Southern Link Road Stage 2

Water Management & Impact Assessment

Prepared for the City of Canning

By Urbaqua

November 2018

urbaqua
land and water solutions

Disclaimer and Limitation

This document is published in accordance with and subject to an agreement between Urbaqua and the Client, City of Canning, for who it has been prepared for their exclusive use. It has been prepared using the standard of skill and care ordinarily exercised by environmental professionals in the preparation of such Documents.

This report is a qualitative assessment only, based on the scope of services defined by the Client, budgetary and time constraints imposed by the Client, the information supplied by the Client (and its agents), and the method consistent with the preceding. Urbaqua has not attempted to verify the accuracy or completeness of the information supplied.

Any person or organisation that relies upon or uses the document for purposes or reasons other than those agreed by Urbaqua and the Client without first obtaining the prior written consent of Urbaqua, does so entirely at their own risk and Urbaqua, denies all liability in tort, contract or otherwise for any loss, damage or injury of any kind whatsoever (whether in negligence or otherwise) that may be suffered as a consequence of relying on this Document for any purpose other than that agreed with the Client.

Copying of this report or parts of this report is not permitted without the authorisation of the Client or Urbaqua.

CONTENTS

Figures

Tables

1 INTRODUCTION

Undertaking planning studies that aim to improve amenity and facilitate intensification of land use, the City of Canning prepared the City Centre Structure Plan to guide implementation of town planning instruments. The Structure Plan has proposed new roads and other infrastructure to be constructed around Cannington Swamp and these have the potential to impact the wetland and threatened ecological community (TEC).

Stage 2 of the Southern Link Road proposes to connect Grey Street and the Grose Avenue / Liege Street roundabout in Cannington. The proposed route traverses along the boundary of the Cannington Swamp which is recognised for its conservation values, containing a TEC and a conservation category wetland (CCW).

This Water Management and Impact Assessment has been prepared for the City of Canning to inform the construction of the proposed road and to determine the potential impacts of road construction and other infrastructure and identify the ongoing management requirements for the TEC and surrounding land.

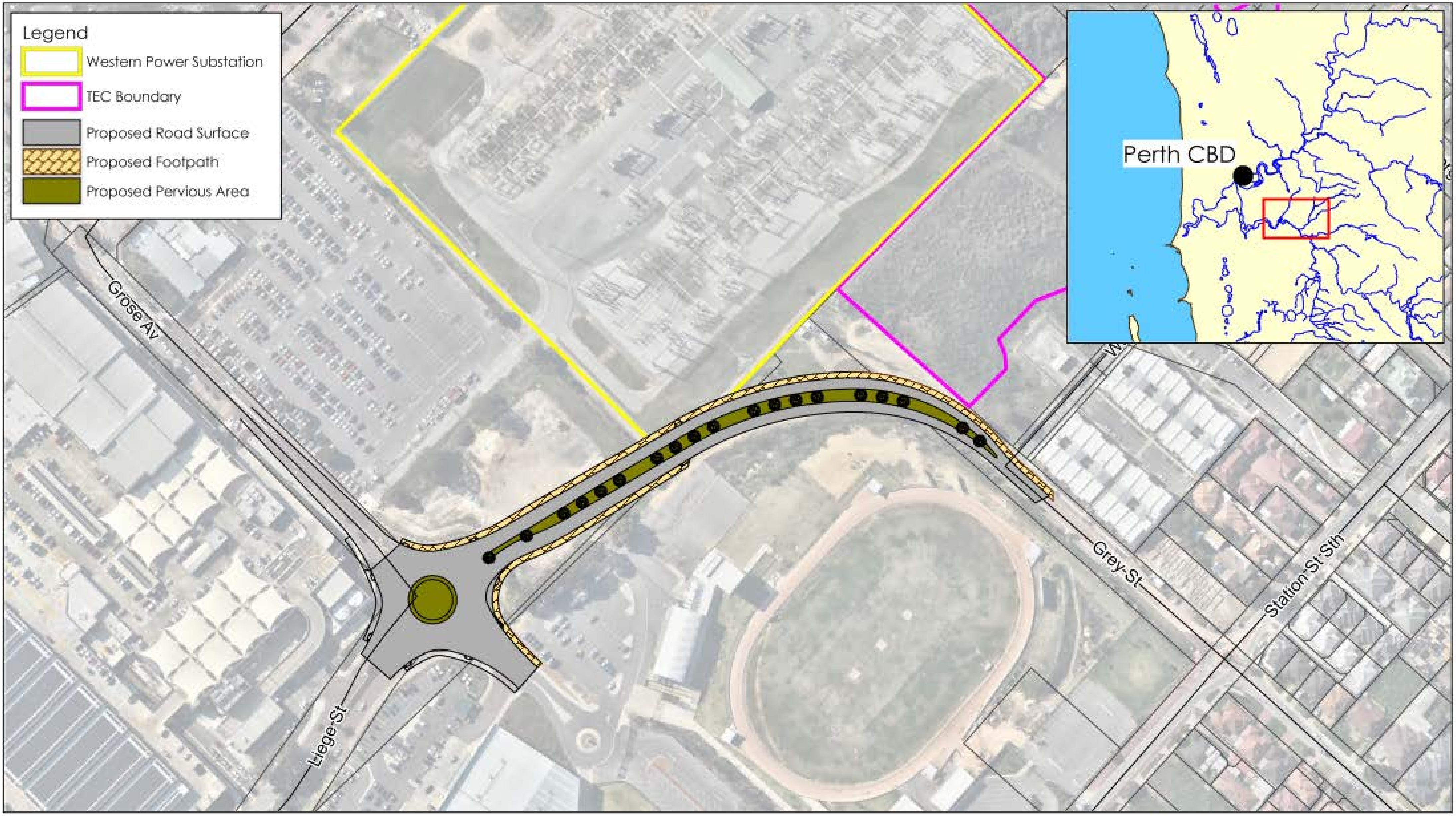
1.1 Location and proposed road design

Cannington Swamp is located approximately 11km southeast of Perth on Western Power land (behind the Cannington substation) and private land. The Cannington TEC has been identified as: Shrublands and woodlands on Muchea Limestone (endangered).

The proposed Southern Link Road stage 2 will consist of two asphalt sealed carriageways with a central landscaped area and a footpath proposed at the northern side. Details of the road design are shown in Appendix A. The road is bordering the Western Power substation and Cannington Swamp and connecting the Grose Avenue / Liege Street roundabout to Grey Street. The site location and the proposed Southern Link Road Stage 2 are illustrated in Figure 1.

This report assesses the potential environmental impacts of the road design.

Southern Link Road Stage 2 - Water Management & Impact Assessment
Figure 1 - Site location and proposed road layout



Data source: Nearmap, City of Canning Database. Created by:AN Projection: MGA: zone 50.

urbaqua
land and water solutions

2 SITE CHARACTERISTICS AND ENVIRONMENTAL ISSUES

The following review provides relevant information on the site characteristics sourced from available data and potential environmental issues.

2.1 Climate

The sites climate is typical of the Perth Metropolitan region, with warm dry summers and cooler wetter winters. The closest Bureau of Meteorology (BoM) weather station is Gosnells City located at approximately 6 km away from the site. This station has been in operation continuously since 1961.

As demonstrated in Figure 2a, there is a variation in the annual totals, ranging between 499.6mm (2010) and 1,184mm (1965). The data indicates a decreasing trend in annual and winter rainfall totals, particularly since 2000 where the annual average rainfall has decreased from 820.3mm to 729.4mm (approximately a 11.1% decrease).

Evaporation (Armadale Station), as shown in Figure 2b, is highest between November and March. A comparison of the mean monthly rainfall and evaporation totals demonstrates that the region is water limited between September and April. Between May and August rainfall exceeds evaporation.

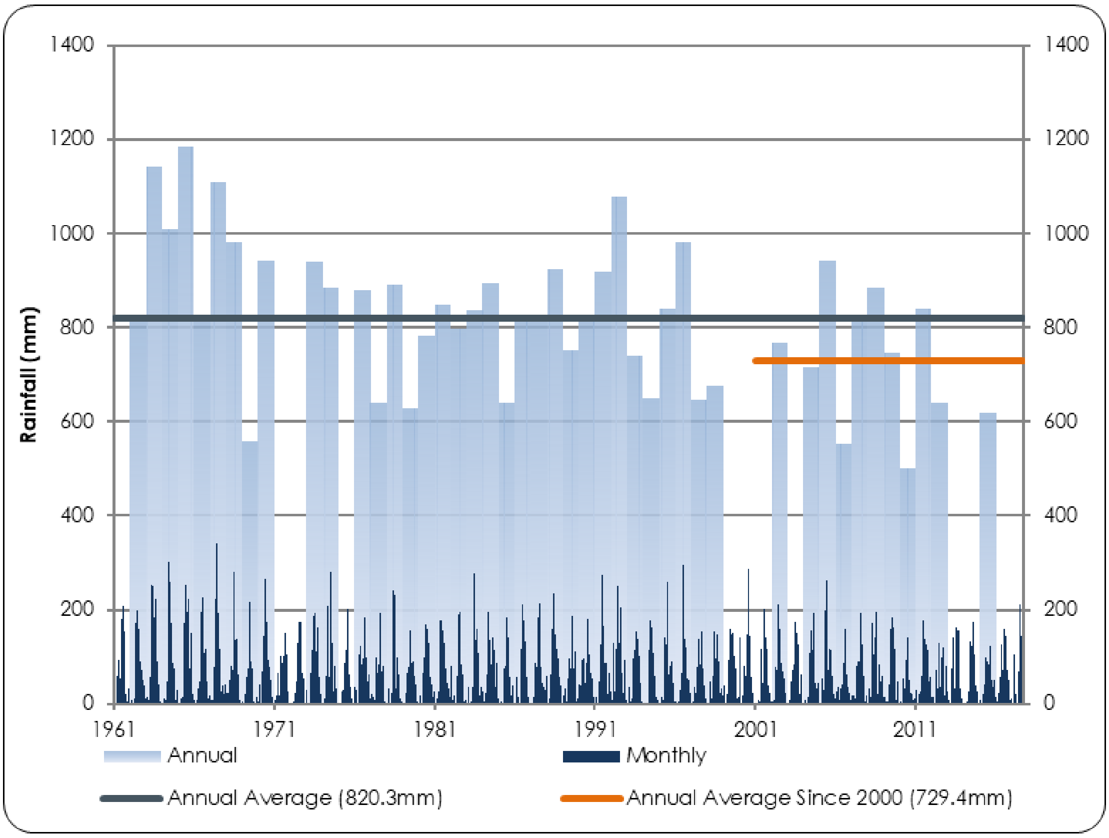


Figure 2a: Average annual and monthly climate data (station no. 9106) (BoM, 2018a)

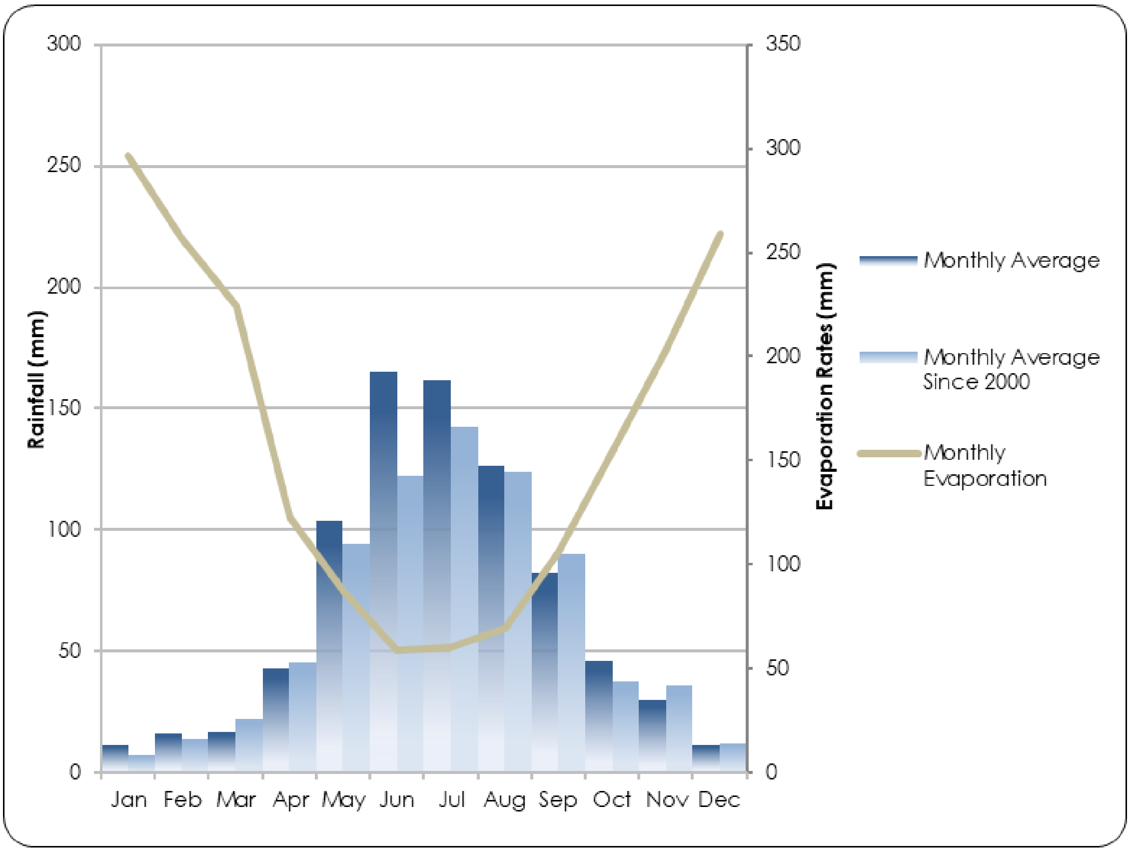


Figure 2b: Average Monthly Rainfall and Evaporation Data

2.2 Geology

The Perth Metropolitan Region 1:50,000 Environmental Geology Mapping (Jordan J. E., 1986 Armadale part sheets 2033 I and 2133 IV) defines the materials as S10, thin Bassendean Sand over Sandy Clay to Clayey Sand of the Guildford Formation of eolian origin.

The site-specific soil investigation (PB, 2005) indicates the swamp soil profile as below:

- Sandy Clay (depth of 0 – 5.5m): underlain by sand and clay layers, the clay is brown above the sandy layers and changing to dull green with depth, representing a change from oxidising to reducing condition;
- Limestone Gravel (depth of 1.5 – 4.5m): Gravel clasts are sub-angular to rounded and contain minor quartz sand fraction;
- Chalky Clay (depth of 3.5 – 5.5m): Contains coarse sand to granule cementations, occasionally range to gravel and cobble size;
- Interlayered Sand and Sandy Clay (depth of 3 – 12): sandy lenses are generally medium to coarse grained and yielded small volumes of water during air-core drilling;
- Black Clay (depth of 12 – 13m): underlain by a grey sandy unit containing some limestone cobbles and shelly material; and
- Sand with Calcareous Gravel and Shells (depth of 13 – 15m).

2.3 Biodiversity

The Southern Link Road Stage 2 construction area is entirely outside of the Cannington Swamp TEC and CCW in an area of limited cover with highly degraded vegetation. However, it is important to understand the biodiversity values present in the TEC and CCW areas so that any potential indirect impacts can be understood and managed appropriately.

2.3.1 Vegetation description

A Flora, Vegetation and Fauna Survey undertaken (Natural Area, 2016) for the TEC and CCW area identified the presence of nine vegetation types:

- Open *Casuarina obesa* Woodland;
- *Viminaria juncea* and *Melaleuca lateritia* Shrubland;
- Open *Hakea prostrata* Shrubland;
- *Melaleuca lateritia* Heathland;
- *Meeboldina* Sedgeland;
- *Baumea juncea* Sedgeland;
- Open *Bolboschoenus caldwellii* Sedgeland;
- *Verticordia densiflora* var. *densiflora* Heathland; and
- *Melaleuca rhaphiophylla* Woodland.

Vegetation condition was assessed in spring and ranged from Completely Degraded to Very Good, with the majority of the site (51.2%) recorded as Completely Degraded.

2.3.2 Flora

A total of 111 flora species were recorded from 43 families in the TEC and CCW area, of which:

- 42 were monocotyledons (21 native species, 21 introduced species)
- 69 were dicotyledons (36 native species, 33 introduced species).

The threatened species *Eremophila glabra subsp. chlorella*, and the Priority 4 species *Ornduffia submersa* were observed during the site survey activities (Natural Area, 2016).

2.3.3 Fauna

The fauna surveys identified the presence of three mammals (including the *European Red Fox (Vulpes Vulpes)* and the *European Rabbit (Oryctolagus cuniculus)* which are listed as C3 declared pests on the Western Australian Organism List (WAOL) under the Biosecurity Agriculture Management Act 2007 (WA)), 15 birds, five reptiles, four amphibians and 42 invertebrate species.

A native Bee of conservation significance, Leioproctus douglasiellus (a short-tongued bee) is listed by the Department of Biodiversity, Conservation and Attractions as having been recorded within the survey boundary. According to the Threatened Species Scientific Committee (2013), the Bee is closely associated with the presence of flora species Goodenia filiformis (Thread-leaved Goodenia) and Anthotium junciforme, neither of which were recorded at the site during the surveys undertaken by Natural Area in 2016. However, this does not necessarily preclude the presence of bees in the swamp area. No threatened or priority listed fauna was found during this survey activities.

2.3.4 Potential biodiversity impacts

Direct impacts

Any physical disturbance within vegetated portions of the TEC and CCW area has the potential to impact on its biodiversity values and as such should be minimised.

Indirect impacts

Any changes to the hydrological regime that supports the TEC and CCW has the potential to impact on its biodiversity values and as such should be minimised. These potential impacts are dealt with in more detail in sections 2.4 and 2.5 below.

2.4 Groundwater

The site is situated in the City of Canning subarea of the Perth groundwater area. This area consists of three aquifers, in order of depth from the surface:

- Perth-Superficial Swan Aquifer;
- Leederville Aquifer; and
- Yarragadee North Aquifer.

2.4.1 Groundwater Levels

The Perth Groundwater Atlas (DWER, 2018) indicates that the Maximum Groundwater Level (MGL) is approximately between 4 and 5 mAHD at and around the proposed road (Figure 3).

A groundwater monitoring program was undertaken by Urbaqua at Cannington TEC between July 2017 and June 2018. Monitoring included measurement of groundwater levels and groundwater sampling from the four installed bores and four existing bores. Groundwater samples were taken in July and October 2017 as per Australian Standards (AS/NZS 5667.4:1998 and AS/NZS 5667.11.1998). Location of the bores are illustrated in Figure 3.

The monthly average groundwater levels at the monitoring bores are provided in Table 1.

Table 1: Local monthly groundwater levels (mAHD)

	Urbaqua Bores (2017)			PB Bores (2005)	
Month	CS-U2	CS-U3	CS-U6	C4	C6
Jul 2017	2.65	2.94	3.92	3.31	3.40
Aug 2017	3.50	4.14	4.06	3.77	3.83
Sep 2017	3.56	4.13	3.91	3.35	3.61
Oct 2017	3.36	3.99	3.74	3.21	3.48
Nov 2017	3.00	3.21	3.27	3.01	3.19
Dec 2017	2.52	2.62	3.03	2.79	2.98
Jan 2018	2.45	2.28	3.19	2.99	3.08
Feb 2018	2.02	2.05	2.93	2.57	2.86
Mar 2018	1.56	1.77	2.84	2.49	2.74

	Urbaqua Bores (2017)			PB Bores (2005)	
Month	CS-U2	CS-U3	CS-U6	C4	C6
Apr 2018	1.67	1.59	2.98	2.49	2.77
May 2018	1.35	NA*	2.96	2.39	2.69
Jun 2018	2.26	NA	3.73	3.13	NA

*NA: NO ACCESS to the bore

2.4.2 *Groundwater quality*

Groundwater quality testing was undertaken from all the bores onsite in July and October 2017. The results of groundwater quality within the superficial aquifer are provided in Table 2.

pH levels were typically recorded within the guideline range for the wetlands (ANZECC & ARMCANZ, 2000) with levels slightly below 7 only at Bores CS-U1 and CS-U6. The superficial groundwater at the site is considered as Fresh with the average salinity of 3.68mg/L.

Nitrogen levels in groundwater were found to be relatively low across the site, elevated total nitrogen concentrations were identified at CS-U1 and CW1(S) (north and north west of the site). Total Phosphorus and Ammonia levels exceeded the wetland criteria in All bores.

Table 2: Local groundwater quality (July & October 2017)

Parameter	Monitoring Results	
	Range	Average
Temperature (°C)	16.9 – 23.30	19.89
Electrical Conductivity @ 25°C (µS/ cm)	2353 - 16033	6613
Dissolved Oxygen (mg/L)	0.02 – 7.07	0.84
pH Value	6.26 – 7.78	7.19
Total Dissolved Solids @180°C (mg/L)	1541 - 10419	4300
Salinity (mg/L)	1.21 – 9.42	3.68
Total Nitrogen as N (mg/L)	0.20 – 2.80	0.69
Total Phosphorus as P (mg/L)	0.10 – 1.30	0.31
Filterable Reactive Phosphorus (mg/L)	0.01 – 0.09	0.03
Nitrite + Nitrate as N (mg/L)	0.01 – 2.00	0.25
Ammonia (mg/L)	0.02 – 0.32	0.09
Total Kjeldahl Nitrogen as N (mg/L)	0.20 – 1.80	0.48

2.4.3 *Potential groundwater impacts*

The construction of the road will include compaction of the soil layers beneath the road. This has the potential to make a barrier to the groundwater flow and impact the groundwater flows and levels.

2.5 Hydrology

The Cannington Swamp has been classified as a Conservation Category Wetland by the Department of Biodiversity, Conservation and Attractions in its Swan Coastal Plain geomorphic wetlands database.

2.5.1 *Local drainage*

The proposed road and the Cannington Swamp are located within a Water Corporation drainage catchment named as Cockram Street Main Drain (Urbaqua, 2016a) which ultimately discharges to the Liege Street constructed wetlands.

The drainage system underlying the swamp is comprised of an underground pipe network which may surcharge via raised manholes during major storm events (>20% AEP). However, this surcharge is not expected to have a significant impact on overall hydrology of the swamp as it occurs only during large storm events and have little influence on the annual hydrological cycle of the swamp (Urbaqua, 2016b).

2.5.2 *Existing water balance*

A water balance model has been prepared to assess the existing water levels in the swamp. Results from the model are summarised in Table 3 and Appendix B. The water balance considers the last 10 years of daily rainfall (Gosnells City station, 9106). Monthly pan evaporation rates (Armadale Station) were sourced from BOM average pan evaporation mapping (grid data) and adjusted by a pan factor of 0.75 to account for reduced evaporation that could be expected to occur from the large water bodies. Modelling assumes that the swamp is connected to the underlying aquifer with infiltration rate of 0.008m/day for Sandy Clay soils. The existing average inundation area during winter is illustrated in Figure 4.

Table 3: Existing water balance modelling inputs and results

Swamp invert (mAHD)	Base Area (ha)	Overflow level (mAHD)	Total Storage (ML)	Max GW only level (mAHD)	Winter average levels (last 10yrs) (mAHD)
3.50	0.09	4.75	65.6	3.83	4.02

2.5.3 *Potential hydrological impacts*

The proposed construction of the road has the potential to generate increased runoff, reduce the storage capacity and/or change the natural hydrology at the Cannington TEC.

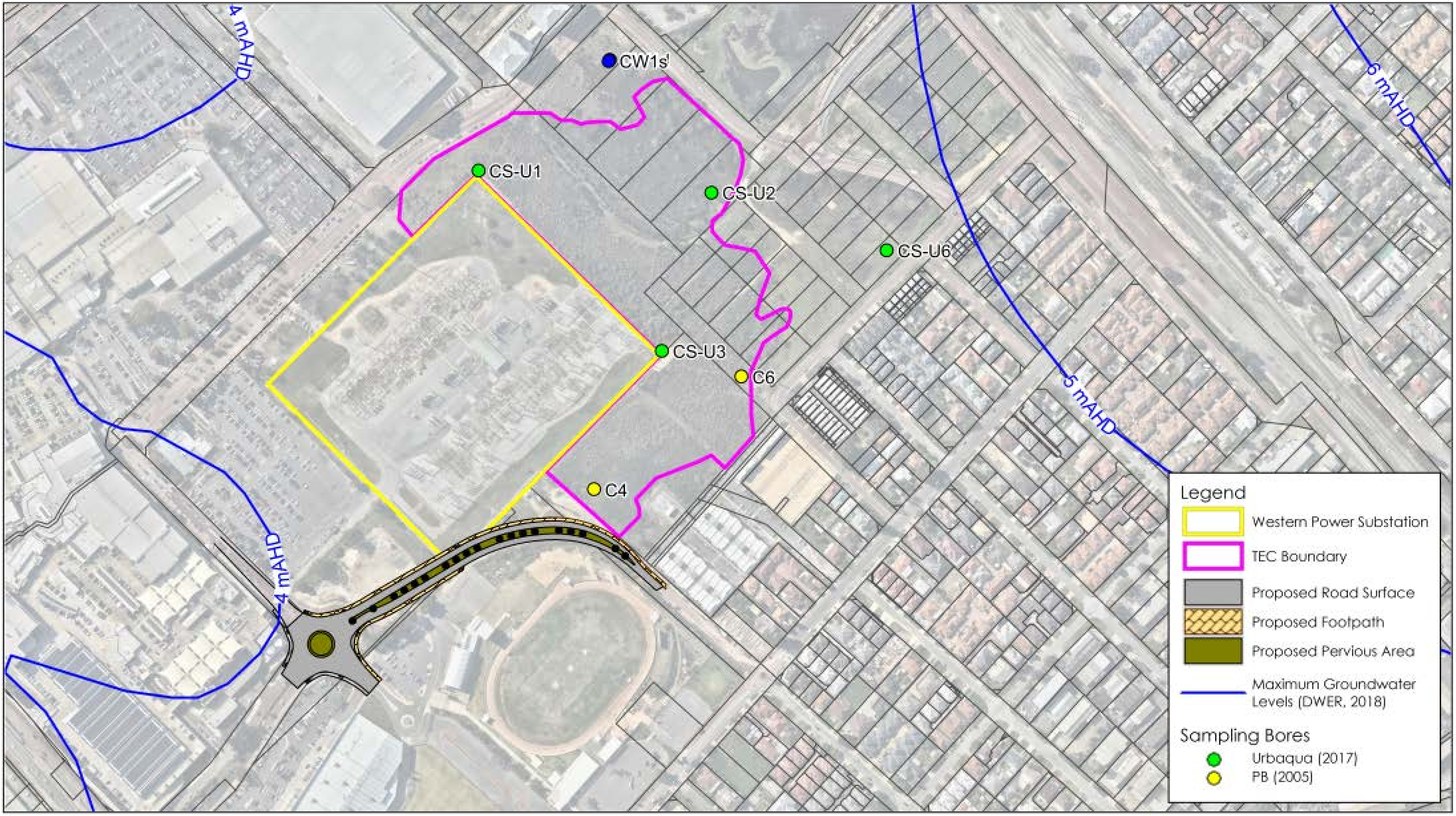
Construction of the extended part of the road may impact the quality of stormwater. Treatment of stormwater runoff may be required to prevent export of pollutants to the swamp.

2.6 Summary of potential impacts

The identified potential impacts to the Cannington TEC following the road construction are:

- Excavation and filling works – impact on wetland hydrology and water levels;
- Road drainage discharge treatment – impacts to downstream water quality;
- Road compaction – impacts to groundwater flows/levels; and
- Clearing and physical disturbance – impact on flora/fauna and biodiversity values.

Southern Link Road Stage 2 - Water Management & Impact Assessment
Figure 3 - Groundwater



Data source: Nearmap, City of Canning Database. Created by:AN Projection: MGA: zone 50.

N

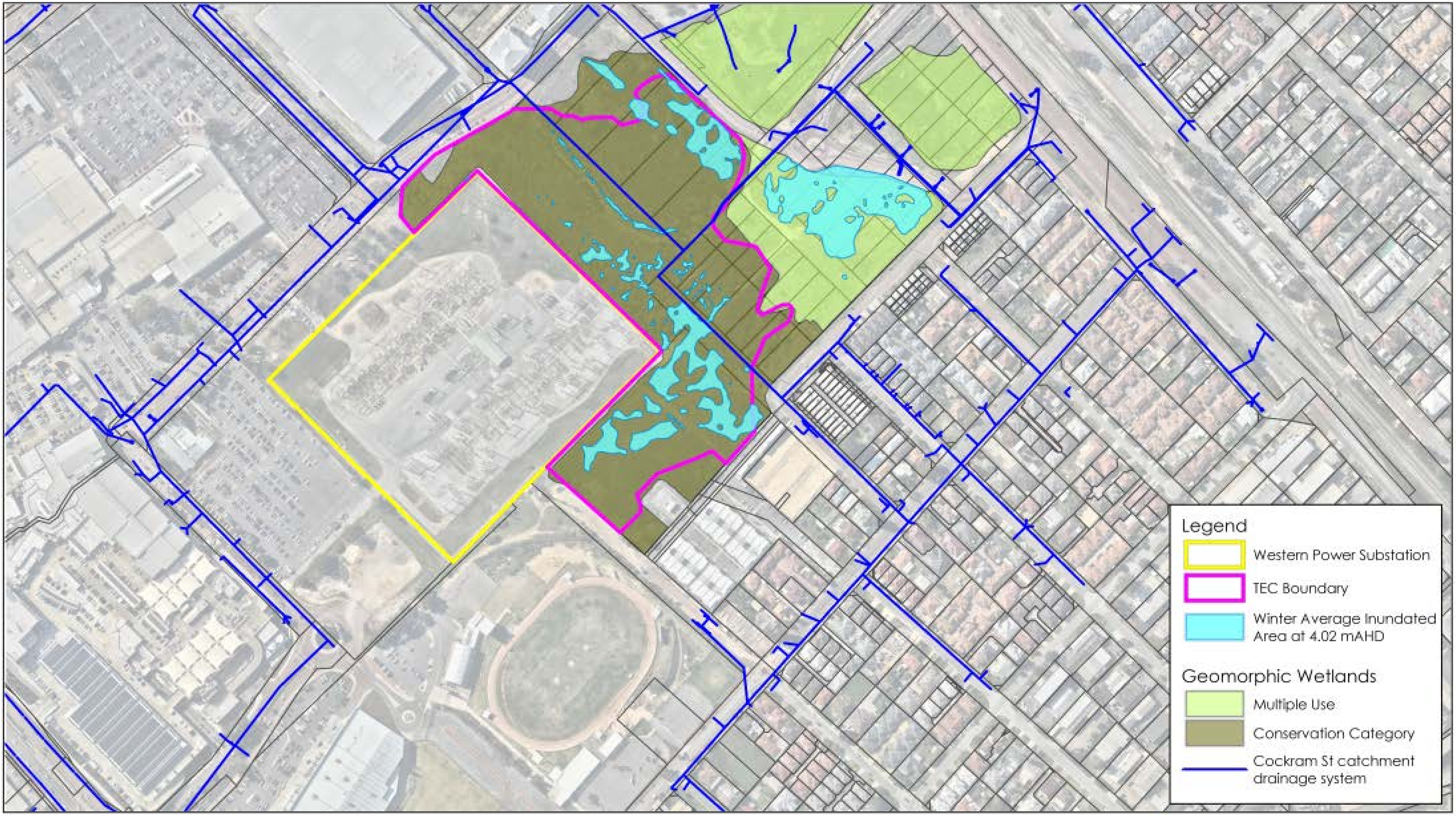
0 100

meters

Scale 1:4,500 @ A4

urbaqua
land and water solutions

Southern Link Road Stage 2 - Water Management & Impact Assessment
Figure 4 - Existing drainage, water levels and extent



Data source: Nearmap, City of Canning Database. Created by:AN Projection: MGA: zone 50.

urbaqua
land and water solutions

3 PRELIMINARY REVIEW AND SITE INSPECTION

The following is a summary of the findings of the site inspections and the desktop review of the proposed road design.

3.1 Onsite groundwater monitoring

As mentioned in Section 2.4, groundwater monitoring program and site inspections were undertaken by Urbaqua staff between July 2017 and June 2018. During August, September and October 2017, inundation was observed at some areas of the Swamp. Figure 5 illustrates the inundation around bore CS-U3 at the corner of the Western Power Sub Station in October 2017. The groundwater has been below the ground level at the other sampling bores during the monitoring period.

Figure 5: Inundation around bore CS-U3 (looking north-west)

3.2 Review of proposed construction

The potential impacts to the Cannington Swamp TEC and CCW resulting from construction of the proposed Southern Link Road are discussed in the sections below.

3.2.1 Post development drainage system

In order to maintain the existing hydrology within the swamp, no runoff from the proposed road will be directed to the swamp. Formal drainage system will be installed for the proposed road to direct its runoff to the existing drainage systems. Based on the local topography, the road surface will be divided into two catchments as shown in Figure 6.

In order to determine post development flows from the proposed road, hydrologic and hydraulic modelling was undertaken with the model XP-Storm. A multi-storm analysis was conducted to determine the critical duration event that produces the largest peak discharge from the modelled catchments. The rainfall used for the modelling is based on 2016 IFD data (BoM,2018b). The peak flows discharging from each section of the road are provided in Figure 6 and Table 4. There is no external catchment draining to the road.

Table 4: Proposed Southern Link Road Stage 2 post development flows

Discharge location	Catchment Area (ha)	20% AEP (5yr ARI)		1% AEP (100yr ARI)	
		Flow Rate (m^3/s)	Critical Duration	Flow Rate (m^3/s)	Critical Duration
1 (to Grey St drainage system)	0.23	0.05	15 min	0.09	10 min
2 (to Liege St drainage system)	0.41	0.08	15 min	0.13	10 min

The modelling results indicate that post development flow rates from the proposed road are relatively small and are not expected to cause substantial erosion effects. Underground pipes can be designed to convey runoff from up to the 20% AEP event downstream to provide for appropriate serviceability. Extreme flooding events (up to the 1% AEP event) that exceed the capacity of pipes can be directed through overland flow on the road.

3.2.2 Post development water balance at the swamp

The water balance for the swamp's existing condition was updated with the proposed road to assess the post development levels within the swamp. Similar to the existing conditions, there will be no upstream catchment discharging to the Cannington Swamp. Runoff from the new road is assumed be directed to the existing drainage systems (Section 3.2.1).

Post development details of the swamp and the winter average water levels during the model period (10-years) are provided in Table 5 and post development inundation area is illustrated in Figure 7. Post-development water balance model details are provided in Appendix C.

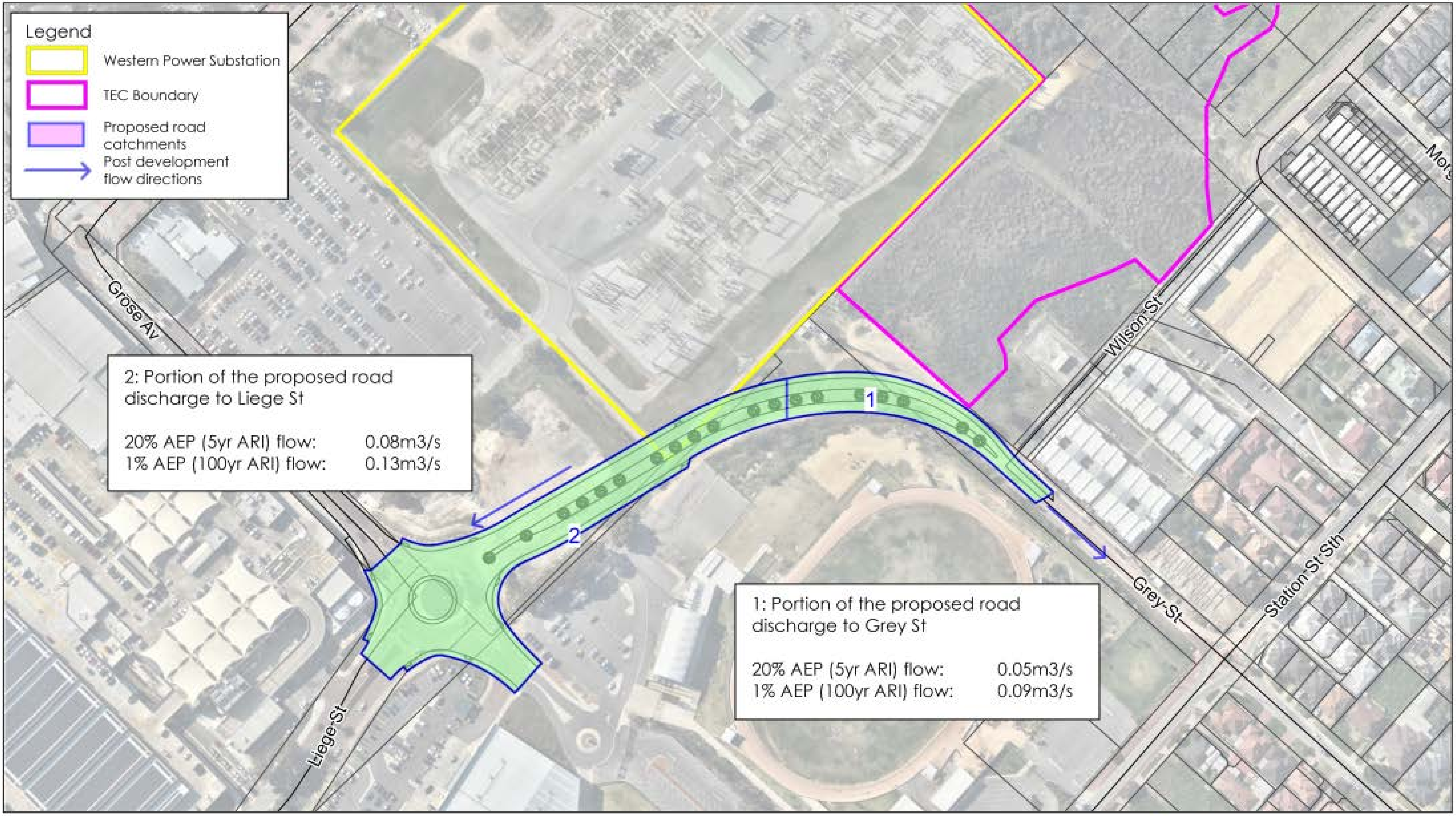
Table 5: Post development water balance modelling inputs and results

Swamp invert (mAHD)	Base Area (ha)	Overflow level (mAHD)	Total Storage (ML)	Max GW only level (mAHD)	Winter average levels (last 10yrs) (mAHD)
3.50	0.09	4.75	65.6	3.83	4.02

3.2.3 Post development water quality

Runoff from the proposed road is not expected to discharge to the swamp, therefore treatment area/swale is not proposed within the road reserve.

Southern Link Road Stage 2 - Water Management & Impact Assessment
Figure 6 - Proposed road drainage



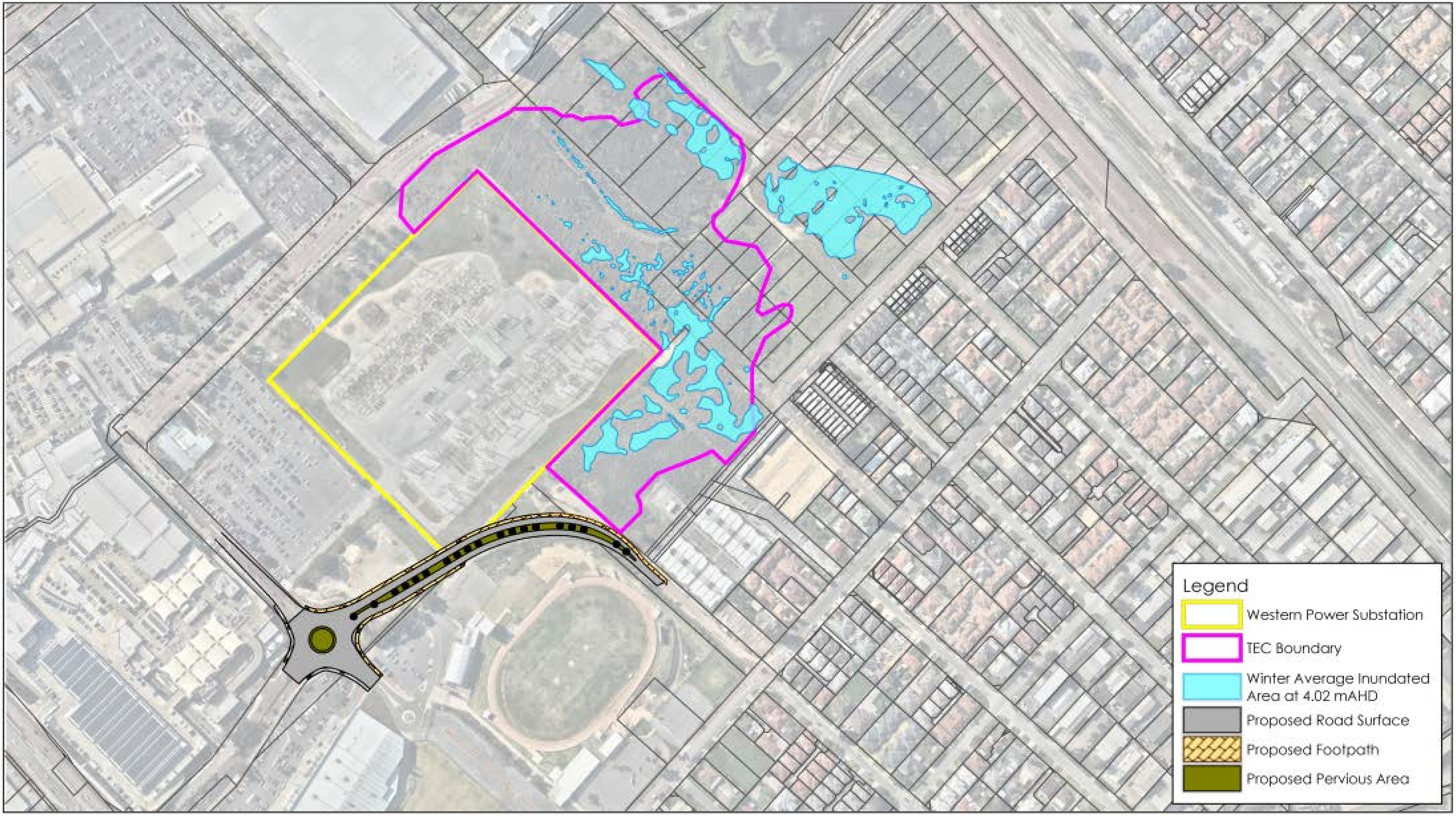
Data source: Nearmap, City of Canning Database. Created by:AN Projection: MGA: zone 50.

N

0 100
meters
Scale 1:2,500 @ A4

urbaqua
land and water solutions

Southern Link Road Stage 2 - Water Management & Impact Assessment
Figure 7 - Post development water levels and extent



Data source: Nearmap, City of Canning Database. Created by:AN Projection: MGA: zone 50.

N

0 100
meters
Scale 1:4,500 @ A4

urbaqua
land and water solutions

4 ASSESSMENT OF POTENTIAL IMPACTS

As discussed in Section 2, the critical issues for assessment of environmental impact that were considered by the preliminary review and site inspection are:

- Excavation and filling works – impact on wetland hydrology and water levels;
- Road drainage discharge treatment – impacts to downstream water quality;
- Road compaction – impacts to groundwater flows/levels; and
- Clearing and physical disturbance – impact on flora/fauna and biodiversity values.

4.1 Wetland hydrology and water level impacts

4.1.1 Post development drainage system

As shown in Section 3.2, a formal drainage system including underground pipes and overland flow on the road will direct all the runoff from the proposed road to the existing drainage systems at Grey Street and Liege Street existing drainage systems and no stormwater from the proposed road will flow to the swamp. The proposed road construction will be undertaken outside of the Cannington Swamp boundaries and post development hydrology and water levels at the swamp will remain consistent with the existing condition.

4.1.2 Post development water balance for the swamp

Water balance model was developed to consider the response of the swamp water levels to the road construction. The post development inundation area is illustrated in Figure 7.

A comparison of the estimated water balance for the proposed and existing systems indicates no change in the water depth or extent within the swamp. The proposed road construction will not interfere with the Cannington Swamp catchment and none of the runoff from the proposed road will be directed to the swamp, as such, the post development water balance at the swamp will be similar to the existing condition.

Construction of the proposed road will result in no change to surface water levels in the TEC and CCW when compared to existing conditions.

4.2 Water quality impacts

Runoff generated by frequent rainfall events has the potential to mobilise pollutants within the catchment. It is proposed that runoff generated by the first 15mm of rainfall onto the new road reserve will be managed in median swales within the road reserve while runoff from larger events will be conveyed directly into the existing downstream drainage system.

Runoff from the proposed road will not discharge into the Cannington Swamp area. Therefore, any change in downstream water quality will not affect the TEC or CCW.

4.3 Groundwater impacts

The proposed Southern Link Road Stage 2 is in an area where the groundwater gradient is quite flat (approximately 1:750) and sloped to the west as can be observed in Figure 3. This indicates that groundwater in the area flows slowly towards the Canning River along a similar alignment to the proposed road reserve and therefore it is considered highly unlikely that the proposed road will present any obstruction to these flows.

4.4 Flora/fauna and biodiversity impacts

The extent of clearing and compaction is entirely outside of the TEC and CCW boundaries. Therefore, the proposed road construction will have no impact on the biodiversity values of the TEC or CCW. However, an application for clearing of native vegetation outside of the TEC and CCW for the proposed road construction is required and is in preparation.

4.5 Risk of potential impacts

Table 6 provides the risk of potential impacts from the construction of the Southern Link Road Stage 2. The proposed development has been considered to maintains a minimal risk of impact on the wetland.

Table 6: Relative risk of impacts for construction of the Southern Link Road Stage 2

Potential impact	Relative risk
Excavation and filling works – impact on wetland hydrology and water levels	Very low
Road drainage discharge treatment – impacts to downstream water quality	Very low
Road compaction – impacts to groundwater flows/levels;	Very low
Clearings and physical disturbance – impact on flora/fauna and biodiversity values	Very low

4.6 Management of construction phase impacts

In addition to the long-term risks to the wetland previously discussed in this report, it is important to consider the short-term risks presented by construction activity at the wetland boundary. The following strategies are recommended for consideration in developing an appropriate construction environmental management plan:

- Construction traffic should be contained outside of the wetland boundaries;
- Construction during periods of low groundwater is preferred to avoid requirements for any dewatering;
- Construction during periods of low rainfall is preferred to avoid dispersal of sediment and construction materials into the wetland;
- Sediment fencing should be provided along the edge of the construction area to provide protection from wind and water borne sediment and construction materials; and
- Temporary stockpiles should be located outside the wetland boundaries and contained by sediment fencing.

5 REFERENCES AND RESOURCES

Australian and New Zealand Environment and Conservation Council and Agriculture and Resource Management Council of Australia and New Zealand (ANZECC & ARMCANZ) 2000, *National Water Quality Management Strategy: Australian and New Zealand Guidelines for Fresh and Marine Water Quality*, Paper No. 4, Volume 1, October 2000.

Bureau of Meteorology (BoM) 2018a, *Climate Data Online Database, Government of Australia.* Available at: http://wir.water.wa.gov.au/SitePages/SiteExplorer.aspx

Bureau of Meteorology (BoM) 2018b, *Intensity-Frequency-Duration Database, Government of Australia.* Available at: http://www.bom.gov.au/water/designRainfalls/ifd/index.shtml

Department of Environmental Regulation (DER) 2016, *A guide to preparing revegetation plans for clearing permits*, Government of Western Australia, Perth.

Department of Water and Environmental Regulation (DWER) 2018, Perth Groundwater Map, Perth. Available at: http://www.water.wa.gov.au/maps-and-data/maps/perth-groundwater-atlas

Dieback Working Group (DWG) 2013, *Photo Gallery*. Available at: <http://www.dwg.org.au/go/news-and-media/photo-gallery/index.cfm> [18th November 2013]

Jordan J. E., 1986, *Environmental Geology Mapping - Armadale Part sheets 2033 I and 2133 IV*

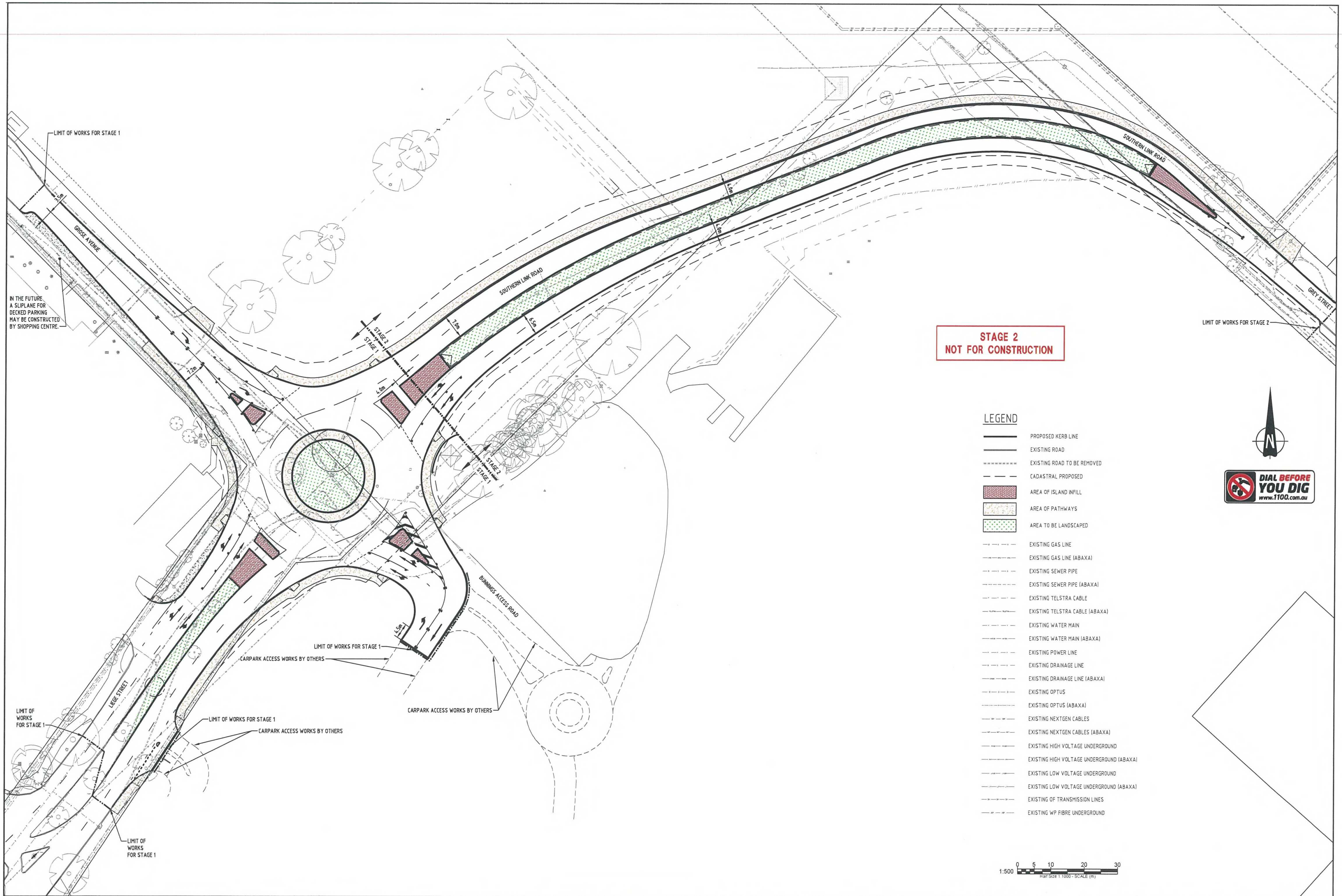
Natural Area 2016, *Flora, Vegetation and Fauna Survey, Southern Link Road,* prepared for the City of Canning

Parsons Brinckerhoff (PB) 2015, *Flora, Cannington Swamp Soil and Hydrogeological Investigations,* prepared for Woodman Environmental Consulting

Urbaqua 2016a, *Canning Activity Centre Local water management strategy,* prepared for the City of Canning

Urbaqua 2016b, *Canning City Centre and Queens Park Local drainage plan,* prepared for the City of Canning

APPENDIX A – ENGINEERING DRAWINGS OF THE PROPOSED WORK



PROJECT:

SOUTHERN LINK ROAD
CANNINGTON

No.	DATE	REVISION	BY
0	24-8-2016	STAGE 1 ISSUED FOR CONSTRUCTION	MJV
C	10-8-2016	DETAILED DESIGN ADDED. ABAXA LEVELS ADDED. FUTURE WORK BY OTHERS.	MJV
B	2-6-2016	CROSSOVER CHANGES. BUNNINGS ACCESS REVISED. CADASTRAL ADDED.	MJV
A	30-5-2016	PRELIMINARY PLOT FOR APPROVAL	MJV

Porter Consulting Engineers

Level 2 Kishorn Court
58 Kishorn Road
Mt Pleasant 6153 WA

PO Box 1036
Canning Bridge 6153 WA

Tel (08) 9315 9955
Fax (08) 9315 9959
Email office@porterenq.com.au
www.porterenq.com.au

TUSHO Pty Ltd ACN 070 097 148 as trustee for the Consulting Engineering Unit Trust trading as Porter Consulting Engineers ABN 78 606 396 305

CLIENT:

CITY OF CANNING

DRAWING:

LAYOUT PLAN

STATUS: **FOR CONSTRUCTION**

SCALE	1:500	DRAWING No.	REV No.	ORIGINAL DRAWING SIZE
DATE	AUG 2016	16-4-49/100	0	A1
DESIGN	ELW			
DRAWN	MJV	FILE NAME S:\ACTIVE PROJECTS\16-04-049\ACAD\16449-100.dwg		
CHECK		APP'D		

APPENDIX B – WATER BALANCE MODEL – EXISTING CONDITION

WATER BALANCE CALCULATIONS
Lagoon Water Balance - Options Analysis

urbaqua
land and water solutions

Calculation Sheet | 1

Scenario	Existing Condition
Inf Model	Aquifer connected
Rainfall Data	
Source	
Reference	9106

Date	Rainfall mm
1/01/2008	0
2/01/2008	0
3/01/2008	0
4/01/2008	0
5/01/2008	0
6/01/2008	0
7/01/2008	0
8/01/2008	0
9/01/2008	0
10/01/2008	0
11/01/2008	0
12/01/2008	0
13/01/2008	0
14/01/2008	0
15/01/2008	0
16/01/2008	0
17/01/2008	0
18/01/2008	0
19/01/2008	0
20/01/2008	0
21/01/2008	0
22/01/2008	0
23/01/2008	0
24/01/2008	0
25/01/2008	0
26/01/2008	0
27/01/2008	0
28/01/2008	0
29/01/2008	0
30/01/2008	0

Climate Data

Month	Pan Evap mm/month	mm/day	Surr GWL m AHD
Jan	297	9.6	2.80
Feb	257	8.9	2.52
Mar	224	7.2	2.33
Apr	123	4.1	2.33
May	87	2.8	2.30
Jun	59	2.0	2.95
Jul	60	1.9	3.21
Aug	69	2.2	3.83
Sep	106	3.5	3.68
Oct	154	5.0	3.53
Nov	203	6.8	3.13
Dec	259	8.4	2.80
Jan	297	9.6	2.80125

Model Inputs

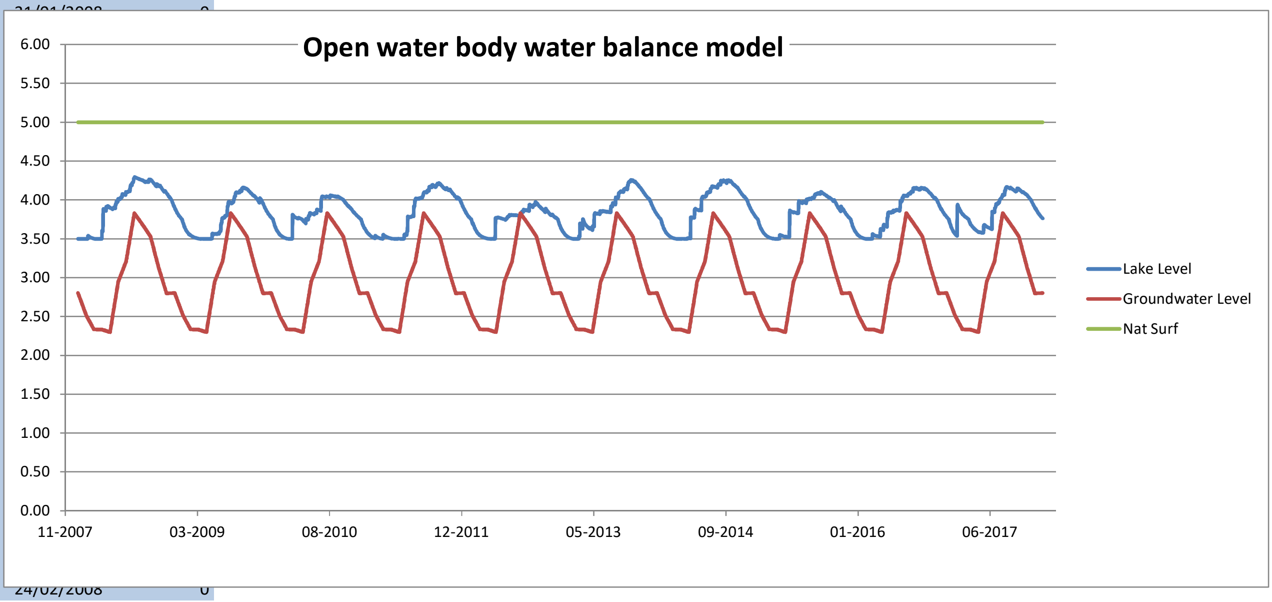
initial water level	2.80	mAHD
pan evaporation factor	0.75	El/Ep
aquifer conductivity - 10^		m/s
aquifer conductivity	0.008	m/day
distance of influence	150	m
base of aquifer	-15	m
base of lake	3.5	mAHD
depression storage	15	mm
natural surface level	5	mAHD
site area draining to lake	9.137	ha
overflow level	4.75	mAHD
max volume	65565.625	m3
Runoff parameter	100.00%	
Low flow discharge rate		L/s
Drain invert		mAHD

Lake Surface Area Contours

Level	Area (m2)	Perimeter	Storage
3.5	875	167.633023	0
3.75	13257	652.496488	1767
4	43833	1186.46832	8903
4.25	73421	1535.55614	23560
4.5	85999	1661.88991	43487
4.75	90630	1706.04916	65566
5	91349	1712.80314	88313
5.25	91370	1713	111153

Model Results	Total (ML)	
Change in Storage	0.9	
INPUTS		Peak Annual
Direct Rainfall	252.4	41.1
Catchment Runoff	93.0	12.9
net inflow/outflow	0.0	0.0
OUTPUTS		
Evaporation	342.1	45.6
Net seepage to GW	2.3	22.4
Overflow as Stormwater	0.0	0.0
Low flow discharge	0.0	0.0

Annual Inflow	ML
Maximum	0.0
Minimum	0.0
Average	0.0



APPENDIX C – WATER BALANCE MODEL – POST DEVELOPMENT CONDITION

WATER BALANCE CALCULATIONS
Lagoon Water Balance - Options Analysis

Calculation Sheet 1

Scenario	Post Development Condition
Inf Model	Aquifer connected
Rainfall Data	
Source	
Reference	9106

Date	Rainfall mm
1/01/2008	0
2/01/2008	0
3/01/2008	0
4/01/2008	0
5/01/2008	0
6/01/2008	0
7/01/2008	0
8/01/2008	0
9/01/2008	0
10/01/2008	0
11/01/2008	0
12/01/2008	0
13/01/2008	0
14/01/2008	0
15/01/2008	0
16/01/2008	0
17/01/2008	0
18/01/2008	0
19/01/2008	0
20/01/2008	0
21/01/2008	0
22/01/2008	0
23/01/2008	0
24/01/2008	0
25/01/2008	0
26/01/2008	0
27/01/2008	0
28/01/2008	0
29/01/2008	0
30/01/2008	0

Climate Data

Month	Pan Evap mm/month	mm/day	Surr GWL m AHD
Jan	297	9.6	2.80
Feb	257	8.9	2.52
Mar	224	7.2	2.33
Apr	123	4.1	2.33
May	87	2.8	2.30
Jun	59	2.0	2.95
Jul	60	1.9	3.21
Aug	69	2.2	3.83
Sep	106	3.5	3.68
Oct	154	5.0	3.53
Nov	203	6.8	3.13
Dec	259	8.4	2.80
Jan	297	9.6	2.80125

Model Inputs

initial water level	2.80	mAHD
pan evaporation factor	0.75	El/Ep
aquifer conductivity - 10^		m/s
aquifer conductivity	0.008	m/day
distance of influence	150	m
base of aquifer	-15	m
base of lake	3.5	mAHD
depression storage	15	mm
natural surface level	5	mAHD
site area draining to lake	9.137	ha
overflow level	4.75	mAHD
max volume	65565.625	m3
Runoff parameter	100.00%	
Low flow discharge rate		L/s
Drain invert		mAHD

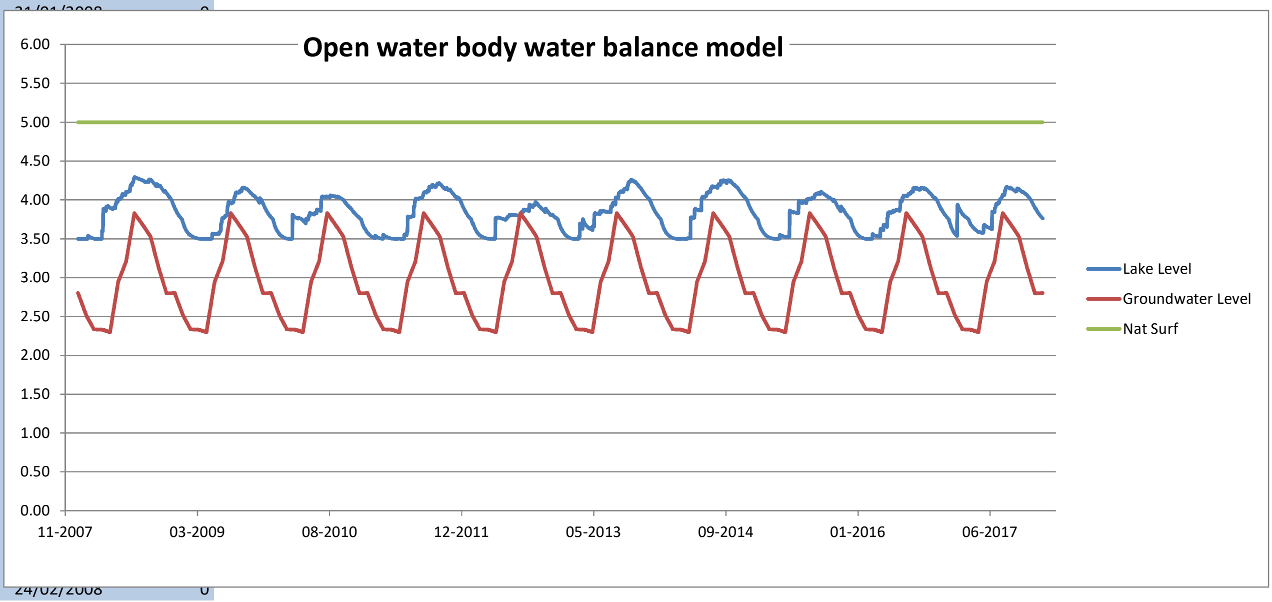
Lake Surface Area Contours

Level	Area (m2)	Perimeter	Storage
3.5	875	167.633023	0
3.75	13257	652.496488	1767
4	43833	1186.46832	8903
4.25	73421	1535.55614	23560
4.5	85999	1661.88991	43487
4.75	90630	1706.04916	65566
5	91349	1712.80314	88313
5.25	91370	1713	111153

Model Results	Total (ML)
Change in Storage	0.9

INPUTS		Peak Annual
Direct Rainfall	252.4	41.1
Catchment Runoff	93.0	12.9
net inflow/outflow	0.0	0.0
OUTPUTS		
Evaporation	342.1	45.6
Net seepage to GW	2.3	22.4
Overflow as Stormwater	0.0	0.0
Low flow discharge	0.0	0.0

Annual Inflow	ML
Maximum	0.0
Minimum	0.0
Average	0.0



land and water solutions

Client: City of Canning

Report	Version	Prepared by	Reviewed by	Submitted to Client	
				Copies	**Date**
Preliminary draft	V1	AN	HB	Electronic	13/11/2018
Final report	V2	AN	HB	Electronic	15/11/2018
Minor revisions	V3	HB	HB	Electronic	21/11/2018

Urbaqua
land & water solutions
Suite 4/226 Carr Place
p: 08 9328 4663 | f: 08 6316 1431
e: info@urbaqua.org.au
www.urbaqua.org.au