *Waterwise communities* toolkit is being developed.

This toolkit will promote water conservation and recycling to local government, developers and other users. It will provide access to information on both recycling and wise water use, including:

- the availability of shallow groundwater
- the availability of sources for recycled water
- key land planning considerations
- alternative water solutions including rainwater tanks, community bores, greywater and landscaping
- streamlined application and approval processes.

The toolkit is currently under development led by the Department of Water, and will be finalised by 2010.

H2Options

H2Options (Water Corporation, 2008) is a seven-step guide for developers considering alternative water supplies, in addition to the existing processes for securing water supply, wastewater and drainage services within a development.

Water conservation/efficiency plans

The *State water strategy* (Government of Western Australia, 2003) introduced the concept of water users developing and implementing water conservation/efficiency plans as part of the Department of Water's water licensing process and integrating water use efficiency measures into water users' daily operations.

Water conservation/efficiency plans enable licensees to obtain a thorough knowledge of their water use and provide details of a water efficiency implementation program to achieve improved water use efficiency. *Statewide policy no 16 – Policy on water conservation/efficiency plans: Achieving water use efficiency through water licensing* (Department of Water, 2008a) further discusses the plans.

In the Perth region, water conservation plans are required for local governments to:

- develop and implement climate change adaption strategies
- ensure that water use remains within licensed allocations
- demonstrate efficient groundwater use
- address decreasing groundwater availability while maintaining amenity, sport and recreation and biodiversity outcomes
- promote a culture of continuous improvement.

Developers should liaise with the relevant local government authority to ensure that any development will align with the requirements of their water conservation plan.

Other documents that may also provide guidance are:

- *Interim position statement: constructed lakes* (Department of Water, 2007)
- *Interim position statement: third pipe (community bores)* (Department of Water in press)
- *Stormwater management manual for Western Australia* (Department of Water, 2004–07).

Non-drinking water schemes

The selection of a non-drinking water source is site-specific. For example, where a development is close to a wastewater treatment plant, this could provide a reliable non-drinking water supply option. The Department of Water can provide some preliminary assistance in identifying a suitable non-drinking water source; ultimately this information will be provided in an on-line toolkit for developers and local governments on the Department of Water's website (expected to be online by 2010).

The following are the key non-drinking water sources:

- **Treated wastewater** – is obtained from a wastewater treatment plant, where it has been treated to a quality suitable for disposal. Further treatment will usually be required to enable reuse.
- **Wastewater (via sewer mining)** – is extracted from sewers (e.g. Water Corporation sewer mains); raw sewage requires considerable treatment to enable reuse. An on-site wastewater treatment plant will be required, which has considerable approvals requirements.
- **Greywater** – is water is sourced from households, and consists of water from showers, washing machines and hand basins. (Greywater from the kitchen is not recommended for reuse due to the high levels of organic matters such as oils and fats.) This water source is most likely to be used at the household level, that is, individual on-site systems at each household; however, theoretically it could be reused at the community scale through a non-drinking water reticulation scheme provided by a water service provider.
- **Stormwater** – refers to rainwater draining into the stormwater system from roofs and ground surfaces. This water can be harvested and reused for irrigation.
- **Rainwater** – is water collected from roofs of buildings. It has minimal surface contact and is therefore relatively free of impurities.
- **Groundwater** – for example as used in community bores.

The following are some of the non-drinking water supply options:

- **Non-drinking water reticulation schemes** (often referred to as 3rd pipe) – involve a dedicated set of pipes (purple colour) that supply non-drinking water to households for toilet flushing and garden watering, and for the irrigation of public and private open space. These schemes require a water service provider.

  - Community bore scheme (groundwater)
  - Treated wastewater – from WWTP or sewer mining
  - Community greywater – for irrigation within a development.
- **Managed aquifer recharge** – is the intentional injection or infiltration of stormwater or recycled water for later abstraction:
  - by a community bore scheme for irrigating parks, household gardens and for flushing toilets
  - by private licensed bores for irrigation of public open space, golf courses, etc
  - by private unlicensed bores (domestic garden bores).
- **Greywater systems** – these systems are designed to supply water for household irrigation. Except from bucketing greywater, all reuse systems must irrigate greywater below ground unless it is treated and disinfected to a secondary effluent standard. All greywater reuse systems must be approved by the Department of Health.
- **Rainwater tanks** – Roof and tank size are relevant for the volume of rainwater harvested. To optimise the full potential of rainwater as an alternative water resource (in Perth) it is recommended that the rainwater system be connected to internal plumbing connections (e.g. toilet, washing machine).

The water recycling and efficiency branch of the Department of Water can provide preliminary assistance in the identification of such opportunities.

6 Stormwater management strategy

The key objectives for surface water management are:

- protection of wetlands and waterways from the impacts of urban runoff
- protection of infrastructure and assets from flooding and inundation.

6.1 Floodplain management strategy

The proposed floodplain management plan includes structural and non-structural measures for flood mitigation, focused on managing potential flooding impacts on the site and the immediate neighbouring land and drainage infrastructure.

Flood modification

The purpose of flood modification measures is to modify the behaviour of a flood by reducing flood levels or velocities or by excluding floodwaters from areas at risk. Flood modification measures by their nature may have environmental and ecological impacts (positive or negative); so any proposal for such works must be subject to strict and detailed assessment in accordance with planning and assessment legislation.

Suggested flood modification measures in the Jandakot structure plan area are outlined below.

- Retention and/or detention of the one-year-one-hour average recurrence interval event at source.
- Maximisation of infiltration at source – use of soak wells, swales, basins and other structures to encourage infiltration and reduce the volume of stormwater generation at the source. Infiltration is generally only an option in areas with adequate infiltration rates (i.e. sandy soils).
- Detention near source – use of detention storages (e.g. swales, constrained public open space, and wetlands) widely disbursed throughout mainly urban areas to hold back stormwater temporarily, thus reducing downstream peak flow rates and water levels. Storage volumes need to be large enough to contain a suitable amount of stormwater and need to have suitably regulated outlets to control outflow rates.
- Channel modification – extensive modification of existing waterways is not generally supported and would require prior advice to be given by the Department of Water. However, modifications may be proposed that will ensure the ability of streamlines to safely convey flow, particularly reducing the effects of man-made structures in creating ponding (afflux), such as undersized culverts and constructed drains. Where such proposals are made, the impact on the regional drainage strategy must be investigated. Components of this option are revegetation, maintenance and upgrade of drainage infrastructure:

- Revegetation – strategic channel stabilisation and improved land-use practices for the flood plain, drainage channels and adjacent areas could also have environmental and aesthetic benefits. Works could include: revegetation with native species, weed control, erosion stabilisation and land-use change (e.g. reduced fertiliser and pesticide use near or on the floodplain or drainage lines). Key aims of these works could be to stabilise banks and floodplain areas against erosion, help improve water quality (e.g. by reducing nutrient export) and improve aesthetic and general environmental characteristics.
- Maintenance – appropriate maintenance is important to minimise erosion and deposition issues and to prevent culvert blockage, scour etc, which reduces channel capacity.
- Upgrade of undersized infrastructure should also be included as part of a maintenance/upgrade program.

Property modification

Property modification involves works that make property (e.g. houses and roads) located within the floodplain less susceptible to flooding.

Suggested property modification options include the following.

- Land-use zoning, planning controls and building regulations for the floodplain area.
- Design guidelines, including addressing setbacks, fencing types and drainage.
- Adequate flood protection from a 100-year average recurrence interval flood, provided by building floor-level controls. Specified finished floor levels for new buildings in flood-prone areas, based on predicted flood levels plus a freeboard.
    - New dwellings in proposed and existing residential areas located within an area that is below 0.50 m above the 100-year average recurrence interval (of rivers and the main drainage system), must have their floor levels elevated 0.50 m above the 100-year average recurrence interval flood level.
    - New industrial or commercial premises located within an area that is below 0.50 m above the 100-year average recurrence interval (of rivers and the main drainage system), should have their floor levels elevated 500 mm above the 100-year average recurrence interval flood level.
    - Major arterial roads with immunity to the 100-year average recurrence interval flood level that access new residential areas and can provide egress to emergency services must be identified. Other residential streets should be designed to be serviceable up to the five-year average recurrence interval flood event.
    - The design of the new urban areas should incorporate current best practice in water sensitive urban design to mitigate the impacts of urbanisation on regional water quantity and quality in the catchments.

- Proposed development may not detrimentally impact on the existing 100-year average recurrence interval flooding regime of the general area. Where proposed developments include new or modified waterways and drainage corridors, the following criteria apply.
  - New and modified waterways within the structure plan area should be constructed to manage the flooding from the 100-year average recurrence interval flood event within their channels and floodplains without allowing flooding from the upstream catchment to enter adjacent residential areas.
  - New and modified waterways should be designed with consideration of the current practice in water sensitive urban design by incorporating water quality management controls and riparian vegetation to allow the drainage paths to recover to a more natural state.

Response modification

Response modification involves modifying the response of the community to a flood threat. Unless designed for a probable maximum flood, all flood protection measures will, at some time, be overwhelmed. The implementation of appropriate flood warning, evacuation and clean-up plans can be effective in managing flood impacts. In some cases, response modification may be the only economic or socially acceptable flood management option.

Response modification measures that may be appropriate for the Jandakot structure plan area include:

- community awareness, including community involvement in floodplain management practices and education
- community preparedness, that is, the ability of the community to defend their properties and wellbeing from flood threat, using appropriate preparatory and evacuation measures
- flood prediction and warning (warnings based on weather predictions are likely to be of most value to the catchment)
- emergency response plans, including evacuation planning and definition of tasks and responsibilities
- emergency recovery plans, including clean-up planning and definition of tasks and responsibilities
- flood insurance, including awareness of exclusions in general insurance policies relating to flood damage and potentially for locally funded speciality insurance schemes.

6.2 Surface water quantity management

Minimise changes in hydrology to prevent impacts on receiving environments

Urbanisation causes an increase in impervious area, resulting in increased rates and volumes of stormwater runoff which must be managed to protect infrastructure and assets from flooding and inundation; while both water quantity and quality must be managed to protect wetlands and waterways from risk of increased inundation and contaminant loads. Surface water management must ensure that urban development does not increase the peak flows discharging to receiving environments.

Surface water quantity management is not restricted to preventing an increase in runoff due to development, but must also manage the maintenance or even restoration of desirable environmental flows and/or hydrological cycles where potential impacts on significant ecosystems, such as wetlands, are identified.

Design objectives

- For the critical one-year-one-hour average recurrence interval event, the post-development discharge volume and peak flow rates should be maintained relative to pre-development conditions in all parts of the catchment. Where there are identified impacts on significant ecosystems, maintain or restore desirable environmental flows and/or hydrological cycles as outlined in this report.
- Manage catchment runoff within the development area to pre-development peak flow rates. Pre-development critical 10- and 100-year average recurrence interval event peak flow rates are specified in Table 6.2.
- Water sensitive urban design and best management practices, which promote on-site retention of events up to the one-year-one-hour average recurrence interval, form the basis of the surface water quantity management strategy for minor events.

The Department of Water may consider allowing an increase in the post-development peak flow rates from 10- to 100-year average recurrence interval events, where it can be demonstrated (at district or local water management strategy stage) that the pre-development hydrologic, hydraulic, geomorphic and ecological characteristics of the downstream catchment and receiving environment can be protected and maintained.

Manage surface water flows from major events to protect infrastructure and assets

Hydrologic and hydraulic modelling of the study area using the computer model InfoWorks CS (GHD, 2008) has determined indicative subcatchment scale peak discharge flows and volumes, detention volumes required to manage surface water flows from major events, and hydraulic grade lines within the main waterways.

Figure 5.1 in Appendix B, and Table 6.1, present the proposed surface water management year flood levels, subcatchment delineation (Figure A3.1 in Appendix B), and discharge flows, discharge volumes and detention volumes (Table 6.1), are provided as a guide to developers and should be refined and located during local structure planning via the local water management strategy, and finalised during subdivision scale planning via the urban water management plan.

For each subcatchment, the critical 10- and 100-year average recurrence interval event pre-development discharge flow rates are presented in Table 6.1 along with an indicative post-development storage volume required to maintain that flow rate. It is important to note that the drainage and water management plan model assumes that the 1-year-1-hour average recurrence interval event (from allotments and also from the road network) is retained at source, so this volume is not included in the indicative flood detention volumes provided in Table 6.1. Flows from the road network in a 1-year-1-hour average recurrence interval event should be retained (or detained for the duration of the 1-year-1-hour average recurrence interval event) within the road reserve network in a manner that mitigates pollutant export.

Discharge flow rates quoted in Table 6.1 are not within main waterways, and do not include flows generated by upstream subcatchments. Discharge criteria are set for whole subcatchments at the point at which they connect to main waterways as indicated by diagram 4 below.

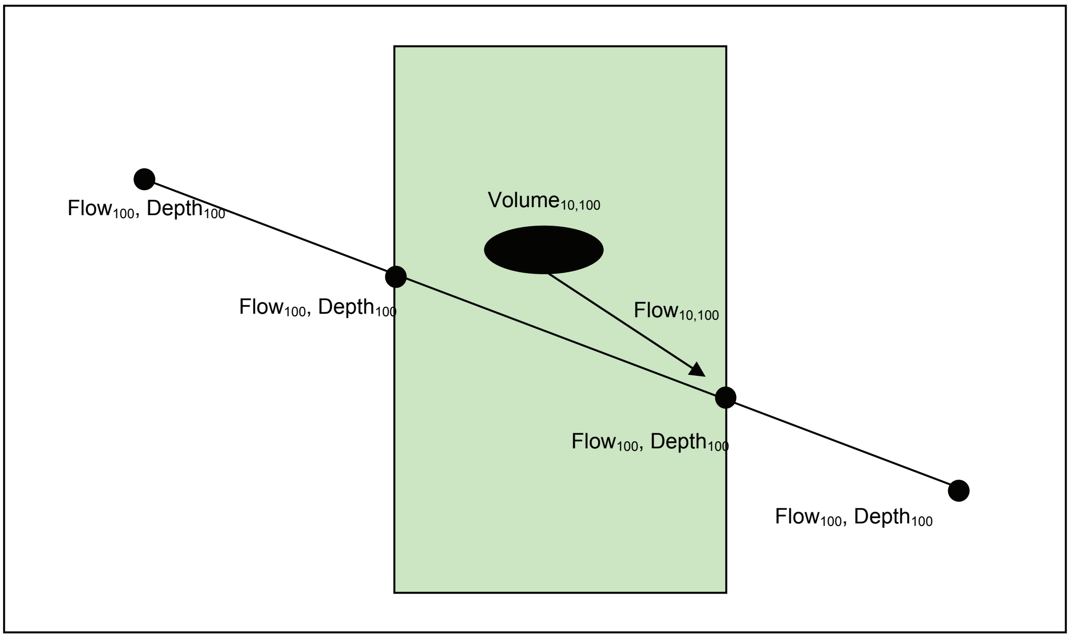


Diagram 4 Schematic presentation of information provided for subcatchments and main waterways

For each modelled node along the main waterways, the critical 100-year average recurrence interval event hydraulic grade line with associated peak flow rates are presented on longitudinal sections in Appendix B of this report.

Where a proposed development forms a part of one or more of the subcatchments presented in Figure 5.1 in Appendix B, the storage volume to be provided by that development should be calculated based on the subcatchment surface area as a percentage of the total subcatchment surface area.

It is proposed that existing drainage routes are retained and, in general, the route of the Peel main drain has been followed. Possible main drainage realignments and a number of the local arterial drainage conceptual designs will necessitate changes to the drainage corridors and public open space provisions within the *Jandakot district structure plan* (WAPC, 2007). Discussions with the local authorities and the Department of Planning to accommodate these changes will be necessary at the local structure planning stage.

Table 6.1 Subcatchment drainage planning criteria – ultimate development

Subcatchment ID	Peak discharge flow (m^3/s)		Detention volume (m^3)	
Subdivisional storage basins	**10-year**	**100-year**	**10-year**	**100-year**
CAT A, CAT B2, CAT B3, CAT B4 and CAT C – Bertram north Subdivision (includes use of Bertram Swamp REW)	0.05	0.14	11,000	15,500
CAT11D	0.09	0.16	7,700	15,100
CAT16A	0.03	0.05	18,700	32,700
CAT17	0.09	0.16	6,300	10,700
CAT17A	0.09	0.16	9,400	18,200
CAT17B (Mandogalup north)	0.05	0.09	31,800	68,500
CAT18A	0.17	0.30	14,400	24,300
CAT19	0.05	0.10	26,100	43,500
CAT20	0.04	0.07	14,500	23,800
CATN1A	0.07	0.13	10,700	17,300
CATN3A	0.07	0.13	6,900	11,600
CATN6A	0.05	0.09	1,700	3,300
CATN6B	0.05	0.07	200	400
CATN7	0.02	0.04	6,000	10,000
CATO3	0.02	0.03	3,100	5,200
CATO3B	0.01	0.01	1,800	3,300
CATO4A	0.02	0.04	10,000	17,500
CATO5A	0.02	0.03	6,400	11,700
CATO6A	0.01	0.02	3,400	5,800
CATP1A	0.01	0.03	6,000	11,100
CATP2	0.12	0.20	26,000	42,600
CATP3	0.02	0.04	8,000	14,100
CATP4A	0.04	0.08	16,700	30,300
CATP7A	0.01	0.02	5,200	8,800
CATP8	0.08	0.14	14,800	24,300
CATR1A	0.08	0.14	36,000	58,900
CATR1B	0.04	0.07	21,500	39,800

Subcatchment ID	Peak discharge flow (m^3/s)		Detention volume (m^3)	
Subdivisional storage basins	10-year	100-year	10-year	100-year
CATW1, CATW3, CATW4, CATW5 and CATW6 – Wellard Subdivision to Peel main drain	0.02	0.04	14,800	16,900
CATW2– Wellard Subdivision to Bollard Bulrush Swamp	0.03	0.05	1,000	2,100

A summary of peak flows and levels at critical locations along Peel main drain and Peel sub-drains (Figure 5.1 in Appendix B) are presented in Table 6.2.

Table 6.2 Flows and levels at critical locations – ultimate development

Location		Peak flows (m^3/s)		Peak levels (m AHD)	
Number(Fig. 5.1) and description		10-year ARI	100-year ARI	10-year ARI	100-year ARI
1	Peel main drain upstream of Mandogalup Swamp	0.75	1.24	15.9	16.1
2	Peel main drain at Hope Valley Road gauging stn, upstream of Spectacles north wetland	1.45	2.00	12.0	12.2
3	Peel R sub-drain downstream of Kwinana Freeway	0.33	0.47	13.4	13.7
4	Culvert between Spectacles north and Spectacles south wetlands	0.87	1.71	9.4	9.6
5	Peel main drain culvert under Thomas Road exiting Spectacles south wetland	0.73	1.68	9.3	9.5
6	Peel P sub-drain downstream of culverts under Thomas Road	0.28	0.43	15.8	15.9
7	Peel P sub-drain entering Peel main drain	1.13	1.58	9.9	10.0
8	Peel O sub-drain downstream of Kwinana Freeway	0.31	0.31	11.0	11.0
9	Peel O sub-drain entering Peel main drain	0.63	0.72	9.8	10.0
10	Peel main drain upstream of Bertram Road culvert (entering Bollard Bulrush Swamp)	2.41	3.80	7.9	8.2
11	Peel N sub-drain upstream of Johnson Road	0.75	1.07	4.9	6.9
12	Peel main drain upstream of Millar Road crossing	4.21	5.08	4.7	5.6

Development of the Mandogalup Swamp area

The surface water modelling of the existing system identified Mandogalup Swamp as important regional flood storage. The swamp serves as a buffer for the Spectacles wetlands, reducing the peak discharges and helping to manage the water level fluctuations. Currently, the area is periodically inundated if a major storm event coincides with the high groundwater table, usually in August–September. Neither *Jandakot structure plan* (WAPC, 2004) nor *Eastern redevelopment intensification concept* (Town of Kwinana, 2004) took into account the regional flood storage within the Mandogalup Swamp.


Mandogalup Swamp, GHD, 2007

The hydraulic modelling of the existing system showed that during the critical 100-year average recurrence interval event, the water level in the Mandogalup Swamp north rises to 13.5 m AHD, a total volume of approximately 85 000 m^3 (Table 6.3). Mandogalup Swamp south mostly remains within the channel banks at 13.45 m AHD, storing approximately 1500 m^3. During these storm events, discharge into the Spectacles wetland north averages 1.5 m^3/s. Under these conditions, the water level in Spectacles wetland north reaches 9.6 m AHD.

The section of Mandogalup Swamp described here as Mandogalup Swamp south includes sections of the swamp to the east and west of the freeway. Modelling has identified that the development of these areas does not represent a significant risk to the downstream wetlands, nor have a limited impact on storage and fill requirements for proposed developments.

Modelling indicates that water level changes due to additional stormwater runoff within the Spectacles wetlands as a result of development are small (less than 0.1m). Larger changes (nearly 0.1m) are possible as a result of regional groundwater level changes (Rockwater, 2005). However *Modelling water level criteria for the development of urban drainage and water management strategy within the Peel Main Drain catchment* (URS, 2007) indicates that the combined effect of both of these changes is negligible when compared to the natural seasonal and inter-annual variability of groundwater levels within the Spectacles wetlands (0.4 m to 1.2 m) and *Ecological water requirements of selected wetlands within the Peel Main Drain catchment* (Ecoscape, 2007) suggests that the predicted top water level (9.6 m AHD) lies within the tolerances of the ecology of the wetlands.

Four scenarios were tested in order to quantify the impact of the removal of Mandogalup Swamp on the hydraulic capacity of the Peel main drain and flood protection of the area. In all post-development scenarios, the starting water level in the Spectacles wetland north was increased from 9.2 m AHD to 9.3 m AHD to take into account the potential increase in groundwater levels (Rockwater, 2006). All scenarios include full development of Mandogalup Swamp south as shown in diagram 5 on the following page.

Diagram 5 Mandogalup Swamp development scenarios – proposed flood storage areas shown in red.

Scenario 1 — Mandogalup Swamp north retained undeveloped

This scenario minimises the impact of development by retaining the whole of Mandogalup Swamp north and development is confined to the surrounding area. The water levels in the Spectacles wetlands rose by nearly 0.1 m purely as a result of increased groundwater levels.

Scenario 2 — Mandogalup Swamp north partially retained undeveloped

The second scenario had Mandogalup Swamp north partially removed. The water rose by approximately 0.1 m in the Spectacles wetland north, a large part of this increase is due to the increase in groundwater level used for modelling of the post-development case.

Scenario 3 — Mandogalup Swamp north partially retained — only power line and pipeline corridors undeveloped

Large sections of Mandogalup Swamp north are contained within existing overhead power line and underground gas pipeline corridors as shown by *Eastern residential intensification concept* (Town of Kwinana, 2004). It is proposed to continue to allow the inundation of these corridors. Under this scenario, the water level in the Spectacles wetland north rose by approximately 0.1 m. A large part of this increase is due to the increase in groundwater level used for modelling of the post-development case.

Scenario 4 — Mandogalup Swamp north fully developed

For the last scenario, Mandogalup swamp was removed and the entire area fully developed as shown by the *Eastern redevelopment intensification concept* (Town of Kwinana, 2004). The water level in the Spectacles wetland north rose by approximately 0.2m.

Table 6.3 Water level and volume in Mandogalup Swamp north for 100-year storm event with pre- and post-development land use

	Water level, m AHD		Storage volume in Mandogalup Swamp [m^3]	Discharge at Hope Valley Road, [m^3/s]
	Mandogalup north	Spectacles north		
Pre-development scenario	13.5	9.4	85,900	1.5
Post-development scenario 1 – Mandogalup north fully retained	13.5	9.6	116,000	1.7
Post-development scenario 2 – Mandogalup north partially retained	13.6	9.6	87,500	1.9
Post-development scenario 3 – Mandogalup north partially retained (power line and pipeline corridors only)	13.7	9.6	68,700	2.0
Post-development scenario 4 – Mandogalup north fully developed	13.8	9.8	3,300	2.3

Preferred scenario

The Department of Water and the Town of Kwinana have agreed that Mandogalup Swamp can be developed in line with scenario 3. This scenario was selected because it has a minimal, and manageable, effect on the Spectacles wetlands. However, there will be increased flows to the Peel–Harvey Estuary especially in minor storm events when the Serpentine River tailwater is not high.

Discussions with WestNet (Dampier Bunbury Natural Gas Pipeline) have been undertaken and approval in principle has been given for the continued use of the pipeline corridors for regional flood detention, including the modelled minor increases in flood level which result from this scenario. Proponents will have to formalise this approval with the Dampier Bunbury Natural Gas Pipeline at subsequent stages of the planning process. No agreement has been sought or gained for the use of these areas for local detention.

Following discussions with Western Power, additional information was requested to allow investigation of the impact of water levels on the tower foundations. The modelling undertaken found that no towers would be inundated above the concrete collar in a 10-year average recurrence interval storm event and five towers will be inundated above the concrete collar in a 100-year average recurrence interval storm event. Western Power concluded that they would undertake inspection and washing of the towers following events greater than the 10-year average recurrence interval storm event in addition to the regular tower inspection program and that therefore Western Power did not object to the strategies presented within this drainage and water management plan.

Development of the Bollard Bulrush Swamp area

Bollard Bulrush Swamp is an Environmental protection policy lake. The wetland lies in the southern part of the Peel main drain catchment, bounded by Bertram, Johnson, Millar and Wellard roads.

Eastern redevelopment intensification concept (Town of Kwinana, 2004) shows future urban development encroaching around the perimeter of Bollard Bulrush Swamp. However, the modelling undertaken for this study has not taken this into account as this proposal does not provide for an appropriate buffer that would give adequate protection from hydrological change to the wetland.

The Bollard Bulrush Swamp is a critical location for flood detention. The Serpentine River flood study indicates that the flood waters from the Serpentine River back up the Peel main drain and inundate the low-lying areas of Bollard Bulrush Swamp. In addition, the Peel main drain is very shallow as it passes through the wetland, causing it to be inundated in >5-year average recurrence interval storm events.

Drain reserves on the perimeter of the Bollard Bulrush swamp were allocated for a drain diversion which never eventuated. The existing drain reserve around the eastern perimeter will no longer be required as the Peel main drain will remain on its present alignment. This drain reserve area could be transferred to the Town of Kwinana to be used for local water quality treatment purposes if required.

6.3 Surface water quality management

The ultimate receiving water for flows discharging from the Peel main drain is the Ramsar listed Peel–Harvey estuarine system. The environmental values of this and other downstream waterways within, and surrounding, the study area must be upheld.

Maintaining pre-development discharge rates and volumes from developed catchments is expected to prevent the majority of contaminants from reaching the waterways by ensuring that the majority of flows from high frequency events are retained or infiltrated on site.

Provided that the initial flow of more significant events is subject to the same detention and treatment received by high frequency events, surface runoff that occurs during more significant events represents a lower risk to downstream water quality. This is because the greatest proportion of nutrients and other contaminants that represent a threat to downstream water quality are typically transported within the ‘first flush’ of an event.

To minimise the average annual load of pollutants discharged by stormwater management systems into receiving environments it is intended, as indicated by the *Water quality improvement plan for the rivers and estuary of the Peel–Harvey system* (EPA, 2008), that appropriate site-specific targets will be developed and adopted.

The water quality improvement plan for the Peel–Harvey system has been developed to address catchment management measures and control actions relating to phosphorus but does not specify site-specific design criteria. Until the outcomes of other investigations are known, and site-specific targets have been developed, interim targets will be adopted and are presented in section 6.4 of this drainage and water management plan.

The water quality objectives of the *Water quality improvement plan for the rivers and estuary of the Peel–Harvey system* (EPA, 2008) are:

- median loadings of total phosphorus to estuarine waters should be less than 75 tonnes per annum in an average year
- with the median load of total phosphorus flowing in the estuary from the Serpentine River being less than 21 tonnes.

Water qualities in streams in winter are to meet mean concentrations of 0.1 mg/L total phosphorous at current mean flows.

Currently in the Peel main drain catchment, the *Water quality improvement plan for the rivers and estuary of the Peel–Harvey system* found that winter concentrations were in the range 0.2–0.3 mg/L and total winter loads were in the range 1–5 tonnes.

The Environmental Protection Authority recognises that there are other problems within the Peel–Harvey system. These include the nitrogen concentrations in estuarine waters; estuarine and riverine habitat loss; acid soil drainage; and bacteria concentrations – animal and human effluent. All require action.

Further investigations are already underway on these issues and will become components to a catchment management plan, as required in the 1989 environmental conditions, subsequently amended in 1991 and 1993 (EPA, 2003).

Water quality treatment systems and water sensitive urban design structures must be designed in accordance with the *Stormwater management manual for Western Australia* (Department of Water, 2007) and *Australian runoff quality* (Engineers Australia, 2006).

The *Water quality improvement plan for the rivers and estuary of the Peel–Harvey system* specifies that reductions of 60–70 per cent for both load and concentration are required in the Peel main drain catchment to meet its objectives and recommends the following best management practices for urban areas.

Table 6.4 Water quality improvement plan for the rivers and estuary of the Peel–Harvey system (EPA, 2008): recommended best management practices

Best management practices	Definition of recommended action
Residential fertiliser	• Use low water soluble fertiliser applied to sandy textured soils, applied sparingly to gardens and turf • Minimise lawn areas or plant an alternative lawn • Fertilise only when symptoms of nutrient deficiency occur e.g. yellowing • If fertiliser is needed, use a complete lawn fertiliser containing nitrogen, phosphorus and potassium • The maximum individual application rate for the fertiliser should be 25 grams per square metre for Couch and 12 grams per square metre for Kikuyu and Buffalo grass • If fertiliser is required, apply in spring or early autumn (Sept, Oct, Nov, Mar and Apr) • Do not fertilise in summer or winter • Do not over water
Full sewerage connection	• To apply to all new urban developments • Build into approvals conditions by decision-making authorities for all new subdivisions and new homes to be connected to reticulated sewerage
Soil remediation	• All new urban developments in areas with sandy soils to undergo soil remediation at the estate scale • At the lot scale blending or applying a layer of higher PRI soil 0–50 cm beneath the finished ground level can provide increased phosphorus retention • Soil amendment materials such as yellow Spearwood sands, Karrakatta soils or brown loams may be used • Remediate soil in accordance with Peel–Harvey coastal catchment water sensitive urban design technical guidelines • Take care to maintain soil permeability
Water and nutrient sensitive principles	• Decision-making authorities to take lead planning role in incorporating best management practices including water sensitive urban design principles, criteria and outcomes in its strategic land-use planning, policies, structure plans and subdivision conditions
Water sensitive urban design	• Compliance with environmental quality criteria in local planning policy • Compliance with stormwater management policies • Application of water sensitive urban design treatment trains • Preparation of water management strategies • Soil amendment • Total phosphorus and total nitrogen import and export criteria • Minimum percentage area of deep-rooted perennial vegetation • Building and landscaping covenants • Construction and building site management
Drainage reform	• Modification to drainage management practices to reduce in-channel sediment movement as opportunities arise • Drainage should be managed as a water resource as part of the total water cycle with the dual objectives of optimising stormwater runoff and reducing nutrient flows into the rivers and streams

6.4 Key design criteria

Surface water quantity

The 1-year-1-hour average recurrence interval event shall be detained at source for the duration of the event through the use of retention (soakage) or storage devices. Refer to Chapter 9 of the *Stormwater management manual for Western Australia* (Department of Water, 2007) for devices suited to the soil types for this catchment. The stormwater management manual contains guidance for the appropriate design of retention and detention systems.

The post-development critical 1-year average recurrence interval peak flow and volume and the 100-year average recurrence interval peak flow shall be consistent with pre-development flows at:

- the discharge points of all subdivisions into waterways
- the discharge points of each subcatchment.

Flows from developed areas must be attenuated, in accordance with Table 6.1. Flood detention/storage areas shall be incorporated into public open space within the subdivision (Figure 7.1 to 7.3 in Appendix B).

Post development flows for all average recurrence interval events must be discharged at flow rates which are consistent with pre-development flow rates for those same events.

Developments along the major stormwater drains should ensure finished floor levels at a minimum of 0.5 m above the 100-year average recurrence interval flood level.

The existing hydraulic capacity of waterways must be maintained. Restoration of waterways is essential and in some cases channel realignments and channel profile modifications may be carried out, provided it is demonstrated that the pre-development hydraulic capacity has been preserved.

Public open space and retention basins should operate as dry basins with a minimum clearance of 0.3 m between the controlled groundwater level and the invert of the basin. No wet basins will be allowed by local authorities.

Defined major arterial roads (as designated by Main Roads Western Australia and the Town of Kwinana) should remain passable in the 100-year average recurrence interval event.

Minor roads should remain passable in the 5-year average recurrence interval event.

Water quality treatment systems and water sensitive urban design structures must be designed in accordance with the *Stormwater management manual for Western Australia* (Department of Water, 2007) and *Australian runoff quality* (Engineers Australia, 2006).

Surface water quality

The Department of Water is currently developing water quality targets. In the interim, designs may be based on the methodology established in the *Stormwater management manual for Western Australia* (Department of Water, 2007)

Targets are to be achieved through adopting a treatment train approach including:

- on-site retention of 1-year-1-hour average recurrence interval event
- bioretention swales to be sized as two per cent of connected impervious areas
- non-structural measures to reduce applied nutrient loads.

If it is proposed to use a computer stormwater modelling tool to size structural controls for protection of downstream surface water quality, the following design targets are recommended until such time as appropriate site-specific targets are developed:

As compared with a development that does not actively manage water quality, developments must achieve:

- at least 80 per cent reduction of total suspended solids
- at least 60 per cent reduction of total phosphorus
- at least 45 per cent reduction of total nitrogen
- at least 70 per cent reduction of gross pollutants.

Proponents shall develop and present the strategies for water quantity and quality management in the local water management strategy and urban water management plans to support the ‘planning approvals’ required for the development to proceed.

Engineering drawings submitted to council for approval must be supported by clear and auditable documentation, providing details of proposed staging and implementation of the surface and groundwater quantity and quality management strategy.

Before completing any local water management strategy or urban water management plan, it is strongly recommended that consultants meet with the local authority and the Department of Water to discuss proposed surface and groundwater management strategies and to gain further guidance on site-specific requirements of the local authority.

7 Groundwater management strategy

The key objectives for groundwater management are:

- protection of infrastructure and assets from flooding and inundation by high seasonal groundwater levels, perching and/or soil moisture
- protection of groundwater-dependent ecosystems from the impacts of urban runoff
- managing and minimising changes in groundwater levels and groundwater quality following development/redevelopment.

It is important to note that groundwater levels are not the same as flood levels and they should be dealt with accordingly.

7.1 Groundwater quantity management

Manage groundwater levels to protect infrastructure and assets

To protect housing from flooding and damage from groundwater, the predicted maximum groundwater level must be determined through modelling and/or measurement. Where this information is not available, local studies shall be undertaken and endorsed by the Department of Water. Where the predicted maximum groundwater level is close to the surface, the provision of a subsoil drainage network and/or importation of fill may be required to manage the risk posed to infrastructure by high groundwater

The modelled current climate maximum groundwater levels in Figure 3.1 in Appendix B are endorsed by the Department of Water for the study area. These levels were modelled using average rainfall for the past 30-year period as reported by Rockwater (2006), revised by URS (2007) and modified by the Department of Water.

The depth to groundwater (very wet and very dry climate) is presented in Figure 3.2 in Appendix B. The very wet climate depth to groundwater levels were modelled using data from the 1920s as reported by Rockwater (2006). The very dry climate depth to groundwater levels were modelled using very dry climate rainfall data as reported by Rockwater (2006) for comparative purposes.

Further investigations will be required to predict the local scale maximum groundwater levels in order to determine whether subsurface drainage and/or fill is required to protect infrastructure. This drainage should always be located at a level endorsed by the Department of Water.

Maintain groundwater regimes for the protection of groundwater-dependent ecosystems

To ensure protection of groundwater-dependent ecosystems, local studies to model and/or measure groundwater levels and refine the district scale modelled groundwater levels shall be undertaken and endorsed by the Department of Water.

The district scale modelled current climate maximum groundwater level (Figure 3.1 in Appendix B) has been developed with consideration of *Ecological water requirements of selected wetlands within the Peel Main Drain catchment* (Ecoscape, 2007). Refinement of local groundwater levels and subsequent drainage design must consider the ecological water requirements of water-dependent ecosystems. Controlled groundwater levels should always aim to meet ecological water requirements. However, if ecological water requirements cannot be met, the likely impacts on the groundwater-dependent ecosystems should be outlined.

Any proposals to control the seasonal or long-term maximum groundwater levels through a controlled groundwater level approach should demonstrate through adequate field investigations, to the satisfaction of the Department of Water and the Department of Environment and Conservation, how any local and regional impacts are to be managed.

Manage the shallow aquifer to protect the value of groundwater resources.

Groundwater in the area is currently used for domestic and commercial purposes and is, potentially, an important source of water for new development in the area.

Groundwater modelling (Rockwater, 2005) has indicated that conventional development in the study area without subsurface drains will result in a rise in groundwater levels of up to 1 m in winter and 0.2 m in summer, while conventional development with controlled groundwater level drains will result in roughly the same groundwater levels. These results would suggest that continued abstraction of groundwater within new developments is acceptable, though ongoing monitoring and control will be essential.

7.2 Groundwater quality management

The environmental values of groundwater within, and surrounding, the study area must be upheld.

Maintain groundwater quality at pre-development levels (median winter concentrations) and, if possible, improve the quality of water leaving the development area to maintain and restore ecological systems in the (sub) catchment in which the development is located.

Water sensitive urban design and best management practices must not only promote infiltration to aid in prevention of possible local flooding from increased runoff due to urbanisation, but must also treat the water before its discharge to waterways, wetlands and to groundwater. This is particularly important given the high variability in phosphorus retention capacity of the soils in the study area and the anticipated increase in nutrient load due to urbanisation.

Where subsoil drainage is installed for groundwater level or soil moisture control, a 'treatment system' (swale/bioretention etc) at each subsoil drain outlet point will be required.

Where appropriate, field investigations must be undertaken to identify acid sulfate soils. Any reduction in groundwater level should not expose acid sulfate soils to the air, as this may cause groundwater or surface water contamination. If field investigations identify acid sulfate soils, further advice should be sought from the Department for Environment and Conservation.

Contaminated sites must be managed in accordance with the *Contaminated Sites Act 2003*.

Ensure that water remains of a good safe quality for the drinking water supply.

There is currently no development proposed within the part of the study area that intersects with the underground water pollution control area. Any future proposals for development within this area should be consistent with all policies relating to the underground water pollution control area (as discussed in section 2.8).

7.3 Key design criteria

The design of the overall surface and groundwater drainage network is an important part of the development process.

The controlled groundwater is the design level at which open and subsoil drainage invert levels are set. The Department of Water is developing a guidance paper to clarify the controlled groundwater level design process.

Groundwater drainage networks are generally constructed in areas where maximum groundwater levels reach within one to two metres of the ground surface every year. A decision needs to be made based upon separation from the historical recorded or modelled maximum groundwater level and management of the risk posed by the high water table. If the decision is to not install a subsurface drainage network, then the development surface level should be determined in accordance with standards set for building foundation integrity and other factors relating to the proposed land use by the appropriate authority.

When designing drainage systems to control groundwater levels, ecological water requirements, groundwater resource requirements and land surface waterlogging issues should be addressed. These two considerations are important to ensure the groundwater resource and environmental assets are protected and that infrastructure is not compromised by groundwater or standing water. Reference should be made to the Department of Water for the latest guidance on groundwater management.

- Where the maximum groundwater level is close to the surface, the provision of a subsoil drainage network and/or importation of fill may be required to manage the risk posed to infrastructure by high groundwater levels. The level at which the inverts of the subsoil drainage network is to be installed is the controlled groundwater level.
- The bioretention system and drainage inverts are to be set at or above controlled groundwater level, although existing inverts below controlled groundwater level may remain.

- Subsurface drainage is to be installed at or above controlled groundwater level.
- Subsurface drainage must be designed with free-draining outlets.
- The clean fill imported onto the site is to incorporate a band of material that will reduce phosphorus export via soil leaching, while also meeting soil permeability and soil compaction criteria specified by the local government authority.
- Where development is associated with a waterway or open drain that intersects the shallow water table and may discharge pollutants from the shallow groundwater to receiving environments, until appropriate site-specific targets are developed (as compared with a development that does not actively manage water quality):the following interim targets will be adopted to achieve:
  - at least 60 per cent reduction of total phosphorous
  - at least 45 per cent reduction of total nitrogen.
- Where development is associated with an ecosystem that is dependent on a particular hydrologic regime for survival, the water quality discharged to the groundwater must be in accordance with the requirements of the Department of Environment and Conservation.
- Development must ensure that watercourses and wetlands do not dry out due to over-abstraction of water resources or lowering of groundwater levels.

Engineering drawings submitted to council for approval must be supported by clear and auditable documentation, providing details of proposed staging and implementation of the surface and groundwater quantity and quality management strategy.

It is strongly recommended that consultants meet with the local authority to discuss proposed surface and groundwater management strategies and to gain further guidance on site-specific requirements of the local authority before completing any local water management strategy or urban water management plan.

8 Commitment to best management practice

In order to meet the design criteria of reductions in total phosphorous, total nitrogen, total suspended solids and gross pollutants as compared to developments in which water treatment is not undertaken, it is necessary to use a combination of best management practice strategies.

In addition, best management practice strategies reduce risks of flooding on housing and infrastructure while maximising the potential for stormwater to be treated as a resource.

The hierarchy of best management practice principles is as follows.

1. Implement controls at or near the source to prevent pollutants entering the system and/or treat stormwater.
2. Install in-transit measures to treat stormwater and mitigate pollutants that have entered the conveyance system.
3. Implement end-of-pipe controls to treat stormwater, addressing any remaining pollutants before discharging to receiving environments.


Rainwater Tank, GHD, 2007

Structural and non-structural best management practice strategies must be used in combination to achieve the required stormwater treatment outcomes.

Recommended best management practices in increasing order of scale include:

- Residential lot scale:
  - on-site soakage devices, where appropriate, with overflow outlets (detention)
  - water-wise and nutrient-wise landscaping, including minimum percentage areas of perennial vegetation cover
  - porous pavements
  - amended topsoil
  - rainwater tanks for harvesting, detention and reuse.
- Commercial lot scale:
  - on-site detention and/or retention
  - water-wise and nutrient-wise landscaping, including minimum percentage areas of perennial vegetation cover
  - maximise permeable surfaces
  - porous pavements
  - amended topsoils

  - landscaped infiltration structures
  - hydrocarbon management and sediment traps
  - rainwater tanks for harvesting, detention and non-potable reuse.
- Street scale:
  - infiltration measures
  - sediment traps
  - porous pavements (car parking)
  - conveyance bioretention systems.

- Estate scale:
  - retention/detention (including water quality treatment) areas integrated within public open space, in accordance with the objectives and requirements of elements 4 (public parkland) and 5 (urban water management) of *Liveable neighbourhoods edition 4* (WAPC, 2008)
  - retain existing waterways and aim to restore a pre-development ecology and channel morphology in new and existing waterways
  - non-structural best management practices such as interpretive signage, garden education programs, publishing a water sensitive urban design web-page for the estate, and inviting residents to engage with existing community catchment groups
  - water-wise and nutrient-wise landscaping within public open spaces, including minimum percentage areas of perennial vegetation cover.
- Area scale:
  - non-structural best management practices such as; public education campaigns, support of local community catchment groups, installation of interpretive signage and web pages, and the adoption of appropriate planning principles including local laws for on-site detention and retention.

The above practices may be limited by several factors, including: local soil and hydrological conditions; the depth and type of fill imported; public safety and public health standards; design life/reliability requirements; maintenance/management costs; legal authority; and streetscape aesthetics. Advice should be sought from the local authority and the Department of Water on the practices most appropriate for adoption within the Jandakot district structure plan area.

9 Implementation

9.1 Requirements for the following stages

State planning policy 2.9: water resources policy (Western Australian Planning Commission, 2004) requires that planning should contribute to the protection and wise management of water resources through local and regional planning strategies, structure plans, schemes, subdivisions, strata subdivisions and development applications. *Better urban water management* (Western Australian Planning Commission, 2008a) provides guidance on implementation of State planning policy 2.9. It identifies the requirements for water management strategies and plans that must be developed to accompany the land-use planning and approvals process in the drainage and water management plan area at each stage of the planning process.

All local structure planning should incorporate a local water management strategy consistent with the strategies and objectives of this drainage and water management plan. Subsequent subdivision applications should be accompanied by urban water management plans where required by the Town of Kwinana and the Department of Water and/or should be consistent with any approved local water management strategy and with the strategies and objectives of this drainage and water management plan. *Urban water management plans: Guidelines for preparing plans and for complying with subdivision conditions* (Department of Water, 2008b) are available from the Department of Water to help with the preparation of urban water management plans. Also available is an interim guideline for the preparation of a local water management strategy *Interim: Developing a local water management strategy* (Department of Water, 2008).

Developers are encouraged to contact the Town of Kwinana early in the planning process to discuss specific water management requirements for proposals.

It is strongly recommended that proponents meet with the local authority to discuss proposed surface and groundwater management strategies and to gain further guidance on site-specific requirements of the local authority before the completion of any local water management strategy or urban water management plan.

The Town of Kwinana is responsible for approving water management plans throughout the structure planning framework and will refer those documents to the Department of Water and the Western Australian Planning Commission for guidance and comment.

It is essential that details of the proposed monitoring strategy and action plan are built into the local water management strategy and urban water management plan for each structure plan area.

9.2 Review of water management plan

It is proposed that the *Jandakot drainage and water management plan* be reviewed in 10 years or earlier if deemed necessary until development has occurred consistent with the *Jandakot structure plan*.

The review should be undertaken by the Department of Water, with agreement from the Department of Environment and Conservation, Western Australian Planning Commission, Shire of Serpentine–Jarrahdale, Town of Kwinana and the Water Corporation. The review should cover, but not be limited to the following:

- assessment of impacts of development
- design objectives
- requirements for local water management strategies and urban water management plans
- cost-recovery mechanisms.

9.3 Monitoring strategy

A groundwater and surface water monitoring program should be designed as part of the local water management strategy to assess the hydrological impacts of the proposed development and to establish a contingency action plan with associated trigger values for specified parameters.

The baseline monitoring program should be conducted for at least three years, with a minimum of two normal[1] winters/wet seasons prior to development to characterise the sites hydrology and hydrogeology. The results of the baseline monitoring strategy should be presented in the final local water management strategy. The Department of Water advises at least five years of post-development monitoring as the impacts of development on water systems may take many years to emerge. This includes both impacts during construction and post-development.

Department of Water may consider alternative monitoring duration (for example, < three years for pre-development and < five years for post-development) if proponents could demonstrate with certainty (resulted from available monitoring data[2] or monitoring programs) that there are not or will not be any unpredictability in levels, flow and quality of groundwater and surface water. The monitoring data should be reviewed at the end of first year of monitoring and the monitoring program adjusted if required. Subsequent regular reviews are also required.

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[1] A ‘normal’ winter is defined as one of approximately average rainfall (based on the last 10 years).

[2] Monitoring data is available by contacting Water Information (WIN) section of the Department of Water by e-mailing <WIN@water.wa.gov.au>.

The monitoring results can then provide:

- pre-development baseline data
- post-development – a comparison to target design objectives and criteria
- a trigger for contingency action, as per the contingency plan
- an interim internal assessment tool of the monitoring program.

All monitoring results should be provided to the Department of Water in an agreed format. A report on these results is not usually required; however, where a trigger for contingency action has been reached it will be necessary to report on the action taken.

Standards

Monitoring sampling should follow the Australian Standards AS/NZ 5667 series of water quality sampling guidance notes and a National Association of Testing Authorities accredited laboratory is required to perform water quality testing.

Monitoring network

The groundwater monitoring bore network's extent and density should spatially represent the hydrogeology of the local area, to the satisfaction of the local government authority and the Department of Water.

Surface water monitoring sites should capture the sites' inflow and outflows, and detention or retention storages inflow to water-dependent ecosystems, including selected conservation category wetlands as agreed with the Department of Environment and Conservation.

Monitoring parameters

Monitoring of groundwater levels should be initially on a monthly basis to establish water level fluctuations. The appropriate frequency, period and duration of surface and groundwater quality sampling and surface water flow monitoring is site-specific, and must meet the regulatory body's recommendations. An example of a monitoring program is presented in Table 9.1 and may be adapted for pre- and post-development circumstances.

Samples should be analysed for at least the following water quality parameters:

- in-situ pH, electrical conductivity and temperature, dissolved oxygen, depth to water (groundwater)
- heavy metals – arsenic, cadmium, chromium, copper, lead, nickel, zinc, mercury, boron, calcium, cobalt, manganese, molybdenum and selenium
- total suspended solids
- total nitrogen and total kjeldahl nitrogen

- ammonia
- nitrate and nitrite
- total phosphorus
- orthophosphate.

The following additional parameters are recommended in locations where drainage intercepts shallow groundwater systems:

- total titratable acidity and total alkalinity
- major anions (chloride, bromide and sulfate)
- major cations (calcium, magnesium, sodium and potassium)
- iron and aluminium.

The effective management of urban stormwater quality typically focuses on the treatment of frequent, low intensity stormwater events. These small but frequent flows account for the majority of nutrient loads and represent the best opportunity for water quality improvement.

The process of infiltration filters the stormwater and is effective in removing particulate nutrients. Dissolved nutrients cannot be filtered and are therefore more difficult to treat. Urban runoff is a combination of dissolved and particulate nutrients.

If the treatment measure is infiltration, then both filtered and unfiltered samples of total nutrient concentrations should be measured to quantify the proportion of dissolved and particulate nutrients generated within the development site; and the method should be recorded.

A summary of an example monitoring program is presented in Table 9.1 below.

The format and frequency of pre- and post-development reporting should be proposed within the local water management strategy and approved by the local authority and the Department of Water. Where a trigger for contingency action, as specified in the local water management strategy, is reached it will be necessary to report on the action taken.

Table 9.1 Monitoring programme summary

	Sites	Frequency	Parameters
Surface water	Developments inflow and outflow locations	Site specific	– Flows – Water levels
	Detention storages inflow and outflow Water bodies	Monthly grab samples while flowing, to be reviewed after the first year of monitoring	– **In-situ** pH, EC and temperature, dissolved oxygen. – **Unfiltered sample:** pH, EC, TN, FRP, TKN, ammonia, TP, heavy metals – **Filtered sample:** nitrate/nitrite and PO_4,
Groundwater	Network of monitoring bores should include bores over old market gardens and other high pollutant areas, as well as providing a suitable spatial representation of the study area	Monthly	water level, pH and EC
		Quarterly (typically Jan, Apr, July, Oct)	– **In-situ** pH, EC and temperature, dissolved oxygen and depth to water. – **Unfiltered sample:** pH, EC, TN, FRP, TKN, ammonia, TP, heavy metals – **Filtered sample:** nitrate/nitrite and PO_4,

Contingency action plan

A site-specific contingency action plan with associated trigger values must be developed and presented in the local water management strategy. As a minimum, the contingency action plan must include communication with the Department of Water and the Town of Kwinana as a priority action when trigger values are breached.

A summary of monitoring requirements and responsibilities is provided in Table 9.2.

Table 9.2 Assessment requirements of development proposals – monitoring

Responsible agency	Timing	Monitoring requirement
Developers	Period of 3 years pre-development preferred, with at least two normal winters-wet seasons	Monitor key criteria for maintenance of hydrologic regimes, buffers and ecological corridors/linkages of environmental assets
		Monitor local superficial aquifer groundwater levels
		Monitor flow and water quality (including nutrients, total suspended solids, and gross pollutants) at regular intervals
		Monitor peak flows within developments and wetlands
	Intervening period	While it is not expected that extensive monitoring should continue between the pre-development and post-development periods, there are specific monitoring requirements that still need to occur
		Continuity of hydrology: a small number of monitoring points need to be continued throughout the development process to ensure that the more detailed monitoring can be referenced to a known baseline. This is particularly important due to the highly variable nature of the parameters and the uncertain impacts of climate change. Where appropriate, some of these sites may be long-term DoW monitoring sites
		Construction: during the construction period, monitoring needs to be increased significantly, with surface runoff (especially TSS) and monitoring of impacts on wetland
	Period of 5 years post-development, including at least 1 year following completion of the majority (80%) of developments	Monitor key criteria for maintenance of hydrologic regimes, buffers and ecological corridors/linkages of environmental assets
		Monitor local superficial aquifer groundwater levels
		Monitor flow and water quality (including nutrients, total suspended solids, and gross pollutants) at regular intervals
		Monitor peak flows within developments and wetlands
		Monitor performance of new drainage structures
Department of Water	Ongoing	Monitor efficacy of water conservation measures and achievement of water consumption targets
		Monitor regional surface water flows and quality
		Monitor confined aquifer groundwater levels and regional superficial aquifer groundwater levels and quality
		Monitor groundwater abstraction in the Jandakot structure plan area
		Monitor surface water quality and flows at strategic locations in main drains and waterways
		Monitor structural best management practices for efficacy with advice from the Best Management Practice Technical Reference Group

Responsible agency	Timing	Monitoring requirement
ToK	From 3 years post-development	Monitor performance of new drainage systems across catchment and property boundaries Monitor key criteria for maintenance of hydrologic regimes, buffers and ecological corridors/linkages of environmental assets Monitor local Superficial aquifer groundwater levels Monitor water quality and flows within developments and wetlands

9.4 Action plan

Table 9.3 presents the key actions necessary to implement this drainage and water management plan, identifying the responsible agency and proposed time for completion. The following acronyms are used within this table:

DEC – Department of Environment and Conservation

DoW – Department of Water

SSJ – Shire of Serpentine–Jarrahdale

ToK – Town of Kwinana

WAPC – Western Australian Planning Commission

DP – Department of Planning

Table 9.3 Actions and responsibilities for implementation of the Jandakot drainage and water management plan

Strategy	Action	Lead agency	Timing
Protection of environmental assets			
Minimise changes to hydrology to prevent impacts on watercourses and wetlands	Establish a process for ongoing evaluation of the impacts of development on significant environmental assets and review of the strategy	DEC	As part of the planning process
	Identify land required for protection of environmental assets and to allow for the management of their hydrologic regimes	DEC	As part of the planning process
	Incorporate environmental assets as a key part of community planning	DP, SSJ, ToK	Through assessment of planning proposals
Manage and restore watercourses and wetlands	Determine post-development hydrology for the wetlands and waterways of the Peel main drain catchment	DoW	Through assessment of local water management strategies and urban water management plans
	Develop management plans for the wetlands and waterways of the Peel main drain catchment consistent with the post-development hydrology	DEC, SSJ, ToK	Commencing immediately and ongoing

Strategy	Action	Lead agency	Timing
Assess and manage impacts on native flora and fauna	Provide appropriate buffers and ecological corridors/linkages in local structure plans	WAPC, SSJ, ToK	Through assessment of planning proposals
	Establish responsibilities for ongoing management of natural areas	DEC, SSJ, ToK	As part of the planning process
	Undertake more detailed fauna assessments at the local structure plan stage, including details of management measures to deal with issues such as habitat protection, fauna relocation and non-native animal control	WAPC, SSJ, ToK	Through assessment of planning proposals
Surface water management			
Minimise changes in hydrology to prevent impacts on receiving environments	Ensure development complies with the stormwater design objectives for flooding and ecological water protection	DoW	Through assessment of water management strategies/plans
Manage surface water flows from major events to protect infrastructure and assets	Ensure development in the Jandakot structure plan area complies with the stormwater design criteria for flood management in this drainage and water management plan	SSJ, ToK	Through assessment of water management strategies/plans
	Develop and implement flood management, response and recovery plans	SSJ, ToK	As part of the planning process
	Secure land that might be required for arterial drainage in the Jandakot catchment	WAPC, SSJ, ToK WC	Through local structure planning
	Design and construct modified drainage within and associated with development cells	Developers and SSJ, ToK where modifications on boundaries are required	Through local water management strategies
Apply the principles of water sensitive urban design	Seek opportunities to include environmental and social objectives in planning of stormwater management, such as incorporation of multiple use corridors to provide habitat values and opportunities for recreation	SSJ, ToK	Through assessment of local structure plans
	Retain existing natural waterways and drainage lines in the design of stormwater management systems for urban development	SSJ, ToK	Through assessment of water management strategies/plans
Adopt nutrient load reduction design objectives for stormwater runoff	Ensure development in the Jandakot structure plan area complies with the design objectives for stormwater quality	SSJ, ToK	Through assessment of water management strategies/plans
Groundwater management			
Manage groundwater levels to protect infrastructure and assets	Monitor superficial aquifer groundwater levels pre- and post-development at the local scale	Developers, data to be passed by SSJ/ToK to DoW for collation	3 years each pre- and post-development
	Monitor confined aquifer groundwater levels and regional superficial aquifer groundwater levels	DoW	Commencing immediately and ongoing
	Investigate potential changes to local water balance and implications for groundwater rise	DoW	Through assessment of water management strategies/plans

Strategy	Action	Lead agency	Timing
	Manage groundwater levels within ranges reported in this drainage and water management plan via a combination of subsoil drainage at local controlled groundwater levels, imported fill and groundwater abstraction as appropriate for management of groundwater rise, and via recharge mechanisms for falling groundwater levels	Developers for 3 years post-development, after that time responsibility of SSJ/ToK	Commencing immediately and ongoing
Maintain groundwater regimes for groundwater-dependent ecosystems	Review developers' investigations of local groundwater regime to establish local groundwater management criteria near groundwater-dependent ecosystems	DoW	Through assessment of water management strategies/plans
Protect the value of groundwater resources	Prepare a groundwater allocation plan for the Jandakot structure plan area	DoW	Commencing immediately and . ongoing
Adopt nutrient load reduction design objectives for discharges to groundwater	Check that developer's proposals comply with the design objectives for groundwater quality in the Jandakot structure plan area.	DoW	Through assessment of water management strategies/plans
Monitoring and Implementation			
Adopt an adaptive management approach	Develop and implement a contingency action plan with associated trigger values for surface and groundwater	Developers	Through local water management strategies
	Monitor water quality and flows pre- and post-development, both within developments and at strategic locations in main drains, wetlands and waterways. This includes both regular sampling for flow and water quality and targeted peak flow during storm events. Locations to include key drains/waterways and wetlands.	At the local scale: developers then Water Corporation (main drainage areas) and SSJ/ToK, data to be passed to DoW for collation At the regional scale (sub-catchment outlets): Water Corporation (main drainage areas) DoW	3 years pre- and post-development, then ongoing
	Collate and analyse monitoring data to establish baseline water quality data throughout Jandakot structure plan area	Developer to pass data to DoW. Department to collate and organise data, CSIRO's real-time data collection system to support the data analysis	Commencing immediately and ongoing
	Assess behavioural patterns with respect to non-structural measures and the effectiveness of non-structural measures, using a method such as community-based social marketing	Developer to implement with guidance from local government; local government to take over responsibility 3 years post-development	Ongoing
	Determine efficacy of structural best management practices, provide feedback to developers and allow for alteration of practices if necessary	DoW with advice from the Best Management Practice Technical Reference Group	Ongoing

Strategy	Action	Lead agency	Timing
	Engage the research community in the process of evaluation and feedback	DoW with advice from the Best Management Practice Technical Reference Group	Ongoing
Water use efficiency			
Adopt household consumption target	Check that residential development complies with consumption targets	DoW	Through assessment of water management strategies/plans
	Check that scheme water substitution does not lead to an overall increase in water consumption	DoW	Through assessment of water management strategies/plans
Non-potable water supply systems deliver a net benefit to the community	The impact of a non-potable water supply system on the local water balance is to be assessed as part of the local water management strategy	DoW	Through assessment of water management strategies/plans
	The design of a non-potable water supply system must be subject to a sustainability assessment as part of the local water management strategy to determine the net benefit or cost of the scheme	DoW	Through assessment of water management strategies/plans
Non-potable water supply systems are to be designed as part of an integrated water supply	Non-potable water supply systems must be designed in conjunction with potable water supply systems, to ensure that fire fighting requirements can be met from one or both of the systems and that both systems are designed for efficiency (e.g. minimising pipe sizes and pumping requirements where possible)	DoW	Through assessment of water management strategies/plans
	Seek agreement between the developer, local government authority and licensed service provider (e.g. Water Corporation) on the design, operation and management of a non-potable water supply system, including arrangements for use in public open space and appropriate level of water quality, to ensure that all water demands are met appropriately	DoW	Through assessment of water management strategies/plans

Appendices

Appendix A — Stormwater modelling in InfoWorks CS

A.1 Hydraulic modelling in InfoWorks CS

A.2 Modelling assumptions

A.3 Surface runoff parameters

A.4 Model calibration

A.5 Local arterial drainage – conceptual design

A.1 Hydraulic modelling in InfoWorks CS

InfoWorks CS is a computer hydraulic modelling package used to simulate stormwater drainage systems. The software package is capable of hydrological modelling of the complete urban water cycle, including stormwater drainage master planning or studies, assessments of flooding in urban drainage systems and hydraulic response of the stormwater network infrastructure to the changes in the land use. The hydraulic software component can resolve open channel and closed conduit flows and model the effect of backwater and reverse flow. The model is used predominantly for calculations of event-based simulations; therefore, the initial conditions are usually set to the worst-case scenario.

Time-varying surface runoff, generated by the runoff routing model, discharges into the hydraulic network. The hydraulic network consists of interconnected nodes (manholes, outfalls and storage basins) and links (weirs, pipes, culverts and open channels).

Manning's roughness coefficients applied to the conduits are summarised in Table A3..

Table A3.1 Culverts roughness coefficients (Manning's n)

Drain type	Manning's Coefficient of Roughness
Reinforced concrete pipe	0.012
Concrete box culvert	0.013
Over road flood route	0.015
Maintained open drain	0.030
Over land flood route	0.035

Nodes and manholes in the hydraulic network are modelled by standard units offered in InfoWorks CS. Most commonly, the flood level for nodes was set to a ground level. The exceptions were the basins connected to the main drain by an overland flow path; in this case, flood level was elevated by 0.3 m to allow utilisation of the flow path. The default values used for nodes are summarised in Table A3..

Table A3.2 Default fields for nodes and manholes

Node field	Unit	Value
Shaft area bottom	m^2	1.2
Shaft area top	m^2	1.2
Floodable area	m^3	1.0

Regional detention basins were designed according to the principles outlined in Figure 6.1. First, the InfoWorks CS model is run for pre-development land use to determine maximum discharge from the catchment for a critical 100-year average recurrence interval rainfall event. The discharge of the catchment is to be maintained in the post-development scenario.

The catchment drains into a detention basin. A sealed dummy node is connected to the invert of the detention basin by a nominal 100 mm pipe to prevent the detention basin from filling with water in the initialisation of the model. The outflow pipe is connected at the invert level of the storage. The diameter of the outflow pipe will depend on storage size, pre-development discharge and storage elevation relative to the main drain, but rarely exceeds 450–600 mm.

The detention storage design is tested by running a critical 100-year average recurrence interval rainfall event for a post-development scenario. The discharge from the detention basin should not exceed the pre-development level; the storage volume should also be fully utilised. If the storage volume is inadequate, the basin is resized to achieve required volume utilisation, discharge out of the basin and the shape of the hydrograph.

Groundwater levels in drains and basins were modelled by the application of water levels and inflows directly into the drain or basin via dummy outfall nodes with reversed flap valves to prevent drain flows from discharging out of the model. Inflows were used to represent subsurface drainage flows estimated from the groundwater modelling of the Peel main drain catchment (Rockwater, 2005) and were applied at several locations throughout the model. Appropriate levels to represent groundwater inflows were identified with reference to the peak winter groundwater levels (CGL) determined by groundwater modelling of the Peel main drain catchment (URS, 2007). This approach results in base flows at the Hope Valley Road gauging station that are approximately equivalent to the long-term record.

Groundwater level (maximum level for post-development land use) at the proposed location of the basin determines fill requirements and the invert of the detention basin. The invert of the storage basin should be at least 300 mm above the groundwater level.

A.2 Modelling assumptions

The following assumptions were used for modelling of the Peel main drain catchment:

- Peak winter groundwater levels applied as starting water levels in basins and as baseflows in drains
- 100-average recurrence interval year rainfall event applied to whole catchment with universal start time
- 100-year river level applied as constant tailwater in the Serpentine River floodplain
- No infiltration modelled
- Conservative parameterisation.

In isolation, these are all reasonable design assumptions to make, but it is essential that the build-up of conservatism is not forgotten. Any one of these assumptions when considered in isolation could have significant implications for the cost of the final solution and, when combined, that effect could be multiplied.

A.3 Surface runoff parameters

InfoWorks CS uses the Storm Water Management Model (US EPA) routing model to generate rainfall runoff from the catchment. The flow is routed using a single non-linear reservoir; its routing coefficients depend on surface roughness, surface area, ground slope, and catchment width. The runoff model consists of three components: initial losses, runoff model and runoff rate (routing). Each sub-catchment in the study area (Figure A3.1) is subdivided into surface types (Table A3.). These are pervious without depression storage (runoff routing value of 0.025; fixed runoff coefficient of 20%), pervious with depression storage (runoff routing value of 0.025, fixed runoff coefficient of 20%) and impervious with depression storage (runoff routing value of 0.015, fixed runoff coefficient 100%). In rural areas, an initial loss (depression storage) of 15 mm is set for natural pervious surface to account for initial wetting of the catchment.

Table A3.3 InfoWorks model runoff area properties

Runoff surface ID	Description	Surface type	Surface roughness (Manning's n)	Initial loss (mm)	Fixed runoff coefficient
11	RURAL (Clay) 2yr	Pervious	0.05	0	0.3
12	RURAL (Clay) 10yr	Pervious	0.05	0	0.35
13	RURAL (Clay) 100yr	Pervious	0.05	0	0.4
2	RURAL (Veg' Sand)	Pervious	0.08	25	0.1
21	RURAL (Veg' Sand) Wet wetlands	Impervious	0.001	0	1
3	RURAL (Cleared Sand)	Pervious	0.07	15	0.2
4	SPEC' RURAL (Perv')	Pervious	0.05	15	0.2
5	SPEC' RURAL (Imp')	Impervious	0.015	15	0.5
61	URBAN (Perv') 2yr	Pervious	0.025	0	0.1
62	URBAN (Perv') 10yr	Pervious	0.025	0	0.15
63	URBAN (Perv') 100yr	Pervious	0.025	0	0.2
7	URBAN (IMP)	Impervious	0.015	15	1

The on-site retention of the 1-year-1-hour average recurrence interval event that is a requirement of this drainage and water management plan for developed urban catchments was modelled as 15 mm initial loss applied to impervious surfaces. This value corresponds to the depth of 1-year 1-hour average recurrence interval stormwater event at the Jandakot Airport.

Permanently wet areas within the swamps and the wetlands were modelled as 100 per cent Impervious (fixed runoff coefficient 100%) without any initial losses.

The land use of the existing catchments was determined from the existing cadastre; the *Eastern residential intensification concept* (Town of Kwinana, 2005) provided the land-use breakdown for the ultimate development. Each land use was assigned a runoff coefficient according to the Water Corporation's *Urban main drainage manual*

(Water Corporation, 1998); the coefficients are summarised in Table A3.. The equivalent runoff coefficients, which can be used to convert the Storm Water Management Model (US EPA) routing model coefficients to rational method parameters, are also presented.

Table A3.4 InfoWorks model land-use surface breakdown

Land-use category	Runoff area 1 (percent)	Runoff area 2 (percent)	Equivalent runoff coefficient
Commercial zone	28%	72%	0.80
Community facilities	28%	72%	0.75
EPP wetland	100%	0%	0.40
Home-based business	65%	35%	0.20
Mixed business	28%	72%	0.80
Parks and recreation	100%	0%	0.40
Public open space	100%	0%	0.40
Power lines and multiple use corridors	100%	0%	0.40
Primary regional roads	100%	0%	0.40
Public purposes – prison	28%	72%	0.75
Railway	100%	0%	0.40
Urban	72%	28%	0.20
Roads	20%	80%	0.80
Rural	100%	0%	0.40
Rural – water protection	100%	0%	0.40
Special residential	100%	0%	0.20

The percentage of surface types for individual catchments was calculated from the existing land use and *Eastern residential intensification concept*; the results are summarised in Table A (pre-development scenario) and Table A3. (post-development scenario).

The design rainfall events for the 1-hour, 3-hour, 6-hour, 12-hour, 24-hour, 48-hour and 72-hour durations were run for two-year, 10-year and 100-year average recurrence interval occurrences and were generated from long-term continuous rainfall records. These were then used to design the stormwater drainage infrastructure.

Table A3.5 Existing catchment land-use breakdown and loss model

Land use	Catchment area (ha)	Equivalent (rational method) runoff coefficient
Rural	2290.6	0.40
Rural – water protection	1652.3	0.40
Urban (including balance of public open space)	616.2	0.20
Urban deferred (Including balance of public open space)	6.2	0.20
Parks and recreation	837.4	0.40
Public purposes – Water Corporation	47.7	0.40
Public purposes – prison	99.1	0.20
Public purposes – special uses	45.9	0.40
Primary regional roads	185.4	0.20
Other regional roads	55.7	0.80
Railways	47.6	0.20
Total	5884.1	0.40

Table A3.6 Eastern residential intensification concept catchment land-use breakdown and loss model

Land use	Catchment area (ha)	Equivalent (rational method) runoff coefficient
Home-based business	17	0.20
Multiple use corridors	71	0.40
Community facilities	25	0.75
Conservation category wetlands, environmental protection policy lakes, parks and recreation reservation (inc. proposed).	1125	0.40
Urban (including balance of public open space)	1706	0.20
Rural	2603	0.40
Railway	7	0.40
Power lines	49	0.40
Mixed business/commercial	66	0.80
Roads	214	0.80
Catchment total	5883	0.33

Notes:

The high runoff coefficient for unfilled areas takes into account the high groundwater table of the catchment.

The small increase in total catchment runoff does not reflect the increased flow into drains via subsoil drainage; this has been separately accounted for in the model and represents an increase in regional groundwater levels.

Table A3.7 InfoWorks model catchment properties for predevelopment scenario

Subcatchment ID	Total area (ha)	Vector slope (percent)	Catchment width (m)	Runoff area 1 (ha)	Runoff area 2 (ha)	Fraction impervious
CAT A	23.0	3.5	270	23.0	0	–
CAT B2	3.2	2.5	100	3.2	0	–
CAT B3	2.8	2	90	2.8	0	–
CAT B4	3.5	0.9	100	3.5	0	–
CAT C	7.3	0.4	150	7.4	0	–
CAT11	222.1	2.2	840	222.1	0	–
CAT11_B1	22.7	1	270	19.3	3.4	0.15
CAT11_B2	4.3	1.3	120	3.7	0.6	0.15
CAT11_B5	9.7	1.7	180	8.3	1.5	0.15
CAT11_B6	2.8	2.5	90	2.4	0.4	0.15
CAT11C	107.1	2	580	96.4	10.7	0.10
CAT11D	39.3	3.1	350	39.3	0	–
CAT11E	2.9	4.7	100	2.9	0	–
CAT11F	28.9	0	300	28.9	0	–
CAT12	33.6	1.1	330	33.6	0	–
CAT12A	4.2	1.5	120	4.2	0	–
CAT14	108.9	0.6	590	76.2	32.7	0.30
CAT15	287.7	4	960	201.4	86.3	0.30
CAT16	42.9	0.4	370	42.9	0	–
CAT16A	53.4	0.3	410	53.4	0	–
CAT17	50.0	3.2	370	50.0	0	–
CAT17A	85.2	1.3	440	85.2	0	–
CAT17B	86.2	1.4	400	86.2	0	–
CAT18	50.5	1.1	510	50.5	0	–
CAT18A	81.6	0	320	81.6	0	–
CAT19	97.4	7.5	560	97.4	0	–
CAT20	61.7	1.5	440	61.7	0	–
CAT21	283.0	0.7	820	283.0	0	–
CAT22	195.7	1.6	850	195.7	0	–
CAT23	346.3	0.6	1050	346.3	0	–
CAT_RAIL1	4.1	0.1	110	4.1	0	–
CAT_REW	8.0	0.4	160	8.0	0	–
CATN1	8.9	0.4	170	8.9	0	–

Subcatchment ID	Total area (ha)	Vector slope (percent)	Catchment width (m)	Runoff area 1 (ha)	Runoff area 2 (ha)	Fraction impervious
CATN1A	46.7	0.4	390	46.7	0	–
CATN2	112.2	0.3	560	112.3	0	–
CATN3	9.7	0.3	180	9.7	0	–
CATN3A	40.8	0.4	360	40.9	0	–
CATN4	121.5	1.1	610	121.5	0	–
CATN5	68.5	0.8	490	68.5	0	–
CATN6	32.5	0.7	320	32.5	0	–
CATN6A	21.2	2.8	260	21.2	0	–
CATN6B	6.3	1.9	140	6.3	0	–
CATN6C	10.1	2.7	180	10.1	0	–
CATN6D	5.3	4.4	130	5.3	0	–
CATN7	20.6	2.9	260	20.6	0	–
CATO1	35.1	1.5	330	29.8	5.3	0.15
CATO2	15.8	1	220	13.4	2.4	0.15
CATO2_B1	12.7	1	200	10.8	1.9	0.15
CATO2a	16.9	1.2	230	16.9	0	–
CATO3	25.7	0.6	290	25.7	0	–
CATO3B	7.3	0.9	150	7.3	0	–
CATO4	7.2	1.3	150	7.2	0	–
CATO4A	32.8	1.1	320	32.9	0	–
CATO5	8.8	0.4	170	8.8	0	–
CATO5A	25.6	1.1	290	25.6	0	–
CATO6	171.3	0.2	740	171.3	0	–
CATO6A	13.3	1.2	210	13.3	0	–
CATOB	0.8	1.3	50	0.8	0	–
CATP1	19.4	1.7	250	19.4	0	–
CATP1A	22.6	0.9	270	22.6	0	–
CATP2	74.7	0.4	490	74.7	0	–
CATP2A	14.9	0.6	220	14.9	0	–
CATP3	29.6	0.3	310	29.6	0	–
CATP3A	32.7	1.4	320	32.7	0	–
CATP3B	75.6	0.7	490	75.6	0	–
CATP3C	48.4	0.5	390	48.4	0	–
CATP4	52.4	0.8	410	52.4	0	–
CATP4A	60.5	1.9	440	60.5	0	–

Subcatchment ID	Total area (ha)	Vector slope (percent)	Catchment width (m)	Runoff area 1 (ha)	Runoff area 2 (ha)	Fraction impervious
CATP5	168.2	0.8	920	168.2	0	–
CATP6	108.0	0.3	810	108.0	0	–
CATP6A	112.7	0.3	570	101.4	11.3	0.10
CATP6B	82.8	0.7	530	82.8	0	–
CATP7	70.6	0.6	470	70.6	0	–
CATP7A	17.7	1.8	240	17.7	0	–
CATP8	51.2	0.7	400	51.2	0	–
CATR1A	131.2	0.8	650	131.2	0	–
CATR1B	53.8	2.3	410	53.8	0	–
CATR1C	9.5	2.5	170	9.5	0	–
CATR1D	24.9	2.3	280	24.9	0	–
CATW1	13.8	0.7	210	13.8	0	–
CATW2	10.1	0.1	180	10.1	0	–
CATW3	12.1	1.2	200	12.1	0	–
CATW4	9.3	1.2	170	9.3	0	–
CATW5	6.0	0.4	140	6.1	0	–
CATW6	8.5	0.8	160	8.5	0	–
CATX10	27.8	0.3	300	27.8	0	–
CATX5	34.3	0.7	330	34.3	0	–
CATX6	27.2	0.4	290	27.2	0	–
CATX7	27.0	0.7	290	27.0	0	–
CATX8	21.5	0.9	260	21.5	0	–
CATX9	27.5	0.6	300	27.5	0	–

Table A3.8 InfoWorks model catchment properties for post-development scenario

Subcatchment ID	Total area (ha)	Vector slope (percent)	Catchment width (m)	Runoff area 1 (ha)	Runoff area 2 (ha)	Fraction impervious
CAT A	23.0	3.5	270	16.5	6.4	0.28
CAT B2	3.2	2.5	100	2.3	0.9	0.28
CAT B3	2.8	2	90	2.0	0.8	0.28
CAT B4	3.5	0.9	100	2.5	1.0	0.28
CAT C	7.3	0.4	150	5.3	2.1	0.28
CAT11	222.1	2.2	840	222.1	0.0	–
CAT11_B1	22.7	1	270	15.4	7.3	0.32
CAT11_B2	4.3	1.3	120	2.8	1.5	0.34

Subcatchment ID	Total area (ha)	Vector slope (percent)	Catchment width (m)	Runoff area 1 (ha)	Runoff area 2 (ha)	Fraction impervious
CAT11_B5	9.7	1.7	180	6.8	2.9	0.30
CAT11_B6	2.8	2.5	90	2.0	0.8	0.28
CAT11C	107.1	2	580	96.4	10.7	0.10
CAT11D	39.3	3.1	350	27.5	11.8	0.30
CAT11E	2.9	4.7	100	2.1	0.8	0.29
CAT11F	28.9	0	300	28.9	0.0	–
CAT12	33.6	1.1	330	33.6	0.0	–
CAT12A	4.2	1.5	120	4.2	0.0	–
CAT14	108.9	0.6	590	76.2	32.7	0.30
CAT15	287.7	4	960	201.4	86.3	0.30
CAT16	42.9	0.4	370	42.9	0.0	–
CAT16A	53.4	0.3	410	36.9	16.6	0.31
CAT17	50.0	3.2	370	38.5	11.5	0.23
CAT17A	85.2	1.3	440	76.7	8.5	0.10
CAT17B	86.2	1.4	400	76.7	8.5	0.10
CAT18	50.5	1.1	510	44.4	6.1	0.12
CAT18A	81.6	0	320	71.8	9.8	0.12
CAT19	97.4	7.5	560	77.0	20.5	0.21
CAT20	61.7	1.5	440	52.4	9.3	0.15
CAT21	283.0	0.7	820	283.0	0.0	–
CAT22	195.7	1.6	850	195.7	0.0	–
CAT23	346.3	0.6	1050	346.3	0.0	–
CAT_RAIL1	4.1	0.1	110	3.0	1.2	0.28
CAT_REW	8.0	0.4	160	8.0	0.0	–
CATN1	8.9	0.4	170	8.9	0.0	–
CATN1A	46.7	0.4	390	32.2	14.5	0.31
CATN2	112.2	0.3	560	112.3	0.0	–
CATN3	9.7	0.3	180	9.7	0.0	–
CATN3A	40.8	0.4	360	30.2	10.6	0.26
CATN4	121.5	1.1	610	121.5	0.0	–
CATN5	68.5	0.8	490	68.5	0.0	–
CATN6	32.5	0.7	320	32.5	0.0	–
CATN6A	21.2	2.8	260	17.4	3.8	0.18
CATN6B	6.3	1.9	140	5.1	1.2	0.19
CATN6C	10.1	2.7	180	7.4	2.7	0.27

Subcatchment ID	Total area (ha)	Vector slope (percent)	Catchment width (m)	Runoff area 1 (ha)	Runoff area 2 (ha)	Fraction impervious
CATN6D	5.3	4.4	130	5.3	0.0	–
CATN7	20.6	2.9	260	14.0	6.6	0.32
CATO1	35.1	1.5	330	25.3	9.8	0.28
CATO2	15.8	1	220	11.4	4.4	0.28
CATO2_B1	12.7	1	200	9.1	3.6	0.28
CATO2a	16.9	1.2	230	12.2	4.7	0.28
CATO3	25.7	0.6	290	24.4	1.3	0.05
CATO3B	7.3	0.9	150	5.4	1.9	0.26
CATO4	7.2	1.3	150	7.2	0.0	–
CATO4A	32.8	1.1	320	22.7	10.2	0.31
CATO5	8.8	0.4	170	8.8	0.0	–
CATO5A	25.6	1.1	290	19.0	6.7	0.26
CATO6	171.3	0.2	740	171.3	0.0	–
CATO6A	13.3	1.2	210	9.9	3.5	0.26
CATOB	0.8	1.3	50	0.6	0.2	0.28
CATP1	19.3	1.7	250	19.3	0.0	–
CATP1A	22.6	0.9	270	16.3	6.3	0.28
CATP2	74.7	0.4	490	42.6	32.1	0.43
CATP2A	14.9	0.6	220	14.9	0.0	–
CATP3	29.6	0.3	310	21.9	7.7	0.26
CATP3A	32.7	1.4	320	32.7	0.0	–
CATP3B	75.6	0.7	490	75.6	0.0	–
CATP3C	48.4	0.5	390	48.4	0.0	–
CATP4	52.4	0.8	410	52.4	0.0	–
CATP4A	60.5	1.9	440	46.0	14.5	0.24
CATP5	168.2	0.8	920	168.2	0.0	–
CATP6	108.0	0.3	810	108.0	0.0	–
CATP6A	112.7	0.3	570	101.4	11.3	0.10
CATP6B	82.8	0.7	530	82.8	0.0	–
CATP7	70.6	0.6	470	70.6	0.0	–
CATP7A	17.7	1.8	240	13.0	4.8	0.27
CATP8	51.2	0.7	400	32.2	18.9	0.37
CATR1A	131.2	0.8	650	99.7	31.5	0.24
CATR1b	53.8	2.3	410	28.0	25.8	0.48
CATR1C	9.5	2.5	170	9.5	0.0	–

Subcatchment ID	Total area (ha)	Vector slope (percent)	Catchment width (m)	Runoff area 1 (ha)	Runoff area 2 (ha)	Fraction impervious
CATR1D	24.9	2.3	280	24.9	0.0	–
CATW1	13.8	0.7	210	10.2	3.6	0.26
CATW2	10.1	0.1	180	7.2	2.8	0.28
CATW3	12.1	1.2	200	9.1	3.0	0.25
CATW4	9.3	1.2	170	6.7	2.6	0.28
CATW5	6.0	0.4	140	4.2	1.8	0.30
CATW6	8.5	0.8	160	6.6	1.9	0.22
CATX10	27.8	0.3	300	27.8	0.0	–
CATX5	34.3	0.7	330	34.3	0.0	–
CATX6	27.2	0.4	290	27.2	0.0	–
CATX7	27.0	0.7	290	27.0	0.0	–
CATX8	21.5	0.9	260	21.5	0.0	–
CATX9	27.5	0.6	300	27.5	0.0	–

A.4 Model calibration

The pre-development model was calibrated to the Hope Valley Road flow gauging station data (Figure 4.1 in Appendix B). The station is located on the Peel main drain just upstream of Anketell Road culverts. During the winter months the baseflow averaged 90 L/s, which in the model was achieved by specifying a constant groundwater water level at Mandogalup Swamp north and Peel R sub drain. In the model, the peak flows for a critical 100-year average recurrence interval storm event averaged 1.47 m^3/s. The peak flow measured at the gauge station in June 2000 was 1.34 m^3/s and was estimated to the 80-year average recurrence interval occurrence storm.

A.5 Local arterial drainage — conceptual design

Local arterial drainage conceptual designs are presented in Figures 7.1 to 7.3.

The local arterial drainage designs presented in this drainage and water management plan for individual precincts are conceptual designs only. While they may be developed directly into detailed designs, the Department of Water prefers that they be used to provide an initial set of drainage characteristics for a development from which drainage designs following water sensitive urban design principles are developed.

Conceptual designs include:

- proposed arterial drainage alignments, designed to provide optimum performance for the subcatchment
- detention basins, designed to compensate the 100-year average recurrence interval event to not exceed its pre-development peak flow.

The conceptual design of a dry basin is presented in Figure 6.1. Imported fill will be required in some locations to ensure that residential lots are constructed with a finished floor level at a minimum of 500 mm above the 100-year flood level, both in the drain and within the basin.

The Department of Water does not generally support the construction of wet basins, ornamental lakes, irrigation lakes or open water bodies. Further information on this may be found in *Interim position statement: constructed lakes* (Department of Water, 2007).

The Department of Water preference is for shallow flood storage areas rather than detention basins, and prefers them to be off-line rather than on-line.

A.5.1 Town of Kwinana—Peel main drain north of Anketell Road

Figure 7.1 shows the layout of the proposed drainage network and the locations of planned compensating basins in Mandogalup and sub R drain catchment.

With the development of Peel main drain catchment, in particular around the Mandogalup Swamp, the drainage design must be such that the additional runoff due to urban development is compensated and flows are maintained at pre-development levels.

Banjup Swamp to Anketell Road crossing

To compensate catchments in the Mandogalup area, the following local compensating basins were proposed.

Detention basin		Lyon Road compensating basin	Norkett Road compensating basin	Mandogalup west compensating basin
100y peak discharge	m^3/s	0.07	0.10	0.30
100y peak downstream tailwater	m	20.7	17.3	13.5
Catchment area	ha	61.7	97.4	81.4
100y surface area	ha	2.7	4.8	2.8

Detention basin		Mandogalup east compensating basin	Hoffman Road compensating basin
100y peak discharge	m^3/s	0.16	0.16
100y peak downstream tailwater	m	13.5	13.5
Catchment area	ha	61.0	42.6
100y surface area	ha	2.1	1.5

Peel Sub R drain catchment

Detention basin		Anketell Road compensating basin	Darling Chase compensating basin
100y peak discharge	m^3/s	0.07	0.14
100y peak downstream tailwater	m	13.5	13.5
Catchment area	ha	53.8	131.2
100y surface area	ha	4.4	6.6

Peel Sub Q drain catchment

Detention basin		Clementi Road compensating basin
100y peak discharge	m^3/s	0.05
100y peak downstream tailwater	m	12.1
Catchment area	ha	53.4
100y surface area	ha	3.7

A.5.2 Town of Kwinana—Peel sub P drain catchment

Figure 7.2 provides details of compensating basins proposed within Peel sub P drain catchment as well as showing proposed arterial drainage routes that, in general, follow the routes of existing drains.

Generally, the design of this area ensures that post-development flows are similar to pre-development flows and the wetlands are not affected by the proposed development.

With the development of Peel sub P drain catchment, the drainage design must be such that flows into Peel main drain are maintained at pre-development levels.

Modelling indicates that in the existing system, the Peel P sub drain overtops during minor storm events to flood areas upstream of Thomas Road and the Kwinana Freeway culverts. In the post-development scenario, this regional storage is no longer available. However, modelling of the post-development system has shown that this will have little impact on the performance of the downstream main drainage system. Additionally, the 1500 mm culvert under the Kwinana Freeway can be choked off to limit the discharge into the Peel main drain to pre-development levels.

Peel Sub P1 and P1A drain catchment

Detention basin		Landgren Road north compensating basin	Landgren Road south compensating basin	Orton Road compensating basin
100y peak discharge	m^3/s	0.14	0.02	0.20
100y peak downstream tailwater	m	16.4	16.3	14.6
Catchment area	ha	51.2	17.7	74.7
100y surface area	ha	3.7	1.1	6.4

A.5.3 Town of Kwinana—Peel sub O drain and Peel sub N drain catchments

Peel sub O drain catchment

Figure 7.3 provides details of compensating basins proposed within Peel sub O drain catchment, as well as showing proposed arterial drainage routes that, in general, follow the routes of existing drains. Generally, the design of this area ensures that post-development flows are similar to pre-development flows.

Detention basin		Nicolas Road compensating basin	Lugg Road north compensating basin	Lugg Road south compensating basin
100y peak discharge	m^3/s	0.02	0.03	0.04
100y peak downstream tailwater	m	17.9	15.9	13.8
Catchment area	ha	13.3	25.6	32.8
100y surface area	ha	0.7	1.4	2.0
Detention basin		**Johnson Road east compensating basin**	**Johnson Road north compensating basin**	**Centennial Avenue compensating basin**
100y peak discharge	m^3/s	0.03	0.01	0.82 (online)
100y peak downstream tailwater	m	11.9	0.0	11.0
Catchment area	ha	25.7	7.3	29.2
100y surface area	ha	1.2	0.6	1.6

Peel Sub N drain catchment

The proposed arterial drainage routes and compensating basin details for Peel sub N drain are shown in Figure 7.3.

There is currently some uncertainty regarding the existing hydrological regime of the Mortimer Road wetland and control levels will need to be set ensuring that any change between the pre- and post-development 100-year average recurrence interval levels are acceptable to the relevant environmental regulators.

Detention basin		Wake Way north compensating basin	Wake Way south compensating basin	Millar Road north compensating basin
100y peak discharge	m^3/s	0.04	0.09	0.13
100y peak downstream tailwater	m	10.2	9.9	8.2
Catchment area	ha	20.6	21.2	40.8
100y surface area	ha	1.2	0.4	1.4
Detention basin		**Millar Road south compensating basin**	**Millar Road west compensating basin**	**Wellard Road compensating basin**
100y peak discharge	m^3/s	0.13	0.02	0.09
100y peak downstream tailwater	m	8.1	8.1	5.6
Catchment area	ha	46.7	2.9	39.3
100y surface area	ha	2.1	0.1	1.8
Detention basin		**Millar Road south compensating basin**	**Millar Road west compensating basin**	**Wellard Road compensating basin**
100y peak discharge	m^3/s	0.13	0.02	0.09
100y peak downstream tailwater	m	8.1	8.1	5.6
Catchment area	ha	46.7	2.9	39.3
100y surface area	ha	2.1	0.1	1.8

Generally, the design of this area ensures that post-development flows are similar to pre-development flows. At the time of writing, the design of this area remains subject to investigation but, in general, will ensure that post-development flows are not exceeding the pre-development flows.

A.5.4 Town of Kwinana—Bertram north and Wellard subdivisions

Bertram north subdivision

A conceptual design for the drainage in Bertram north has been prepared by consultants (Cossill and Webley) working on behalf of developers. The drainage, as designed by the consultants, has been incorporated into the InfoWorks model.

Total catchment area	= 51.9 ha
Estimated pre-development 100-year peak discharge	= 0.2 m^3/s
Estimated 100-year tailwater condition	= 7.8 m AHD

In designs submitted by the developers, stormwater runoff for events exceeding the 10-year average recurrence interval runs over roads and into the swales, which then overtop into the adjacent resource enhancement wetland. This wetland is then connected to the Peel main drain via a 375 mm pipe. In the future this connection should be retained and flows into Peel main drain should not exceed the pre-development flows.

Details of the allowable discharge from the Bertram Swamp resource enhancement wetland into the Peel main drain are provided in the table below and in Figure 7.3.

Detention basin		Bertram Swamp
100y peak discharge	m^3/s	0.14
100y peak downstream tailwater	m	8.31
Catchment area	ha	8.0
100y surface area	ha	3.2

Wellard subdivision

A conceptual design for the drainage in the Wellard subdivision has been prepared by consultants (Cardno BSD) working on behalf of developers. The drainage, as designed by the consultants, has been incorporated into the InfoWorks model. Figure 7.3 shows the layout of the proposed drainage network and the locations of planned compensating basins.

Total catchment area	= 59.8 ha
Estimated pre-development 100-year peak discharge	= 0.3 m^3/s
Estimated 100-year tailwater condition	= 7.9 m AHD

Detention basin		Wellard 1 compensating basin	Bollard Bulrush Swamp	Wellard 3 compensating basin
100y peak discharge	m^3/s	0.06	0.02	0.05
100y peak downstream tailwater	m	8.1	8.1	8.1
Catchment area	ha	13.8	10.1	12.1
100y surface area	ha	0.6	0.4	0.4

Detention basin		Wellard 4 compensating basin	Wellard 5 compensating basin	Wellard 6 compensating basin
100y peak discharge	m^3/s	0.04	0.03	0.04
100y peak downstream tailwater	m	8.1	8.1	7.9
Catchment area	ha	9.3	6.0	8.5
100y surface area	ha	0.4	0.3	0.4

Currently part of the catchment drains into Bollard Bulrush Swamp. Following development, the discharge from the subdivision to Peel sub N drain should not exceed 0.3 m^3/s. In the preliminary design submitted by the developer, the stormwater runoff for events exceeding the 10-year average recurrence interval runs over the roads into swales, which then overtop into a regional basin at the bottom of the catchment.

It is essential that the building conditions for these two sites stipulate on site detention of all flows up to and including the critical 100-year average recurrence interval event.

Appendix B — Figures

AUTHOR: SLee   DESIGN FILE: Figure_2.1_LocalityMap.dgn

PROJECT N°: 6116977   DATE: 26/06/2008   COORDINATE SYSTEM: MGA94 - Zone 50

WATER CORPORATION

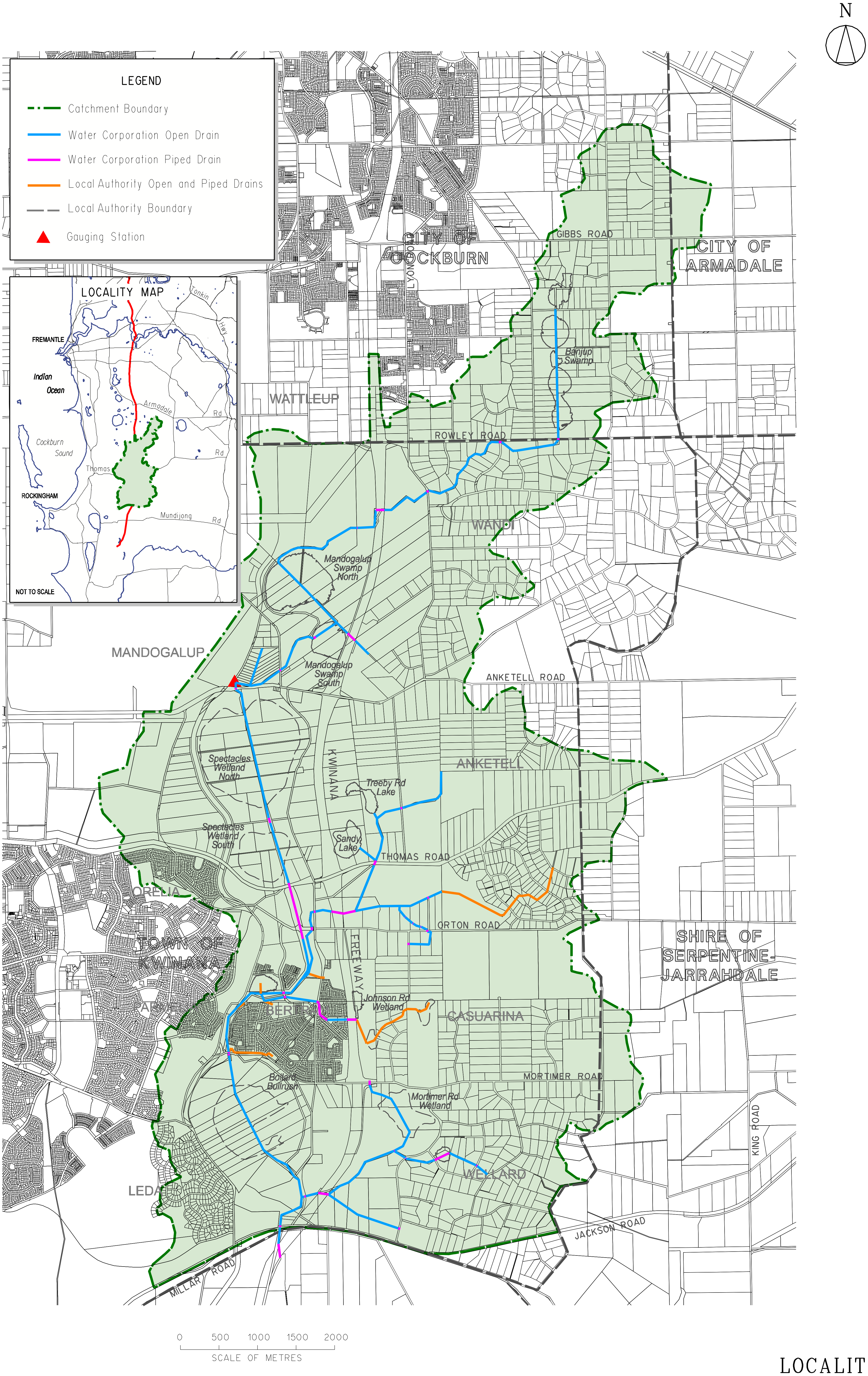

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Figure 2.1

LOCALITY

AUTHOR: SLee DESIGN FILE: Figure_2.2_TopographyGeology.dgn

PROJECT Nº: 6116977 DATE: 26/06/2008 COORDINATE SYSTEM: MGA94 - Zone 50

WATER CORPORATION

N

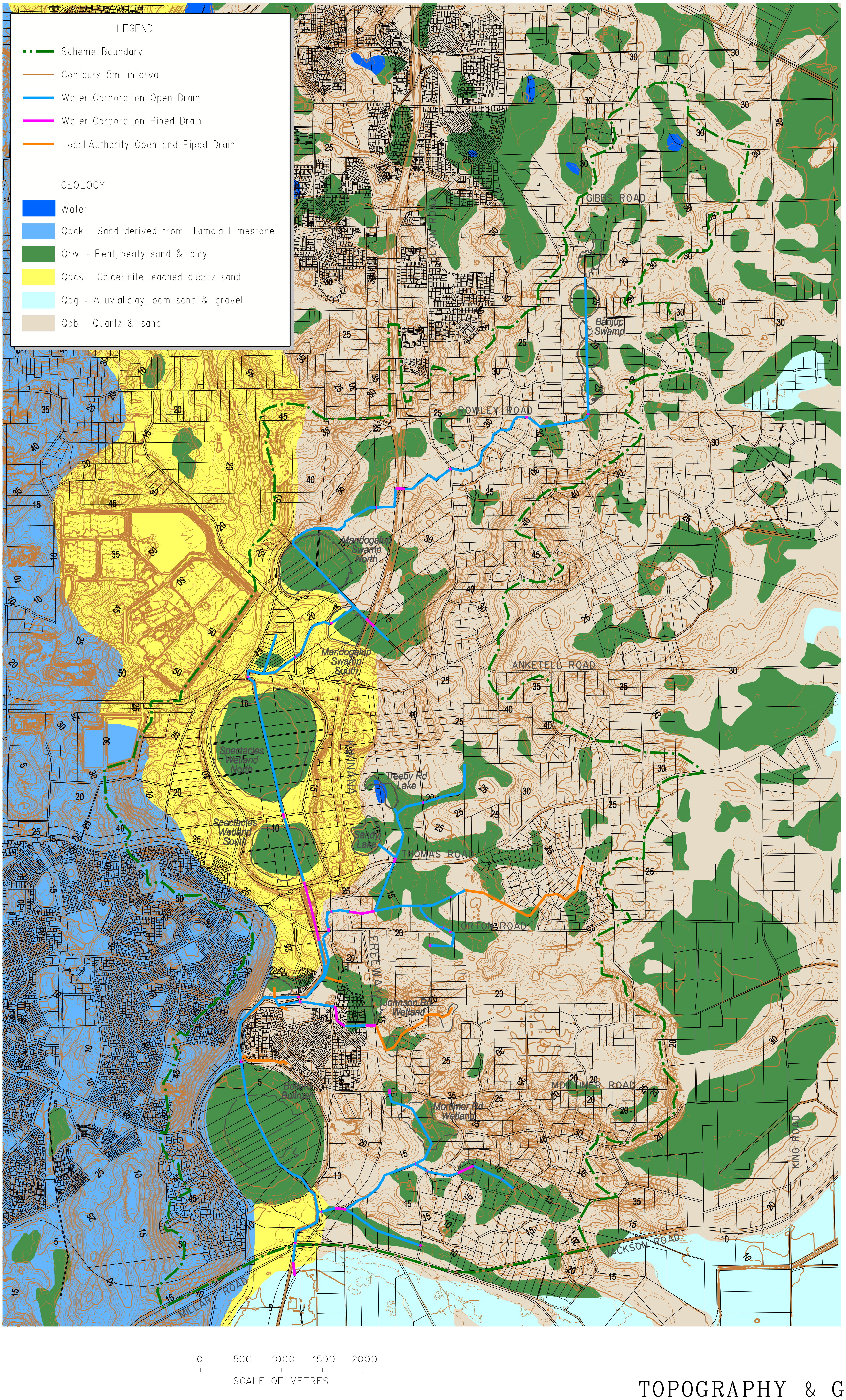

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Figure 2.2

TOPOGRAPHY & GEOLOGY

AUTHOR: SLee DESIGN FILE: Figure 2.3 AcidSulphateSoils.dgn

PROJECT N°:6116977 DATE: 26/06/2008 COORDINATE SYSTEM: MGA94 - Zone 50

WATER CORPORATION

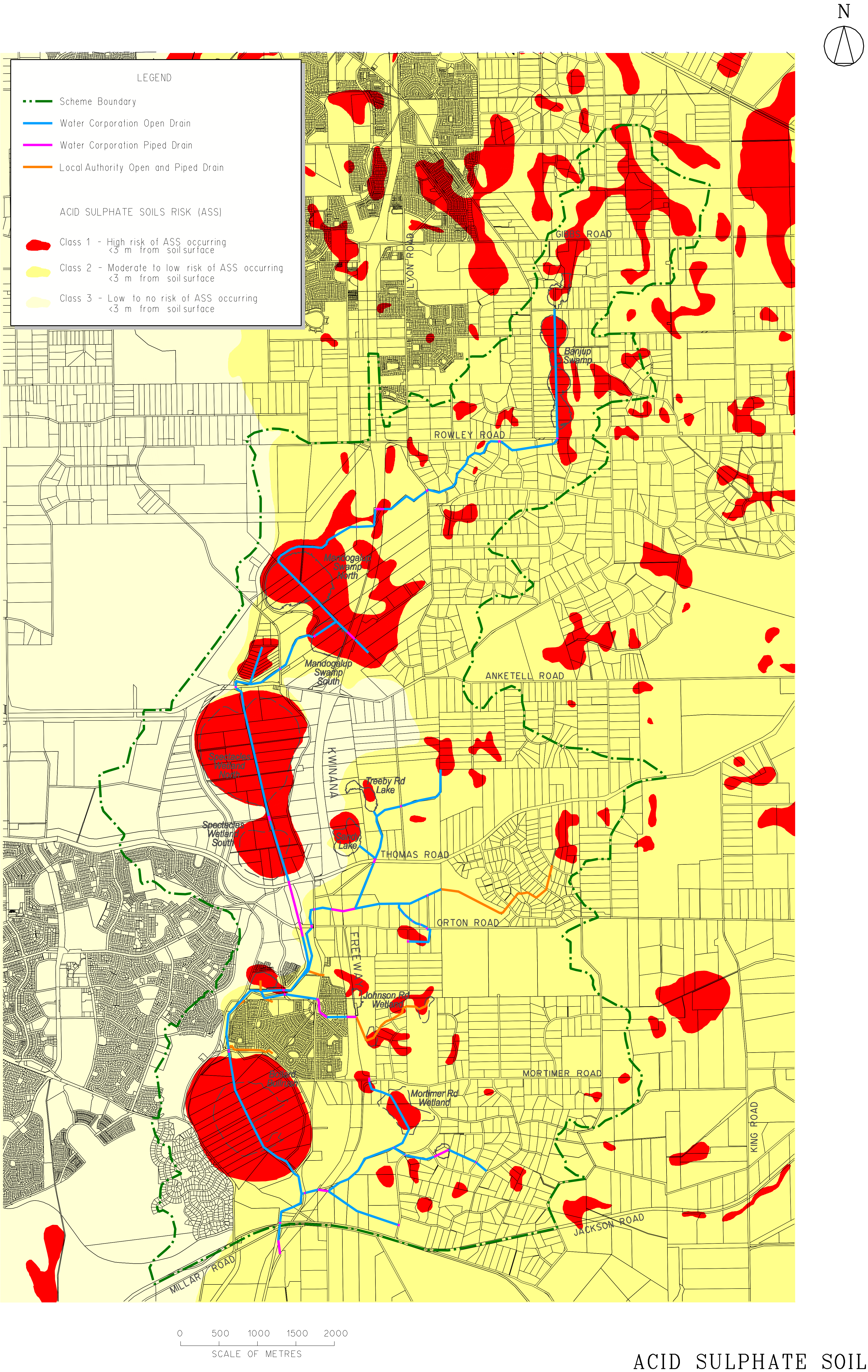

Figure 2.3

ACID SULPHATE SOILS

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AUTHOR: SLee DESIGN FILE: Figure_2.4_ExistingLandUse.dgn

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PROJECT N°: 6116977 DATE: 26/06/2008 COORDINATE SYSTEM: MGA94 - Zone 50

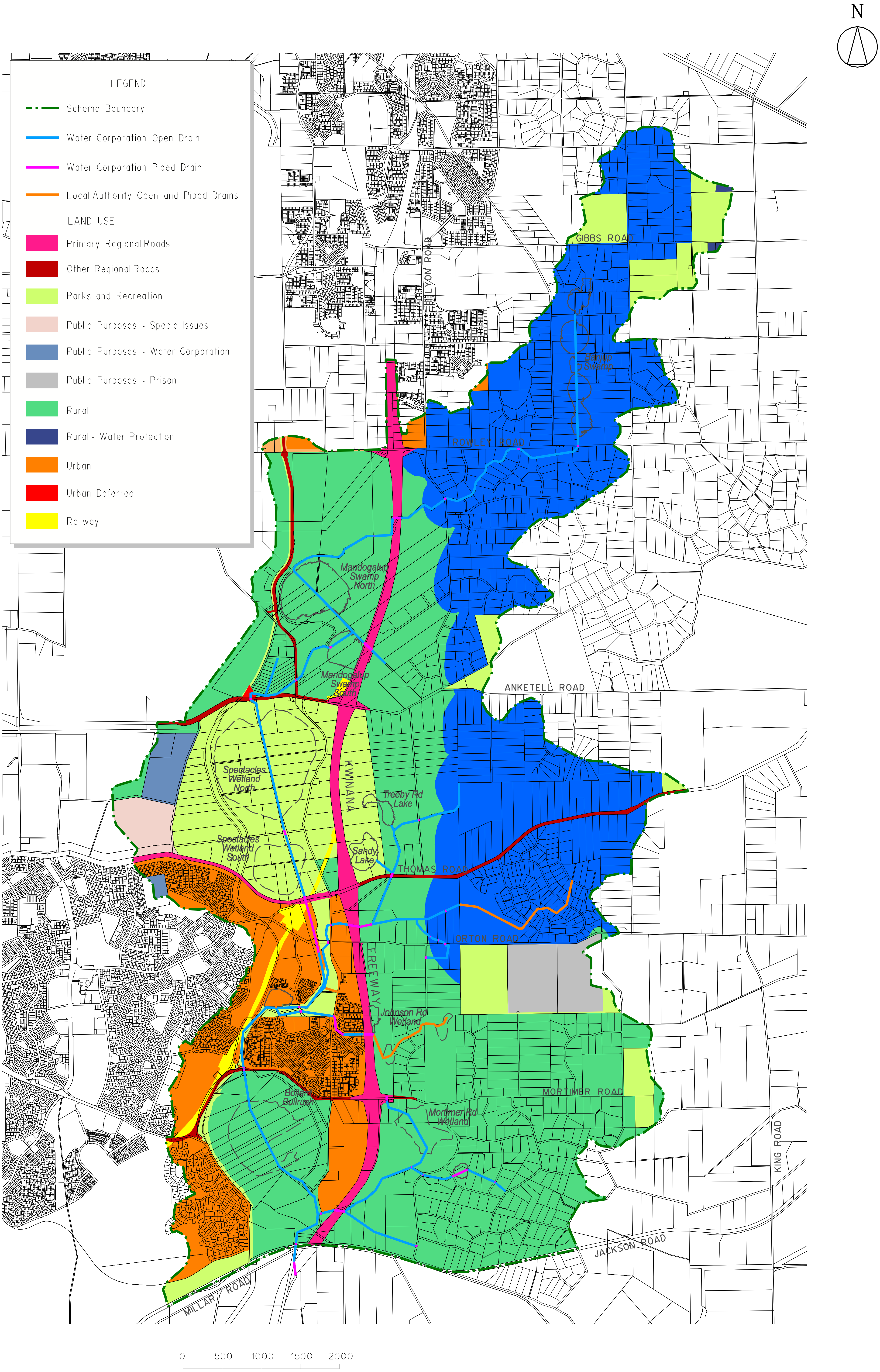

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Figure 2.4

EXISTING LAND USE

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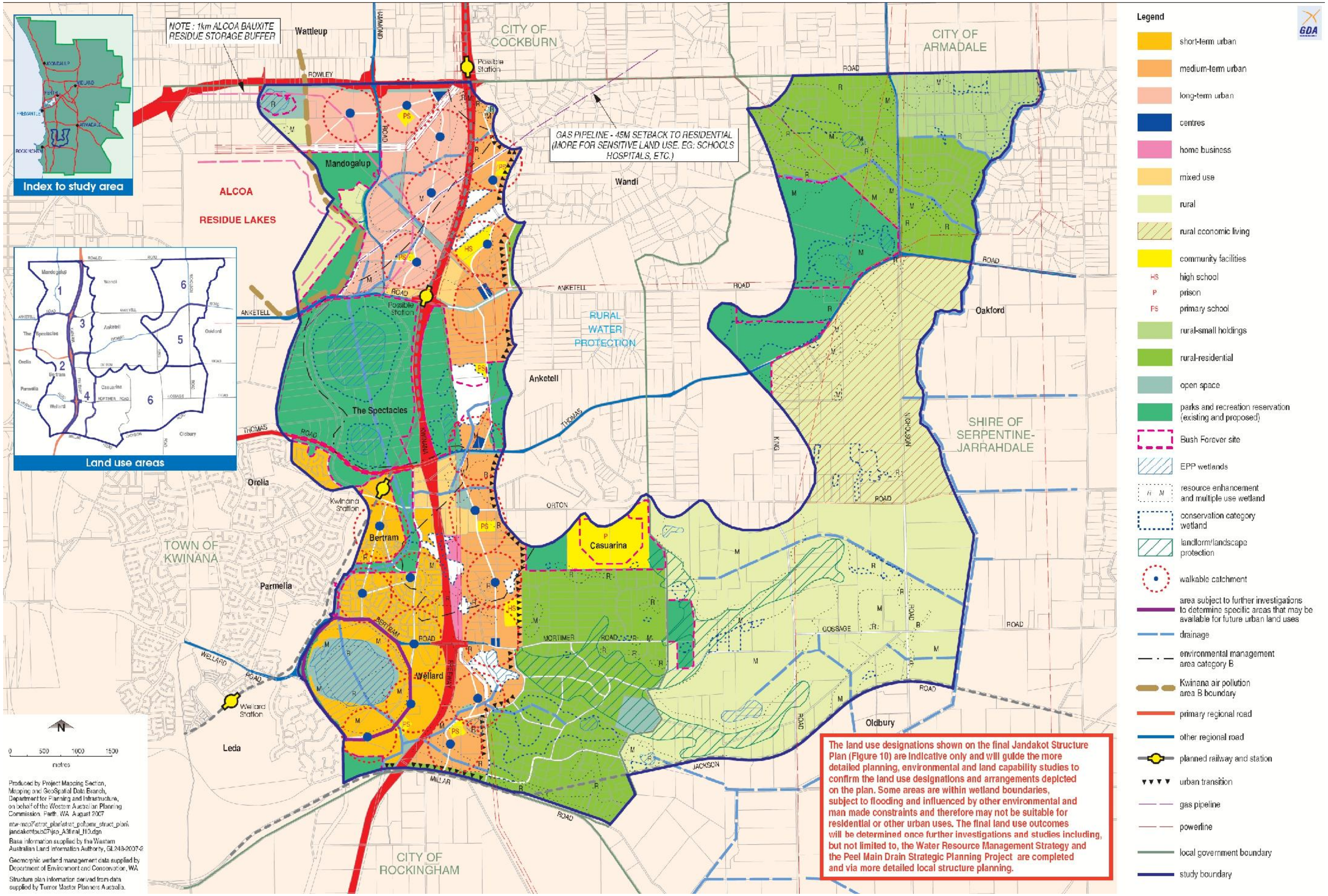

Image Source: Figure 9, Final Structure Plan, Jandakot Structure Plan Final Report / August 2007 (WA Planning Commission) page 55

DESIGN FILE: Figure 2.5a JandakotStructurePlan.dgn

AUTHOR: SLee

WATER CORPORATION

PROJECT N°: 6116977 DATE: 26/06/2008

JANDAKOT DISTRICT STRUCTURE PLAN

Proposed Land Use

Figure 2.5a

AUTHOR: SLee DESIGN FILE: Figure 2.5b ERICStructurePlan.dgn

PROJECT Nº: 6116977 DATE: 26/06/2008 COORDINATE SYSTEM: MGA94 - Zone 50

WATER CORPORATION

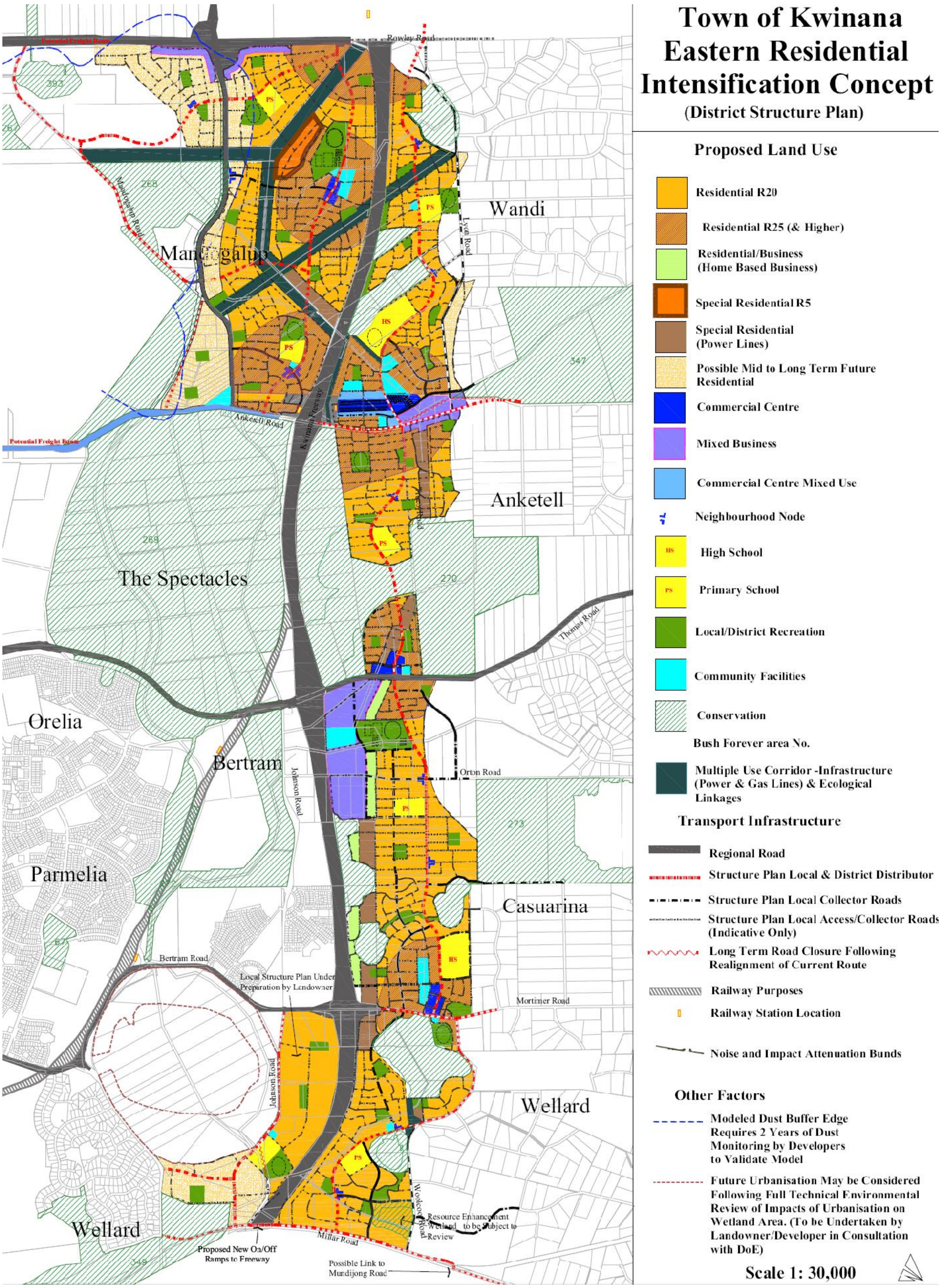

Image Source: Plan 24, District Structure Plan (Eastern Residential Intensification Concept), Town of Kwinana Draft District Structure Plan, page 81

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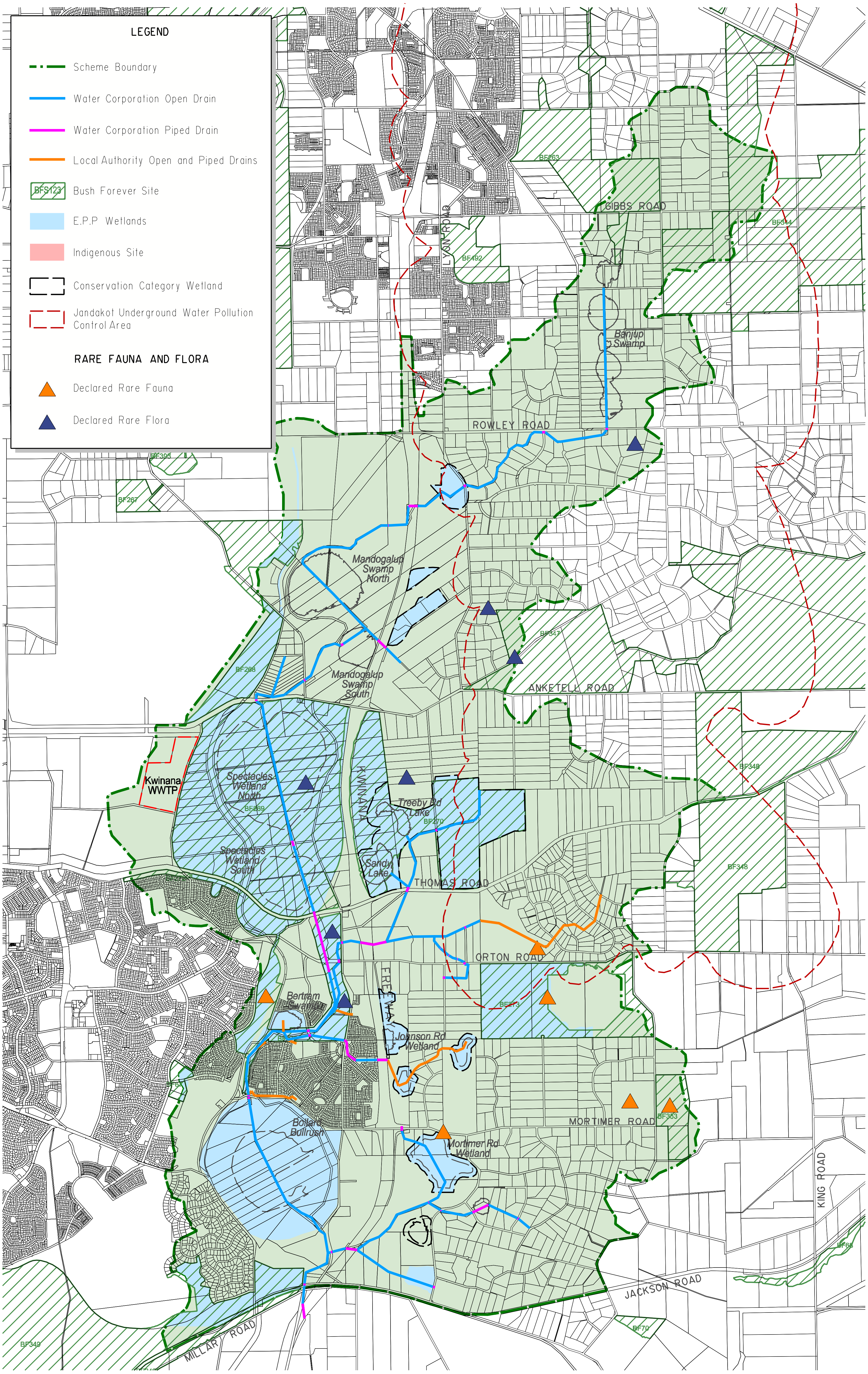
Figure 2.5b

ERIC STRUCTURE PLAN
Proposed Land Use

AUTHOR: SLee DESIGN FILE: Figure_2.6_EnvironmentalSocial.dgn

PROJECT N°: 6119723 DATE: 06/08/2009 COORDINATE SYSTEM: MGA94 - Zone 50

N



0 500 1000 1500 2000

SCALE OF METRES

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Figure 2.6

ENVIRONMENTAL AND SOCIAL CONSIDERATIONS

AUTHOR: SLee DESIGN FILE: Figure_3.1_Pre_Dev_AAMGL.dgn

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PROJECT N°: 6116977 DATE: 15/10/2009 COORDINATE SYSTEM: MGA94 - Zone 50

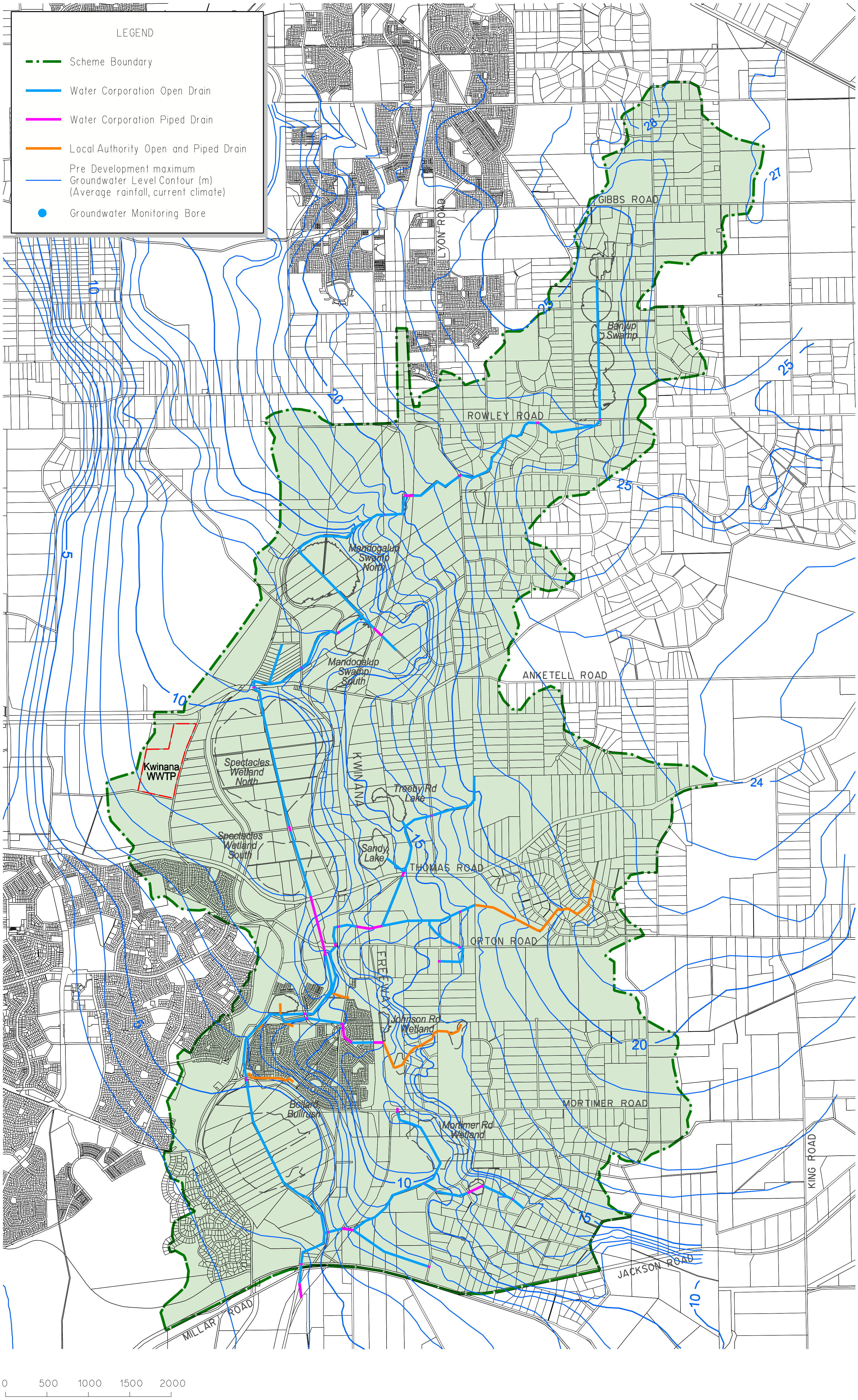

Figure 3.1

MODELLED CURRENT CLIMATE MAXIMUM GROUNDWATER LEVEL

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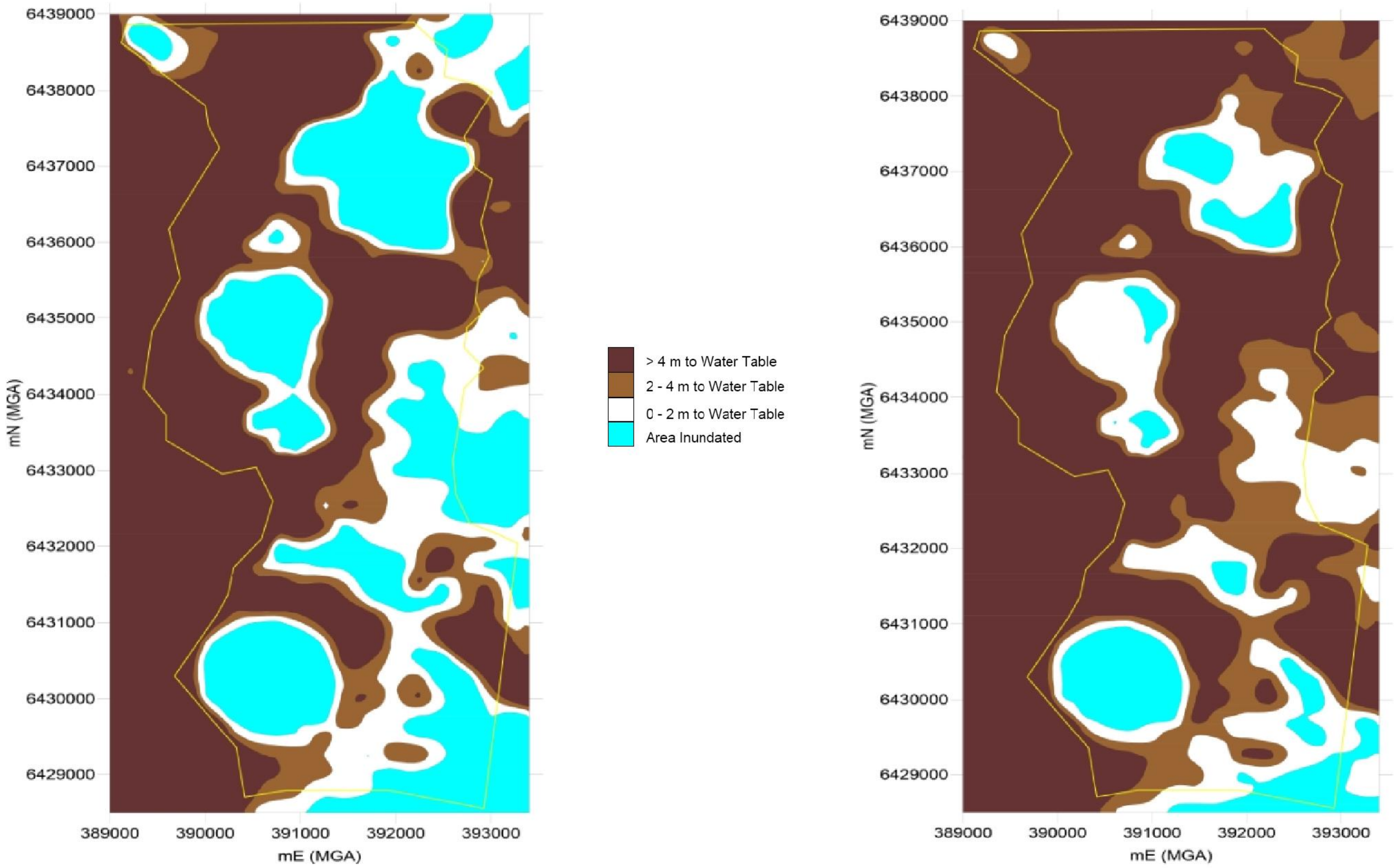

Very Wet (1929)

Image Source: Figure 25, Report "Groundwater Modelling To Assess Effects Of Climatic Variations, And Planned Urban Development July 2006", Water Corporation

Very Dry (2020)

Image Source: Figure 23, Report "Groundwater Modelling To Assess Effects Of Climatic Variations, And Planned Urban Development July 2006", Water Corporation

DESIGN FILE: Figure 3.2 DepthToGroundwater.dgn

AUTHOR: SLee

WATER CORPORATION

MODEL-CALCULATED DEPTH TO GROUNDWATER (ROCKWATER)

For a Very Wet (1929) and Very Dry (2020) Cycles

Figure 3.2

PROJECT N°: 6116977 DATE: 26/06/2008

AUTHOR: SLee DESIGN FILE: Figure_4.1_ExistingSystem.dgn

PROJECT N°: 6116977 DATE: 26/06/2008 COORDINATE SYSTEM: MGA94 - Zone 50

WATER CORPORATION

N

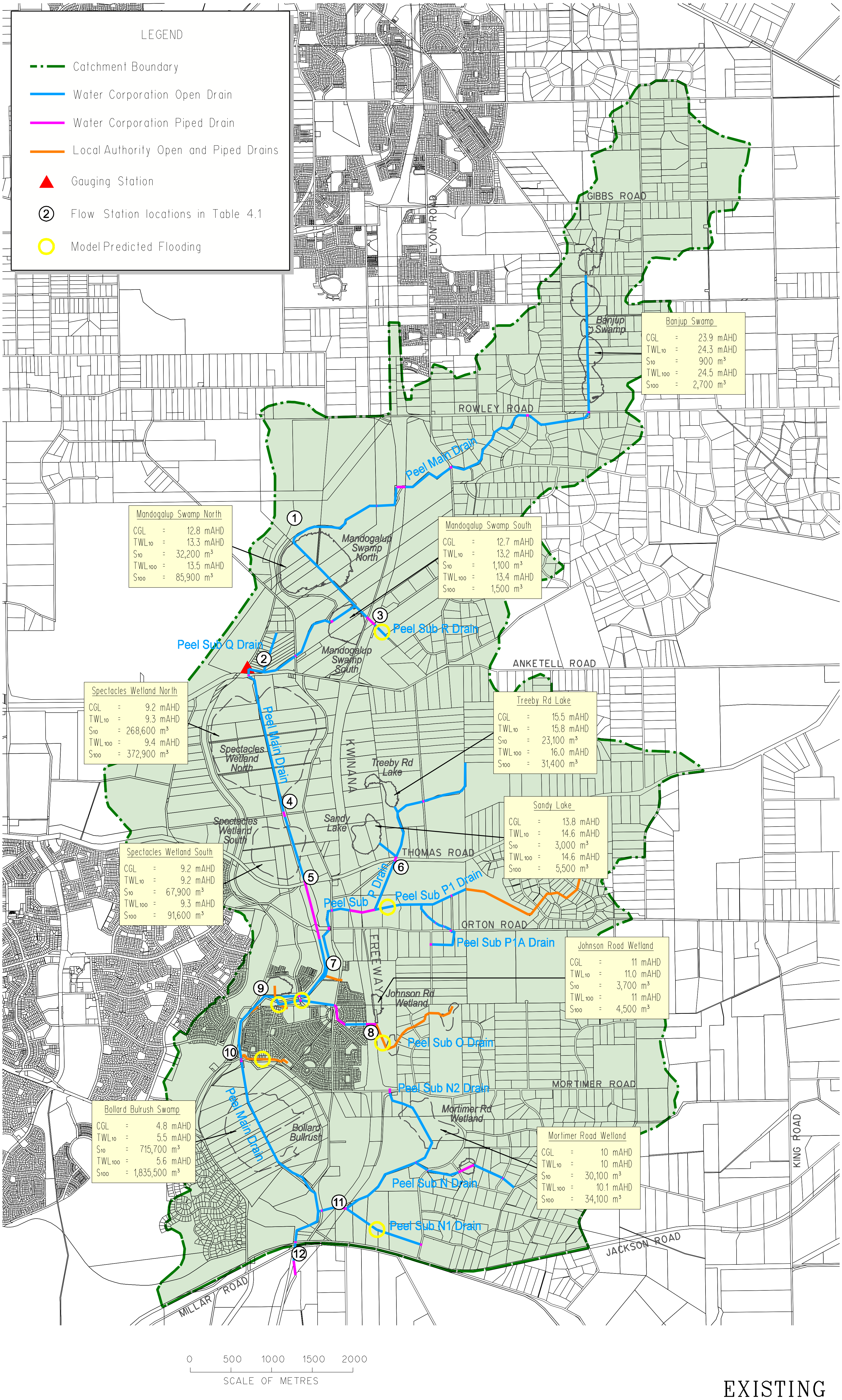

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Figure 4.1

EXISTING SYSTEM

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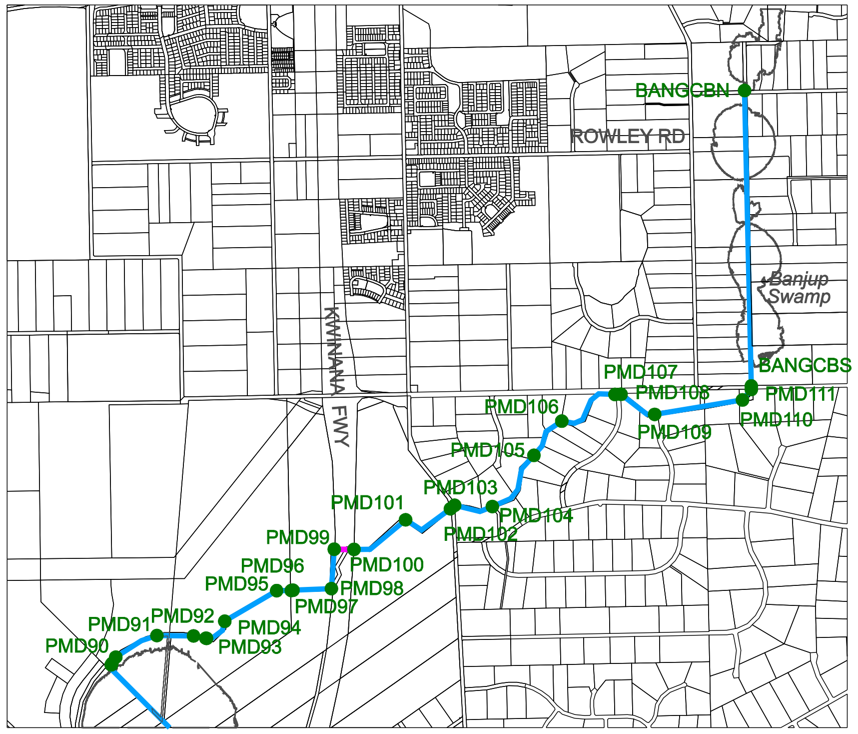
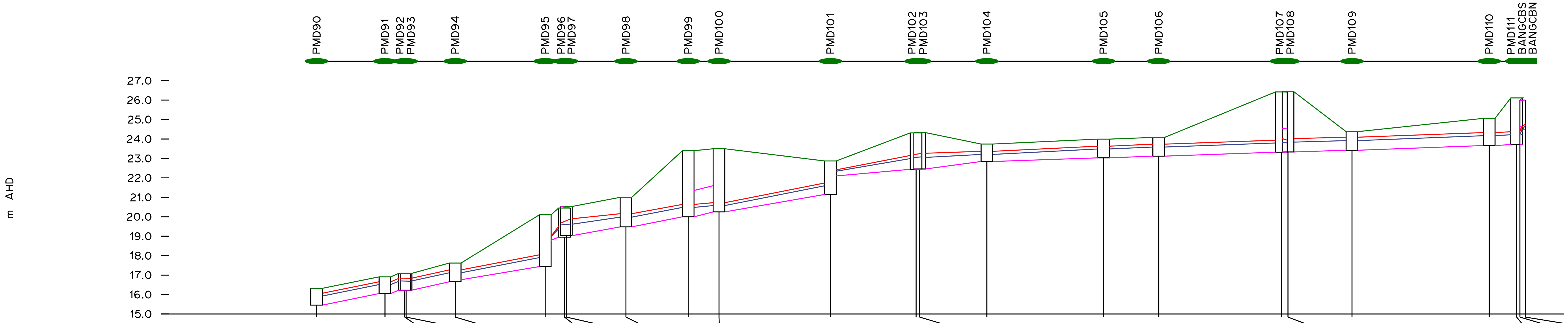
N





Chainage (m)	Ground level (m AHD)	10 year ARI HGL level (m AHD)	100 year ARI HGL level (m AHD)	Invert level (m AHD)
0	16.32	16.01	16.16	- / 15.46
249	16.91	16.59	16.75	16.05 / 16.05
321	17.09	16.77	16.92	16.23 / 16.23
326	17.09	16.78	16.98	16.23 / 16.23
505	17.62	17.20	17.36	16.66 / 16.76
833	20.10	19.11	19.22	17.44 / 18.79
903	20.45	19.45	19.59	18.95 / 18.95
910	20.53	19.80	20.05	19.03 / 19.03
1127	21.00	20.08	20.28	19.48 / 19.48
1354	23.40	20.56	20.74	20.00 / 20.00
1466	23.50	20.65	20.83	20.25 / 20.25
1872	22.87	22.44	22.55	21.15 / 22.10
2184	24.31	23.08	23.26	22.44 / 22.44
2197	24.33	23.17	23.42	22.46 / 22.46
2442	23.74	23.29	23.49	22.84 / 22.84
2867	23.99	23.57	23.73	23.03 / 23.03
3068	24.08	23.67	23.82	23.12 / 23.12
3515	26.42	23.88	24.03	23.32 / 23.32
3539	26.43	23.94	24.13	23.33 / 23.33
3772	24.38	24.01	24.20	23.42 / 23.42
4272	25.06	24.26	24.42	23.66 / 23.66
4372	26.11	24.31	24.46	23.71 / 23.71
4384	26.00	24.39	24.61	23.72 / 24.49
4404	26.00	24.75	24.84	24.50 / -

Size (mm)	Max 10 year ARI flow (m3/s)	Max 100 year ARI flow (m3/s)
4660x860	0.98	1.66
4660 x860	0.98	1.66
4660 x860	0.98	1.66
4660 x860	0.98	1.66
4660 x860	0.90	1.53
4660 x860	0.90	1.53
1500	0.90	1.53
5700 x1500	0.90	1.53
5700 x1500	0.90	1.53
3X 1350	3X0.30	3X0.51
6900x1420	0.86	1.45
3980x770	0.82	1.38
1250 x1050	0.82	1.38
4660 x860	0.45	0.75
4660x860	0.45	0.75
5060 x960	0.45	0.75
5060x960	0.45	0.75
1200	0.45	0.75
5060 x960	0.45	0.75
4740x960	0.45	0.75
6500 x1400	0.45	0.75
915	0.45	0.75
1500	0.15	0.27

AUTHOR: PHaywood DESIGN FILE: Figure 4.2a Peel MD Pt 1 of 4

WATER CORPORATION

Peel Main Drain Part 1 of 4

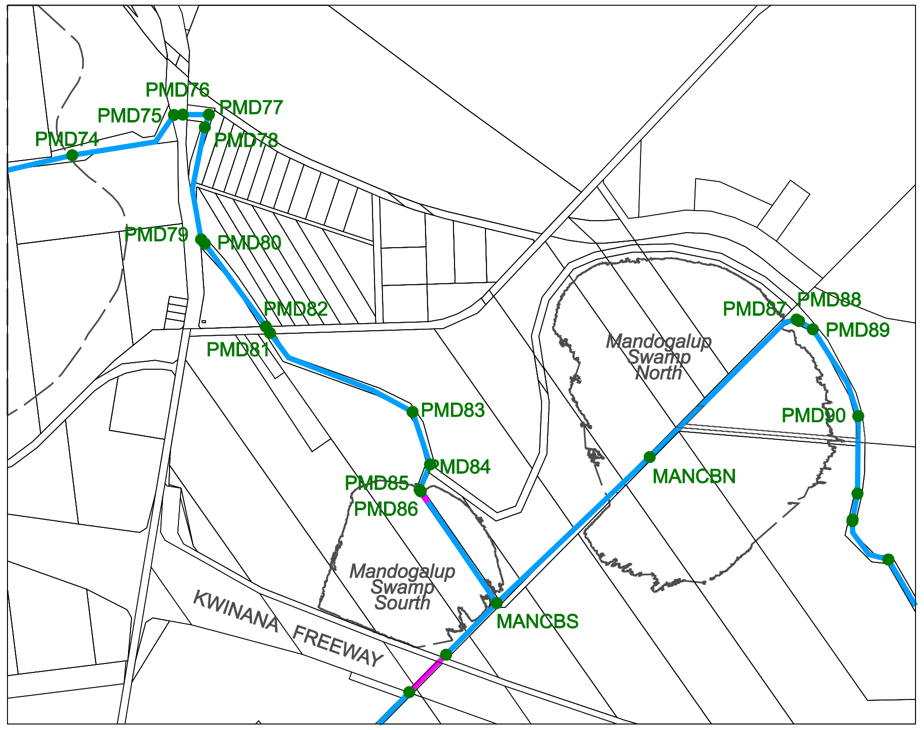
LONGITUDINAL SECTION

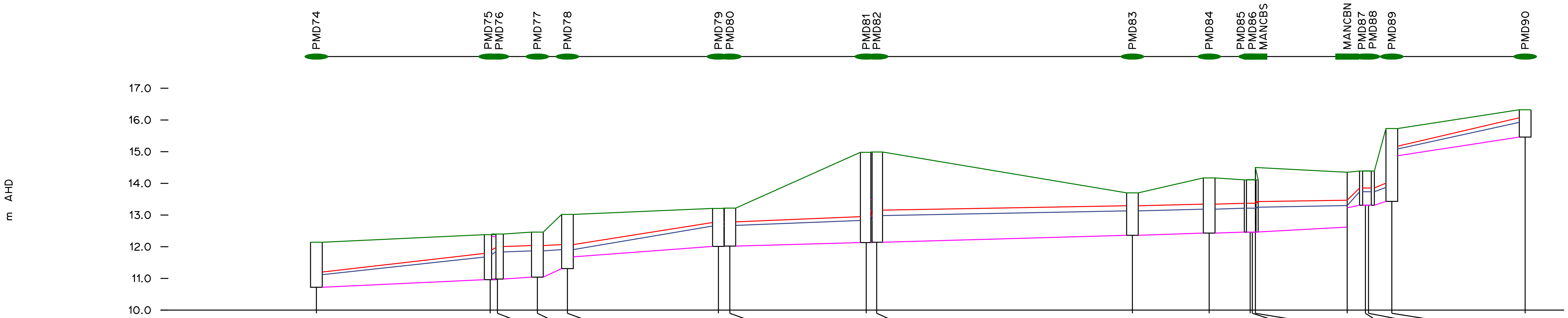
Existing System HGLs & Flows

Figure 4.2a

PROJECT N°: DP2 DATE: 24/04/2009

N





Chainage (m)	Ground level (m AHD)	10 year ARI HGL level (m AHD)	100 year ARI HGL level (m AHD)	Invert level (m AHD) (upstream side)	Invert level (m AHD) (downstream side)
0	12.14	11.09	11.16	-	10.72
335	12.38	11.70	11.81	10.96	10.96
349	12.40	11.88	12.05	10.98	10.98
426	12.46	11.91	12.07	11.04	11.04
484	13.02	11.95	12.10	11.31	11.68
775	13.21	12.68	12.79	12.01	12.01
797	13.22	12.70	12.81	12.02	12.02
1060	14.98	12.86	12.98	12.13	12.13
1080	14.99	13.03	13.19	12.14	12.14
1573	13.70	13.18	13.33	12.36	12.36
1721	14.17	13.23	13.38	12.43	12.43
1800	14.11	13.26	13.41	12.46	12.46
1804	14.11	13.26	13.41	12.46	12.46
1810	14.50	13.29	13.46	12.46	12.46
1987	14.35	13.34	13.51	12.62	13.23
2022	14.39	13.80	13.93	13.31	13.31
2028	14.39	13.80	13.93	13.31	13.31
2073	15.73	15.21	15.32	13.43	14.87
2330	16.32	16.01	16.16	15.46	-

Chainage (m)	Size (mm)	Max 10 year ARI flow (m3/s)	Max 100 year ARI flow (m3/s)
0–335	6900x1420	1.15	1.59
335–349	1350	1.15	1.59
349–426	6900 x1420	1.15	1.59
426–484	6900 x1420	1.10	1.52
484–775	6020x1200	1.10	1.52
775–797	6325 x1200	1.10	1.52
797–1060	6630x1200	1.10	1.52
1060–1080	1350	1.10	1.52
1080–1573	7030x1300	1.10	1.52
1573–1721	7030x1300	1.10	1.52
1721–1800	7030 x1300	1.10	1.52
1800–1804	7030 x1300	1.07	1.47
1804–1810	2X 900	2X0.53	2X0.73
1810–1987	7030 x1300	0.94	1.30
1987–2022	5300 x1020	0.98	1.66
2022–2028	5300 x1020	0.98	1.66
2028–2073	5300 x1020	0.98	1.66
2073–2330	4660x860	0.98	1.66

AUTHOR: PHaywood DESIGN FILE: Figure 4.2b Peel MD Pt 2 of 4

WATER CORPORATION

Peel Main Drain Part 2 of 4

LONGITUDINAL SECTION
Existing System HGLs & Flows

Figure 4.2b

PROJECT N°: DP2 DATE: 24/04/2009

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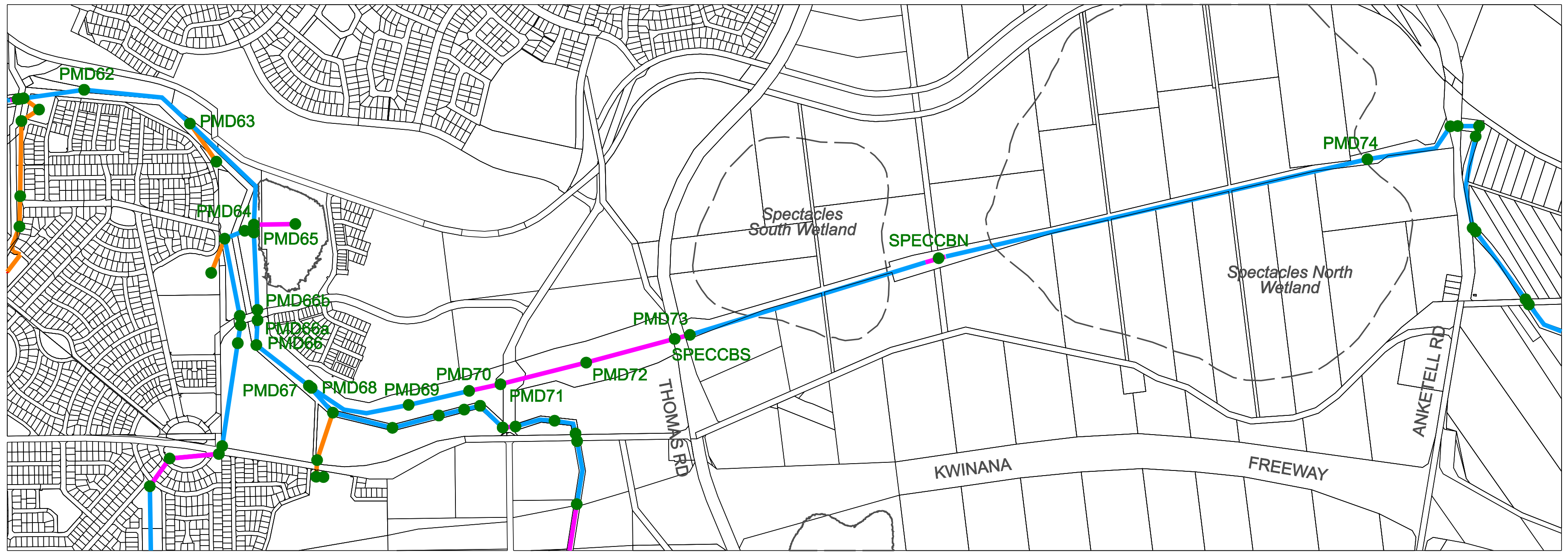

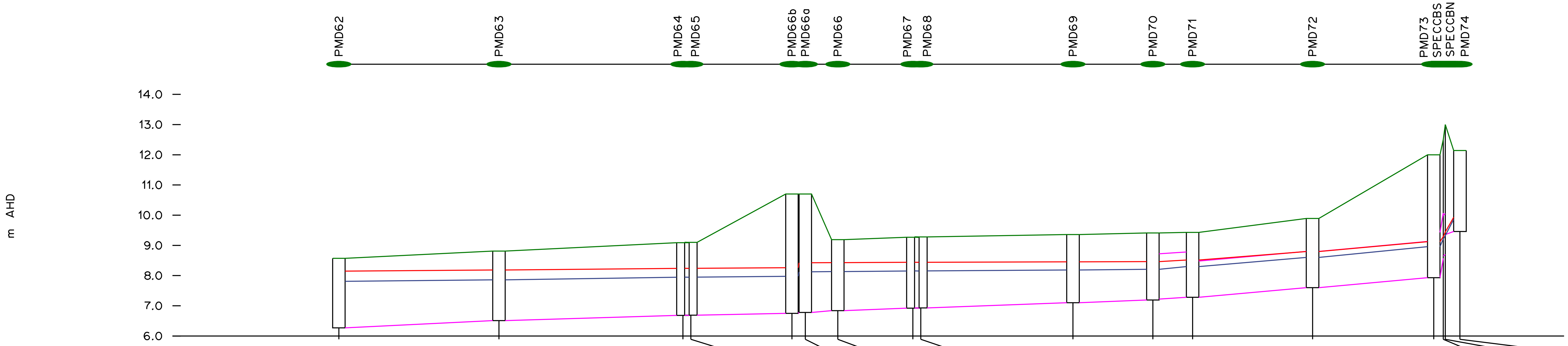

Chainage (m)	Ground level (m AHD)	10 year ARI HGL level (m AHD)	100 year ARI HGL level (m AHD)	Invert level (m AHD)
0	8.57	7.83	8.17	- / 6.27
403	8.81	7.88	8.21	6.51 / 6.51
866	9.09	7.97	8.26	6.68 / 6.68
886	9.10	7.97	8.26	6.69 / 6.69
1140	10.70	7.99	8.28	6.75 / 6.75
1174	10.70	8.14	8.44	6.78 / 6.78
1255	9.19	8.15	8.45	6.84 / 6.84
1444	9.27	8.17	8.40	6.92 / 6.92
1464	9.28	8.17	8.46	6.93 / 6.93
1847	9.36	8.20	8.47	7.10 / 7.10
2048	9.41	8.22	8.48	7.19 / 7.22
2148	9.43	8.31	8.53	7.28 / 7.28
2450	9.89	8.62	8.81	7.60 / 7.60
2755	12.00	8.97	9.15	7.93 / 7.93
2779	12.50	9.22	9.31	8.57 / 8.65
2784	13.00	9.34	9.46	8.70 / 9.36
2821	12.14	11.09	11.16	9.46 / 10.72

Section (chainage m)	Size (mm)	Max 10 year ARI flow (m3/s)	Max 100 year ARI flow (m3/s)
0 – 403	9890x1710	3.02	3.69
403 – 866	9890x1710	3.01	3.69
866 – 886	10435 x1770	2.41	2.96
886 – 1140	10500 x1710	2.41	2.96
1140 – 1174	1500	2.41	2.96
1174 – 1255	10500 x1710	2.41	2.96
1255 – 1444	10500 x1710	2.36	2.88
1444 – 1464	9890 x1710	1.32	1.53
1464 – 1847	8760x1580	1.32	1.53
1847 – 2048	8760x1580	1.32	1.53
2048 – 2148	1500	1.34	1.52
2148 – 2450	1200	1.34	1.52
2450 – 2755	1200	1.33	1.52
2755 – 2779	1500	1.33	1.52
2779 – 2784	1350	1.12	1.48
2784 – 2821	12760 x2580	1.15	1.59

AUTHOR: SLee

DESIGN FILE: Figure 4.2c Peel MD Pt 3of4

WATER CORPORATION

Peel Main Drain Part 3 of 4

LONGITUDINAL SECTION

Existing System HGLs & Flows

Figure 4.2c

PROJECT N°: DP2 DATE: 24/04/2009

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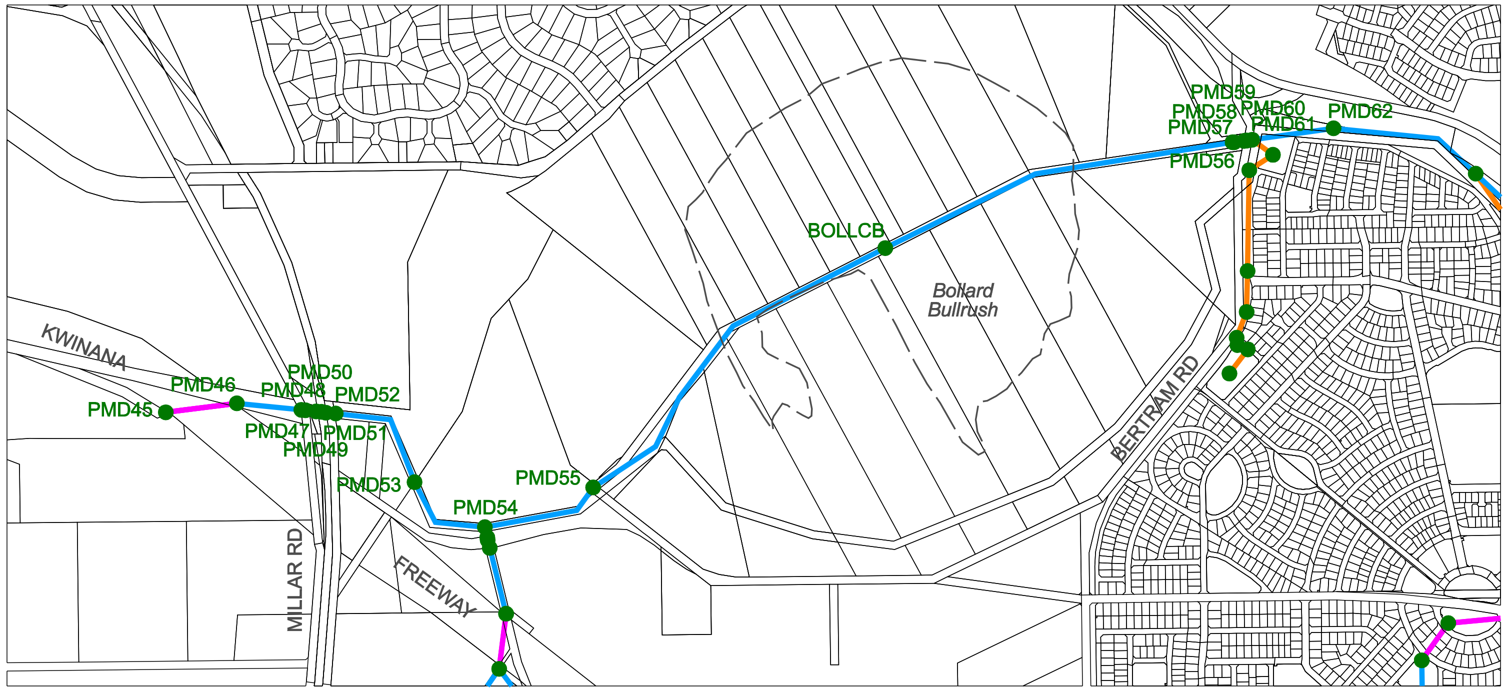

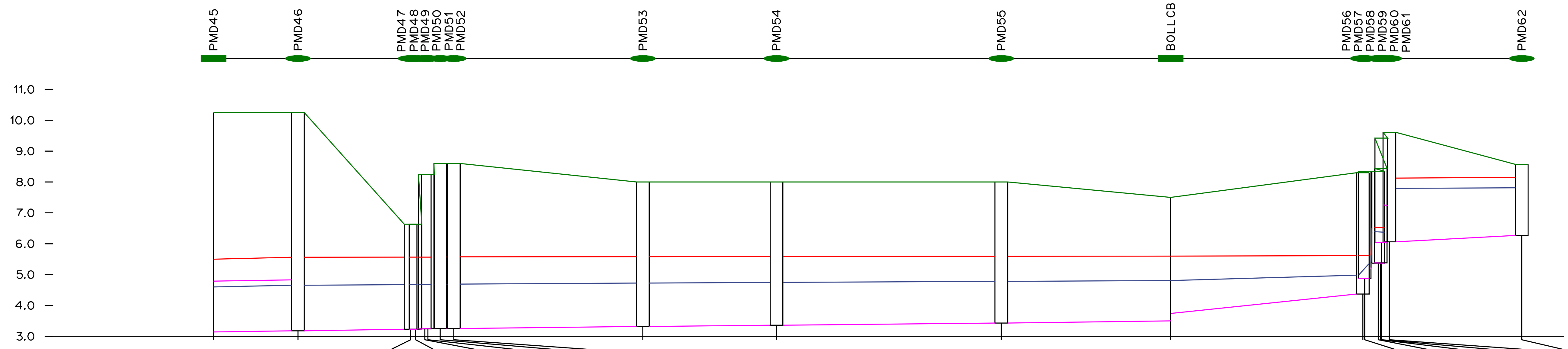

Chainage (m)	Ground level (m AHD)	10 year ARI HGL level (m AHD)	100 year ARI HGL level (m AHD)	Invert level (m AHD)	Invert level (m AHD)
0	10.25	4.60	5.50	-	3.14
137	10.25	4.66	5.56	3.18	3.18
320	6.63	4.68	5.57	3.23	3.23
328	6.63	4.68	5.57	3.23	3.23
343	8.24	4.68	5.57	3.24	3.24
348	8.25	4.68	5.57	3.25	3.25
368	8.60	4.68	5.57	3.25	3.25
390	8.60	4.69	5.58	3.25	3.25
697	8.00	4.73	5.58	3.32	3.32
914	8.00	4.75	5.59	3.36	3.36
1279	8.00	4.79	5.60	3.43	3.43
1554	7.50	4.81	5.60	3.50	3.74
1866	8.30	4.99	5.62	4.37	4.87
1869	8.35	4.40	5.63	4.88	5.18
1891	8.35	6.39	6.53	5.37	5.37
1895	8.44	6.40	6.55	5.38	6.04
1896	9.42	6.78	6.87	6.04	6.04
1909	9.61	7.82	8.15	6.06	6.06
2124	8.57	7.83	8.17	6.27	-

Size (mm)	Max 10 year ARI flow (m3/s)	Max 100 year ARI flow (m3/s)
3X1650	3X1.43	3X1.60
19600x3400	4.30	4.80
19600 x3400	4.30	4.80
19600 x3400	4.30	4.80
26000 x5000	4.30	4.80
26000 x5000	4.30	4.80
2x 3000 x1800	2X2.15	2X2.40
24000 x4500	4.26	4.75
24000x4500	4.26	4.75
24000x4500	3.74	4.10
24000x4500	3.74	4.07
14800x2200	3.19	3.90
8760 x1580	3.19	3.90
3000 x1500	3.19	3.90
4600 x1700	3.19	3.90
4600 x1700	3.19	3.90
1200	3.19	3.90
9890 x1710	3.03	3.70

DESIGN FILE: Figure 4.2d Peel MD Pt 4of4

AUTHOR: SLee

WATER CORPORATION

Peel Main Drain Part 4 of 4

LONGITUDINAL SECTION

Existing System HGLs & Flows

Figure 4.2d

PROJECT N°: DP2 DATE: 24/04/2009

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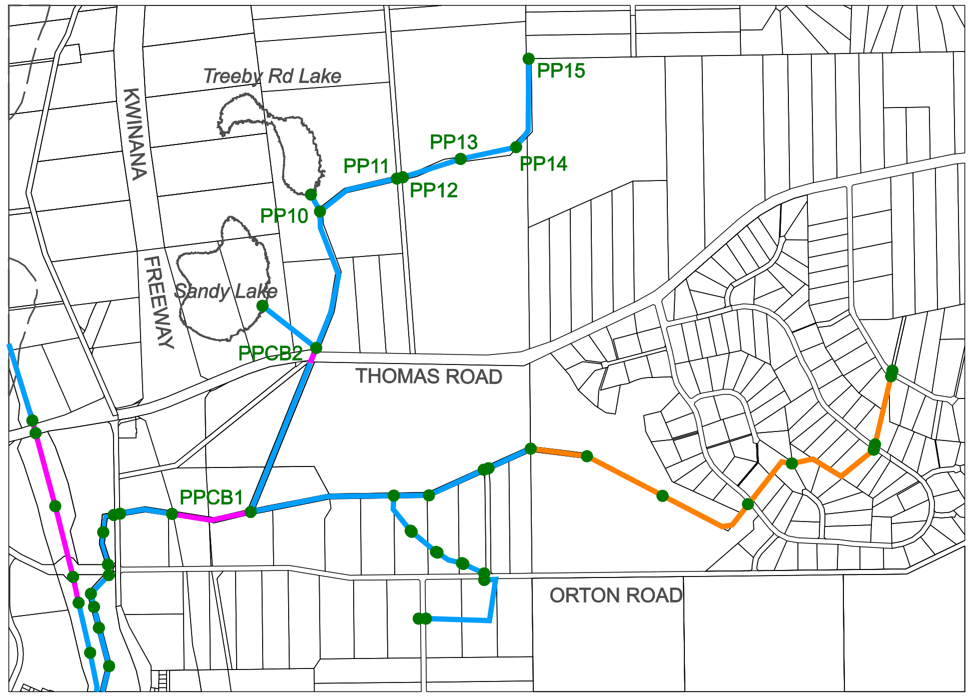
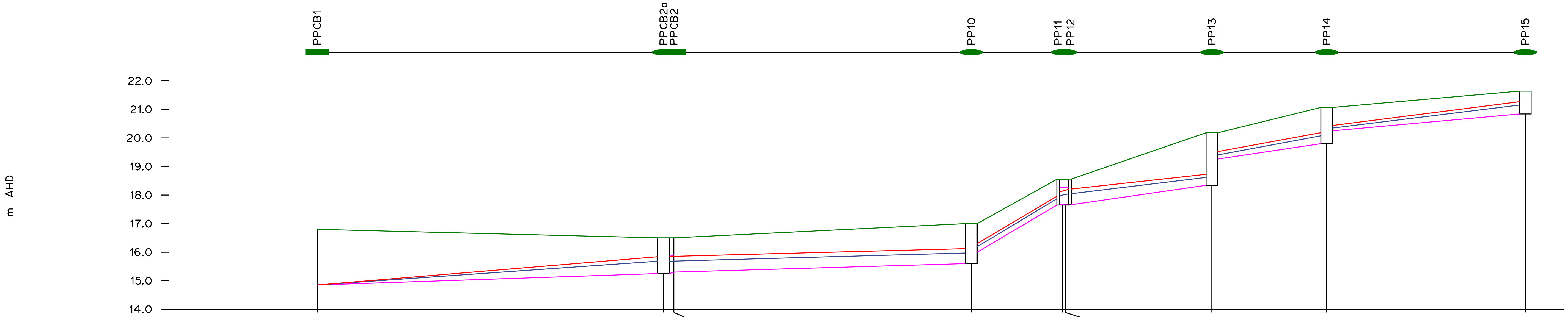




Point	Chainage (m)	Ground level (m AHD)	10 year ARI HGL level (m AHD)	100 year ARI HGL level (m AHD)	Invert level (m AHD)	
PPCB1	0	16.80	15.19	15.29	-	14.85
PPCB2a	666	16.50	15.66	15.81	15.25	15.25
PPCB2	686	16.50	15.67	15.82	15.30	15.30
PP10	1258	17.00	15.95	16.08	15.60	16.00
PP11	1434	18.55	17.85	17.93	17.65	17.65
PP12	1439	18.56	18.01	18.16	17.66	17.66
PP13	1721	20.18	19.39	19.45	18.34	19.26
PP14	1942	21.07	20.38	20.44	19.80	20.25
PP15	2324	21.64	21.12	21.23	20.84	-

Reach (chainage)	Size (mm)	Max 10 year ARI flow (m3/s)	Max 100 year ARI flow (m3/s)
0 – 666	3000x1000	0.19	0.35
666 – 686	3X 600	3X0.06	3X0.12
686 – 1258	3000x1000	0.13	0.24
1258 – 1434	2400x900	0.13	0.24
1434 – 1439	600	0.13	0.24
1439 – 1721	2400x900	0.10	0.18
1721 – 1942	2200x800	0.10	0.18
1942 – 2324	2200x800	0.10	0.18

DESIGN FILE: Figure 4.3a SubDrain P Pt 1of4

AUTHOR: SLee

WATER CORPORATION

PROJECT N°: DP2 DATE: 24/04/2009

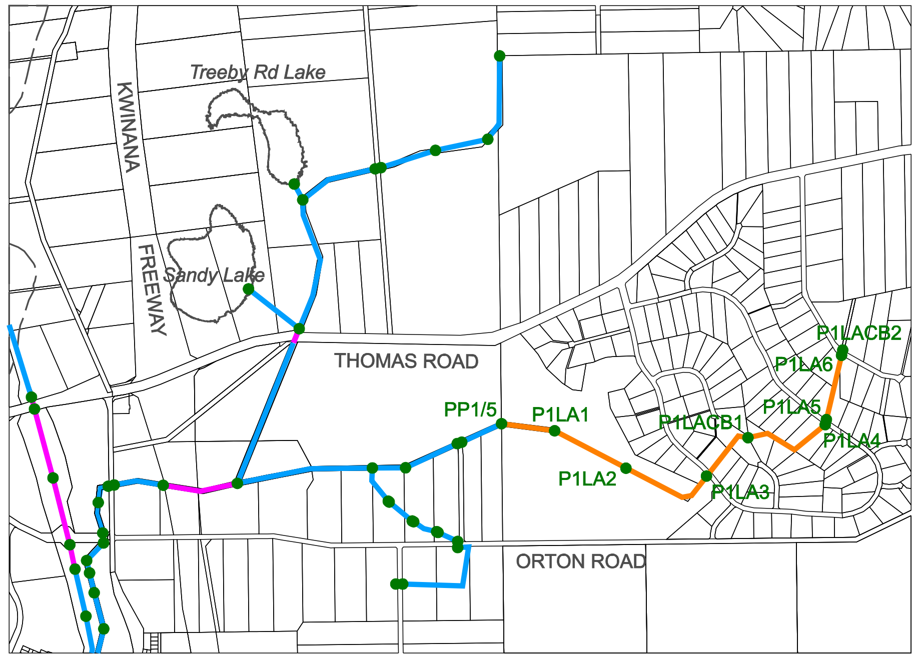
Peel Sub P Drain

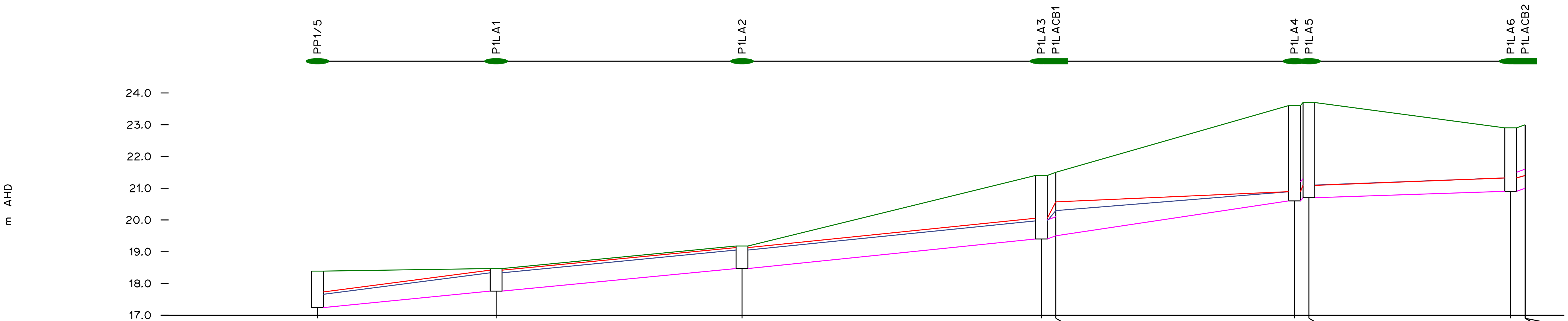
LONGITUDINAL SECTION

Existing System HGLs & Flows

Figure 4.3a

N





Chainage (m)	Ground level (m AHD)	10 year ARI HGL level (m AHD)	100 year ARI HGL level (m AHD)	Invert level (m AHD)
0	18.39	17.66	17.74	- / 17.24
247	18.47	18.34	18.42	17.76 / 17.76
587	19.18	19.05	19.13	18.47 / 18.47
1001	21.40	19.97	20.05	19.40 / 19.40
1021	21.50	20.30	20.57	19.50 / 19.50
1351	23.60	20.89	20.89	20.60 / 20.60
1371	23.70	21.09	21.09	20.70 / 20.70
1650	22.90	21.32	21.32	20.90 / 20.90
1670	23.00	21.40	21.40	21.00 / -
1670	23.00	21.40	21.40	- / -

Size (mm)	Max 10 year ARI flow (m3/s)	Max 100 year ARI flow (m3/s)
2000x700	0.47	0.62
2000x700	0.47	0.62
2000x700	0.47	0.62
600	0.47	0.62
2000x700	0.16	0.19
600	0.15	0.15
2000x700	0.15	0.15
600	0.15	0.15
	-	-

AUTHOR: SLee DESIGN FILE: Figure 4.3b SubDrain P 2 of 4

WATER CORPORATION

PROJECT N°: DP2 DATE: 24/04/2009

Peel Sub P1 Drain (Local Authority)

LONGITUDINAL SECTION

Existing System HGLs & Flows

Figure 4.3b

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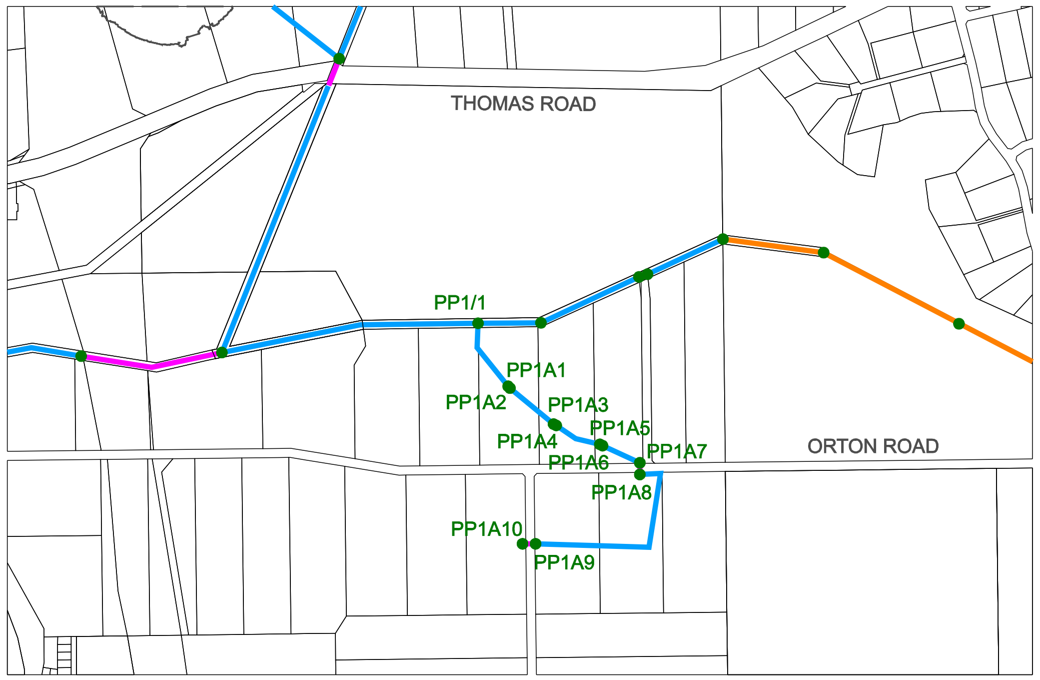

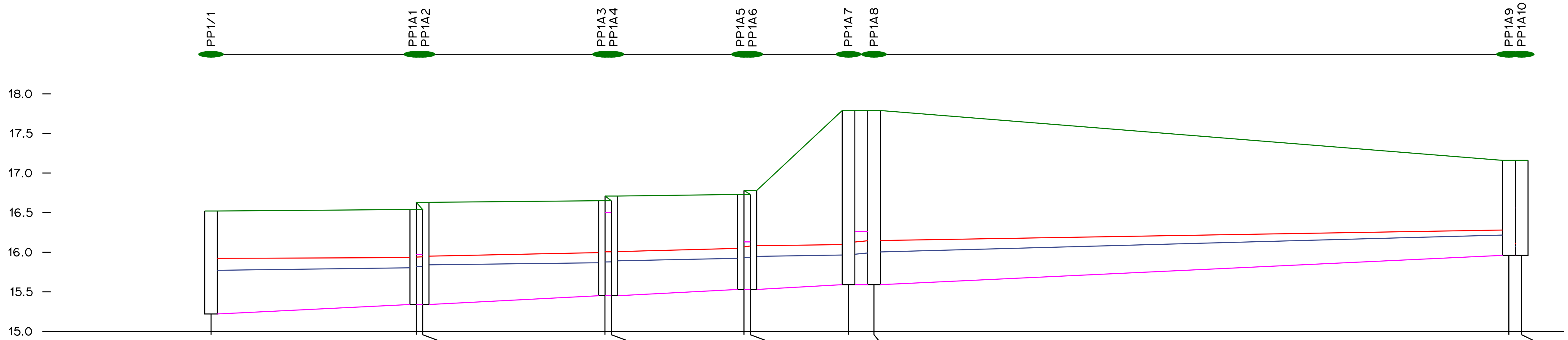

Chainage (m)	Ground level (m AHD)	10 year ARI HGL level (m AHD)	100 year ARI HGL level (m AHD)	Invert level (m AHD)
0	16.52	15.82	15.96	- / 15.22
161	16.54	15.84	15.98	15.34 / 15.34
166	16.63	15.86	16.05	15.34 / 15.34
309	16.65	15.89	16.67	15.45 / 15.45
314	16.71	15.90	16.08	15.45 / 15.45
418	16.73	15.93	16.11	15.53 / 15.53
423	16.78	15.97	16.18	15.53 / 15.53
500	17.79	16.00	16.20	15.59 / 15.59
520	17.79	16.03	16.25	15.59 / 15.59
1018	17.16	16.27	16.39	15.96 / 15.96
1028	17.16	16.32	16.46	15.96 / -

Size (mm)	Max 10 year ARI flow (m3/s)	Max 100 year ARI flow (m3/s)
4500x1200	0.16	0.27
600	0.16	0.27
4500x1200	0.16	0.27
1050	0.16	0.27
4500x1200	0.16	0.27
600	0.16	0.27
4500 x1200	0.16	0.27
675	0.16	0.27
4500x1200	0.12	0.20
600	0.12	0.21

DESIGN FILE: Figure 4.3c SubDrain P Pt 3 of 4

AUTHOR: SLee

WATER CORPORATION

Peel Sub P1A Drain

LONGITUDINAL SECTION

Existing System HGLs & Flows

Figure 4.3c

PROJECT N°: DP2 DATE: 24/04/2009

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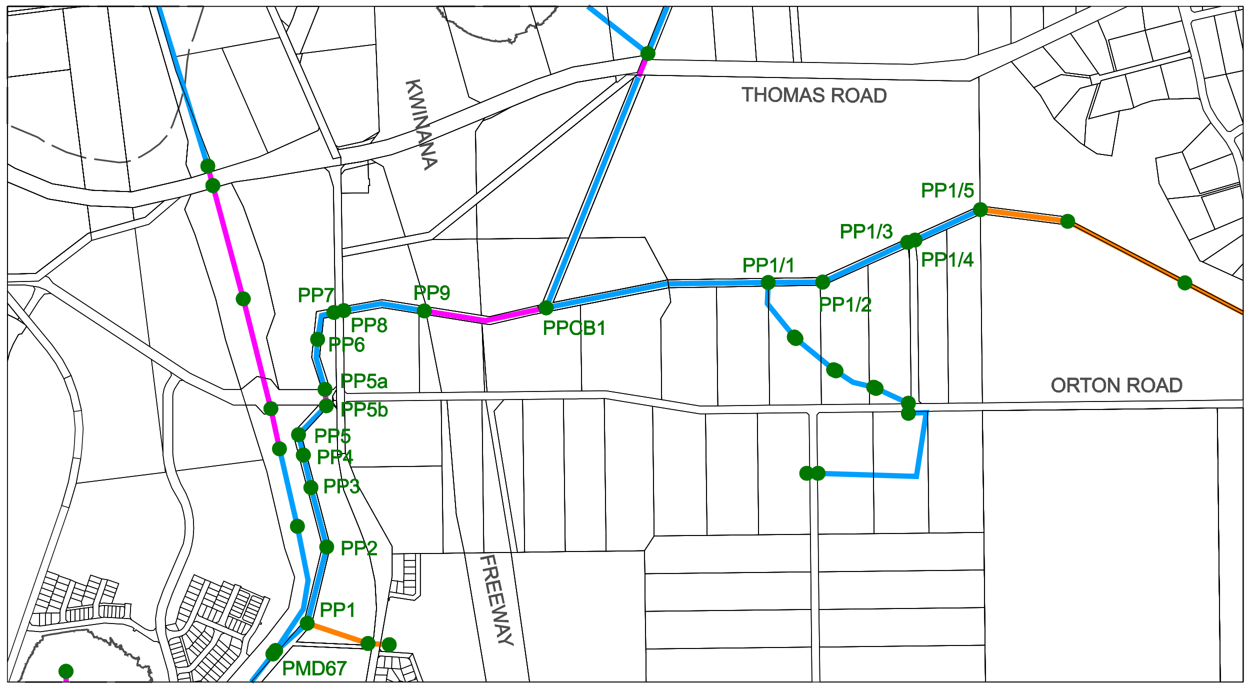

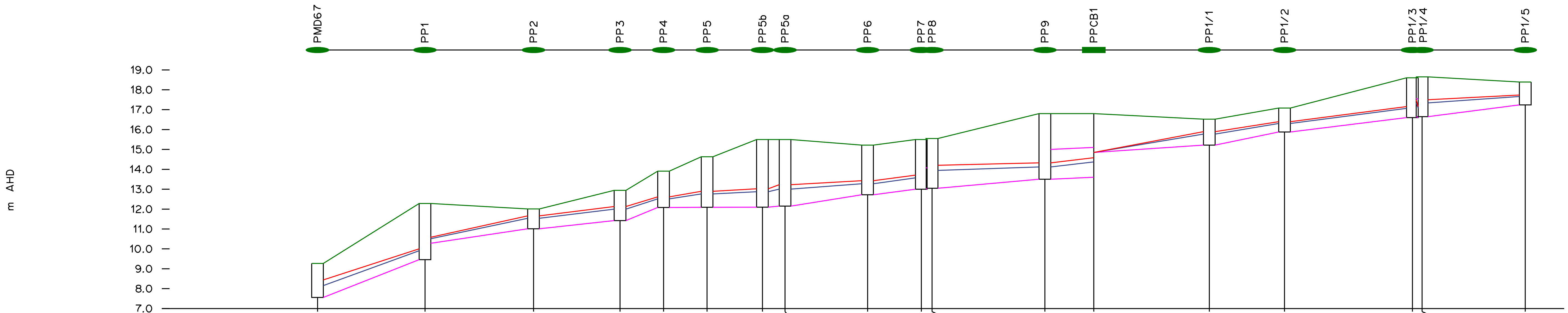

Node	Chainage (m)	Ground level (m AHD)	10 year ARI HGL level (m AHD)	100 year ARI HGL level (m AHD)	Invert level (m AHD)
PMD67	0	9.27	8.17	8.46	- / 7.56
PP1	200	12.28	10.64	10.74	9.46 / 10.28
PP2	402	12.01	11.55	11.67	11.01 / 11.01
PP3	563	12.94	12.00	12.14	11.42 / 11.42
PP4	644	13.91	12.52	12.62	12.08 / 12.08
PP5	725	14.63	12.77	12.90	12.09 / 12.09
PP5b	828	15.50	12.88	13.03	12.10 / 12.10
PP5a	870	15.50	13.01	13.23	12.15 / 12.15
PP6	1023	15.22	13.28	13.43	12.72 / 12.72
PP7	1123	15.50	13.57	13.71	13.00 / 13.00
PP8	1143	15.55	13.96	14.22	13.05 / 13.05
PP9	1353	16.80	14.13	14.33	13.50 / 13.50
PPCB1	1444	16.80	15.19	15.29	13.60 / 14.85
PP1/1	1659	16.52	15.82	15.96	15.22 / 15.22
PP1/2	1799	17.08	16.32	16.40	15.88 / 15.88
PP1/3	2037	18.60	17.07	17.16	16.60 / 16.60
PP1/4	2055	18.65	17.35	17.52	16.65 / 16.65
PP1/5	2247	18.39	17.66	17.74	17.24 / -

Reach	Size (mm)	Max 10 year ARI flow (m3/s)	Max 100 year ARI flow (m3/s)
PMD67 – PP1	6330x1710	1.05	1.58
PP1 – PP2	4200x1000	1.03	1.56
PP2 – PP3	4200x1000	1.03	1.56
PP3 – PP4	5700 x1500	1.03	1.56
PP4 – PP5	6600 x1800	1.03	1.56
PP5 – PP5b	8700 x2500	1.03	1.56
PP5b – PP5a	1200	1.03	1.56
PP5a – PP6	8700 x2500	1.02	1.54
PP6 – PP7	8700 x2500	1.02	1.54
PP7 – PP8	1050	1.02	1.54
PP8 – PP9	9000x2500	1.00	1.51
PP9 – PPCB1	1500	0.96	1.46
PPCB1 – PP1/1	4800x1300	0.75	1.17
PP1/1 – PP1/2	4500x1200	0.64	0.91
PP1/2 – PP1/3	4350x1150	0.60	0.85
PP1/3 – PP1/4	915	0.60	0.85
PP1/4 – PP1/5	4350x1150	0.47	0.62

DESIGN FILE: Figure 4.3d SubDrain P Pt 4 of 4

AUTHOR: SLee

WATER CORPORATION

PROJECT N°: DP2 DATE: 24/04/2009

Peel Sub P Drain and Peel Sub P1 Drain

LONGITUDINAL SECTION

Existing System HGLs & Flows

Figure 4.3d

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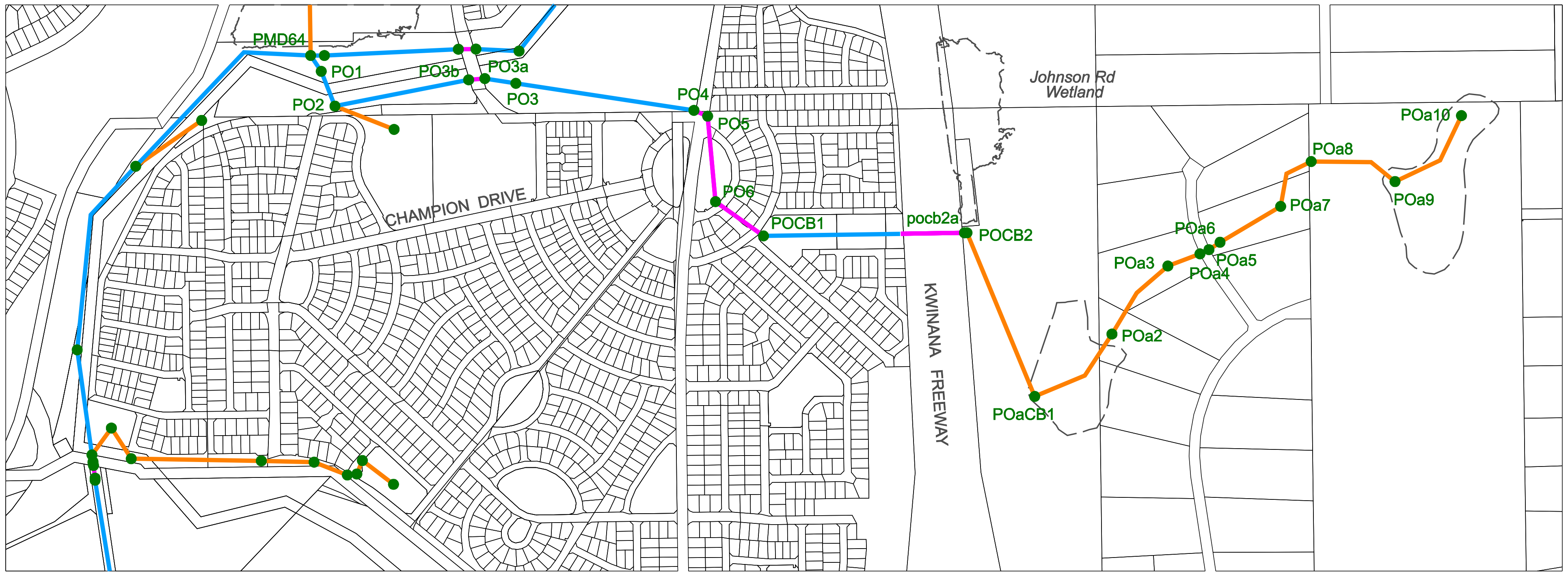
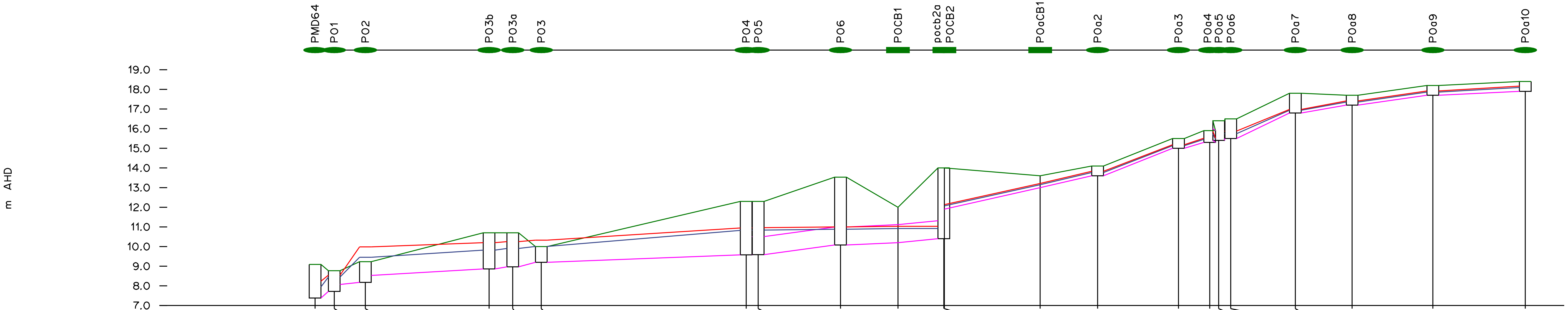
N





Chainage (m)	Ground level (m AHD)	10 year ARI HGL level (m AHD)	100 year ARI HGL level (m AHD)	Invert level (m AHD)	Size (mm)	Max 10 year ARI flow (m3/s)	Max 100 year ARI flow (m3/s)
0	9.09	7.97	8.20	- / 7.38	2590 x1050	1.33	1.77
40	8.77	8.44	8.54	7.72 / 8.07	1890 x700	1.33	1.77
105	9.23	9.42	9.93	8.18 / 8.53	1890x700	0.65	0.75
363	10.70	9.80	10.17	8.86 / 8.86	900 x750	0.61	0.64
412	10.70	9.89	10.22	8.97 / 8.97	1890 x700	0.61	0.64
472	10.00	10.00	10.30	9.20 / 9.20	1890x700	0.61	0.64
900	12.30	10.82	10.95	9.58 / 9.58	2X 915	2X0.34	2X0.39
925	12.30	10.84	10.96	9.59 / 9.59	2X915	2X0.34	2X0.39
1097	13.53	10.88	11.00	10.08 / 10.08	2X915	2X0.38	2X0.44
1217	12.00	10.92	11.03	10.20 / 10.20	4X915	4X0.08	4X0.08
1313	14.00	10.92	11.03	10.40 / 10.40	1000 x500	0.31	0.31
1314	14.00	11.99	12.04	10.80 / 11.90	3000 x500	0.10	0.19
1514	13.60	13.14	13.20	13.00 / 13.00	3000 x500	0.12	0.22
1634	14.10	13.76	13.82	13.60 / 13.60	3000x500	0.10	0.17
1803	15.50	15.12	15.17	15.00 / 15.00	3000 x500	0.10	0.17
1868	15.90	15.45	15.50	15.30 / 15.30	600	0.10	0.17
1887	16.40	15.71	15.83	15.40 / 15.40	3000 x1000	0.08	0.15
1912	16.50	15.73	15.84	15.50 / 15.50	3000 x1000	0.08	0.15
2047	17.80	16.93	16.97	16.80 / 16.80	3000 x500	0.08	0.15
2166	17.70	17.34	17.40	17.20 / 17.20	3000x500	0.08	0.15
2334	18.20	17.85	17.91	17.70 / 17.70	3000x500	0.07	0.13
2527	18.40	18.08	18.15	17.90 / -			

AUTHOR: SLee DESIGN FILE: Figure 4.4 SubDrain O Pt 1 of 1

WATER CORPORATION

Peel Sub O Drain and Local Authority Drain

LONGITUDINAL SECTION

Existing System HGLs & Flows

Figure 4.4

PROJECT N°: DP2 DATE: 24/04/2009

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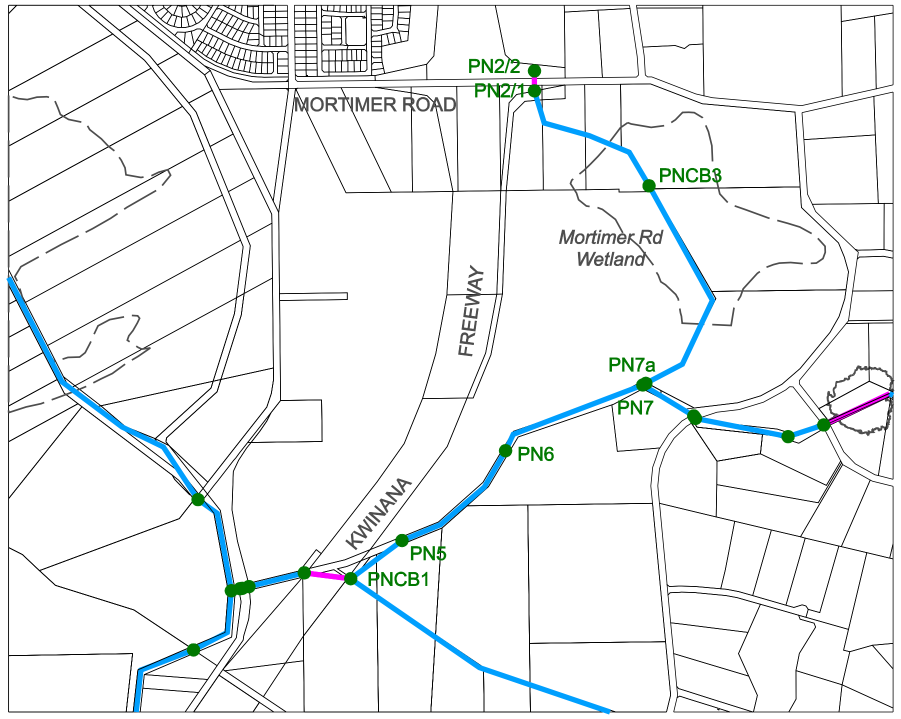
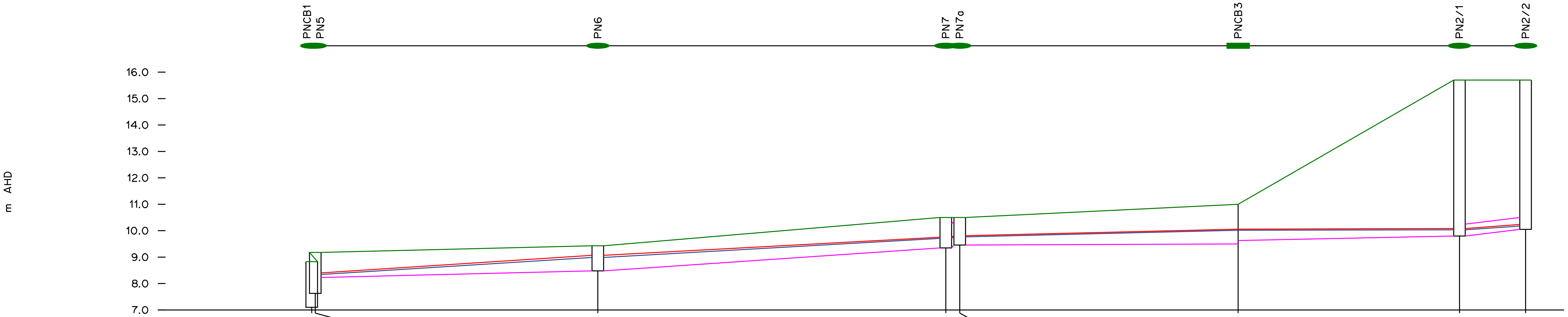




Chainage (m)	0	5	411	911	931	1331	1649	1744
Ground level (m AHD)	8.83	9.18	9.43	10.50	10.50	11.00	15.70	15.70
10 year ARI HGL level (m AHD)	7.63	7.66	9.00	9.71	9.77	10.02	10.04	10.18
100 year ARI HGL level (m AHD)	7.95	7.98	9.08	9.76	9.82	10.07	10.09	10.24
Invert level (m AHD)	- / 7.10	7.63 / 8.23	8.48 / 8.48	9.35 / 9.35	9.46	9.50 / 9.63	9.80 / 9.80	10.05 / -

Segment (chainage)	0–5	5–411	411–911	911–931	931–1331	1331–1649	1649–1744
Size (mm)	7100 x1550	4700x950	4700x950	900	2600x1000	1800x600	450
Max 10 year ARI flow (m3/s)	0.40	0.40	0.30	0.15	0.15	0.02	0.02
Max 100 year ARI flow (m3/s)	0.55	0.55	0.39	0.18	0.18	0.04	0.04

DESIGN FILE: Figure 4.5a SubDrain N Pt 1 of 3

AUTHOR: SLee

WATER CORPORATION

PROJECT N°: DP2 DATE: 24/04/2009

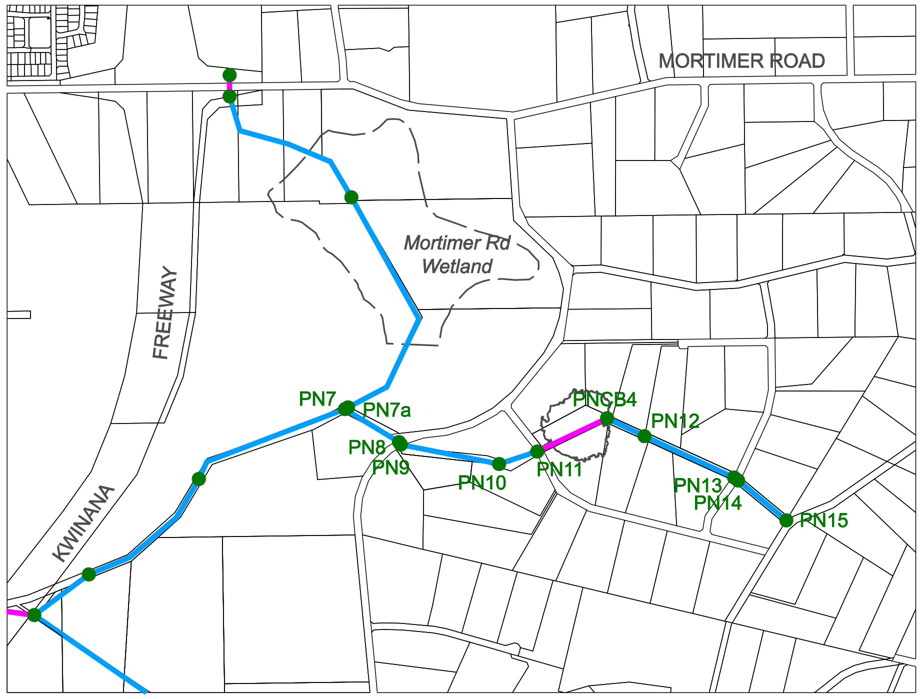
Peel Sub N Drain and Peel Sub N2 Drain

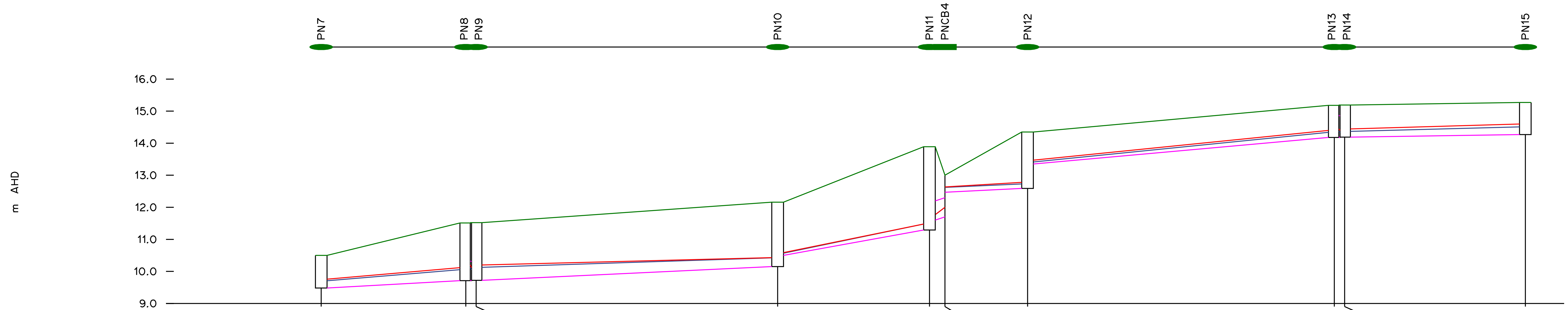
LONGITUDINAL SECTION

Existing System HGLs & Flows

Figure 4.5a

N





Node	Chainage (m)	Ground level (m AHD)	10 year ARI HGL level (m AHD)	100 year ARI HGL level (m AHD)	Invert level (m AHD)
PN7	0	10.50	9.71	9.76	- / 9.48
PN8	140	11.51	10.06	10.12	9.71 / 9.71
PN9	150	11.52	10.13	10.22	9.72 / 9.72
PN10	442	12.16	10.63	10.63	10.15 / 10.50
PN11	589	13.89	11.80	11.80	11.29 / 11.60
PNCB4	604	13.00	12.53	12.56	11.70 / 12.47
PN12	684	14.35	13.44	13.47	12.59 / 13.35
PN13	981	15.18	14.34	14.40	14.18 / 14.18
PN14	991	15.19	14.37	14.45	14.19 / 14.19
PN15	1166	15.27	14.51	14.60	14.27 / -

Reach	Size (mm)	Max 10 year ARI flow (m3/s)	Max 100 year ARI flow (m3/s)
PN7 – PN8	2000x700	0.16	0.22
PN8 – PN9	600	0.16	0.22
PN9 – PN10	4200x1800	0.08	0.08
PN10 – PN11	2800x1100	0.08	0.08
PN11 – PNCB4	600	0.08	0.08
PNCB4 – PN12	3020x530	0.04	0.08
PN12 – PN13	2600x1000	0.04	0.08
PN13 – PN14	675	0.04	0.08
PN14 – PN15	2600x1000	0.04	0.08

DESIGN FILE: Figure 4.5b SubDrain N Pt 2 of 3 »

AUTHOR: SLee

WATER CORPORATION

Peel Sub N Drain

LONGITUDINAL SECTION

Existing System HGLs & Flows

Figure 4.5b

PROJECT N°: DP2 DATE: 24/04/2009

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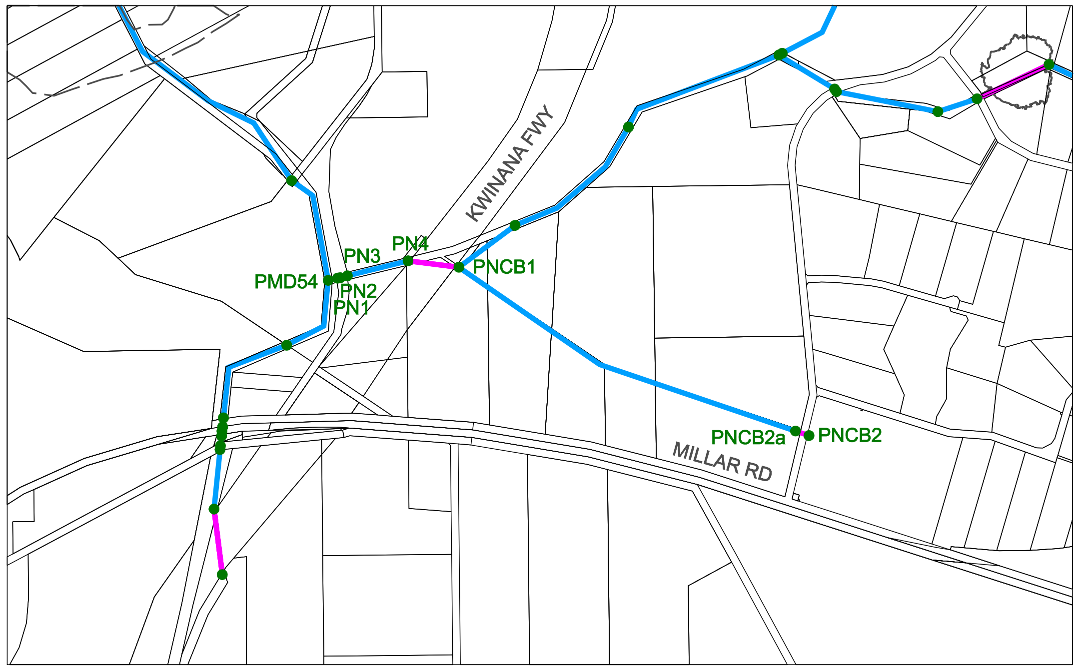
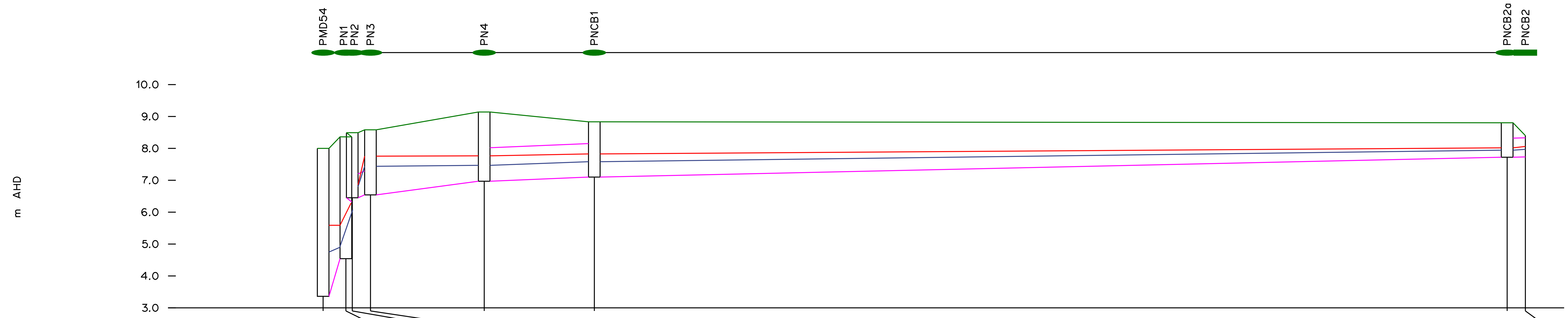
N





Size (mm)	10400 x2300	9360 x2040	750	10160 x2040	2X1050	5000x1000	600
Max 10 year ARI flow (m3/s)	0.84	0.84	0.84	0.65	2X0.32	0.05	0.05
Max 100 year ARI flow (m3/s)	1.23	1.23	1.23	0.97	2X0.48	0.14	0.09

Chainage (m)	0	25	32	52	177	298	1301	1321
Ground level (m AHD)	8.00	8.36	8.49	8.58	9.14	8.83	8.80	8.40
10 year ARI HGL level (m AHD)	4.75	6.69	6.82	7.51	7.54	7.63	7.14	7.96
100 year ARI HGL level (m AHD)	5.59	6.74	6.87	7.89	7.90	7.95	8.01	8.05
Invert level (m AHD)	- / 3.36	4.54 / 6.32	6.45 / 6.45	6.54 / 6.54	6.97 / 6.97	7.10 / 7.10	7.72 / 7.72	7.73 / -

DESIGN FILE: Figure 4.5c SubDrain N Pt 3 of 3

AUTHOR: SLee

WATER CORPORATION

PROJECT N°: DP2 DATE: 24/04/2009

Peel Sub N Drain and Peel Sub N1 Drain

LONGITUDINAL SECTION

Existing System HGLs & Flows

Figure 4.5c

AUTHOR: SLee DESIGN FILE: Figure_5.1_PostDevelopmentSystemDetails.dgn

WATER CORPORATION

PROJECT N°: 6116977 DATE: 26/06/2008 COORDINATE SYSTEM: MGA94 - Zone 50

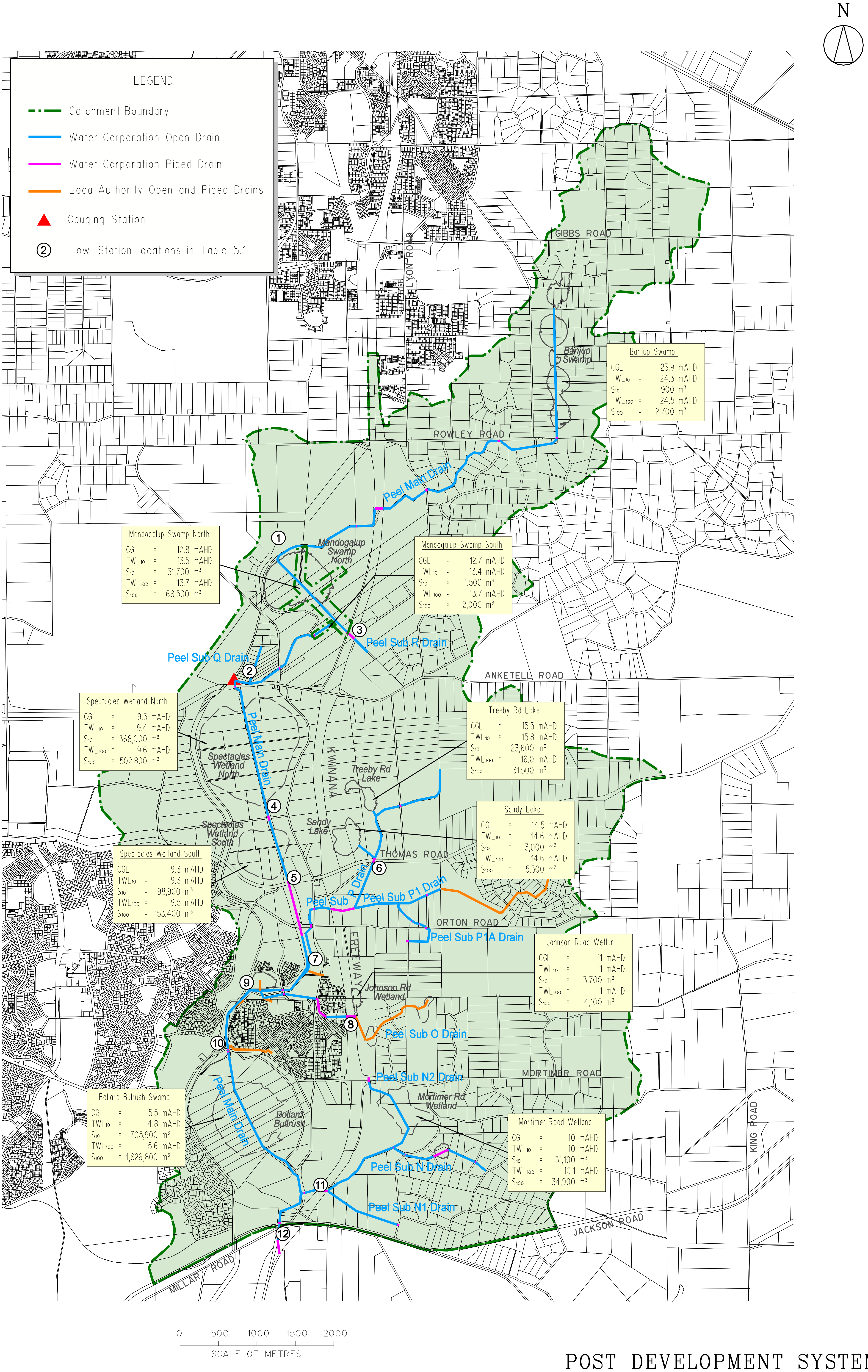


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Figure 5.1

POST DEVELOPMENT SYSTEM

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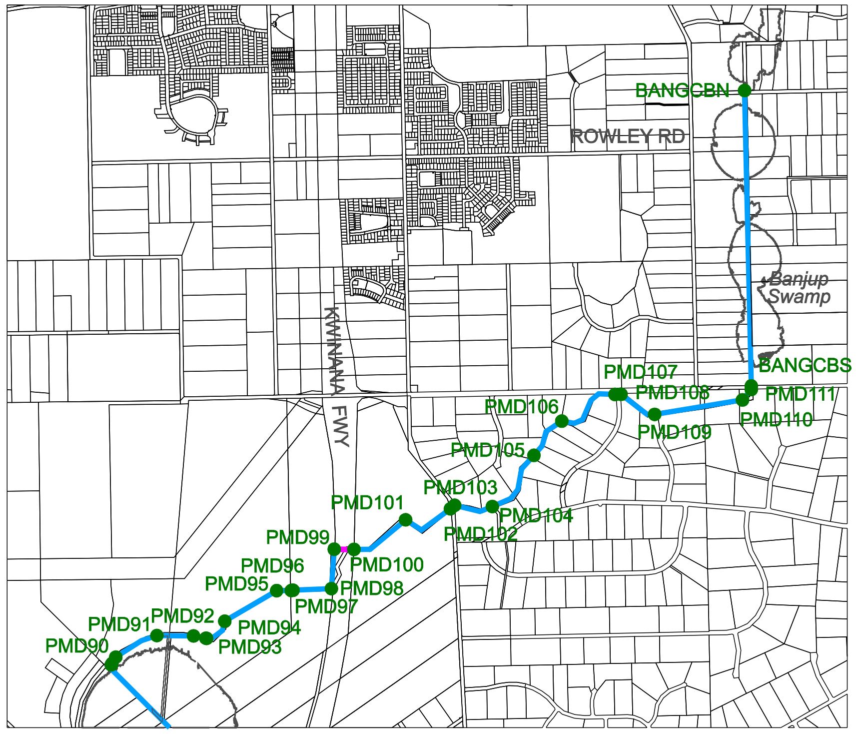
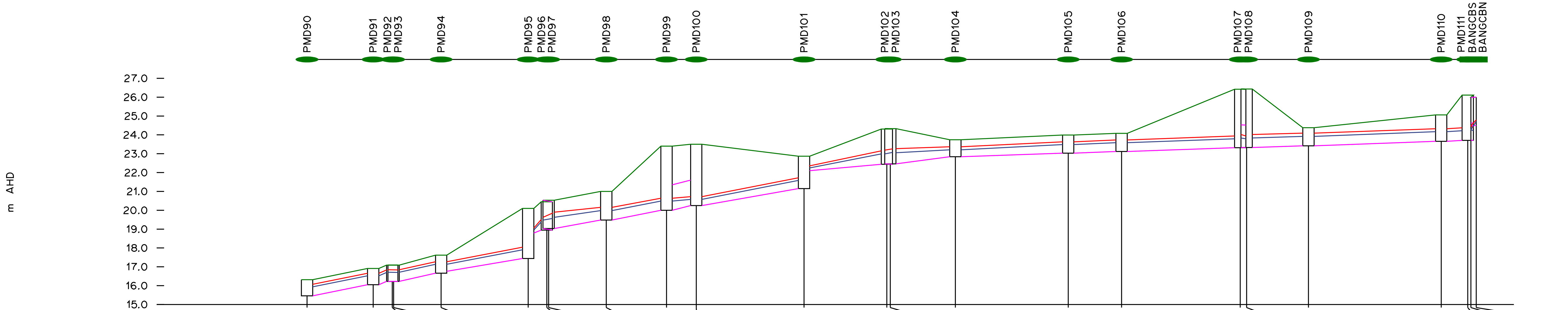




Size (mm)	Chainage (m) (start)	Ground level (m AHD) (start)	100 year ARI HGL level (m AHD) (start)	Invert level (m AHD) (start)	Chainage (m) (end)	10 year ARI HGL level (m AHD) (end)	Invert level (m AHD) (end)	Max 10 year ARI flow (m3/s)	Max 100 year ARI flow (m3/s)
					0	16.01	-		
4660x860		16.32	16.15	15.46	249	16.59	16.05	0.98	1.59
4660x860		16.91	16.74	16.05	321	16.77	16.23	0.98	1.59
4660x860		17.09	16.92	16.23	326	16.78	16.23	0.98	1.59
4660x860		17.09	16.85	16.23	505	17.20	16.66	0.98	1.59
4660x860		17.62	17.34	16.76	833	19.11	17.44	0.90	1.50
4660x860		20.10	19.21	18.79	903	19.45	18.95	0.90	1.50
1500		20.45	19.58	18.95	910	19.79	19.03	0.90	1.50
5700x1500		20.53	20.04	19.03	1127	20.08	19.48	0.90	1.50
5700x1500		21.00	20.27	19.48	1354	20.56	20.00	0.90	1.50
3X 1350		23.40	20.73	20.00	1466	20.05	20.25	3X0.30	3X0.50
6900x1420		23.50	20.83	20.25	1872	22.44	21.15	0.82	1.38
3980x770		22.87	22.55	22.10	2184	23.08	22.44	0.82	1.38
1250x1050		24.31	23.26	22.44	2197	23.17	22.46	0.82	1.38
4660x860		24.33	23.42	22.46	2442	23.29	22.84	0.45	0.75
4660x860		23.74	23.49	22.84	2867	23.57	23.03	0.45	0.75
5060x960		23.99	23.73	23.03	3068	23.67	23.12	0.45	0.75
5060x960		24.08	23.82	23.12	3515	23.88	23.32	0.45	0.75
1200		26.42	24.03	23.32	3539	23.94	23.33	0.45	0.75
5060x960		26.43	24.13	23.33	3772	24.02	23.42	0.45	0.75
4740x960		24.38	24.20	23.42	4272	24.26	23.66	0.45	0.75
6500x1400		25.06	24.42	23.66	4372	24.31	23.71	0.45	0.75
915		26.11	26.11	23.71	4384	24.39	23.72	0.45	0.75
1500		26.00	24.61	24.49	4404	24.75	24.50	0.15	0.27
		26.00	24.84	-					

AUTHOR: SLee

DESIGN FILE: Figure 5.2a Peel MD Pt 1of4

WATER CORPORATION

PROJECT N°: DP2 DATE: 24/04/2009

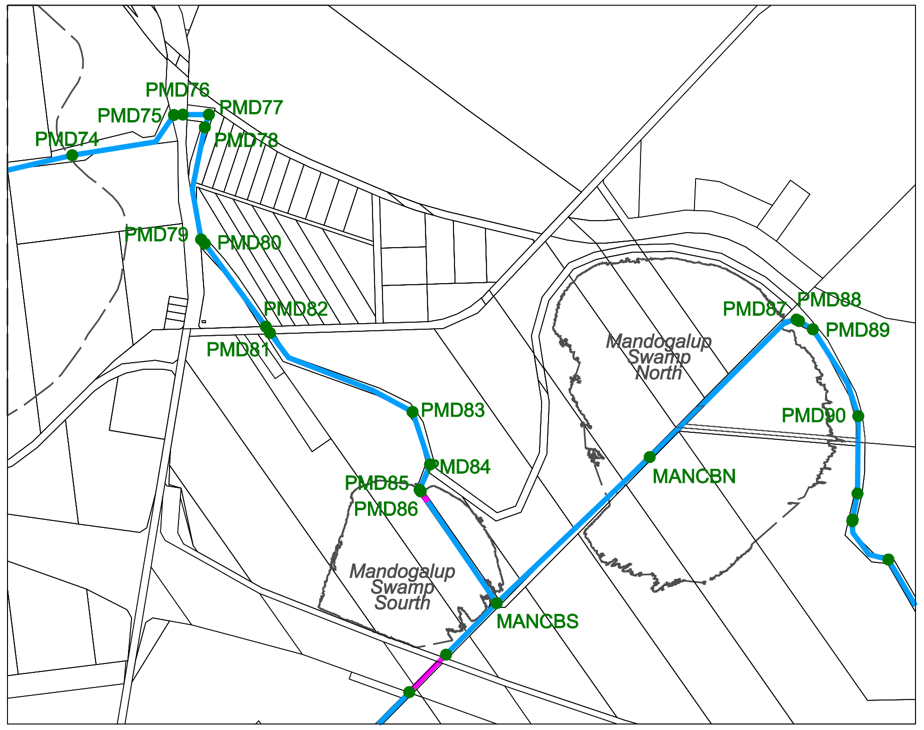
Peel Main Drain Part 1 of 4

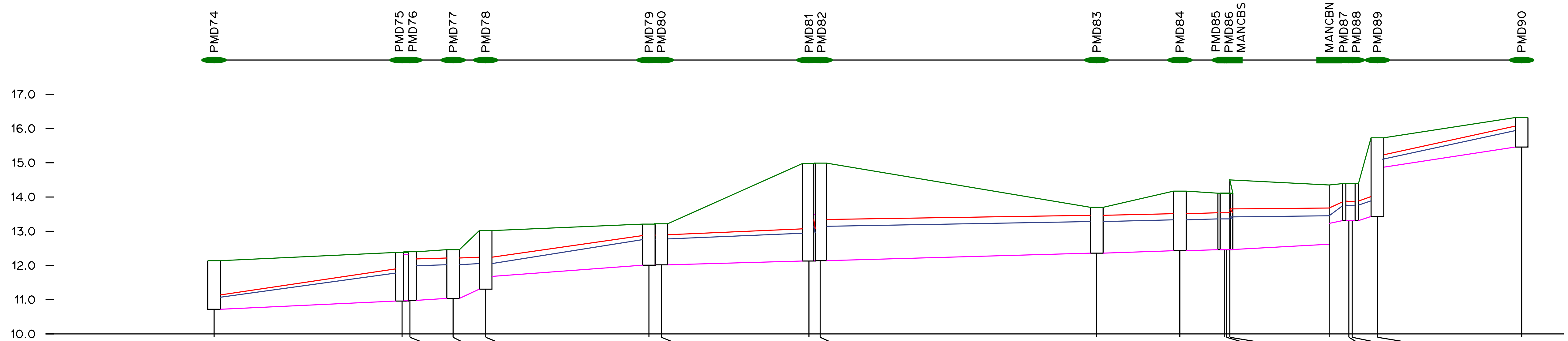
LONGITUDINAL SECTION

Post Development HGLs & Flows

Figure 5.2a

N





Chainage (m)	Ground level (m AHD)	10 year ARI HGL level (m AHD)	100 year ARI HGL level (m AHD)	Invert level (m AHD)	
0	12.14	11.16	11.23	-	10.72
335	12.38	11.81	11.93	10.96	10.96
349	12.40	12.04	12.24	10.98	10.98
426	12.46	12.07	12.26	11.04	11.04
484	13.02	12.10	12.29	11.31	11.68
775	13.21	12.78	12.90	12.01	12.01
797	13.22	12.81	12.92	12.02	12.02
1060	14.98	12.97	13.10	12.13	12.13
1080	14.99	13.19	13.39	12.14	12.14
1573	13.70	13.32	13.51	12.36	12.36
1721	14.17	13.37	13.55	12.43	12.43
1800	14.11	13.40	13.58	12.46	12.46
1804	14.11	13.40	13.58	12.46	12.46
1810	14.50	13.47	13.70	12.46	12.46
1987	14.35	13.50	13.73	12.62	13.23
2022	14.39	13.80	13.92	13.31	13.31
2028	14.39	13.82	13.94	13.31	13.31
2073	15.73	15.21	15.31	13.43	14.87
2330	16.32	16.01	16.15	15.46	-

Size (mm)	Max 10 year ARI flow (m3/s)	Max 100 year ARI flow (m3/s)
6900x1420	1.57	2.13
1350	1.57	2.13
6900 x1420	1.57	2.13
6900 x1420	1.54	2.10
6020x1200	1.51	2.06
6325 x1200	1.51	2.06
6630x1200	1.51	2.06
1350	1.51	2.06
7030x1300	1.51	2.06
7030x1300	1.51	2.06
7030 x1300	1.51	2.06
7030 x1300	1.51	2.06
2X 900	2X0.75	2X1.03
7030 x1300	1.15	1.59
5300 x1020	0.98	1.59
5300 x1020	0.98	1.59
5300 x1020	0.98	1.59
4660x860	0.98	1.59

DESIGN FILE: Figure 5.2b Peel MD Pt 2 of 4

AUTHOR: SLee

WATER CORPORATION

Peel Main Drain Part 2 of 4

LONGITUDINAL SECTION

Post Development HGLs & Flows

Figure 5.2b

PROJECT N°: DP2 DATE: 24/04/2009

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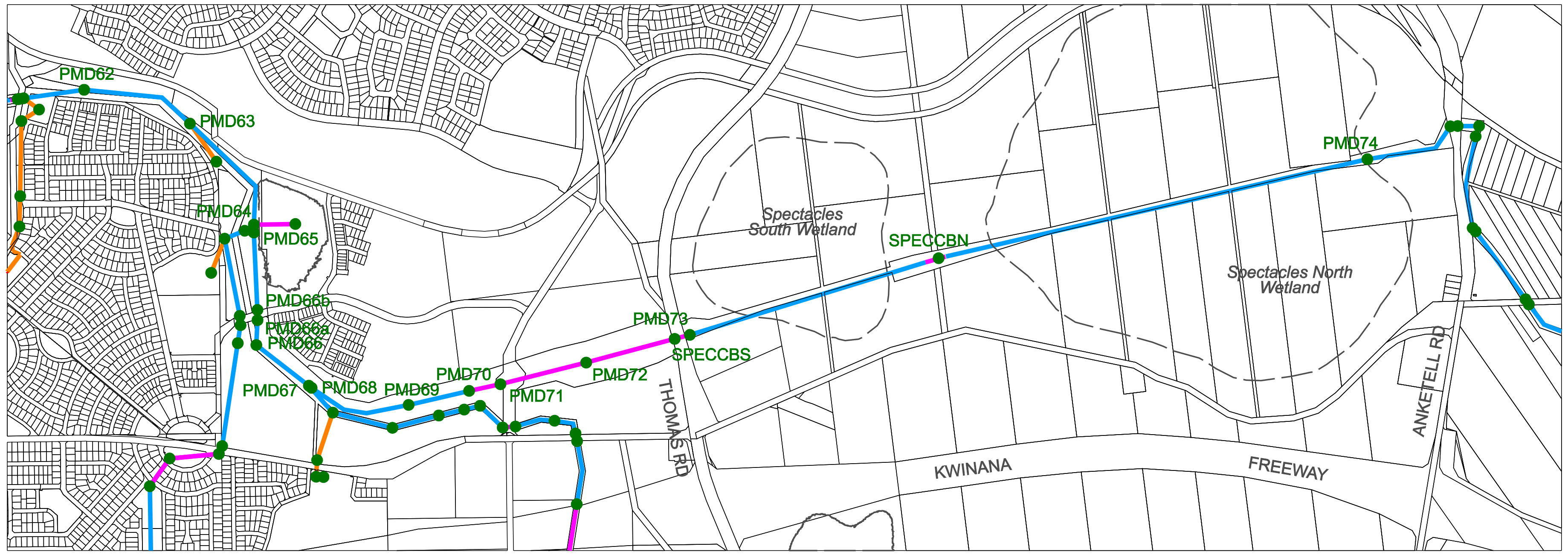

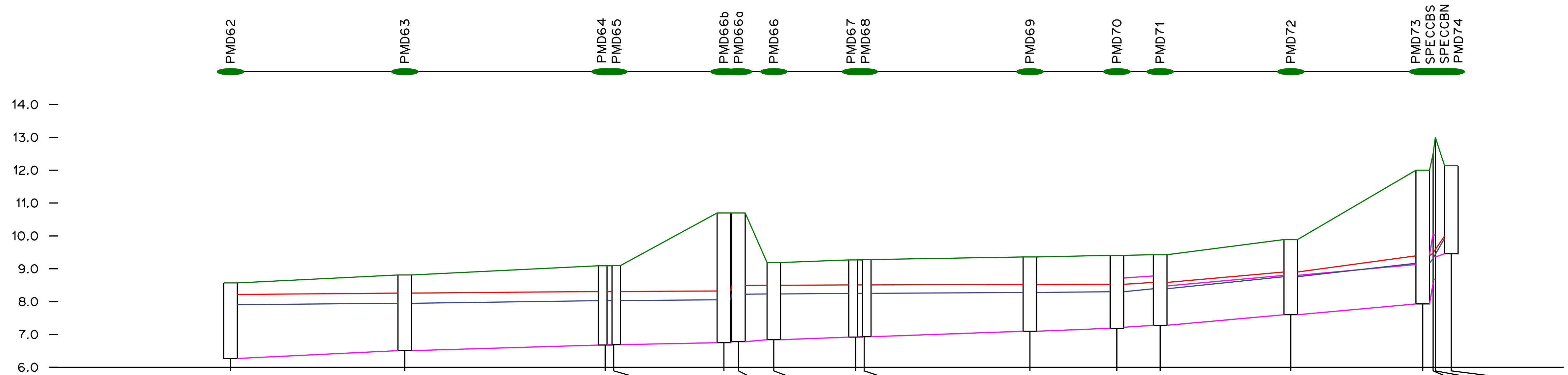

Chainage (m)	Ground level (m AHD)	10 year ARI HGL level (m AHD)	100 year ARI HGL level (m AHD)	Invert level (m AHD)	Invert level (m AHD)
0	8.57	7.92	8.23	-	6.27
403	8.81	7.96	8.27	6.51	6.51
866	9.09	8.04	8.31	6.68	6.68
886	9.10	8.04	8.32	6.69	6.69
1140	10.70	8.07	8.33	6.75	6.75
1174	10.70	8.23	8.50	6.78	6.78
1255	9.19	8.24	8.50	6.84	6.84
1444	9.27	8.25	8.51	6.92	6.92
1464	9.28	8.25	8.51	6.93	6.93
1847	9.36	8.28	8.53	7.10	7.10
2048	9.41	8.30	8.53	7.19	7.22
2148	9.43	8.39	8.59	7.28	7.28
2450	9.89	8.76	8.91	7.60	7.60
2755	12.00	9.17	9.50	7.93	7.93
2779	12.50	9.32	9.60	8.57	8.65
2784	13.00	9.45	9.60	8.70	9.36
2821	12.14	11.16	11.23	9.46	10.72

Size (mm)	Max 10 year ARI flow (m3/s)	Max 100 year ARI flow (m3/s)
9890x1710	3.25	3.80
9890x1710	3.26	3.80
10435 x1770	2.63	3.05
10500 x1710	2.63	3.05
1500	2.63	3.05
10500 x1710	2.63	3.05
10500 x1710	2.58	2.98
9890 x1710	1.54	1.70
8760x1580	1.53	1.70
8760x1580	1.57	1.70
1500	1.59	1.70
1200	1.59	1.70
1200	1.52	1.70
1500	1.53	1.70
1350	1.45	1.74
12760 x2580	1.57	2.13

DESIGN FILE: Figure 5.2c Peel MD Pt 3of4

AUTHOR: SLee

WATER CORPORATION

Peel Main Drain Part 3 of 4

LONGITUDINAL SECTION

Post Development HGLs & Flows

Figure 5.2c

PROJECT N°: DP2 DATE: 24/04/2009

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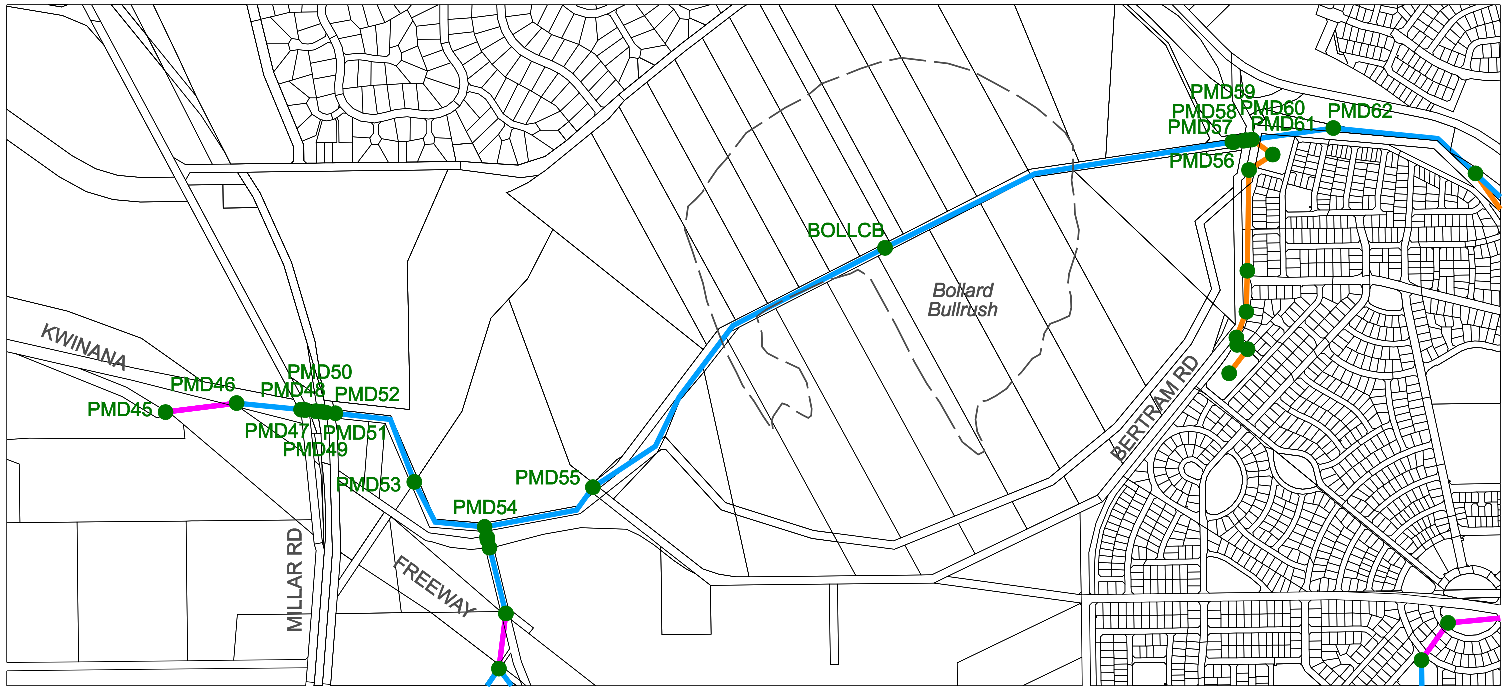

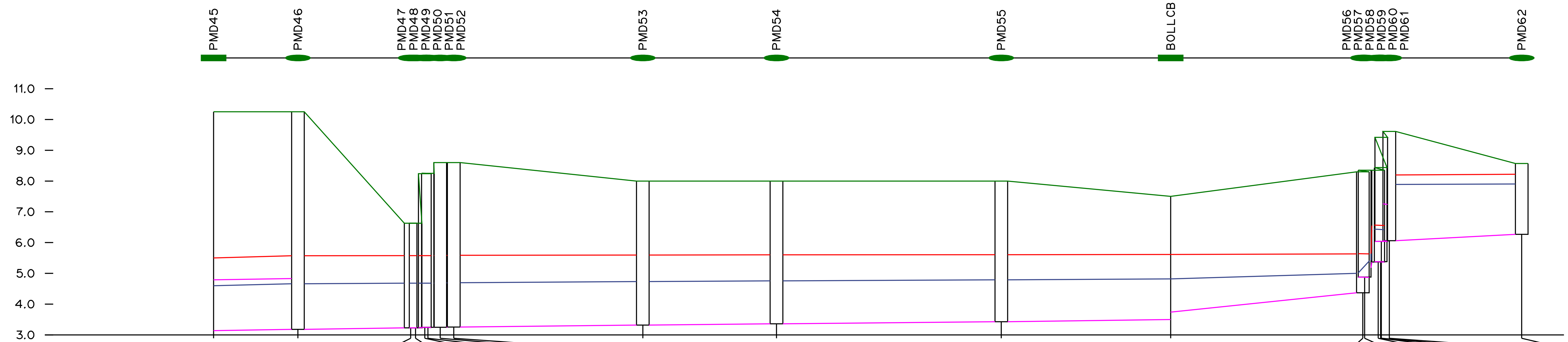

Chainage (m)	Size (mm)	Ground level (m AHD)	10 year ARI HGL level (m AHD)	100 year ARI HGL level (m AHD)	Invert level (m AHD)	Max 10 year ARI flow (m3/s)	Max 100 year ARI flow (m3/s)
0		10.25	4.60	5.50	- / 3.14		
	3X1650					3X1.47	3X1.70
137		10.25	4.66	5.58	3.18 / 3.18		
	19600x3400					4.42	5.10
320		6.63	4.68	5.58	3.23 / 3.23		
	19600 x3400					4.42	5.10
328		6.63	4.68	5.58	3.23 / 3.23		
	19600 x3400					4.42	5.10
343		8.24	4.68	5.58	3.24 / 3.24		
	26000 x5000					4.42	5.10
348		8.25	4.68	5.58	3.25 / 3.25		
	26000 x5000					4.42	5.10
368		8.60	4.69	5.58	3.25 / 3.25		
	2x 3000 x1800					2X2.21	2X2.55
390		8.60	4.70	5.59	3.25 / 3.25		
	24000 x4500					4.38	5.06
697		8.00	4.73	5.60	3.32 / 3.32		
	24000x4500					4.38	5.06
914		8.00	4.76	5.60	3.36 / 3.36		
	24000x4500					3.74	4.23
1279		8.00	4.79	5.61	3.43 / 3.43		
	24000x4500					3.74	4.14
1554		7.50	4.82	5.61	3.50 / 3.74		
	14800x2200					3.38	4.00
1866		8.30	5.00	5.63	4.37 / 4.87		
	8760 x1580					3.39	4.01
1869		8.35	5.42	5.64	4.88 / 5.18		
	3000 x1500					3.39	4.01
1891		8.35	6.43	6.56	5.37 / 5.37		
	4600 x1700					3.39	4.01
1895		8.44	6.44	6.57	5.38 / 6.04		
	4600 x1700					3.39	4.01
1896		9.42	6.81	6.88	6.04 / 6.04		
	1200					3.39	4.01
1909		9.61	7.90	8.20	6.06 / 6.06		
	9890 x1710					3.25	3.82
2124		8.57	7.92	8.23	6.27 / -		

AUTHOR: SLee

DESIGN FILE: Figure 5.2d Peel MD Pt 4of4

WATER CORPORATION

Peel Main Drain Part 4 of 4

LONGITUDINAL SECTION

Post Development HGLs & Flows

Figure 5.2d

PROJECT N°: DP2 DATE: 24/04/2009

THE INFORMATION CONTAINED HEREIN IS SUBJECT TO ONGOING REVIEW AND AMENDMENTS AND SHOULD BE READ IN CONJUNCTION WITH THE ASSOCIATED REPORT.

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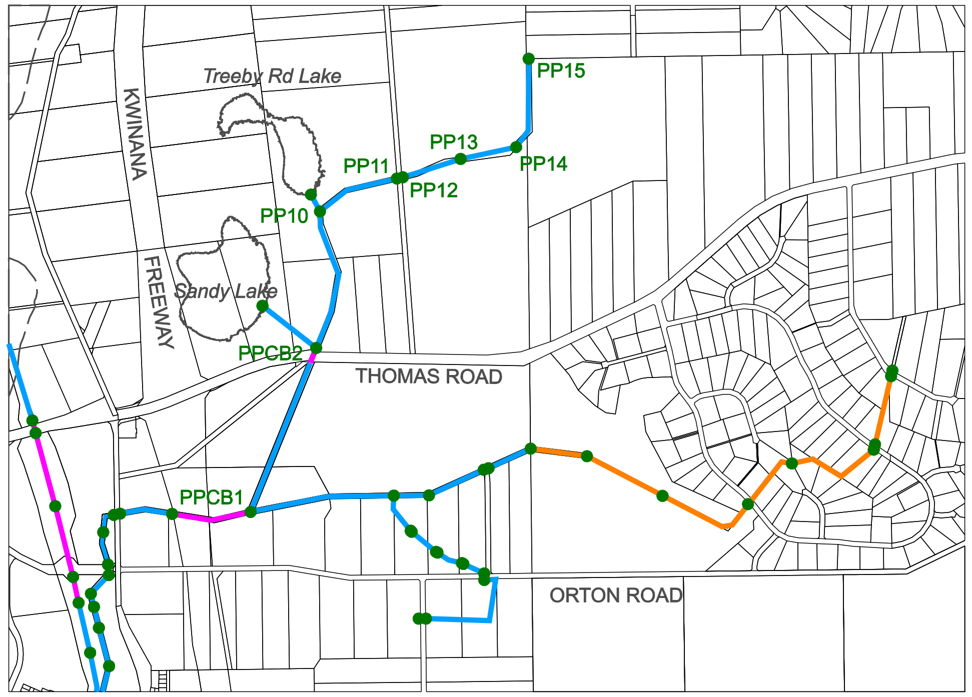

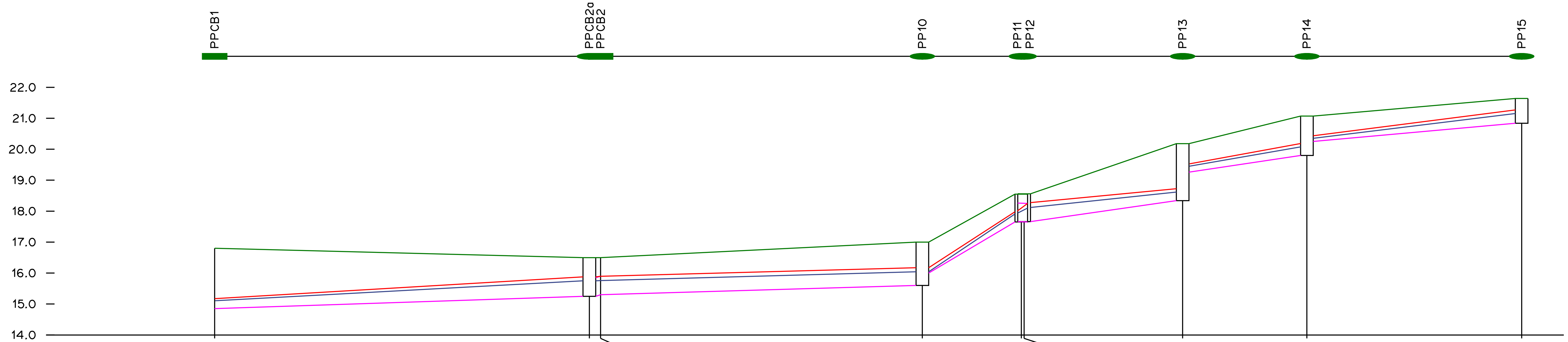

Chainage (m)	Ground level (m AHD)	10 year ARI HGL level (m AHD)	100 year ARI HGL level (m AHD)	Invert level (m AHD)	
0	16.80	15.19	15.27	-	14.85
666	16.50	15.74	15.85	15.25	15.25
686	16.50	15.73	15.87	15.30	15.30
1258	17.00	16.02	16.14	15.60	16.00
1434	18.55	17.89	17.96	17.65	17.65
1439	18.56	18.09	18.23	17.66	17.66
1721	20.18	19.39	19.45	18.34	19.26
1942	21.07	20.38	20.44	19.80	20.25
2324	21.64	21.12	21.23	20.84	-

Reach (chainage)	Size (mm)	Max 10 year ARI flow (m3/s)	Max 100 year ARI flow (m3/s)
0 – 666	3000x1000	0.26	0.40
666 – 686	3X 600	3X0.09	3X0.13
686 – 1258	3000x1000	0.18	0.29
1258 – 1434	2400x900	0.18	0.29
1434 – 1439	600	0.18	0.29
1439 – 1721	2400x900	0.10	0.18
1721 – 1942	2200x800	0.10	0.18
1942 – 2324	2200x800	0.10	0.18

AUTHOR: SLee

DESIGN FILE: Figure 5.3a SubDrain P Pt 1of4

WATER CORPORATION

PROJECT Nº: DP2 DATE: 24/04/2009

Peel Sub P Drain

LONGITUDINAL SECTION

Post Development HGLs & Flows

Figure 5.3a

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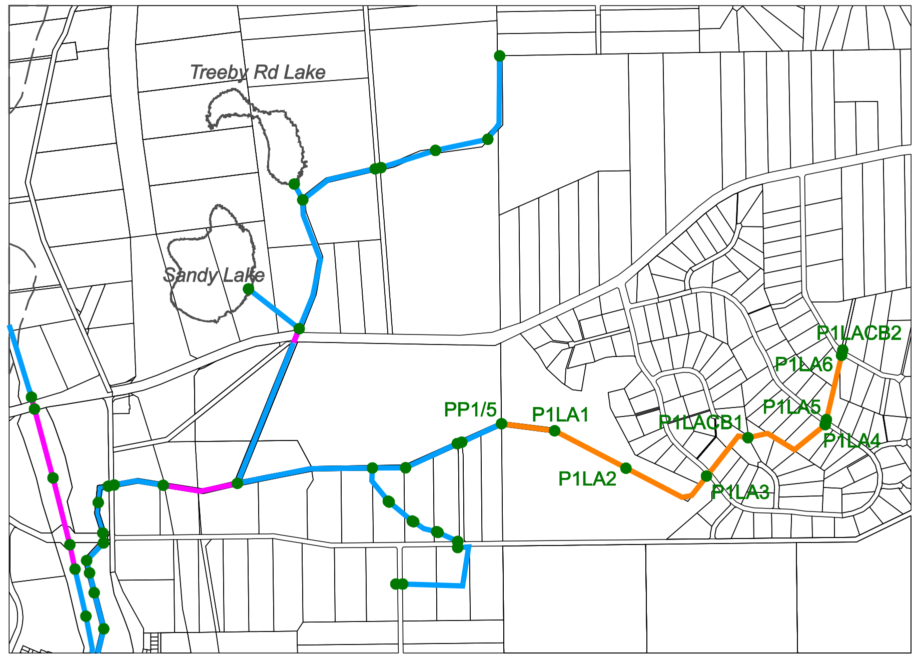

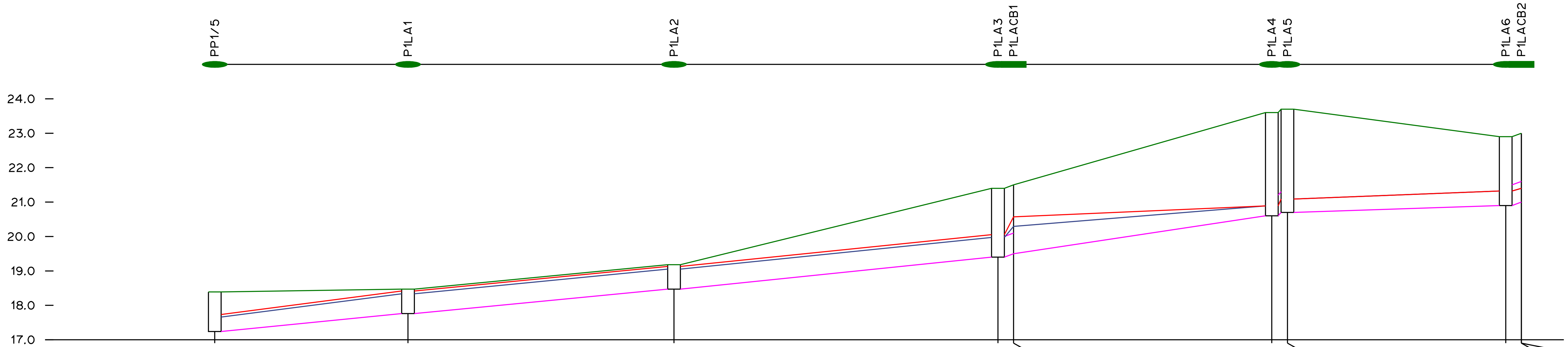

Chainage (m)	Ground level (m AHD)	10 year ARI HGL level (m AHD)	100 year ARI HGL level (m AHD)	Invert level (m AHD)	
0	18.39	17.66	17.74	-	17.24
247	18.47	18.34	18.42	17.76	17.76
587	19.18	19.05	19.13	18.47	18.47
1001	21.40	19.97	20.05	19.40	19.40
1021	21.50	20.30	20.57	19.50	19.50
1351	23.60	20.89	20.89	20.60	20.60
1371	23.70	21.09	21.09	20.70	20.70
1650	22.90	21.32	21.32	20.90	20.90
1670	23.00	21.40	21.40	21.00	-
1670	23.00	21.40	21.40	-	-

Segment	Size (mm)	Max 10 year ARI flow (m3/s)	Max 100 year ARI flow (m3/s)
0 – 247	2000x700	0.47	0.62
247 – 587	2000x700	0.47	0.62
587 – 1001	2000x700	0.47	0.62
1001 – 1021	600	0.47	0.62
1021 – 1351	2000x700	0.16	0.19
1351 – 1371	600	0.15	0.15
1371 – 1650	2000x700	0.15	0.15
1650 – 1670	600	0.15	0.15
1670 – 1670		-	-

DESIGN FILE: Figure 5.3b SubDrain P 2 of 4

AUTHOR: SLee

WATER CORPORATION

Peel Sub P1 Drain (Local Authority)

LONGITUDINAL SECTION

Post Development HGLs & Flows

Figure 5.3b

PROJECT N°: DP2 DATE: 24/04/2009

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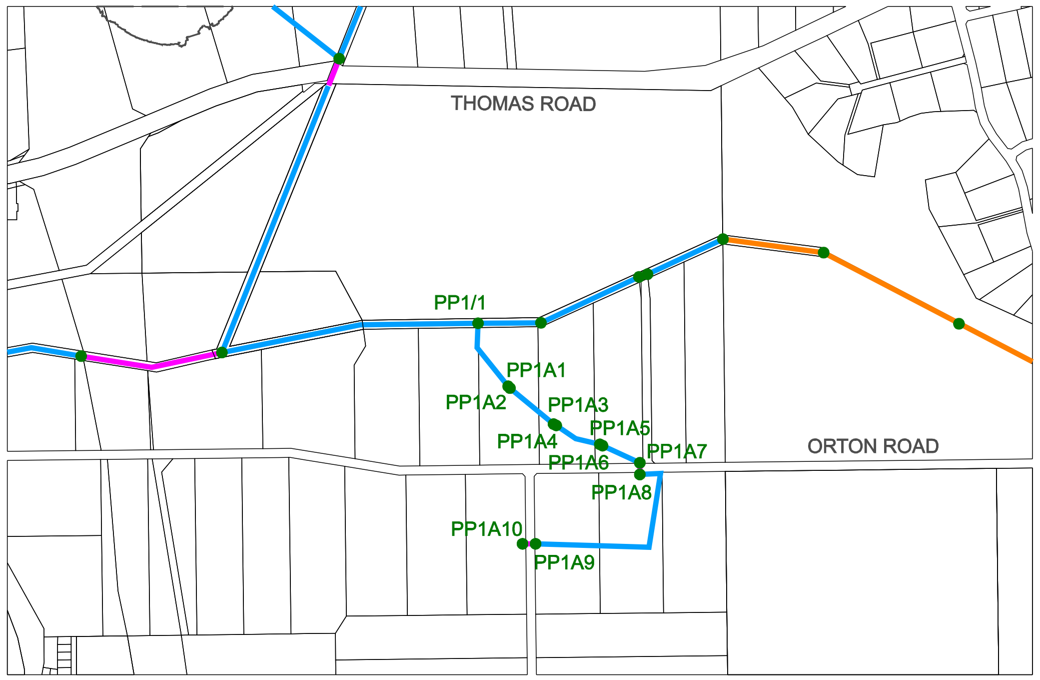
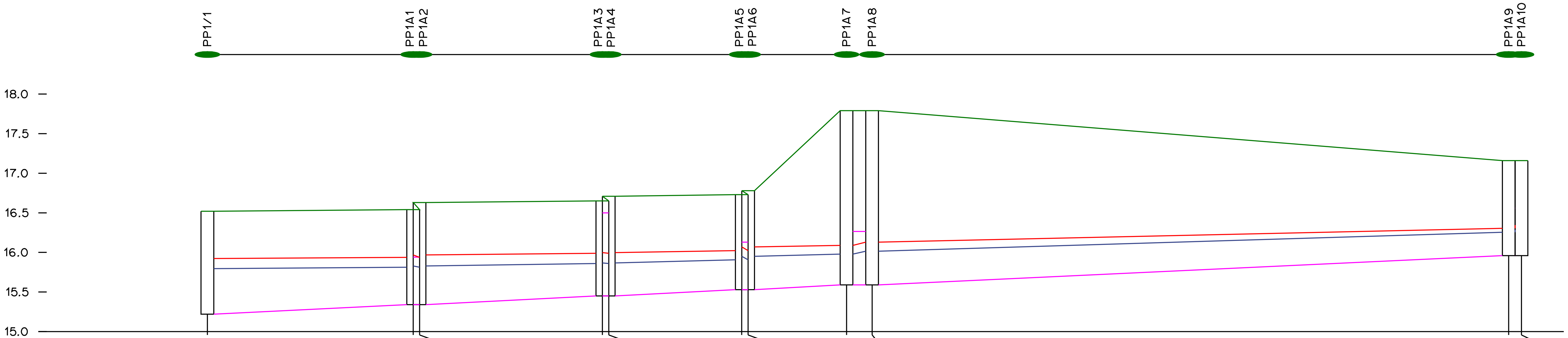




Chainage (m)	0	161	166	309	314	418	423	500	520	1018	1028
Ground level (m AHD)	16.52	16.54	16.63	16.65	16.71	16.73	16.78	17.79	17.79	17.16	17.16
10 year ARI HGL level (m AHD)	15.81	15.82	15.84	15.87	15.87	15.91	15.95	15.98	16.02	16.26	16.29
100 year ARI HGL level (m AHD)	15.93	15.95	15.98	16.00	16.01	16.03	16.08	16.10	16.14	16.31	16.35
Invert level (m AHD)	- / 15.22	15.34 / 15.34	15.34 / 15.34	15.45 / 15.45	15.45 / 15.45	15.53 / 15.53	15.53 / 15.53	15.59 / 15.59	15.59 / 15.59	15.96 / 15.96	15.96 / -

Chainage (m)	0–161	161–166	166–309	309–314	314–418	418–423	423–500	500–520	520–1018	1018–1028
Size (mm)	4500x1200	600	4500x1200	1050	4500x1200	600	4500 x1200	675	4500x1200	600
Max 10 year ARI flow (m3/s)	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.11	0.10
Max 100 year ARI flow (m3/s)	0.22	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.15	0.13

DESIGN FILE: Figure 5.3c SubDrain P Pt 3 of 4

AUTHOR: SLee

WATER CORPORATION

PROJECT N°: DP2 DATE: 24/04/2009

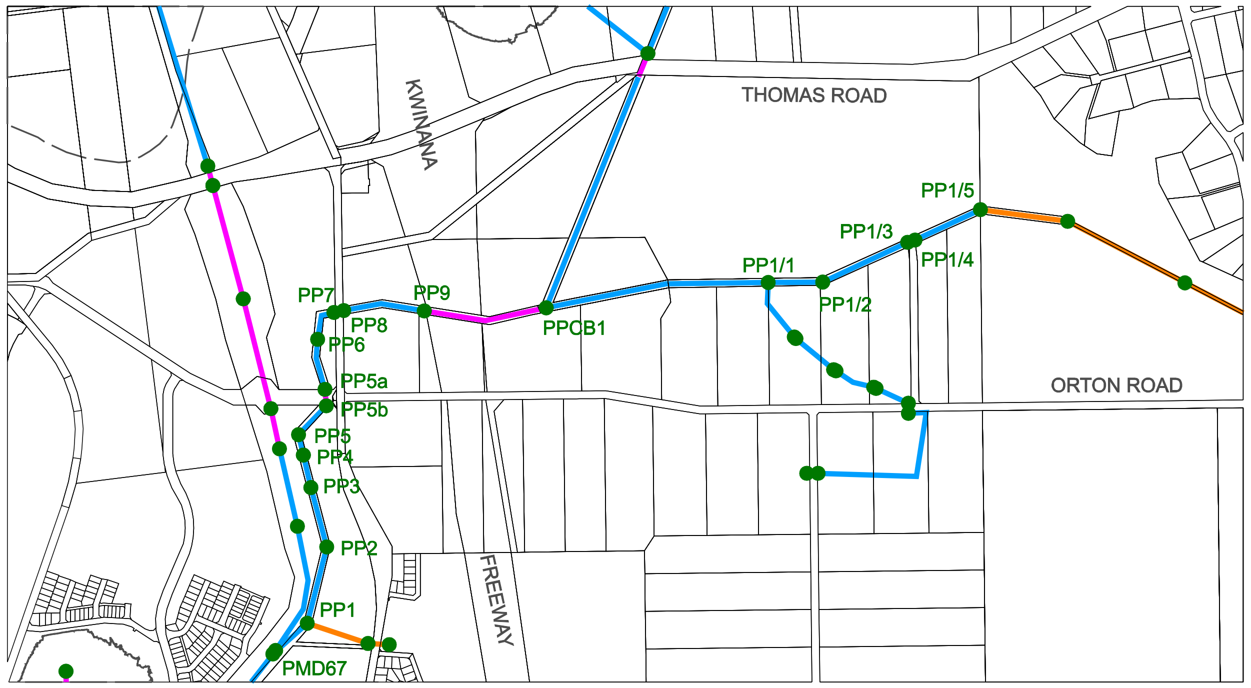
Peel Sub P1A Drain

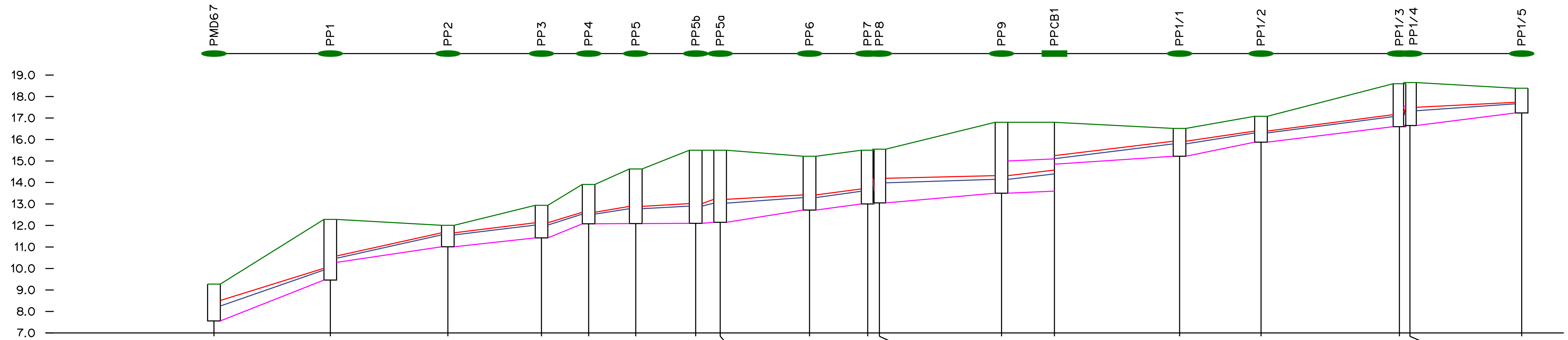
LONGITUDINAL SECTION

Post Development HGLs & Flows

Figure 5.3c

N





Node	Chainage (m)	Ground level (m AHD)	10 year ARI HGL level (m AHD)	100 year ARI HGL level (m AHD)	Invert level (m AHD) (in)	Invert level (m AHD) (out)
PMD67	0	9.27	8.25	8.51	-	7.56
PP1	200	12.28	10.66	10.73	9.46	10.28
PP2	402	12.01	11.56	11.66	11.01	11.01
PP3	563	12.94	12.02	12.13	11.42	11.42
PP4	644	13.91	12.53	12.61	12.08	12.08
PP5	725	14.63	12.78	12.89	12.09	12.09
PP5b	828	15.50	12.90	13.02	12.10	12.10
PP5a	870	15.50	13.04	13.22	12.15	12.15
PP6	1023	15.22	13.30	13.42	12.72	12.72
PP7	1123	15.50	13.59	13.70	13.00	13.00
PP8	1143	15.55	13.98	14.20	13.05	13.05
PP9	1353	16.80	14.15	14.31	13.50	13.50
PPCB1	1444	16.80	15.19	15.27	13.60	14.85
PP1/1	1659	16.52	15.81	15.93	15.22	15.22
PP1/2	1799	17.08	16.32	16.40	15.88	15.88
PP1/3	2037	18.60	17.07	17.16	16.60	16.60
PP1/4	2055	18.65	17.35	17.52	16.65	16.65
PP1/5	2247	18.39	17.66	17.74	17.24	-

Reach	Size (mm)	Max 10 year ARI flow (m3/s)	Max 100 year ARI flow (m3/s)
PMD67 – PP1	6330x1710	1.13	1.57
PP1 – PP2	4200x1000	1.09	1.52
PP2 – PP3	4200x1000	1.09	1.52
PP3 – PP4	5700 x1500	1.09	1.52
PP4 – PP5	6600 x1800	1.09	1.52
PP5 – PP5b	8700 x2500	1.09	1.52
PP5b – PP5a	1200	1.09	1.52
PP5a – PP6	8700 x2500	1.07	1.50
PP6 – PP7	8700 x2500	1.07	1.50
PP7 – PP8	1050	1.07	1.50
PP8 – PP9	9000x2500	1.05	1.47
PP9 – PPCB1	1500	1.01	1.43
PPCB1 – PP1/1	4800x1300	0.72	1.09
PP1/1 – PP1/2	4500x1200	0.64	0.91
PP1/2 – PP1/3	4350x1150	0.60	0.85
PP1/3 – PP1/4	915	0.60	0.85
PP1/4 – PP1/5	4350x1150	0.47	0.61

AUTHOR: SLee DESIGN FILE: Figure 5.3d SubDrain P Pt 4 of 4

WATER CORPORATION

Peel Sub P Drain and Peel Sub P1 Drain

LONGITUDINAL SECTION

Post Development HGLs & Flows

Figure 5.3d

PROJECT N°: DP2 DATE: 24/04/2009

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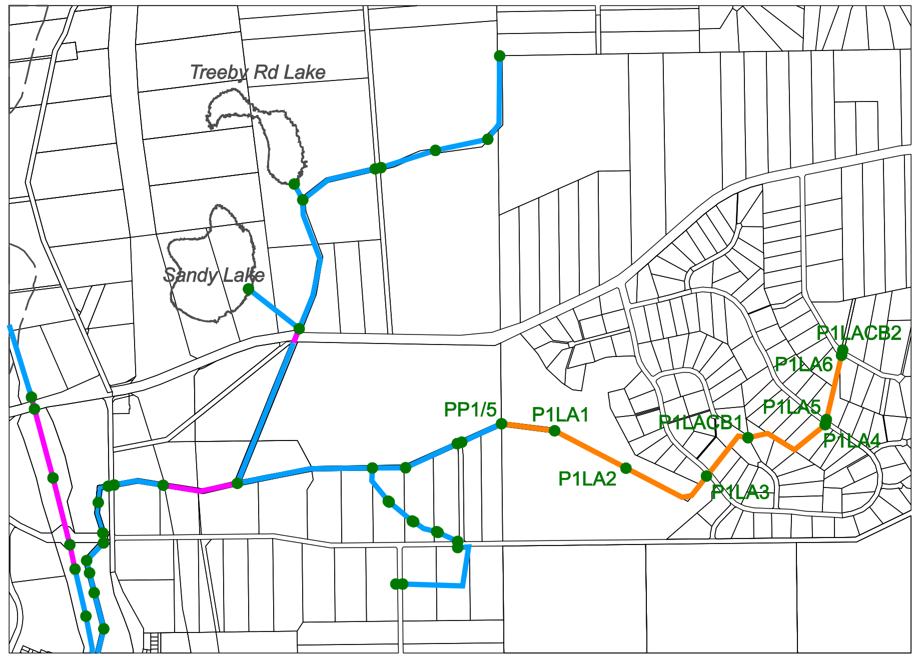
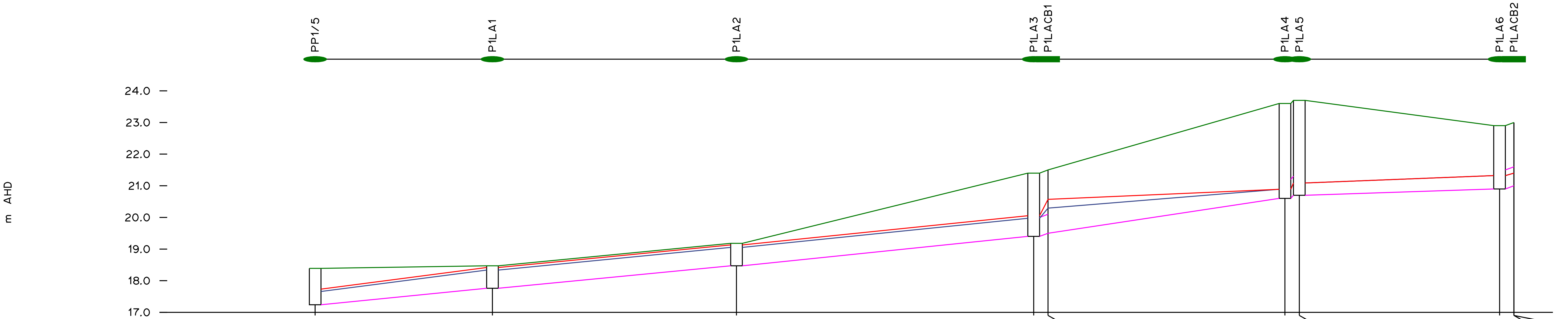




Chainage (m)	Ground level (m AHD)	10 year ARI HGL level (m AHD)	100 year ARI HGL level (m AHD)	Invert level (m AHD)
0	18.39	17.66	17.74	- / 17.24
247	18.47	18.34	18.42	17.76 / 17.76
587	19.18	19.05	19.13	18.47 / 18.47
1001	21.40	19.97	20.05	19.40 / 19.40
1021	21.50	20.30	20.57	19.50 / 19.50
1351	23.60	20.89	20.89	20.60 / 20.60
1371	23.70	21.09	21.09	20.70 / 20.70
1650	22.90	21.32	21.32	20.90 / 20.90
1670	23.00	21.40	21.40	21.00 / -
1670	23.00	21.40	21.40	- / -

Size (mm)	Max 10 year ARI flow (m3/s)	Max 100 year ARI flow (m3/s)
2000x700	0.47	0.62
2000x700	0.47	0.62
2000x700	0.47	0.62
600	0.47	0.62
2000x700	0.16	0.19
600	0.15	0.15
2000x700	0.15	0.15
600	0.15	0.15
	-	-

AUTHOR: SLee DESIGN FILE: Figure 5.3b SubDrain P 2 of 4

WATER CORPORATION

Peel Sub P1 Drain (Local Authority)

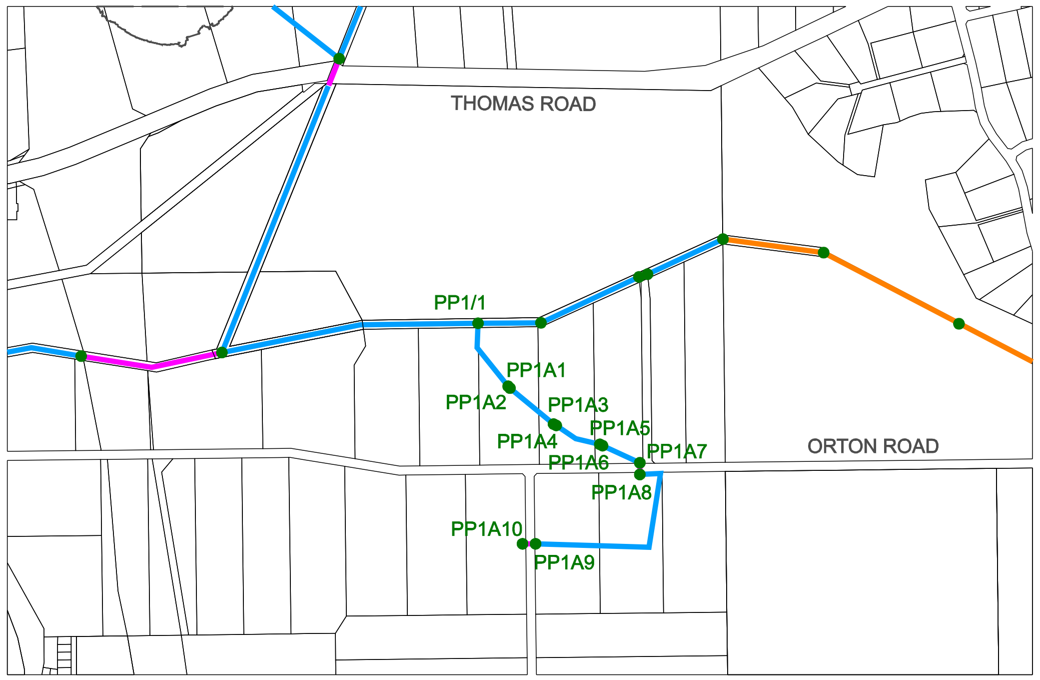
LONGITUDINAL SECTION

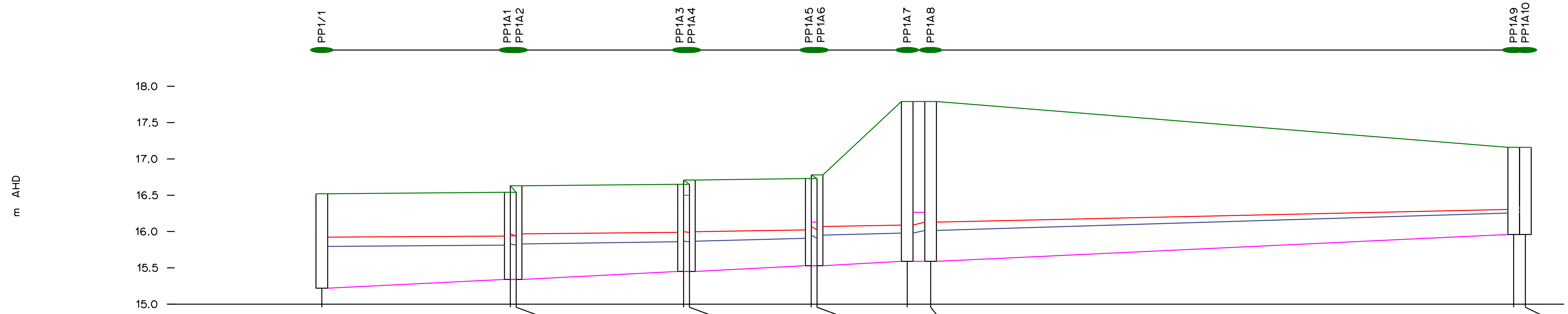
Post Development HGLs & Flows

Figure 5.3b

PROJECT N°: DP2 DATE: 24/04/2009

N





Chainage (m)	Ground level (m AHD)	10 year ARI HGL level (m AHD)	100 year ARI HGL level (m AHD)	Invert level (m AHD)
0	16.52	15.81	15.93	- / 15.22
161	16.54	15.82	15.95	15.34 / 15.34
166	16.63	15.84	15.98	15.34 / 15.34
309	16.65	15.87	16.00	15.45 / 15.45
314	16.71	15.87	16.01	15.45 / 15.45
418	16.73	15.91	16.03	15.53 / 15.53
423	16.78	15.95	16.08	15.53 / 15.53
500	17.79	15.98	16.10	15.59 / 15.59
520	17.79	16.02	16.14	15.59 / 15.59
1018	17.16	16.26	16.31	15.96 / 15.96
1028	17.16	16.29	16.35	15.96 / -

Segment (chainage)	Size (mm)	Max 10 year ARI flow (m3/s)	Max 100 year ARI flow (m3/s)
0–161	4500x1200	0.15	0.22
161–166	600	0.15	0.21
166–309	4500x1200	0.15	0.21
309–314	1050	0.15	0.21
314–418	4500x1200	0.15	0.21
418–423	600	0.15	0.21
423–500	4500 x1200	0.15	0.21
500–520	675	0.15	0.21
520–1018	4500x1200	0.11	0.15
1018–1028	600	0.10	0.13

DESIGN FILE: Figure 5.3c SubDrain P Pt 3 of 4

AUTHOR: SLee

WATER CORPORATION

Peel Sub P1A Drain

LONGITUDINAL SECTION

Post Development HGLs & Flows

Figure 5.3c

PROJECT N°: DP2 DATE: 24/04/2009

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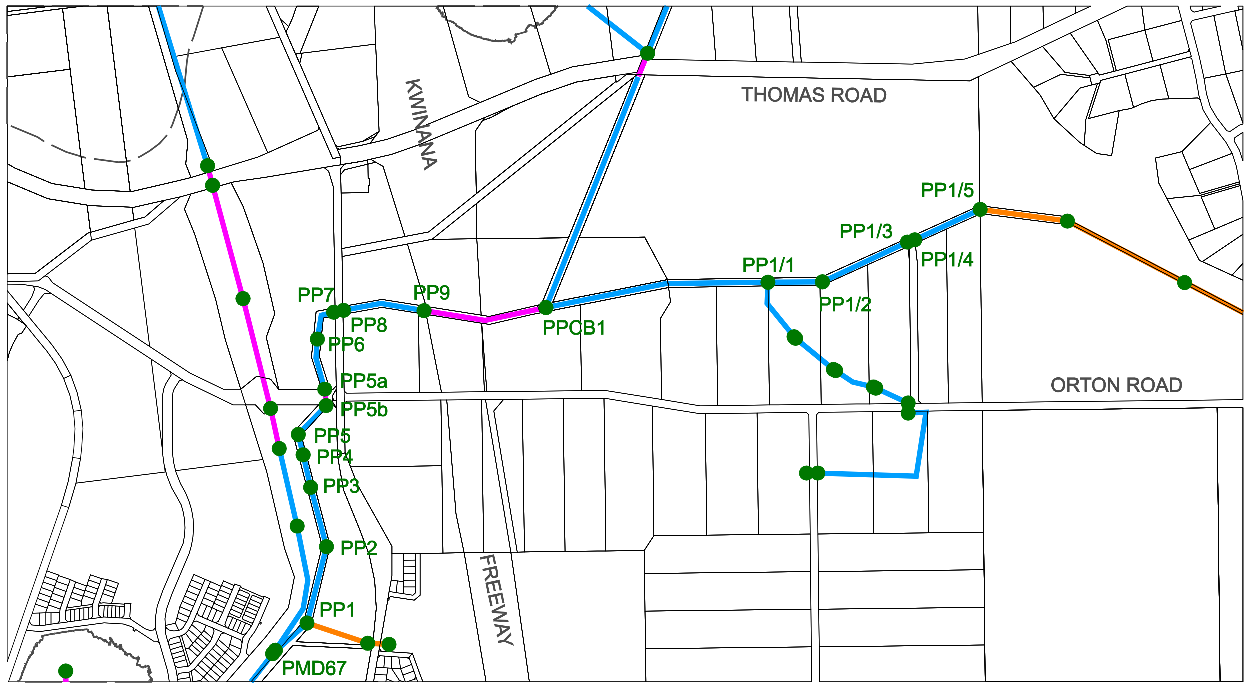
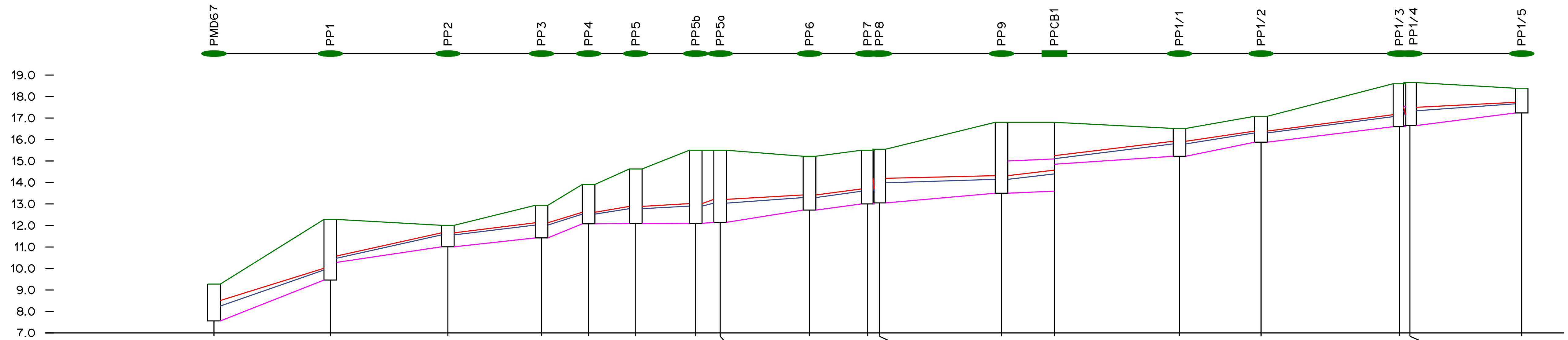
N





Node	Chainage (m)	Ground level (m AHD)	10 year ARI HGL level (m AHD)	100 year ARI HGL level (m AHD)	Invert level (m AHD), left of node	Invert level (m AHD), right of node
PMD67	0	9.27	8.25	8.51	-	7.56
PP1	200	12.28	10.66	10.73	9.46	10.28
PP2	402	12.01	11.56	11.66	11.01	11.01
PP3	563	12.94	12.02	12.13	11.42	11.42
PP4	644	13.91	12.53	12.61	12.08	12.08
PP5	725	14.63	12.78	12.89	12.09	12.09
PP5b	828	15.50	12.90	13.02	12.10	12.10
PP5a	870	15.50	13.04	13.22	12.15	12.15
PP6	1023	15.22	13.30	13.42	12.72	12.72
PP7	1123	15.50	13.59	13.70	13.00	13.00
PP8	1143	15.55	13.98	14.20	13.05	13.05
PP9	1353	16.80	14.15	14.31	13.50	13.50
PPCB1	1444	16.80	15.19	15.27	13.60	14.85
PP1/1	1659	16.52	15.81	15.93	15.22	15.22
PP1/2	1799	17.08	16.32	16.40	15.88	15.88
PP1/3	2037	18.60	17.07	17.16	16.60	16.60
PP1/4	2055	18.65	17.35	17.52	16.65	16.65
PP1/5	2247	18.39	17.66	17.74	17.24	-

Chainage (m)	Size (mm)	Max 10 year ARI flow (m3/s)	Max 100 year ARI flow (m3/s)
0–200	6330x1710	1.13	1.57
200–402	4200x1000	1.09	1.52
402–563	4200x1000	1.09	1.52
563–644	5700 x1500	1.09	1.52
644–725	6600 x1800	1.09	1.52
725–828	8700 x2500	1.09	1.52
828–870	1200	1.09	1.52
870–1023	8700 x2500	1.07	1.50
1023–1123	8700 x2500	1.07	1.50
1123–1143	1050	1.07	1.50
1143–1353	9000x2500	1.05	1.47
1353–1444	1500	1.01	1.43
1444–1659	4800x1300	0.72	1.09
1659–1799	4500x1200	0.64	0.91
1799–2037	4350x1150	0.60	0.85
2037–2055	915	0.60	0.85
2055–2247	4350x1150	0.47	0.61

DESIGN FILE: Figure 5.3d SubDrain P Pt 4 of 4

AUTHOR: SLee

WATER CORPORATION

Peel Sub P Drain and Peel Sub P1 Drain

LONGITUDINAL SECTION

Post Development HGLs & Flows

Figure 5.3d

PROJECT N°: DP2 DATE: 24/04/2009

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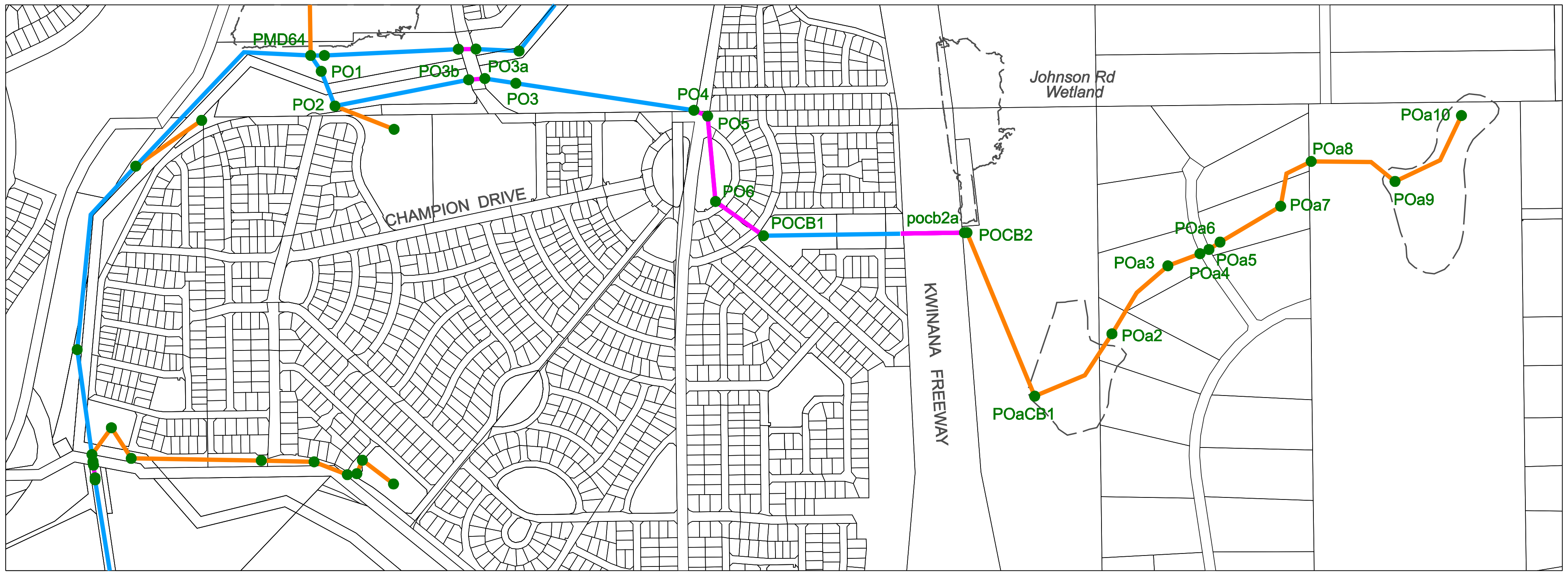
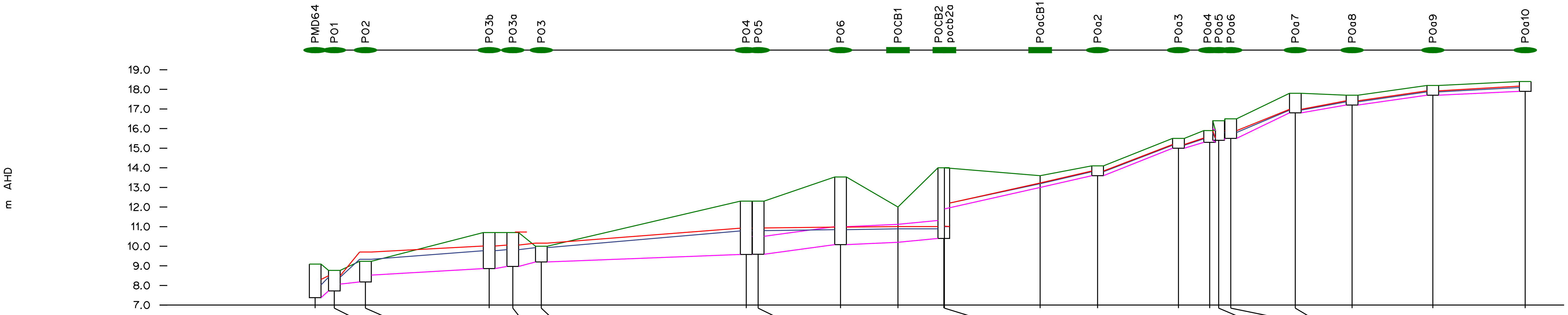




Size (mm)	Ground level (m AHD)	100 year ARI HGL level (m AHD)	Invert level (m AHD)	Chainage (m)	10 year ARI HGL level (m AHD)	Invert level (m AHD)	Max 10 year ARI flow (m3/s)	Max 100 year ARI flow (m3/s)
				0	8.04	-		
2590 x1050	9.09	8.31	7.38	40	8.41	7.72	1.23	1.54
1890 x700	8.77	8.49	8.07	105	9.31	8.18	1.23	1.54
1890x700	9.23	9.66	8.53	363	9.76	8.86	0.63	0.70
900 x750	10.70	10.00	8.86	412	9.81	8.97	0.61	0.64
1890 x700	10.70	10.05	8.97	472	9.92	9.20	0.61	0.64
1890x700	10.00	10.15	9.20	900	10.78	9.58	0.61	0.63
2X 915	12.30	10.92	9.58	925	10.80	9.59	2X0.33	2X0.37
2X915	12.30	10.93	9.59	1097	10.85	10.08	2X0.33	2X0.37
2X915	13.53	10.97	10.08	1217	10.89	10.20	2X0.35	2X0.41
4X915	12.00	11.01	10.20	1313	10.89	10.40	4X0.08	4X0.08
1000 x500	14.00	11.01	10.40	1314	12.03	10.80	0.31	0.31
3000x500	14.00	12.06	11.90	1514	13.18	13.00	0.16	0.22
3000 x500	13.60	13.22	13.00	1634	13.79	13.60	0.16	0.23
3000x500	14.10	13.83	13.60	1803	15.14	15.00	0.12	0.19
3000 x500	15.50	15.18	15.00	1868	15.47	15.30	0.12	0.19
600	15.90	15.51	15.30	1887	15.76	15.40	0.12	0.19
3000 x1000	16.40	15.86	15.40	1912	15.78	15.50	0.12	0.19
3000 x1000	16.50	15.87	15.50	2047	16.93	16.80	0.09	0.15
3000 x500	17.80	16.97	16.80	2166	17.35	17.20	0.09	0.15
3000x500	17.70	17.41	17.20	2334	17.86	17.70	0.09	0.15
3000x500	18.20	17.92	17.70	2527	18.08	17.90	0.07	0.12
	18.40	18.15	-					

AUTHOR: SLee DESIGN FILE: Figure 5.4 SubDrain O Pt 1 of 1

WATER CORPORATION

Peel Sub O Drain and Local Authority Drain

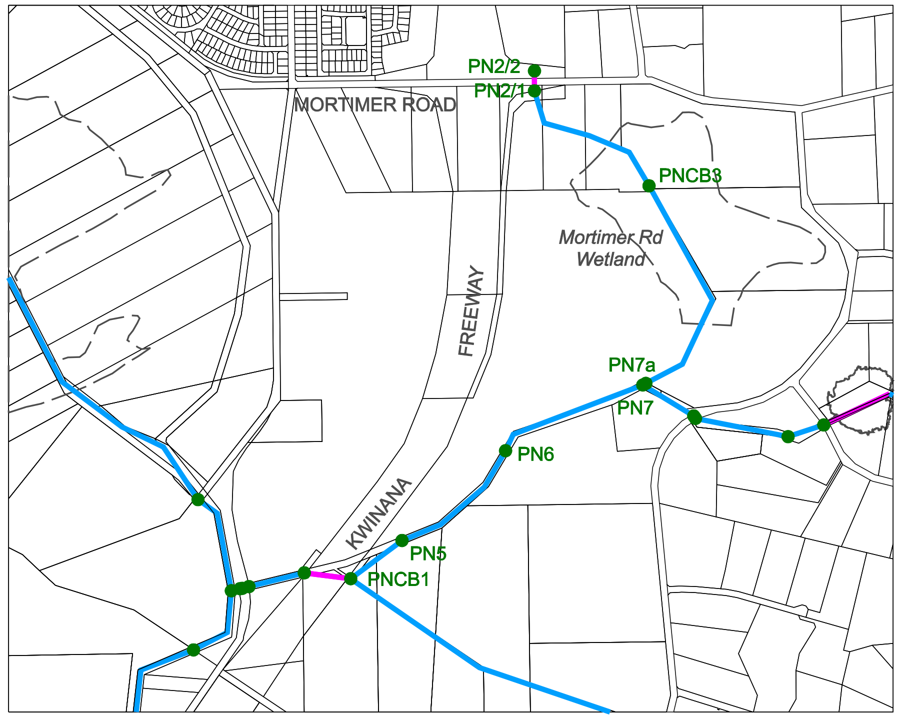
LONGITUDINAL SECTION

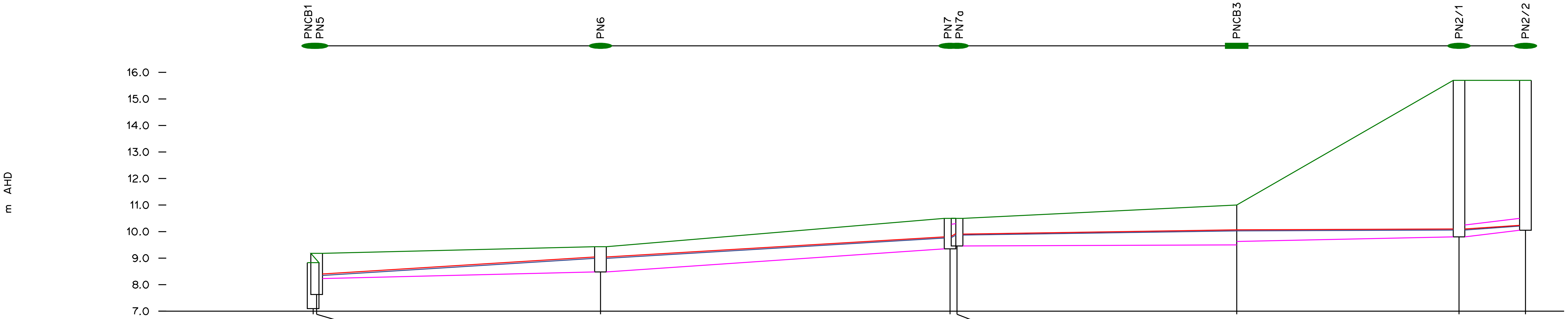
Post Development HGLs & Flows

Figure 5.4

PROJECT N°: DP2 DATE: 24/04/2009

N





Chainage (m)	Ground level (m AHD)	10 year ARI HGL level (m AHD)	100 year ARI HGL level (m AHD)	Invert level (m AHD)
0	8.83	7.63	7.80	- / 7.10
5	9.18	7.86	7.90	7.63 / 8.23
411	9.43	8.99	9.04	8.48 / 8.48
911	10.50	9.76	9.80	9.35 / 9.40
921	10.50	9.87	9.91	9.46 / 9.46
1321	11.00	10.03	10.07	9.50 / 9.63
1639	15.70	10.06	10.10	9.80 / 9.80
1734	15.70	10.21	10.24	10.05 / -

Size (mm)	Max 10 year ARI flow (m3/s)	Max 100 year ARI flow (m3/s)
7100 x1550	0.50	0.61
4700x950	0.39	0.48
4700x950	0.39	0.47
900	0.23	0.26
2600x1000	0.14	0.16
1800x600	0.03	0.04
450	0.03	0.04

Peel Sub N Drain and Peel Sub N2 Drain

LONGITUDINAL SECTION

Post Development HGLs & Flows

Figure 5.5a

WATER CORPORATION

PROJECT N°: DP2 DATE: 24/04/2009

AUTHOR: SLee DESIGN FILE: Figure 5.5a SubDrain N Pt 1 of 3

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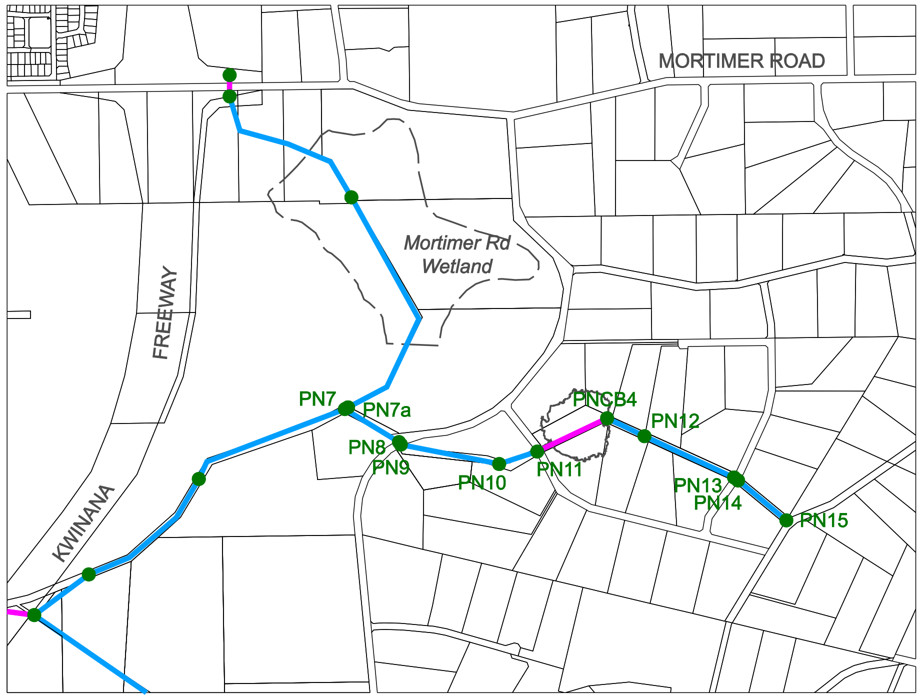
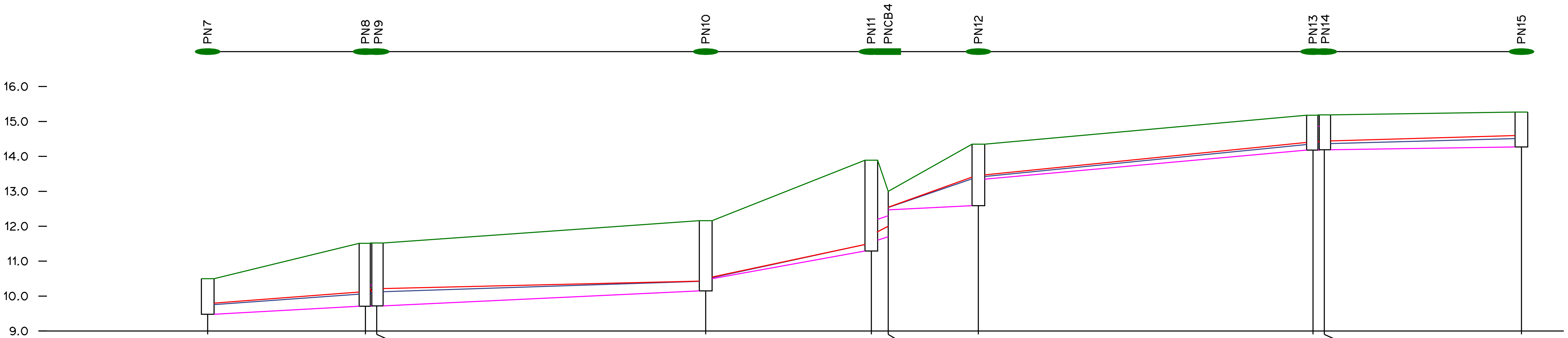
N





Chainage (m)	Ground level (m AHD)	10 year ARI HGL level (m AHD)	100 year ARI HGL level (m AHD)	Invert level (m AHD)
0	10.50	9.76	9.80	- / 9.48
140	11.51	10.06	10.12	9.71 / 9.71
150	11.52	10.13	10.22	9.72 / 9.72
442	12.16	10.63	10.63	10.15 / 10.50
589	13.89	11.80	11.80	11.29 / 11.60
604	13.00	12.53	12.56	11.70 / 12.47
684	14.35	13.44	13.47	12.59 / 13.35
981	15.18	14.34	14.40	14.18 / 14.18
991	15.19	14.37	14.45	14.19 / 14.19
1166	15.27	14.51	14.60	14.27 / -

Size (mm)	Max 10 year ARI flow (m3/s)	Max 100 year ARI flow (m3/s)
2000x700	0.16	0.22
600	0.16	0.22
4200x1800	0.08	0.08
2800x1100	0.08	0.08
600	0.08	0.08
3020x530	0.04	0.08
2600x1000	0.04	0.08
675	0.04	0.08
2600x1000	0.04	0.08

DESIGN FILE: Figure 5.5b SubDrain N Pt 2 of 3

AUTHOR: SLee

WATER CORPORATION

PROJECT N°: DP2 DATE: 24/04/2009

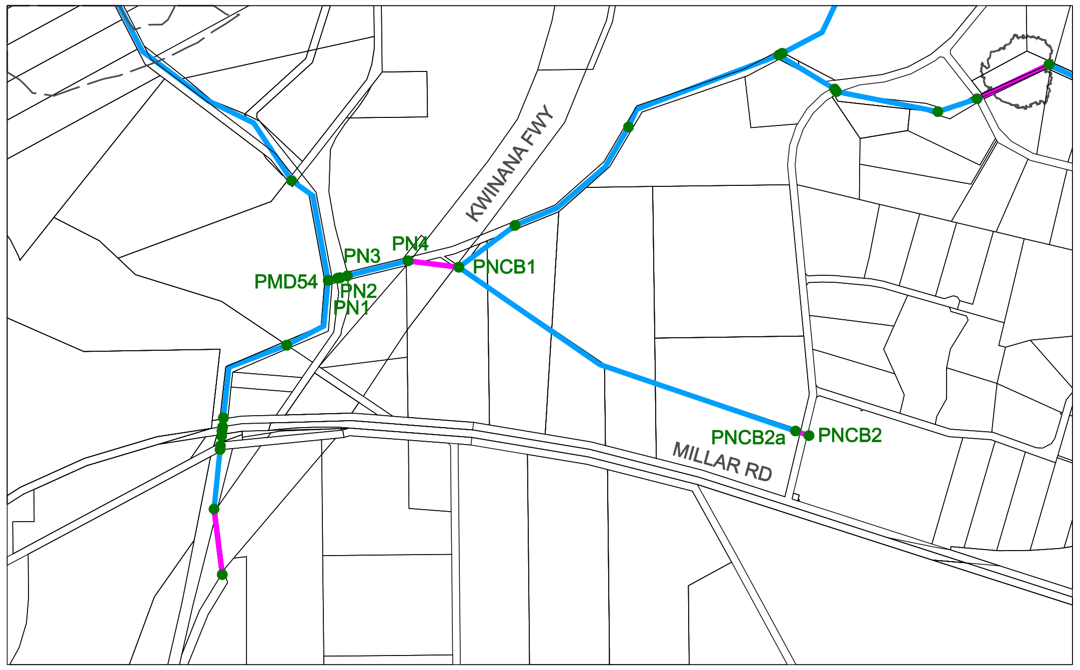
Peel Sub N Drain

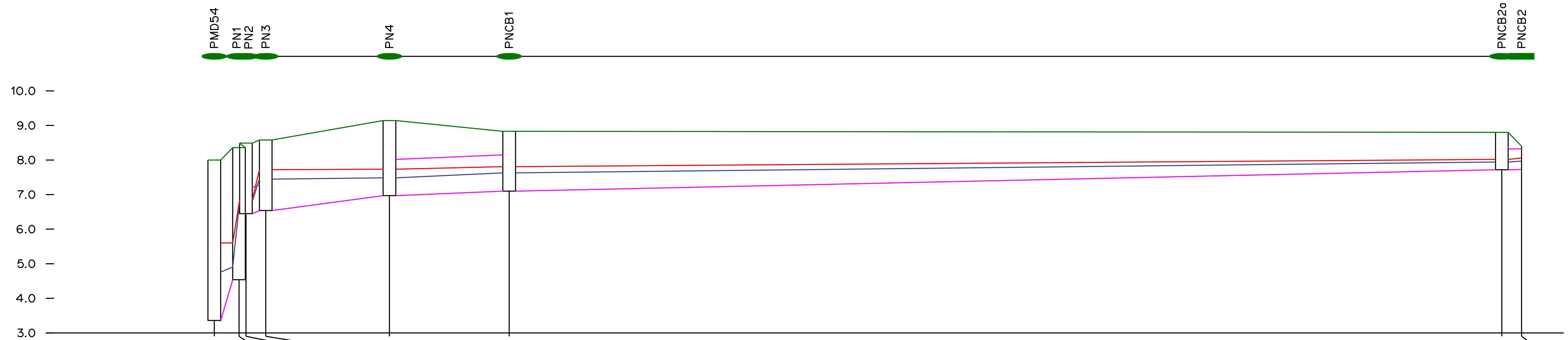
LONGITUDINAL SECTION

Post Development HGLs & Flows

Figure 5.5b

N





Chainage (m)	0	25	32	52	177	298	1301	1321
Ground level (m AHD)	8.00	8.36	8.49	8.58	9.14	8.83	8.80	8.40
10 year ARI HGL level (m AHD)	4.76	6.67	6.80	7.46	7.49	7.63	7.94	7.96
100 year ARI HGL level (m AHD)	5.60	6.72	6.83	7.71	7.73	7.80	8.01	8.05
Invert level (m AHD)	- / 3.36	4.54 / 6.32	6.45 / 6.45	6.54 / 6.54	6.97 / 6.97	7.10 / 7.10	7.72 / 7.72	7.73 / -

Reach (chainage)	0–25	25–32	32–52	52–177	177–298	298–1301	1301–1321
Size (mm)	10400 x2300	9360 x2040	750	10160 x2040	2X1050	5000x1000	600
Max 10 year ARI flow (m3/s)	0.76	0.76	0.76	0.70	2X0.35	0.05	0.05
Max 100 year ARI flow (m3/s)	1.07	1.07	1.07	0.93	2X0.46	0.10	0.09

DESIGN FILE: Figure 5.5c SubDrain N Pt 3 of 3

AUTHOR: SLee

WATER CORPORATION

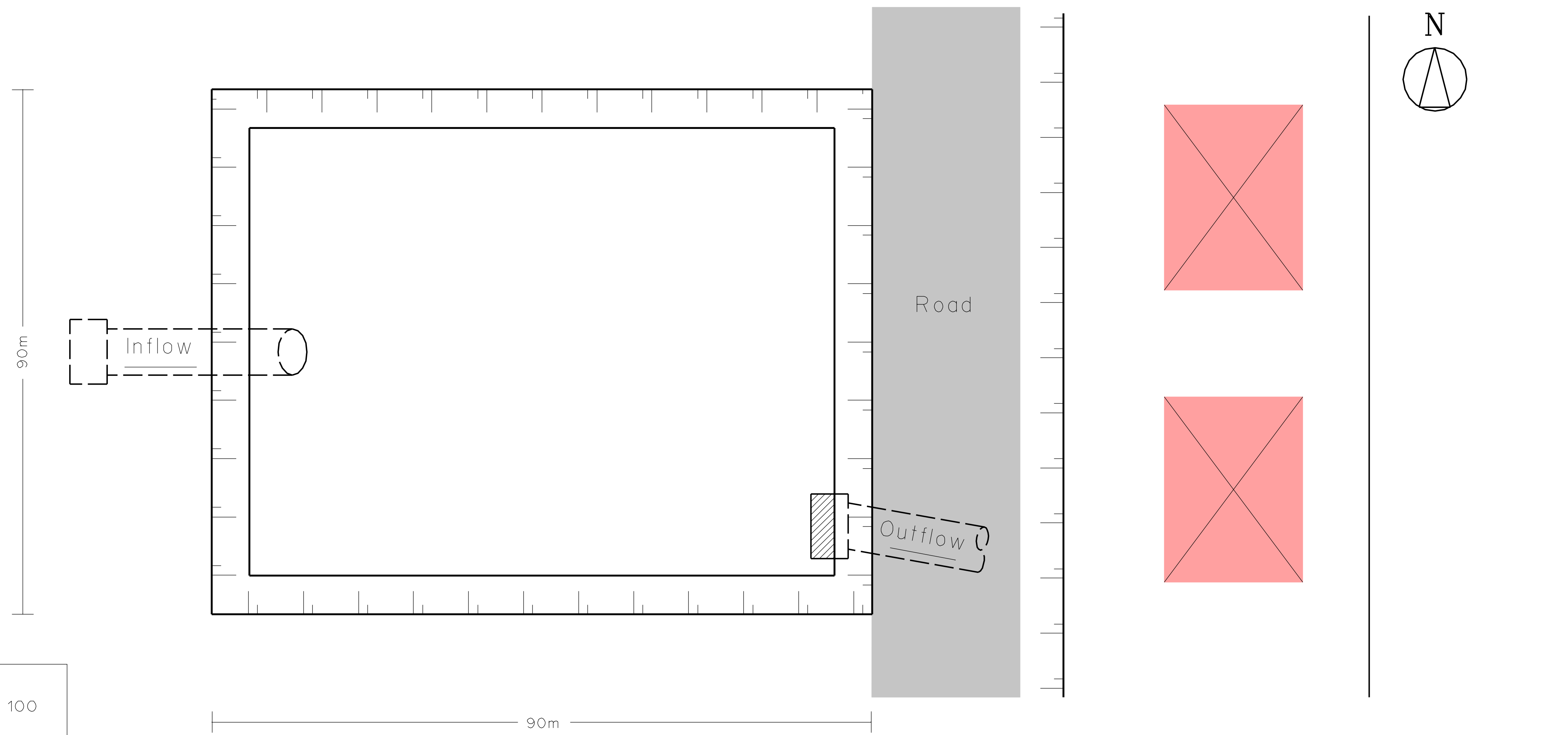
PROJECT N°: DP2 DATE: 24/04/2009

Peel Sub N Drain and Peel Sub N1 Drain

LONGITUDINAL SECTION

Post Development HGLs & Flows

Figure 5.5c



Land Requirement:

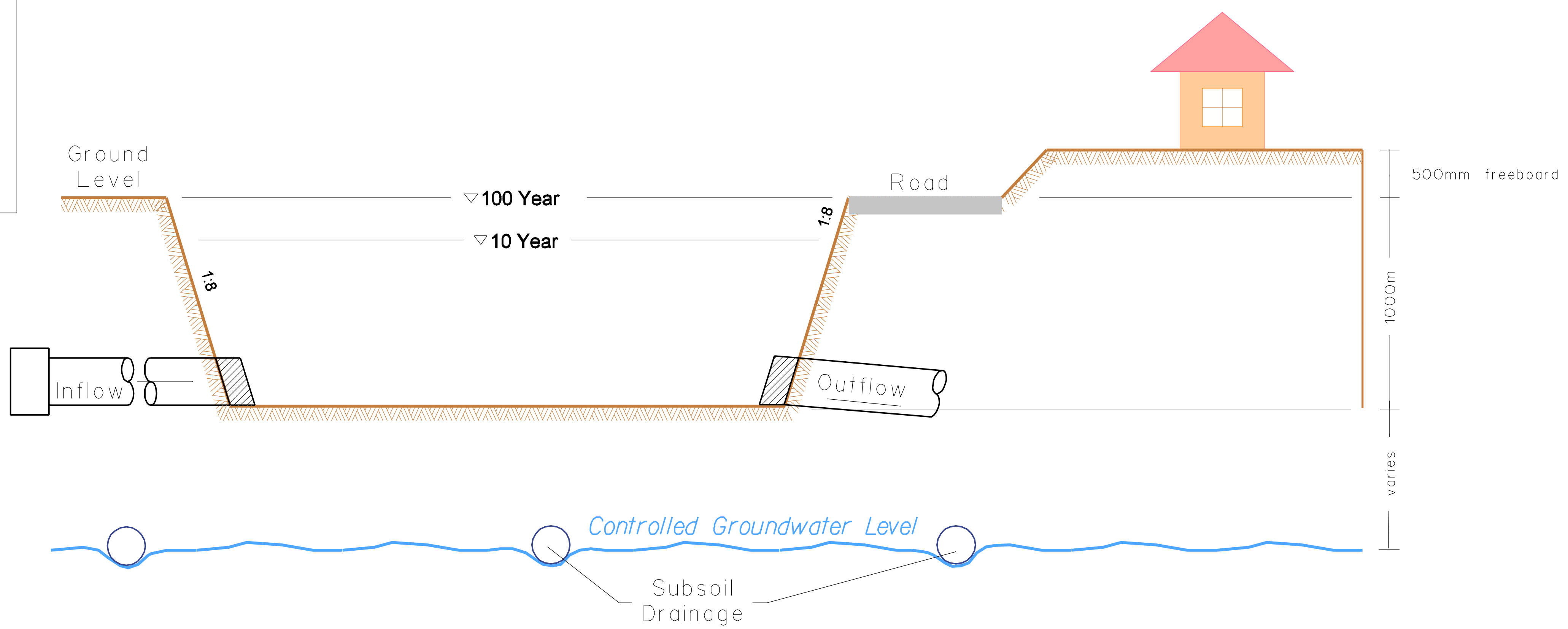
$$\frac{\text{CB Area}}{\text{POS Area}} = \frac{2(90 \times 90)}{50{,}000} \times 100$$

$$= 32\%$$

$$\frac{\text{CB Area}}{\text{S/C Area}} = \frac{2(90 \times 90)}{500{,}000} \times 100$$

$$= 3.2\%$$

Does not qualify to form part of POS.



CONCEPTUAL DESIGN OF LOCAL DRY DETENTION BASINS

Figure 6.1

DESIGN FILE: Figure 6.1 DetentionBasin.dgn

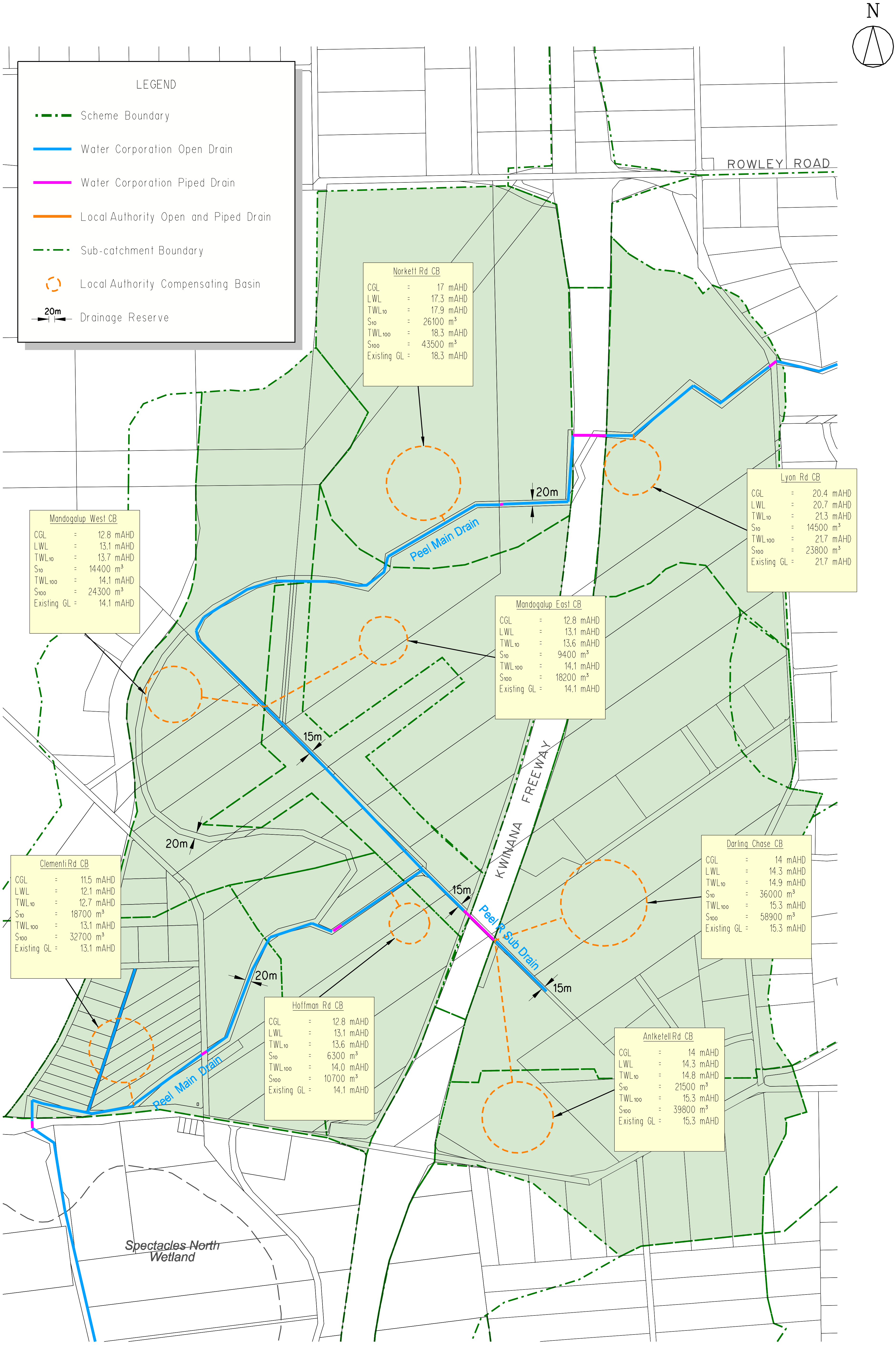
AUTHOR: SLee

PROJECT N°: 6116977 DATE: 10/09/2008 COORDINATE SYSTEM: MGA94 - Zone 50

AUTHOR: SLee DESIGN FILE: Figure 7.1 Local Arterial Design North.dgn

WATER CORPORATION

PROJECT N°: 6118977 DATE: 30/06/2008 COORDINATE SYSTEM: MGA94 - Zone 50



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0 200 400 600 800
SCALE OF METRES

Figure 7.1

LOCAL ARTERIAL DRAINAGE CONCEPTUAL DESIGN MANDOGULUP

AUTHOR: SLee DESIGN FILE: Figure 7.2 Local Arterial Design.dgn

PROJECT N°: 6116977 DATE: 16/06/2008 COORDINATE SYSTEM: MGA94 - Zone 50

WATER CORPORATION

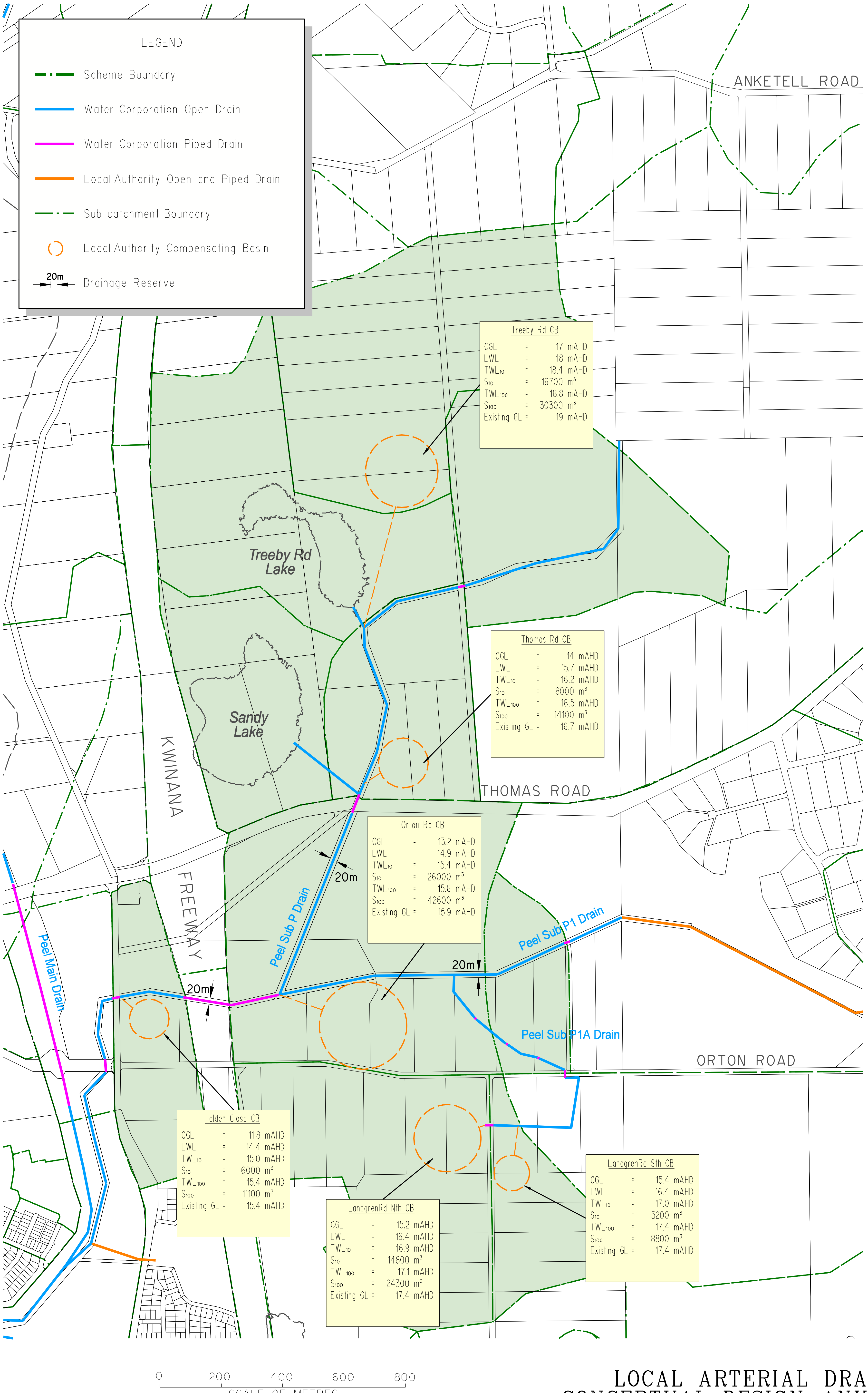

Figure 7.2

LOCAL ARTERIAL DRAINAGE CONCEPTUAL DESIGN ANKETELL

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AUTHOR: SLee DESIGN FILE: Figure 7.3 Local Arterial Design South.dgn

PROJECT N°: 6116977 DATE: 30/06/2008 COORDINATE SYSTEM: MGA94 - Zone 50

WATER CORPORATION

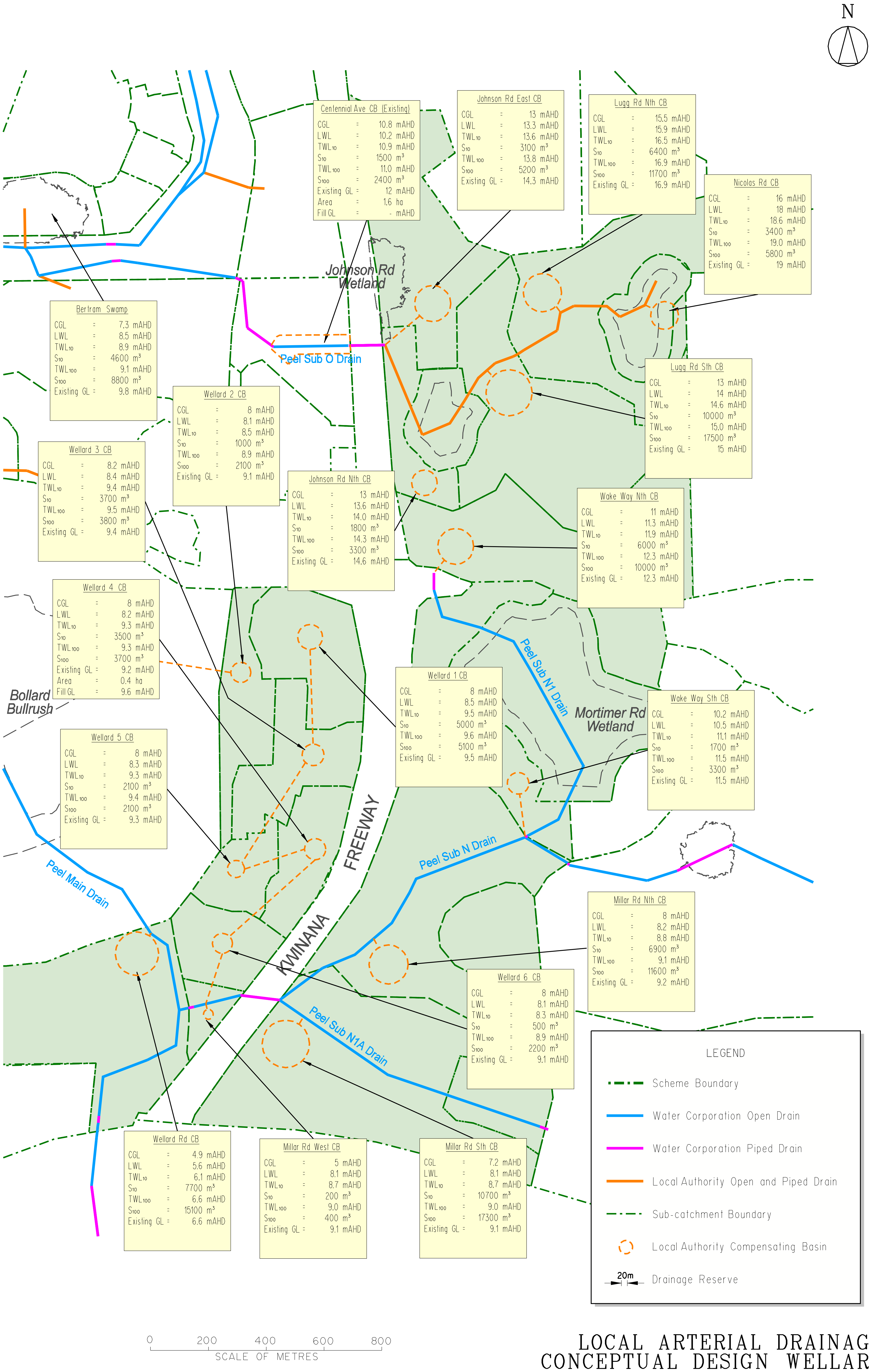

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Figure 7.3

LOCAL ARTERIAL DRAINAGE CONCEPTUAL DESIGN WELLARD

AUTHOR: SLee DESIGN FILE: Figure_A3.1_PreDev_SubCatch.dgn

PROJECT N°: 6116977 DATE: 27/06/2008 COORDINATE SYSTEM: MGA94 - Zone 50

WATER CORPORATION

N

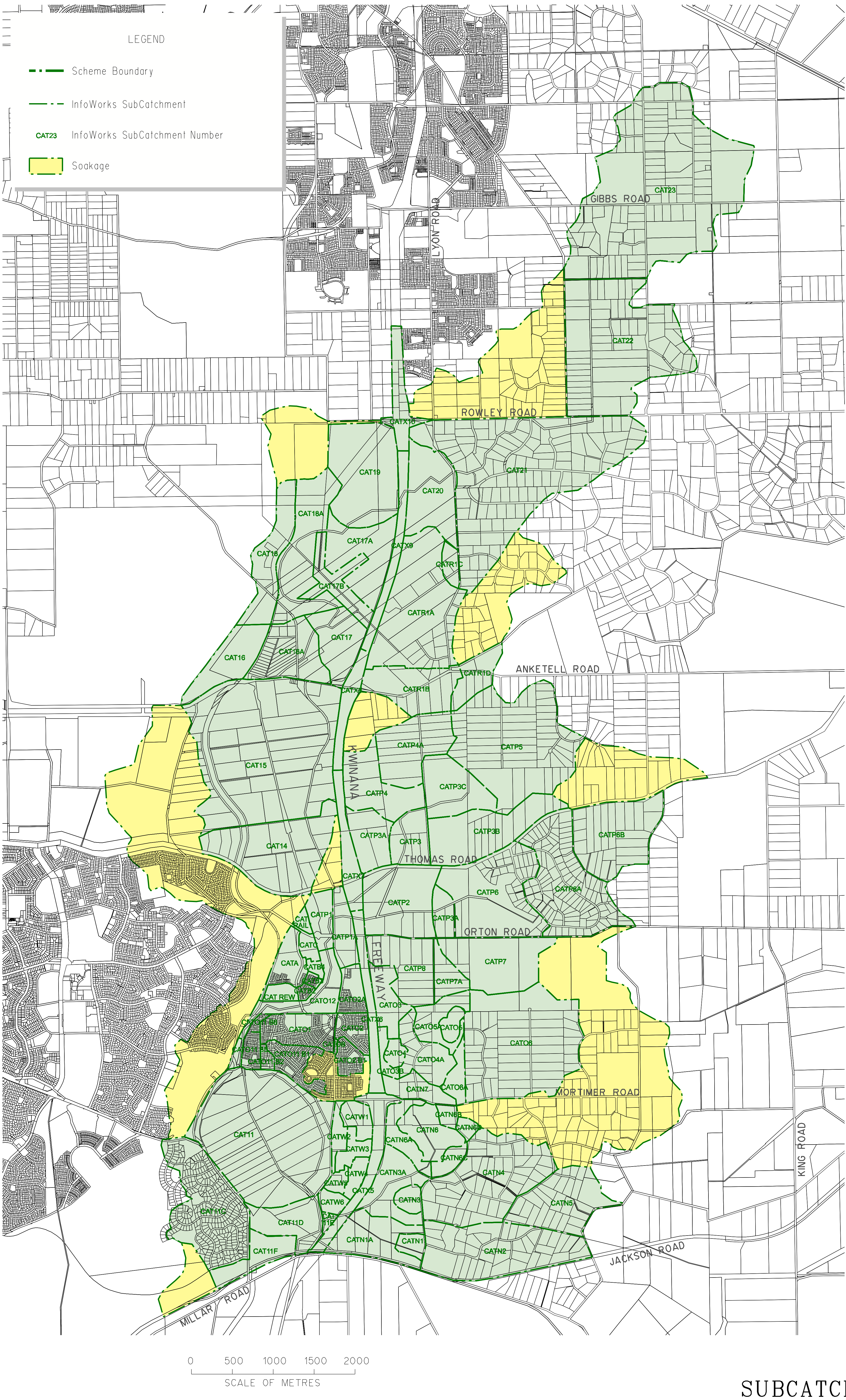

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Figure A3.1

SUBCATCHMENTS

AUTHOR: SLee DESIGN FILE: Figure_ES1_UltimateDrainageSystem.dgn

PROJECT N°: 6116977 DATE: 30/06/2008 COORDINATE SYSTEM: MGA94 - Zone 50

WATER CORPORATION

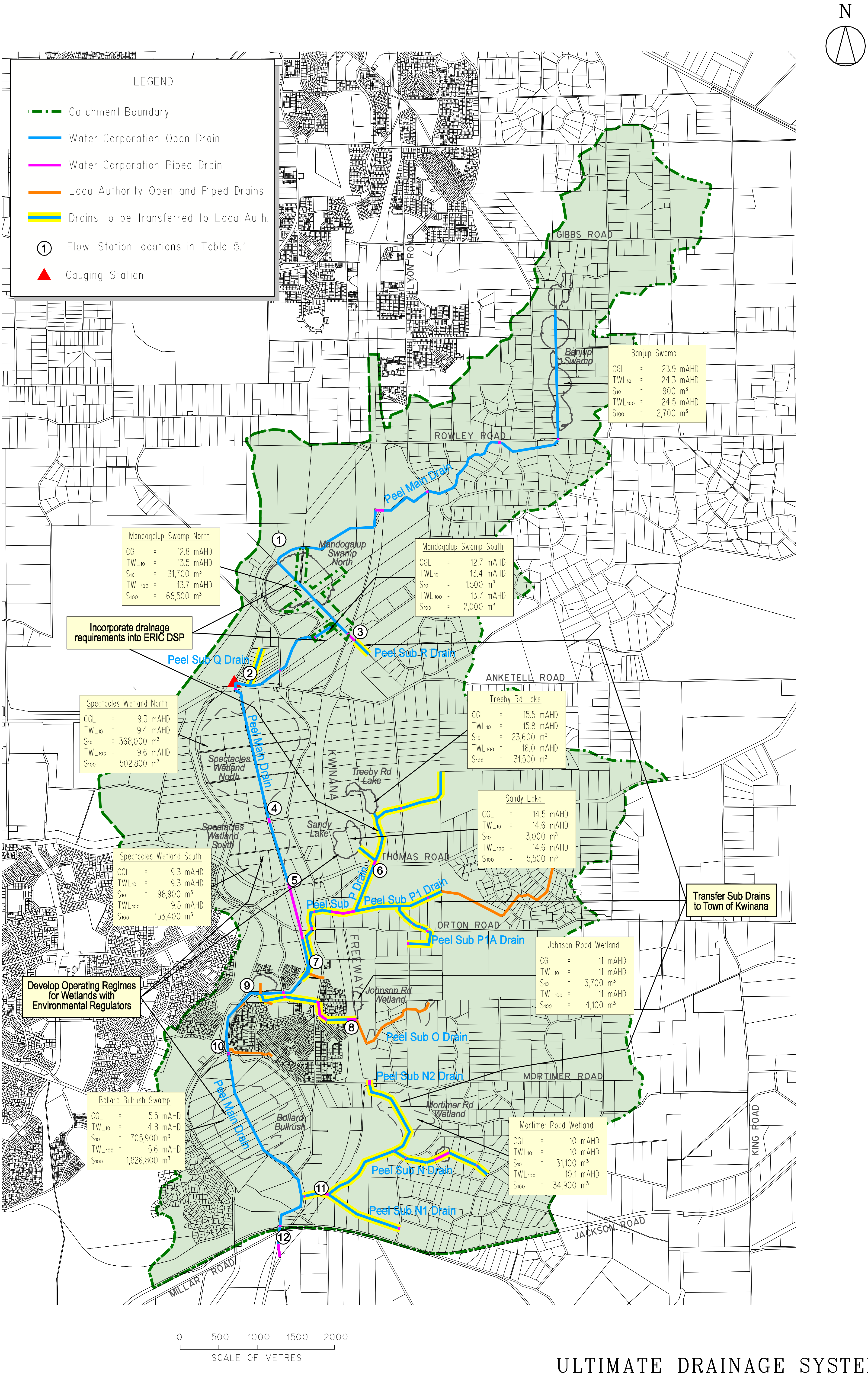

Figure ES1

ULTIMATE DRAINAGE SYSTEM

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Appendix C — Checklist for developers

Local water management strategy checklist for developers

This checklist must be completed and signed by a suitably qualified professional and submitted to Council with the local water management strategy for assessment when an application for a local structure plan is lodged.

For each item on the checklist, please identify where in the local water management strategy the item has been addressed in the submission and the assessor will make comments as to its compliance with the *Jandakot structure plan* (WAPC, 2007) and the drainage and water management plan. All sections must be completed and if an item is not applicable or has not been addressed in the local water management strategy, comments explaining this are required.

Applicant:……………………………………………………………………………………….

Name of structure plan:…………………………………………………………………………

Version of structure plan: ...…………………………………………………………........

Contact: …………………………………………………………………………………….......

Address: ……………………………………………………………………………….............

Telephone number:…………………………Email: ……………………………………………..

Authorised Signature: ……..……………………………………………..…………………........

Date: ………………………………………………………………………………………………

	Item	Submission		Assessment	
		Document Ref.[1]	Comments[2]	Compliance	Comment
1.0	**Introduction**				
1.1	Drainage and water management principles and design objectives for this structure plan				
1.2	Planning background (subject land)				
1.3	Previous studies (related to drainage and water)				
2.0	**Proposed development**				
2.1	Key elements of structure plan				
2.2	Previous land use and potential sources of contamination				
2.3	Finished lot levels – (determined by greater of 100-year flood protection criteria or minimum separation of groundwater to building foundations)				
2.4	Assessment of risk undertaken				
2.5	Is the development located in a public drinking water source area?				
3.0	**Existing site characteristics**				
3.1	Topography and landform identified				
3.2	Environmental geology of the site identified (including soil types, ASS and PASS)				
3.3	Soil hydraulic conductivity and infiltration capacity of the site identified				
3.4	Groundwater levels, flows and quality of the site mapped (include identification and monitoring of any local or regional groundwater bores)				
3.5	Surface water flows and quality of the site identified (include flow monitoring of existing drainage)				
3.6	Environmental assets and water-dependent ecosystems mapped				
3.7	Indigenous sites identified				
3.8	Existing infrastructure and constraints to design identified (include management strategies for any identified constraints)				
3.9	Site water balance pre-development and post-development identified				
3.10	Water sustainability initiatives				

[1] Identify the section in the Local Structure Plan in which this item has been addressed. It is possible that some items are not applicable and if this is the case, please put an explanation in the comments section.

[2] Please make comments as to the applicability of this criterion.

	Item	Submission		Assessment	
		Document Ref.[1]	Comments[2]	Compliance	Comment
4.0	**Stormwater management**				
4.1	Pre- and post-development hydrology (1-year, 5-year and 100-year ARI events)				
4.2	1-year ARI event managed for ecological protection in accordance with water management plan section 6.2				
4.3	5-year ARI event managed for serviceability in accordance with water management plan section 6.2				
4.4	100-year ARI event managed for flood protection in accordance with water management plan section 6.2 (include flow paths and emergency access routes and fully identify flood plain and protection measures)				
4.5	Finished lot levels at minimum of 0.5 m above 100-year ARI flood levels.				
4.6	POS credits identified				
4.7	Water quality management BMPs to achieve design targets: Vegetated bioretention systems sized at 2% of the constructed impervious area they receive runoff from OR to achieve: • at least 80% reduction of total suspended solids • at least 60% reduction of total phosphorus • at least 45% reduction of total nitrogen • at least 70% reduction of gross pollutants				
5.0	**Groundwater management**				
5.1	Groundwater level management strategy				
5.2	Bio-retention system, subsurface drainage and drainage inverts				
5.3	Subsurface drainage design				
5.4	Groundwater management strategies to achieve: • at least 60% reduction of total P • at least 45% reduction of total N.				
5.5	Discharge to water-dependent ecosystems				
5.6	Specifications for imported fill (where proposed)				
6.0	**Monitoring**				
6.1	Monitoring programs commenced 2 years before proposed development				
6.2	Monitoring/sampling to follow Australian Standards				
6.3	Monitoring/sampling locations				
6.4	Water quality parameters to be monitored (refer to section 9.5 of water management plan)				
6.5	Monitoring program to include a contingency action plan to manage risk				
7.0	**Implementation**				
7.1	Commitments				
7.2	Maintenance schedules				
7.3	Roles and responsibilities (for pre-development, during construction and all periods post-development)				
7.4	Funding				
7.5	Review				

[1] Identify the section in the Local Structure Plan in which this item has been addressed. It is possible that some items are not applicable and if this is the case, please put an explanation in the comments section.

[2] Please make comments as to the applicability of this criterion.

Abbreviations

ADS	Arterial drainage scheme
AHD	Australian height datum
ARI	Average recurrence interval
BFS	*Bush forever* site
CCW	Conservation category wetland
CGL	Controlled groundwater level
DEC	Department of Environment and Conservation
DoW	Department of Water
DP	Department of Planning
DRF	Declared rare flora
DSP	District structure plan
DWMS	District water management strategy
EPP	Environmental protection policy
ERIC	Eastern redevelopment intensification project
EWR	Environmental water requirement
GDE	Groundwater-dependent ecosystem
HGL	Hydraulic grade line
LWMS	Local water management strategy
MUW	Multiple use wetland
NATA	National Association of Testing Authorities
PWSA	Public water source area
REW	Resource enhancement wetland
SSJ	Shire of Serpentine and Jarrahdale
TEC	Threatened ecological community

ToK	Town of Kwinana
TN	Total nitrogen
TP	Total phosphorous
TWG	Technical working group
TWL	Top water level
UWMP	Urban water management plan
UWPCA	Underground water pollution control area
WAPC	Western Australian Planning Commission
WC	Water Corporation
WDE	Water-dependent ecosystem
WMP	Water management plan

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