

REPORT

CONDOR NOMINEES PTY LTD LOT 28 BARFIELD ROAD HAMMOND PARK

LOCAL WATER MANAGEMENT STRATEGY

NOVEMBER 2022



DEVELOPMENT
ENGINEERING
CONSULTANTS

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LOT 28 BARFIELD ROAD, HAMMOND PARK

LOCAL WATER MANAGEMENT STRATEGY (LWMS)

Executive Summary

Estate Scale

- Drainage will be directed to the existing POS/Drainage area located in Lot 8001 which is east of Westwood Crescent in the development of former Lot 29 Barfield Road, immediately north of Lot 28. The swale will be designed to ensure all events up to the major 1% AEP storm is infiltrated on site.
- Bio Retention areas will be constructed at the proposed drainage outlet to provide nutrient uptake during the infiltration process.
- The 1% AEP storm will be wholly contained within POS area.
- Information Packages will be provided to all lot purchasers to: (a) Fully inform lot owners of the requirement to install the equivalent of two by 1200mm diameter by 1200 deep soakwells prior to an outflow connection to the drainage system; (b) To encourage the use of rainwater tanks; (c) To utilise water efficient devices & appliances throughout their homes; and (d) To maximise the use Water & Nutrient-wise plants, and minimise the use of lawns.

Access Street Scale

- All piped drainage systems will be designed to accommodate the 20% AEP event.
- Where possible piped drainage will be excluded in preference of swale drains and overland flow.

Allotment Scale

- All lot owners will be encouraged to install rainwater tanks plumbed into their homes for household use in order to assist to contain the 63.2% AEP - 1 hour event on-site in lieu of soakwells.
- All lots are required to install the equivalent of 2 by 1200mm by 1200mm deep soakwells which will hold a 20% AEP storm without outflow.

Public Open Space Areas

- All swale basins constructed within any POS area will be designed to infiltrate all storms up to and including the 1% AEP event.

1 Introduction

This LWMS report has been prepared as a stand-alone document to support the Structure Plan for Lot 28 Barfield Road Hammond Park and will be used to guide the design and construction of the proposed drainage solutions for subdivision within the area.

The location of the site is shown in Appendix A, together with an aerial photograph of the existing site.

The site is located on the eastern side of Barfield Road around 750m north of the intersection between Barfield Road and Rowley Road.

1.1 Drainage / Water Management Principles and Design Objectives

The following water sensitive design criteria, principles & objectives are to be pursued &/or implemented as part of the proposed development:

- *Water Conservation & Water Efficiency*

Objective: To maximise the reuse of stormwater and minimise the use of scheme water outside of the home and to use water as efficiently as possible - both within & outside of the home.

Deliverable: All lot purchasers will be encouraged to install rain water tanks plumbed into their home; to use water efficient devices & appliances throughout their homes and to plant “Water-wise” & “Nutrient-wise” gardens.

Deliverable: All water will be infiltrated on site, mimicking the pre-development conditions.

- *Water Quantity Management and Protection of Property*

Objective: To maintain the total water cycle balance within development areas relative to the predevelopment conditions.

Deliverable: To ensure that post-development discharge is retained on site.

Objective: To protect the built environment from flooding or water logging.

Deliverable: All allotments to be a minimum of 0.3m above the 1% AEP flood level.

Deliverable: Retention basins to be provided to ensure that 1% AEP storm is disposed on site via infiltration.

- *Water Quality Management*

Objective: To improve the overall surface & groundwater quality of the water leaving the estate and if possible improve the quality of water leaving the development.

Deliverable: Ensure that surface water is routed to swale basins and retained on site.

1.2 Planning Background

The subject land is zoned “Urban” under the Metropolitan Region Scheme and “Development” and “Special Use” under the City of Cockburn’s Town Planning Scheme No.3 which requires a Structure Plan for land zoned “Development”.

The proposed Structure Plan is detailed in Appendix A.

2 Proposed Development

2.1 Key Elements of the Structure Plan (LSP)

The site is located within the suburb of Hammond Park within the City of Cockburn and covers an area of approximately 4.8ha of undeveloped land. The site is located on the eastern side of Barfield Road around 750m north of the intersection between Barfield Road and Rowley Road.

It is proposed to develop the western portion of Lot 28 ultimately as up to 46 residential lots with an average area of some 400sqm in accordance with its “Development” zoning and compliance with the City of Cockburn’s “Southern Suburbs District Structure Plan” which prescribes a minimum density of 15 dwellings/ha, with the proposed 46 lots delivering a density of 18.4 dwellings/ha.

The eastern portion of Lot 28 is subject to an easement in favour of Western Power to accommodate two 330kV transmission lines and a single 132kV transmission line. It is expected that, through the Subdivision Approval process pursuant to approval of the Structure Plan, the easement area will be reserved for Open Space and Drainage in the same manner as the constructed development on Lot 29 to the immediate north.

The land is generally higher than the surrounding area falling from around RL34m AHD on the south eastern corner of the site to around RL25.5m AHD in the north western corner of the site.

2.2 Previous Land Use

In the mid to late 1980’s the front portion of the lot was cleared and a house and outbuildings were constructed which were demolished in 2017. That area remains cleared and the area beneath the power lines has been “parkland cleared”.

2.3 Finished Lot Levels

Finished Lot levels will be set using on the basis that they are a minimum of 0.3m above 1% AEP TWL of Drainage basins and that they are set such that major storm will flood into POS in lieu of flooding the lots.

Further criterion is that Lots are to be at least 1.2m above AAMGL, although the existing groundwater is well below surface levels.

3 Design Criteria

The drainage requirements for developments within this area are controlled by the requirements of the City of Cockburn, which are outlined below.

Item	Description	Requirement	Source / Comment
1	Water Quality	63.2% AEP 1 hour storm to be Retained on site	DoW requirements
2	AEP for pipe design	20% AEP	Standard Council requirement
3	AEP for compensating basin design	1% AEP without outflow from site	Standard Council requirement – No predevelopment flows currently exit the site.



Item	Description	Requirement	Source / Comment
4	Min. lot freeboard	0.3m above basin 1% AEP flood level 0.3m above 1% AEP HGL in Road System	Standard Council requirement developments
5	Basin Criteria		
	Side slopes – In POS	Max. 1 in 6	Standard Council requirement
6	Run-off coefficients	Road reserves C _{1%} – 0.72 for Urban Residential Allotments C _{1%} - 0.21 IL 9.79mm CL 9.09mm/hr 0.00 – Developed Rural Areas/POS	Per Council requirements – Based on 90% paved area in road reserve with Run –off Coefficient of 0.9. Lots as per Calculation in Appendix C.

4 Pre-development Environment

4.1 Topography and Landform

The site moderately rises from RL25.5m AHD in the north western corner of the site to around RL34m on the south eastern corner of the site. The western portion of the site outside the Western Power easement grades from RL25.50m AHD in the north western corner to RL28.0m AHD in the south eastern corner. The average grade of the land is around 0.5%.

4.2 Soil Characteristics

The Perth Environmental Geology Mapping (Gozzard JR 1983 Fremantle Part Sheets 2033 I and 2133 IV) 1 indicates that part of the site area consists of a single major soil types being “S8”, defined as sand, very light grey at the surface, yellow at depth, fine to medium grained, sub rounded quartz, moderately well sorted of eolian origin.

In essence the site is suitable for urbanisation, consisting of well graded sands of high permeability meaning that soakage will be effective on the site

The Western Australian Planning Commission Planning Bulletin 64 identifies the whole of the subject site as having Low to no risk of AASS and PASS occurring generally at depths of >3m no known risk of acid sulphate soils occurring.

4.3 Geotechnical

At this stage, no detailed geotechnical investigations have been taken on the site. The drilling undertaken for the groundwater monitoring generally supported the environmental geology mapping. Given the homogeneous sand on the site and excavations in the peripheral areas to the site being consistent with the environmental mapping, no geotechnical investigations have been undertaken on the site to date.

In the Subdivision Approval process pursuant to approval of the Structure Plan, further investigations will be undertaken as part of the Urban Water Management Plan for the area to confirm the soil profile of the area at the proposed development level

given that there is currently sand extraction proceeding which will involve the removal of around 8m of sand from most of the site.

Development that has been carried out in adjacent land holdings has confirmed the soil profile in the area.

4.4 Groundwater Aspects

4.4.1 General

Groundwater flow directions are well documented from regional mapping data.

According to the 2004 Groundwater Atlas², which generally designates Average Annual Maximum Groundwater Levels (AAMGL) as measured from the relevant bores, the groundwater levels grade down from east to west from RL22 mAHD at the eastern boundary of the site to RL21 mAHD on the western side of the site.

The 1997 Groundwater Atlas³ indicates that the groundwater levels grade from say RL23.0m AHD on the western side of the site rising to RL24.00m AHD on the eastern boundary abutting the Kwinana Freeway, this is normally representative of maximum likely groundwater levels (MGL) rather than AAMGL.

Groundwater levels were measured from October 2017 to November 2018 and indicated peak level in September 2018 to range from RL22.80m AHD abutting Barfield Road to RL23.2mAHD on the western side of the power easement. These were compared to the peak levels of surrounding DWER bores and the MGLs accordingly calculated to grade from around 23.3mAHD on Barfield Road to RL23.7 on the western side of the power line easement.

The lowest level of the site is located on the south western corner of the site and is at around RL25.5mAHD, meaning that at its shallowest; the maximum groundwater level would be at least 2.1m below the existing site levels. Based on the measured levels of the site and calibration against the peripheral long term DWER bores, the MGLs have been calculated and are plotted on Drawings L-03 and L-04 in Appendix B.

Looking at these levels, the existing drainage area in Lot 26 the peak groundwater level is some 200mm higher than the existing base of the basin. According to the plans prepared by KCTT for the neighbouring development, the design base was RL23.50 and the peak groundwater level was RL23.40 to 23.50 – thereby indicating that it would be wet in high groundwater conditions. The recent peak in 2021 was an all time high for the area which according to aerial photography was above the existing surface. It is noted that in instances when the expression of groundwater occurs, the wet area more or less acts as a solar bore and the evaporation causes a localized lowering of the groundwater thereby reducing the effective depth of the water.

4.4.2 Predevelopment Groundwater Monitoring

1) Background Information on Data and Summary of Information Received

Monitoring and background information for the site was investigated in 2017 to 2018 as per the results below. The level information was compared to surrounding DWER

bores which have long terms results to gain an understanding of the monitoring results relative to the long term peripheral results.

2) Groundwater Level Information

The collated bore information on measured groundwater levels is outlined below in Table 4.1.

Table 4.1 – Groundwater Depth Results

Bore	EMB01	EMB02	EMB03
RL Surface	25.79	27.10	26.47
26/9/2017	22.273	22.596	22.195
2/10/2017	22.29	22.639	22.198
10/10/2017	22.291	22.645	22.213
13/10/2017	22.284	22.643	22.219
20/11/2017	22.116	22.507	22.098
6/12/2017	22.077	22.462	22.059
22/01/2018	22.151	22.5	22.044
6/02/2018	22.11	22.488	22.045
8/06/2018	21.906	22.271	21.813
29/10/2018	22.74	2.0399	22.694
13/11/2018	22.679	23.036	22.655

Given the whole of the area is likely to be an unconfined aquifer, these were correlated with long term records of DWER bores to ensure that the 95 percentile groundwater contours could be established with reasonable certainty.

Based on the bore records for the site and the surrounding bores, the MGL's grade from RL23.2mAHD on the western side of the power line to around RL22.8mAHD at Barfield Road. Based on the surrounding DWER bores being bore 61410211 on the corner of Barfield Road and Ironbark Terrace and bore 61410087 on Hammond Road opposite Cousins Street. The long term bore records indicate that maximum levels were measured in 2021 which were an average of 0.47m higher than the results recorded in 2018. As a result the maximum likely level will range from RL23.27 on Barfield Road to around RL23.67 on the western side of the power lines.

Although the development levels proposed on Lot 28 are well above this being some 2.1m above the peak groundwater levels.

The existing base of the drainage basin is set at around RL23.50mAHD meaning the base of the basin is likely to be below peak groundwater levels.. Data from recent aerial photography seems to indicate wet areas which is likely that the groundwater has reached the surface with recent high levels. The 95 percentile maximum groundwater level, which would usually be used to establish the MGL is some 0.2m

lower than the absolute maximum recorded in 2021 which means that the base is around level with the MGL.

3) Groundwater Quality Information

Chemical analysis has been undertaken within bores MB1 to MB 5 and the information for that and adjoining bores is outlined in table 4.2 below.

Table 4.2 – Groundwater Quality test results

Sample ID	Date	Trigger	Nutrients		
			Total P	Total N	NH ₄ -N
		LOR	0.01	0.1	0.01
		Refer Below	0.8-12 ¹	5 ¹	0.04 ²
		LIWG	NG	NG	NG
EMB01	10/10/2017		0.04	1.4	0.1
EMB02	10/10/2017		0.01	2.2	0.02
EMB03	10/10/2017		0.03	0.6	0.15
EMB01	22/01/2018		0.02	1	0.14
EMB02	22/01/2018		0.01	0.9	<0.01
EMB03	22/01/2018		0.01	0.6	0.01
EMB01	29/10/2018		0.01	1.2	0.05
EMB02	29/10/2018		0.03	6.1	0.03
EMB03	29/10/2018		0.01	0.4	0.1

1. Irrigation Guidelines ANZECC/ARMCANZ 2000, Chapter 9
2. Values for Wetland environments - Table 3.3.6 ANZECC/ARMCANZ 2000 Freshwater and Marine WQ Guidelines Chapter 3

In looking at the measured nutrient levels it is evident that all nitrogen and phosphorous levels are currently within allowable ANZECC limits, however the measured total Nitrogen at MB02 is slightly elevated above other records.

There was some evidence of growing areas on the site and it may be that there was historic use of fertilisers that may appear in the records following the winter rains. In addition to that, the peak levels were coincidental with the adjoining development works commencing.

The location of existing monitoring bores is shown on Predevelopment Catchment Plan L03 in Appendix B. It is proposed that these bores will be retained for future monitoring.

4.5 Surface Water Aspects

4.5.1 General

As shown in Appendix B, the current site is divided into a single catchment falling to the north of the site. The land keeps falling to the existing development meaning that the existing drainage basin is well located to cater for the site.

4.6 Environmental Assets and Water-Dependent Ecosystems

There are no wetlands or conservation areas within 1.0km of the site.

4.7 Existing Infrastructure and Design Constraints

Sufficient capacity is available in the adjoining development to service the development of the subject land.

The whole of the site is proposed to be sewered into existing infrastructure to the west of the site, which is located within Barfield Road.

5 Water Sustainability Initiatives

5.1 General

The current State Government requirement to increase the efficiency of water use in new developments to a target of less than 100kl per person per year is proposed to be implemented within the development.

This is proposed to be achieved by:

- Increased water efficiency in the household by encouraging the use of waterwise appliances through regulation and financial incentives.
- Encouragement of the use of rainwater tanks to supplement scheme water for irrigation.
- The use of low water requirement plants and minimizing turf areas for gardens and POS areas

5.2 Individual Lot Owner Initiatives

Water conservation will be encouraged by the developer through the promotion of native, water-wise gardens and water efficient household devices & appliances. All requirements for the purchaser will be outlined in their purchase contract and associated information handouts.

The information will also outline the case for all lot owners to use rainwater tanks plumbed into their homes to assist with the retention of the 63.2% AEP event.

5.3 Estate Public Open Space (POS) Initiatives

5.3.1 Aims

The provision of POS within Lot 28 has been resolved with the City of Cockburn and the WAPC and is expected to be resolved through the Structure Plan approval process, however it should be noted that, through the Subdivision Approval process

pursuant to approval of the Structure Plan, the easement area is expected to be ceded to the Crown as a Reserve for Recreation and Drainage in the same manner as Lot 8001 which was ceded from Lot 29 to the immediate north pursuant to the construction of its “Development” zone.

In the same manner as Lot 29, the proponents of Lot 28 have obtained Western Power’s approval to earthwork within their transmission easement over the eastern portion of Lot 28 (which is zoned “Special Use”) to obtain fill for the proposed development on the western portion of Lot 28 which is zoned “Development”. The earthworked batters will be revegetated and the flatter area closest to the development will be grassed and irrigated.

The drainage impacts of the Open Space within Lot 28’s Western Power easement will be managed to ensure that:

- The maximum depth of water within drainage basins during a 1% AEP storm is limited to 1.2m.
- Flush kerbs may be constructed abutting POS areas with either direct run-off for infiltration in lower areas or with swales for infiltration/conveyance to drainage basin areas.

The proposed landscaping development of the Open Space area will address the following objectives:

- Minimising irrigation & fertiliser demands via appropriate species selection
- Managing fertiliser application to minimise impacts on water quality.
- Weed Management
- Fauna Protection

5.3.2 General POS initiatives

The treatment of the potential POS within the Open Space area will typically consist of grassed areas with designated areas of native planting and mulching. All areas will be designed to minimise irrigation requirements with predominantly native plantings incorporated into the landscape design and the use of low water requirement grasses such as kikuyu.

Detailed landscape plans will be prepared at the time of subdivision in accordance with agreed requirements with the City of Cockburn which will address the objectives outlines in Section 5.3.1.

5.3.3 Irrigation

1) Water Sources and required Allocations:

For the POS irrigation the overall water use is limited to a maximum of 7500kl per hectare per annum in accord with the Department of Water requirements. The total area to be irrigated over the total development is approximately 2.00ha (Allowing verges around POS areas to be irrigated) which will require an annual bore yield of some 15,000kL per annum.

An application has been lodged with DWER for this allocation.

Standard conditions require irrigation usage to be metered monthly and submitted annually in accord with DoW requirements.

2) Programming and Irrigation Minimisation.

Establishment irrigation for trees and native POS planting areas is expected to be used for a period of between 2 and 3 years after planting then disconnected.

Typically, watering will start with 10mm three times / day for initial establishment over a period of around 1 month, depending on the weather and the time of the year. This should then be reduced to 10mm once/day for a period of around 2 months - dependent on the time of year. The watering is then reduced to 10mm applied 2 to 3 times a week.

Irrigation should be programmed and maintained to minimise the water used across the site, with the following mechanisms to minimise water use.

- The system should be checked regularly to detect faults and ensure water is being used effectively and efficiently.
- In general the system should be checked at a frequency of
 - November to April - Once per fortnight.
 - May to October - Once a month.
- All sprinklers should be checked to fully pop-up and retract, bubblers and that nozzles are free of blockages and sprinklers are providing adequate coverage. Particular attention should be paid to irrigation of transplanted mature trees and street trees to ensure they are receiving adequate water.
- The watering regime for planted areas should reflect the plants needs in accordance with the plant type and natural rainfall, in accordance with the Water Corporation's "Water-wise" guidelines. Watering should be monitored throughout the year and adjusted accordingly to ensure appropriate watering. Watering should only take place within the hours stipulated by the Water Corporation (Currently 6.00pm to 9.00am).

The Irrigation Schedule is expected to be as follows (based on landscape hydrozones):

- Turf should be separated from shrubbery and turf and shrubbery should be supplied by different stations of irrigation and scheduled separately.
- Areas of turf subject to lower wear in sheltered environments &/or are not in visually prominent positions should be scheduled to receive a lesser amount of irrigation than areas of turf that are subject to high levels of wear, in exposed environments &/or in visually prominent locations;
- Low Water use plants should be scheduled to receive a lesser amount of water than areas of higher water use; and,
- Irrigation should be progressively withdrawn from areas of native shrubbery.

As part of the landscape works, the topsoil in the landscaped areas will be improved to ensure free drainage and nutrient retention properties prior to planting.

6 Stormwater Management Strategy

6.1 Pre-Development Hydrology

As outlined in Section 4, the site consists of sand with excellent soakage characteristics and is moderately steep with most portions of the site grading at around 0.5%.

Based on the fact that little or no run-off occurs from the site and all rainfall is infiltrated, it has been assumed that there is no predevelopment flow from the site. A plan detailing the predevelopment catchment boundaries is shown in L03 in Appendix B.

The majority of the area grades to a low point to the north of the site abutting the neighbouring land.

As outlined above, despite the topography indicating these flow paths, the permeability of the surface means that infiltration occurs at a greater rate than run-off meaning that little or no runoff leaves the site. In the unlikely event that runoff reached the isolated low points, the water infiltrates in that area.

6.2 Pre- & Post- Development Hydrology

The drainage strategy is proposed to infiltrate all stormwater on site within the existing drainage basin off Westwood Ave.

The existing basin has not been provided with a bio retention area despite being excavated close to the existing groundwater levels. As a result it is proposed that a bio retention area will be constructed as part of these works.

Soakage at source will be employed for all allotments without outflow for all storms up to the 20% AEP storm. Beyond that, water will surcharge and run overland to the street drainage system and be conveyed to the drainage basins.

Basins will generally be constructed as swales within POS areas. The basin arrangements are generally constructed as a two tiered arrangement as follows:

- Water will drain into a bioretention area which will contain the 1EY 1 hour storm.
- For the lower, less regular AEP storms, water will then surcharge into a vegetated area which will contain all other storms up to the 1% AEP.

GPT's will be constructed at entry to the POS soakage areas to ensure that all litter and sediment is contained for easy cleaning.

The areas required to contain flows from the post development catchments areas are summarised in Table 6.1 - Refer also to Appendices B and C for the catchment plan and detailed calculations:

Table 6.1 – Drainage Basin Areas/Catchments and Areas affected by Drainage

Basin Description	Total Catchment Lots 28 and 29
Impervious Catchment (Ha) (C ₁ %)	2.43

Basin Description	Total Catchment Lots 28 and 29
Storage provided (1% AEP)	2,519
Storage provided (20% AEP)	827
Storage provided (63.2% AEP)	452
Site Area Required (1% AEP)(m ²)	5,961
Site Area Required (20% AEP) ¹ (m ²)	5,410
Site Area Required (63.2% AEP) ¹ (m ²)	5,284
TWL _{1%} (mAHD)	23.95
Critical Tc (63.2% AEP) (hours)	2
Critical Tc (20% AEP) (hours)	2
Critical Tc (1% AEP) (hours)	9
Basin Drying Time (63.2% AEP) (hours)	16
Basin Drying Time (20% AEP) (hours)	24
Basin Drying Time (1% AEP) (hours)	80

6.3 63.2% AEP event

6.3.1 General

The 63.2% AEP event is typically seen as the storm where most nutrients and particulate matter is generated from.

The separation distance between all of the development and the groundwater is around 2.7m and as generally agreed with DoW, no groundwater control measures are required.

It is proposed that the 63.2% AEP 1 hour storm will be retained on site without outflow in accordance with DoW requirements. This is proposed to be undertaken at the various levels as outlined in the following sections.

6.3.2 Lots:

Lots will either retain water on site in rainwater tanks in conjunction with soakwells or install soakwells to infiltrate water to ensure no outflow into the street drainage system. All Lots are required be fitted with the equivalent 2 by 1200 diameter by 1.2m deep soakwells to achieve full retention of all storms up to the 20% AEP storm without outflow.

Beyond this storm, stormwater will surcharge from the soakwells and run overland to the street drainage system and some infiltration will occur, particularly in back yards.

6.3.3 Streets:

The 63.2% AEP 1 hour storm for roadways, will be contained firstly within drainage pits with open bases to permit soakage for small rainfall events thereby encouraging further soakage “at source”. The baseless pits will cater for around 1.5-2.0mm of rainfall.

Overland flow will be employed in lieu of piped drains where possible. Where roads are constructed adjacent to open space and opportunities for soakage are available, flush kerbs may be used in conjunction with swale drainage in lieu of a piped drainage system. This is subject to final landscape design details and agreement from the Local Authority at detailed design stage.

The remainder of the 63.2% AEP 1 hour event will be contained within the below ground storage without overflow to any surrounding POS areas.

A GPT will be installed prior to any inflow from the piped drainage system into the drainage basin to limit the siltation of the basin.

6.3.4 Detention Basins

Beyond the measures employed in baseless pits and lineal swales, the remainder of the 63.2% AEP 1 hour storm will be retained within the retention basin area. The drainage basins will retain the water until it infiltrates.

Details of the proposed retention basins are included in Appendix D.

6.3.5 Non structural measures

Non structural measures will also be employed to reduce the sources of nutrients. These measures involve providing advice to lot purchasers and stakeholders to reduce nutrient sources from the application of garden fertilisers and eroded particulate matter particularly from the new urban areas during the housing construction phase and in establishment of gardens.

Minimisation of nutrient loading can obviously be achieved through:

- Education of local residents and Council maintenance personnel; and
- By implementing frequent street and storm water maintenance programs – particularly during housing construction.
- By planting and using appropriate native species.

6.4 20% AEP event

All piped drainage systems will be designed to accommodate the 20% AEP event, without any inundation of roadways.

6.5 1% AEP event

For the major event, lot drainage flows in excess of the 20% AEP storm will surcharge and run overland. All roads within the estate will be designed to accommodate and direct extreme event flows towards each POS and drainage basin.

The land will be divided into the same catchment areas as detailed in the post development plan as Appendix B.

6.6 Finished Lot Levels (Relative to the 1% AEP flood levels)

As outlined in Section 0, the land is proposed to be filled a minimum of 300mm above the top water level of drainage basins. In all cases, lots will be set to ensure conveyance for major storms will be along the roadways without flooding homes.

6.7 POS Credits

As outlined in the LSP document all POS credit calculations have been based upon current “Liveable Neighbourhood” policy guidelines - where 100% of the area covered by the 63.2% AEP event of each compensating basin is typically not included as a “usable” POS area. The 20% AEP event is designated as a restricted area normally attracting a 100% credit for the area between the 63.2% AEP and the 20% AEP levels provided this comprises less than 20% of the total POS allocation.

The affected areas of the drainage basins are detailed in Table 6.1. It is noted that the drainage is proposed to be directed to an area that has been provided to the City for the sole purpose of drainage and rehabilitation. By using this area, the POS area within Lot 28 can be fully utilized for recreation and vegetation retention rather than performing a drainage function.

6.8 Best Management Practices Water Quality Targets

The DoW’s Stormwater Manual provides guidelines and information on best management practices that may be applied at land development and construction sites to improve stormwater management and environmental performance.

Poorly managed land development sites can often be a major source of stormwater pollution. Certain construction activities can allow pollutants to be transported (via existing stormwater systems or over-land flow) to adjoining receiving water bodies.

The major source of pollutants from construction activities in this instance will potentially be from:

- Eroded materials in the interim period between opening up the surface of the site and implementing the drainage management measures.
- Litter & waste storage areas- that allow materials to be blown by wind or washed away by rainfall into existing stormwater systems.
- Wash-down areas– poor practices can allow materials to enter stormwater systems.
- Placement & storage of delivered products- particularly sand and soil stockpiles where such materials may be tracked by vehicles onto roads, or blown, or washed on to roads which then get into existing stormwater systems.
- Dewatering activities– which can cause sedimentation of downstream water bodies.

Consequently no construction activities will commence on the site until an appropriate approved Environmental Management Plan (EMP) is prepared that fully addresses:

- litter and waste management practices (non-hazardous & hazardous materials);

- vehicle & equipment washing-down practices;
- water conservation practices;
- product placement & storage practices;
- dewatering activities (if applicable); and
- Any other practices that may adversely impact upon receiving water bodies.

This will be prepared by the contractor undertaking the civil works on the subdivision together with the engineering consultant.

The Best Management measures proposed for this area are proposed to be:

- Non Structural Measures to be implemented reduce applied nutrient loading.
- On Site Retention of 63.2% AEP 1 hour storm.

Research has indicated that this approach will achieve reductions of at least 80% of total suspended solids; 60% of total phosphorus; 45% of total nitrogen & 70% of gross pollutants compared to a conventional drainage system.

7 Groundwater Management Strategy

7.1 Groundwater Level Management

Groundwater levels for the site location are plotted on the site plan in Appendix B. In general the levels are several metres below the site levels. Development levels are generally at a minimum of RL25.6mAHD which is well above the maximum likely groundwater level of around RL22mAHD.

There is no further need for controls of groundwater levels and all drainage pipework will be laid well above the controlled groundwater levels.

7.2 Actions to Address Acid Sulphate Soils or Contamination

The ASS mapping for the area indicates that there is no known risk of ASS soils occurring within 3.0m of natural soil surface (or deeper).

Therefore there is little or no risk of the development proposal encountering any ASS soils.

8 The next stage – Subdivisions and Urban Water management Plans

The structure plan area is under the ownership of a single owner such that the drainage system can be implemented in accord with the development programme.

As a result, the staging of the development and any temporary facilities as required will be addressed in the Urban Water Management Plan (UWMP) which will be required for the subdivision proposal. It is anticipated that the ultimate drainage strategy will generally fit within the framework of this Local Water Management Strategy.

The UWMP will build on the concepts of this report providing ongoing monitoring results and addressing the following major points:

- Further detail in the design of the detention basins.

- Detailed geotechnical investigations.
- Further detail in landscape proposals.
- Testing of groundwater quality for irrigation purposes.

Once this data is received, the approach outlined herein will be reviewed with detailed work required to:

- Finalise the design of the swales in the POS.
- Detail the Drainage basins including the various inlet configurations and edge treatments to ensure the overall functional and aesthetic outcomes are satisfactory.
- Review the drainage calculations relative to final planning proposals for the site to ensure that the land use assumptions within the drainage calculations herein are consistent.

9 Monitoring

9.1 General

Post development monitoring is proposed to be undertaken over the site quarterly following the completion of the first stage. It is proposed to use the same suite of bores used for the pre- development monitoring as detailed in Drawing U-03 in Appendix B.

It is acknowledged that some of these bores may be impacted by the works and if this occurs, they will be reinstated as close as possible to their original locations but in a suitably accessible location.

The level will be measured and samples will be sent to a NATA registered laboratory to undertake the following tests:

Table 9.1 – Proposed Post Development testing regime

Test	Abbreviation	Trigger levels (Based on 10% Exceedance of Initial Levels) (mg/l)
Total Phosphorous	TP	0.044
Ammonia-Nitrogen	NH ₃	0.165
Total Kjeldahl Nitrogen	TKN	6.71
Salinity	EC or TDS	N/A
pH		N/A

The water will be sampled quarterly January, March, June and October commencing after the first stage of development has been completed and will be carried out for two

years following completion of the last stage of civil construction and until hand over of the POS to the City of Cockburn, whichever is the latter.

Hand over to the City of Cockburn will occur two years after completion of establishment works. In the interim period, the developer will accept responsibility for the maintenance and monitoring of the landscaping and monitoring works.

An annual report will be submitted to the City of Cockburn and the DWER until 2 years after the completion of the last stage.

9.2 Contingency Response

The results will be compared between the initial results to those measured each year.

In the event that any of the indicators from the sampling exceeds the initial measurements by 10% for two consecutive samples, Council and DWER will be notified and the matter will be investigated at the developers cost.

The possible contingency measures are as follows:

1. Reduction in irrigation or fertiliser use in key areas and review of timing.
2. Soil amendment in high nutrient areas
3. Increased planting of water and nutrient thirsty plants in groundwater recharge areas.

The measures employed and the timing will be resolved at the time with the DWER and Council.

If standing water occurs within the basin areas for excessive periods of time within the maintenance period for the landscaping (That is two years following completion of the last stage of civil construction or until hand over of the POS to the City of Rockingham, whichever occurs first), the developer shall at its cost investigate the issue and provide a solution for approval by the Local Authority. Following agreement on a strategy, the developer shall implement the strategy and undertake any required rectification works at its cost.

10 Implementation

10.1 Commitments

The developers are committed to

- 1) Physical Outcomes – To be undertaken at the time of construction.
 - Ensuring that all storm water drainage from the estate is infiltrated on site.
- 2) Non Structural – To be undertaken as part of sales documentation, by providing Information Packages to all lot purchasers to:
 - Fully inform lot owners of the requirement to install the equivalent of two 1200mm diameter by 1200mm deep soakwell prior to outflow into the drainage system in the event a rainwater tank is not installed or reduced storage equivalent to the storage of a rainwater tank in the event that one is used.
 - To encourage the use of rainwater tanks (plumbed into their homes); and

- To utilise water efficient devices & appliances throughout their homes, and to encourage all purchasers to install Water & Nutrient-wise plants.
- 3) Further investigation and reporting:
- Prepare Urban Water Management plans to support further detailed subdivision planning.
 - Undertake geotechnical investigations.

10.2 Maintenance Schedules (Incl. Roles & Responsibilities)

Maintenance schedules and arrangements will be resolved as part of the Urban Water Management planning and will be dependent on the detailed design and operation of the mechanisms required. As a brief summary, table 10.1 has been included to provide guidelines for likely maintenance responsibilities.

Table 10.1 – Proposed Maintenance Programme for the development

#	Drainage Element:	Possible Maintenance and Inspection Frequency:	Responsibility:
1	Rainwater tank(s); trapped underground soakage / connection pit(s)	Annually inspection & clean-out (as necessary) – just prior to winter rains	Lot Owner
2	Swale Areas, table drains and detention basins	<u>During developer maintenance period</u> (2 year in conjunction with Landscaping) Inspect, clean-out & maintain plants ~fortnightly intervals (depending on loading) – as part of POS maintenance works <u>After developer maintenance period:</u> Inspect, clean-out & maintain plants (as required) as part of standard Council POS maintenance program	Developer Council
3	Drainage culverts, standard table drains, pipes and pits	<u>During developer maintenance period:</u> (12 month Defects liability period) Inspect, clean-out & maintain structures annually – just prior to winter (& then again in Aug / Sept if necessary) <u>After developer maintenance period:</u> Inspect, clean-out & maintain structures at least annually – just prior to winter – but inspection frequency will need to be higher during home construction phase	Developer Council
4	Trapped Pits and GPT's	<u>During developer maintenance period:</u> (12 month Defects liability period) Inspect, clean-out & maintain pits tri-annually – just prior to winter & then around June / July & again in Oct / Nov for the first two years <u>After developer maintenance period:</u> Inspect, clean-out & maintain pits tri-annually – just prior to winter & then around June / Aug – but inspection frequency will need to be higher during home construction phase.	Developer
5	Base of compensating basins	Initial formal inspection & assessment of performance of bases (say) at around year 3 & then every 5 – 10 years.	Council

10.3 Funding

The cost for the implementation of the capital water management measures will be borne by the developers. Maintenance and monitoring costs will be borne by the developers for the periods as outlined in the maintenance schedule table in section 10.2 above.

10.4 Review

Following the approval of this document, it is not expected that the LWMS for this development will need to be reviewed as this forms the broad structure of the approach for the drainage in the area.

In general minor amendments can be made, provided they meet the outcomes sought within this report. In the event that the management measures used within the state have significantly changed or the first subdivision application following the expiration of 4 years from the first subdivision approval whichever is the later, the measures used for management of stormwater should be reviewed.

11 References:

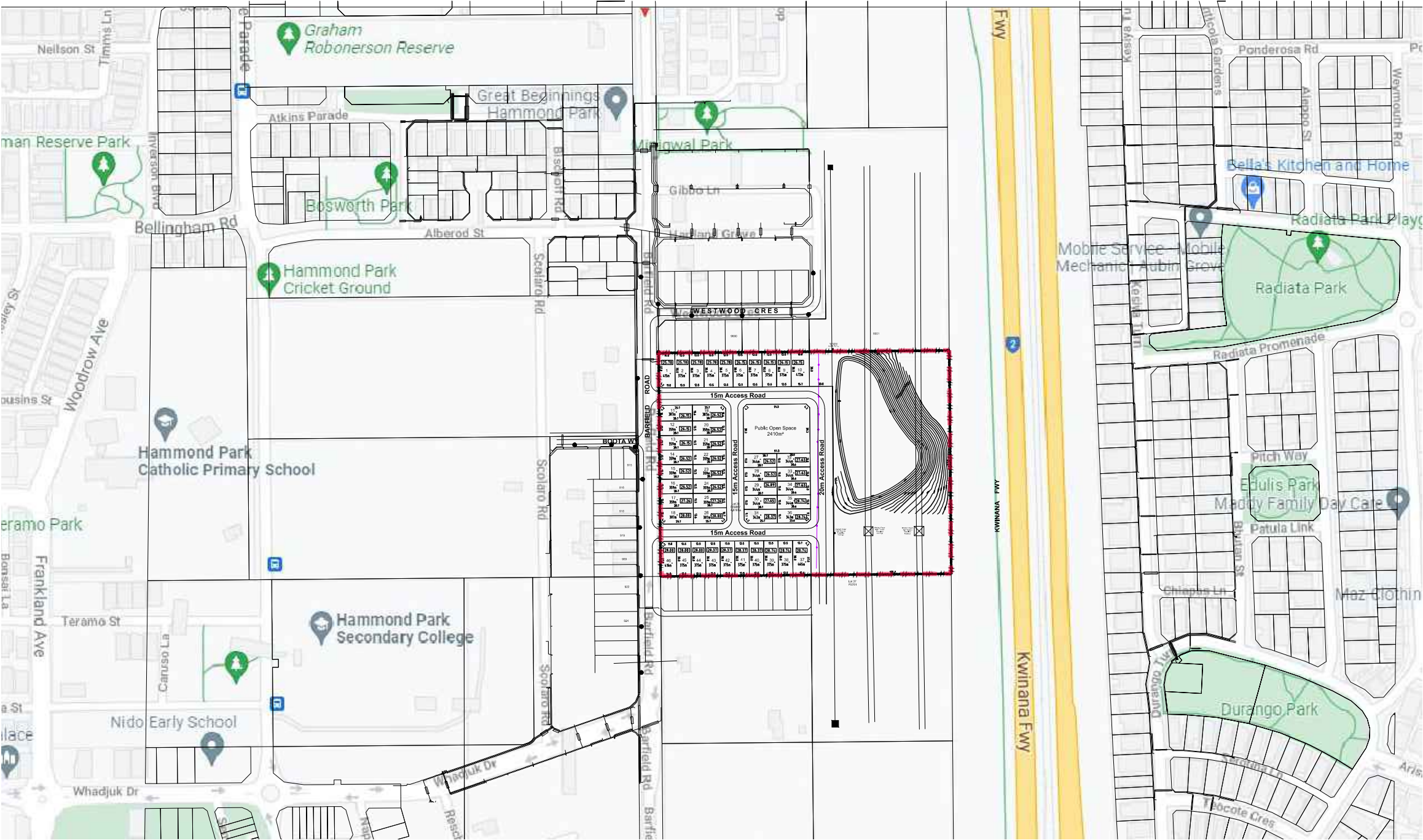
1. Environmental Geology Mapping - Part Sheets 2033 I and 2133 IV, Gozzard JR 1983
2. Perth Groundwater Atlas (Edition 4), Department of Environment, 2004
3. Perth Groundwater Atlas, Waters and Rivers Commission, October 1997.

APPENDIX A –

- L- 01 Locality Plan**
- L- 02 Aerial Photo with Development Superimposed
Thereon**
- Indicative Subdivision Plan**

LEGEND

Site BOUNDARY



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ENGINEERING
CONSULTANTS

SUITE 3, 123A COLIN ST,
WEST PERTH, 6005
WESTERN AUSTRALIA
Ph: (08) 9481 1900
Fax: (08) 9481 1700

PROJECT:

LOT 28 BARFIELD ROAD
HAMMOND PARK

W.A.P.C. No. -

DRAWING:

LOCAL WATER MANAGEMENT STRATEGY
LOCALITY PLAN

CAD DRAWING DO NOT MANUALLY ALTER

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SCALE

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22/12/21

PROJECT NUMBER

PRO1022

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SRA

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DRAWING NUMBER

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WEST PERTH, 6005
WESTERN AUSTRALIA
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Fax: (08) 9481 1700

PROJECT:

LOT 28 BARFIELD ROAD
HAMMOND PARK

W.A.P.C. No. -

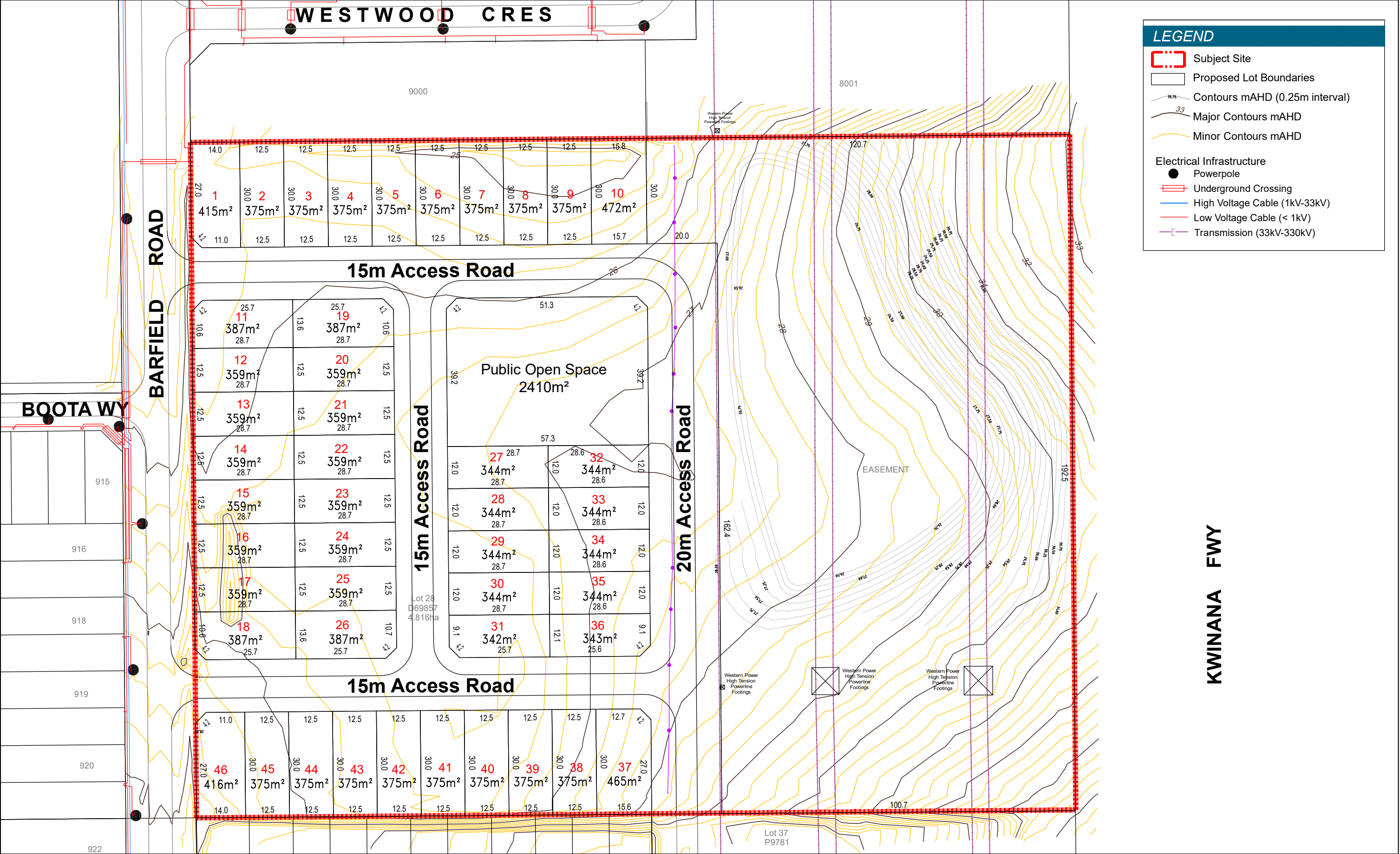
DRAWING:

LOCAL WATER MANAGEMENT STRATEGY
AERIAL PHOTO

CAD DRAWING DO NOT MANUALLY ALTER

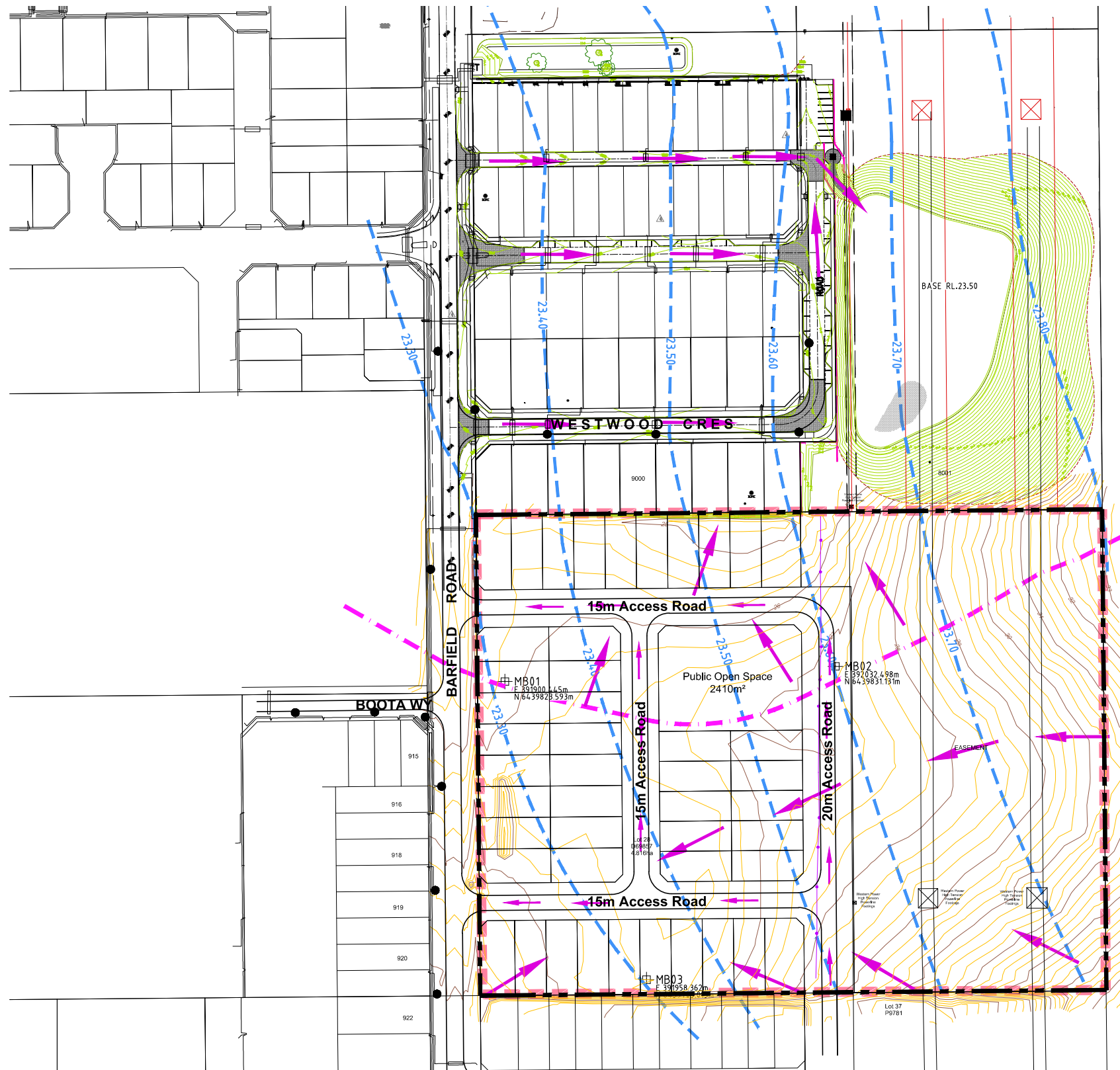
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PROJECT NUMBER				DRAWING NUMBER			
PRO1022				L02			

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APPENDIX B – DRAINAGE CATCHMENT PLANS

- L- 03 - Pre-development catchment plan**
- L- 04 - Post development catchment plan with flow directions and proposed drainage basins**
- L- 05 – Drainage and basin details**



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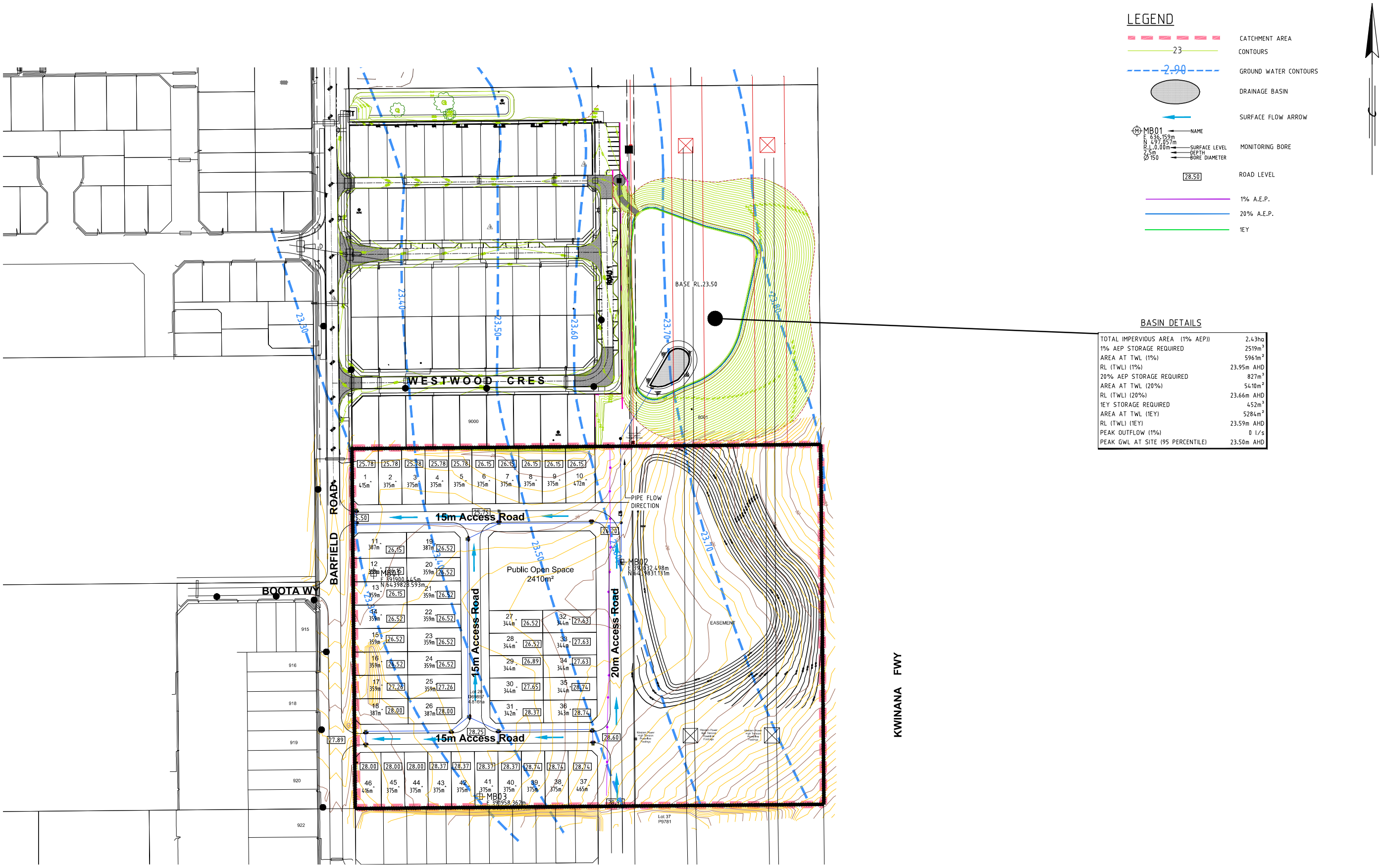
- CATCHMENT AREA
- EXISTING SURFACE CONTOURS
- WATER CONTOURS
- IMPLIED NATURAL RIDGE
- FLOW ARROW

- MONITORING BORE



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CATCHMENT AREA

CONTOURS

GROUND WATER CONTOURS

DRAINAGE BASIN

SURFACE FLOW ARROW

MB01

NAME

8.36m

DEPTH

157m

SURFACE LEVEL

2.5m

DEPTH

150

BORE DIAMETER

MONITORING BORE

ROAD LEVEL

1% A.E.P.

20% A.E.P.

1EY

BASIN DETAILS

TOTAL IMPERVIOUS AREA (1% AEP)	2.43ha
1% AEP STORAGE REQUIRED	2519m ³
AREA AT TWL (1%)	5961m ²
RL (TWL) (1%)	23.95m AHD
20% AEP STORAGE REQUIRED	827m ³
AREA AT TWL (20%)	5410m ²
RL (TWL) (20%)	23.66m AHD
1EY STORAGE REQUIRED	452m ³
AREA AT TWL (1EY)	5284m ²
RL (TWL) (1EY)	23.59m AHD
PEAK OUTFLOW (1%)	0 l/s
PEAK GWL AT SITE (95 PERCENTILE)	23.50m AHD



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Fax: (08) 9481 1700

PROJECT:

LOT 28 BARFIELD ROAD HAMMOND PARK

W.A.P.C. No. -

DRAWING:

LOCAL WATER MANAGEMENT STRATEGY
POST-DEVELOPMENT
CATCHMENT PLAN

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Environmental and Water Resource Software

PCSump Version 6.1



Project Number/Name: Lot 28 Barfiled Road, Hammond Park

Project Description: Northern Basin in Neighbours land

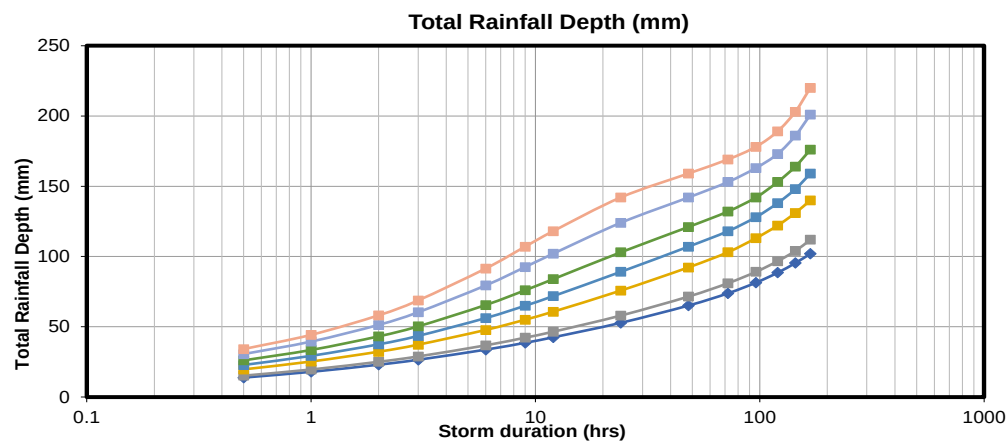
Model Selection:	Shallow Water Table Model
Design AEP(EY)/ARI	1% AEP (100 year ARI)
Design Rainfall Region:	Perth Metro
Design Rainfall Location:	Bibra Lake
Latitude:	-32.099216
Longitude:	115.817393
Temporal Pattern:	West Flatlands
Climate Change Selection (Y/N)	N
Effective Service Life	
Consequence of Failure	
Adjustment Applied	

Swale Selection (Y/N) N

Total Rainfall Depth (mm)							
Duration	EY	Annual Exceedance Probability (AEP)					
	1 EY	50%	20%	10%	5%	2%	1%
30 min	13.8	15.2	19.6	22.8	26.1	30.5	34.1
1 hour	17.9	19.6	25.2	29.3	33.5	39.4	44.2
2 hour	23	25.1	32.2	37.5	43.2	51.3	58.1
3 hour	26.5	28.9	37.2	43.5	50.3	60.3	68.7
6 hour	33.7	36.8	47.7	56.2	65.5	79.4	91.4
9 hour	38.6	42.3	55	65	76	92.5	107
12 hour	42.5	46.5	60.7	71.8	83.9	102	118
24 hour	52.8	58	75.7	89.1	103	124	142
48 hour	65.1	71.5	92.2	107	121	142	159
72 hour	73.8	81	103	118	132	153	169
96 hour	81.4	89.1	113	128	142	163	178
120 hour	88.5	96.7	122	138	153	173	189
144 hour	95.4	104	131	148	164	186	203
168 hour	102	112	140	159	176	201	220

Basin:

Type	Area (ha)	IL (mm)	CL (mm/hr)	PL(%)
Roads	1.56			28.0%
Resi Lots	3.7438	9.79	9.09	



Basin	0.5159			0.0%
POS	4.355			100.0%

Basin Parameters:

<i>Soil Characteristics:</i>	
Saturated Hydraulic Cond. (m/day)	5
Clogged Layer Permeability (m/day)	
Clogged Layer Thickness (mm)	
Soil Suction (cm)	
Porosity	
Aquifer Storage Coefficient	0.2
Base of Aquifer (mAHD)	-17
Design Groundwater Level (mAHD)	23.2
<i>Initial Conditions:</i>	
Water Depth in Basin (m)	0
Wetting Front Depth (m)	0
Initial Degree of Soil Saturation (%)	0%
<i>Basin Geometry:</i>	
Stage-Area-Volume Relationship Entered (Y/N)	N
Base Length (m)	90
Base Width (m)	57
Average Slope (1 in X)	6
Basin Base Elevation (mAHD)	23.5
Maximum Allowable TWL (mAHD)	24.7

Pipe Outflow:

Entrance Type	
Pipe Diameter (mm)	
Pipe Length (m)	
Upstream Invert Level (mAHD)	
Downstream Invert Level (mAHD)	

Weir Outflow:

Weir Type:	
Weir Coefficient	
Weir Width (m)	
Weir Level (mAHD)	

**Project Number / Name:**

Lot 28 Barfiled Road, Hammond Park

Project Description:

Northern Basin in Neighbours land

Model Selection:**Shallow Water Table Model****Results:**

Design Storms				Maximum (Mean of Temporal Patterns)					
Storm	Duration [hrs]	Rainfall Depth [mm]	EY/AEP [%]	Depth [m]	Level [mAHD]	Clearance to Allowable TWL [m]	Volume [m ³]	Area [m ²]	Temporal Pattern No.
1	30 min	34.1	1%	0.24	23.74	0.96	1,272	5,557	10
2	1 hour	44.2	1%	0.31	23.81	0.89	1,653	5,683	3
3	2 hour	58.1	1%	0.38	23.88	0.82	2,075	5,819	3
4	3 hour	68.7	1%	0.39	23.89	0.81	2,158	5,846	1
5	6 hour	91.4	1%	0.42	23.92	0.78	2,315	5,896	5
6	9 hour	107.0	1%	0.45	23.95	0.75	2,519	5,961	3
7	12 hour	118.0	1%	0.37	23.87	0.83	2,049	5,811	8
8	24 hour	142.0	1%	0.31	23.81	0.89	1,702	5,698	5
9	48 hour	159.0	1%	0.2	23.70	1.00	1,071	5,492	1
10	72 hour	169.0	1%	0.16	23.66	1.04	859	5,420	2
11	96 hour	178.0	1%	0.13	23.63	1.07	675	5,359	2
12	120 hour	189.0	1%	0.12	23.62	1.08	644	5,348	1
13	144 hour	203.0	1%	0.14	23.64	1.06	741	5,381	6
14	168 hour	220.0	1%	0.1	23.60	1.10	505	5,302	7
6	9 hour	107.0	1%	0.45	23.95	0.75	2,519	5,961	3

Notes:

Temporal pattern matching closest to mean water level
 If Water Level is coloured **Red**, Maximum Capacity of the Basin has been Exceeded

**Project Number / Name:**

Lot 28 Barfield Road, Hammond Park

Project Description:

Northern Basin in Neighbours land

Model Selection:**Shallow Water Table Model****Results:**

Design Storms				Maximum (Mean of Temporal Patterns)					
Storm	Duration [hrs]	Rainfall Depth [mm]	EY/AEP [%]	Depth [m]	Level [mAHD]	Clearance to Allowable TWL [m]	Volume [m ³]	Area [m ²]	Temporal Pattern No.
1	30 min	19.6	20%	0.11	23.61	1.09	547	5,316	4
2	1 hour	25.2	20%	0.13	23.63	1.07	703	5,368	2
3	2 hour	32.2	20%	0.16	23.66	1.04	827	5,410	6
4	3 hour	37.2	20%	0.15	23.65	1.05	797	5,400	9
5	6 hour	47.7	20%	0.14	23.64	1.06	753	5,385	9
6	9 hour	55.0	20%	0.13	23.63	1.07	664	5,355	7
7	12 hour	60.7	20%	0.11	23.61	1.09	583	5,328	4
8	24 hour	75.7	20%	0.09	23.59	1.11	454	5,284	6
9	48 hour	92.2	20%	0.05	23.55	1.15	280	5,226	7
10	72 hour	103.0	20%	0.04	23.54	1.16	181	5,192	9
11	96 hour	113.0	20%	0.02	23.52	1.18	103	5,165	10
12	120 hour	122.0	20%	0.03	23.53	1.17	151	5,182	5
13	144 hour	131.0	20%	0.02	23.52	1.18	112	5,168	7
14	168 hour	140.0	20%	0.02	23.52	1.18	111	5,168	2
3	2 hour	32.2	20%	0.16	23.66	1.04	827	5,410	6

Notes:

Temporal pattern matching closest to mean water level
 If Water Level is coloured **Red**, Maximum Capacity of the Basin has been Exceeded

**Project Number / Name:**

Lot 28 Barfield Road, Hammond Park

Project Description:

Northern Basin in Neighbours land

Model Selection:**Shallow Water Table Model****Results:**

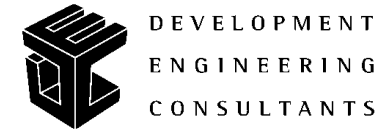
Design Storms				Maximum (Mean of Temporal Patterns)					
Storm	Duration [hrs]	Rainfall Depth [mm]	EY/AEP [%]	Depth [m]	Level [mAHD]	Clearance to Allowable TWL [m]	Volume [m ³]	Area [m ²]	Temporal Pattern No.
1	30 min	13.8	1 EY	0.05	23.55	1.15	269	5,222	9
2	1 hour	17.9	1 EY	0.07	23.57	1.13	377	5,258	2
3	2 hour	23.0	1 EY	0.09	23.59	1.11	452	5,284	5
4	3 hour	26.5	1 EY	0.08	23.58	1.12	395	5,264	1
5	6 hour	33.7	1 EY	0.07	23.57	1.13	365	5,255	3
6	9 hour	38.6	1 EY	0.05	23.55	1.15	279	5,225	6
7	12 hour	42.5	1 EY	0.04	23.54	1.16	226	5,207	2
8	24 hour	52.8	1 EY	0.03	23.53	1.17	133	5,176	5
9	48 hour	65.1	1 EY	0	23.50	1.20	12	5,134	4
10	72 hour	73.8	1 EY	0.01	23.51	1.19	24	5,138	4
11	96 hour	81.4	1 EY	0.01	23.51	1.19	34	5,142	2
12	120 hour	88.5	1 EY	0.01	23.51	1.19	29	5,140	2
13	144 hour	95.4	1 EY	0	23.50	1.20	15	5,135	10
14	168 hour	102.0	1 EY	0.01	23.51	1.19	34	5,142	10
3	2 hour	23.0	1 EY	0.09	23.59	1.11	452	5,284	5

Notes:

Temporal pattern matching closest to mean water level
 If Water Level is coloured **Red**, Maximum Capacity of the Basin has been Exceeded

Development Engineering Consultants - Drainage Basin Spreadsheet

Project: **Lot 28 Barfield Road, Hammond Park**
 Client: **Condor Nominees Pty Ltd**
 Location: **At-lot detention calculations to establish runoff coefficient**
 Designer: **SRA**



Location: **Lot 28 Barfield Road, Hammond Park**
 Nearest
 grid cell: **Latitude 32.1875(S) Longitude 115.8375(E)**

Data to be input

Rainfall AEP (percentage) **1** **ARI** **v Descriptor v**
 1EY impervious catchment (Ha) **0.025** **100** **Infrequent**
 Required storage (1EY - 1hr) (m³) **3.881**

Catchment details	Paved area	Unpaved area	Total
Lot area (m²)			400.00
Proportion paved	70%	30%	100%
Area paved (Ha)	0.028	0.012	0.040
Runoff coefficient (C ₁₀)	0.90	0.00	
ARI multiplier	1.00	1.20	
Runoff coefficient (C _y)	0.90	0.00	
Impervious area (Ha)	0.025	0.000	0.025

Effective C
0.63

AEP	ARI	Effective C	Multiplier
63.2	1	0	-
50	1.44	0	-
20	4.48	0	-
10	9.49	0.01	1.00
5	20	0.09	9.00
2	50	0.17	17.00
1	100	0.21	21.00

Volume and dimensions of available storage

Area above ground inundated to 0.03m deep
 (backyard and front yard) (m²) **40.00** **0.03** **1.20**
 Storage provided manholes/pipe (m³) **-**
 Number of soakwells **2.00**
 Diameter of soakwells (m) **1.20**
 Depth of each soakwell (m) **1.20**
 Storage required soakwells (m³) **2.71**
 Storage provided (m³) **3.91**
Effective Initial Loss (mm) **9.79**
 Soakage rate (L/s/m²) **0.020** **1.70 m/day**

NOTE: All water is retained in soakwells up to and including 5% AEP (1 in 20yr ARI) without surcharge. For greater AEP storms water will surcharge soakwells and soak over an area of 40m² to a maximum depth of 30mm within the lot, and then enter the road drainage system.

Development Engineering Consultants - Drainage Basin Spreadsheet

Client: **Condor Nominees Pty Ltd**

Location: **At-lot detention calculations to establish runoff coefficient**



ENGINEERING
CONSULTANTS

Volume of storage required is 1m ³ per	92.84 m ²	of paved lot area
Volume of storage required is 1m ³ per	102.19 m ²	of total lot area

T _c (min)	T _c (hr)	I (mm/hr)	Q _{IN} (L/s)	Total V _{IN} (m ³)	Q _{OUT} (soakage) (L/s)	Effective Continuing Loss (mm/hr)	V _{OUT} (soakage) (m ³)	Net storage (after soakage) (m ³)	V _{OUT} required (m ³)	Q _{OUT} (L/s)
10	0.17	131.00	9.2	5.50	1.01	9.09	0.61	4.90	0.98	1.64
15	0.25	105.00	7.4	6.62	1.01	9.09	0.91	5.71	1.79	1.99
20	0.33	88.60	6.2	7.44	1.01	9.09	1.21	6.23	2.32	1.93
30	0.50	69.00	4.8	8.69	1.01	9.09	1.82	6.88	2.96	1.65
45	0.75	53.40	3.7	10.09	1.01	9.09	2.73	7.37	3.45	1.28
60	1.00	44.50	3.1	11.21	1.01	9.09	3.63	7.58	3.67	1.02
90	1.50	34.60	2.4	13.08	1.01	9.09	5.45	7.63	3.71	0.69
120	2.00	29.10	2.0	14.67	1.01	9.09	7.27	7.40	3.48	0.48
150	2.50	25.50	1.8	16.07	1.01	9.09	9.09	6.98	3.06	0.34
180	3.00	22.90	1.6	17.31	1.01	9.09	10.90	6.41	2.49	0.23
240	4.00	19.30	1.4	19.45	1.01	9.09	14.54	4.92	1.00	0.07
300	5.00	16.90	1.2	21.29	1.01	9.09	18.17	3.12	0.00	0.00
360	6.00	15.20	1.1	22.98	1.01	9.09	21.81	1.18	0.00	0.00
480	8.00	12.70	0.9	25.60	1.01	9.09	29.08	-3.47	0.00	0.00
720	12.00	9.81	0.7	29.67	1.01	9.09	43.61	-13.95	0.00	0.00
960	16.00	8.51	0.6	34.33	1.01	9.09	58.15	-23.83	0.00	0.00
1440	24.00	5.92	0.4	35.80	1.01	9.09	87.23	-51.42	0.00	0.00
2880	48.00	3.32	0.2	40.16	1.01	9.09	174.45	-134.29	0.00	0.00
4320	72.00	2.34	0.2	42.46	1.01	9.09	261.68	-219.22	0.00	0.00

APPENDIX D – APPLICATION FOR GROUNDWATER LICENCE



LICENCE TO TAKE WATER

Granted by the Minister under section 5C of the Rights in Water and Irrigation Act 1914

Licensee(s)	Condor Nominees Pty Ltd		
Description of Water Resource	Jandakot Perth - Superficial Swan	Annual Water Entitlement	15,000kL
Location of Water Source	LOT 28 ON PLAN 69857 - Volume/Folio 1754/135 - Lot 28 BARFIELD RD HAMMOND PARK		
Authorised Activities	Taking of water for	Location of Activity	
	Irrigation of up to 2 ha of public open space	LOT 28 ON PLAN 69857 - Volume/Folio 1754/135 - Lot 28 BARFIELD RD HAMMOND PARK	
Duration of Licence	From 28 January 2022 to 28 January 2032		

This Licence is subject to the following terms, conditions and restrictions:

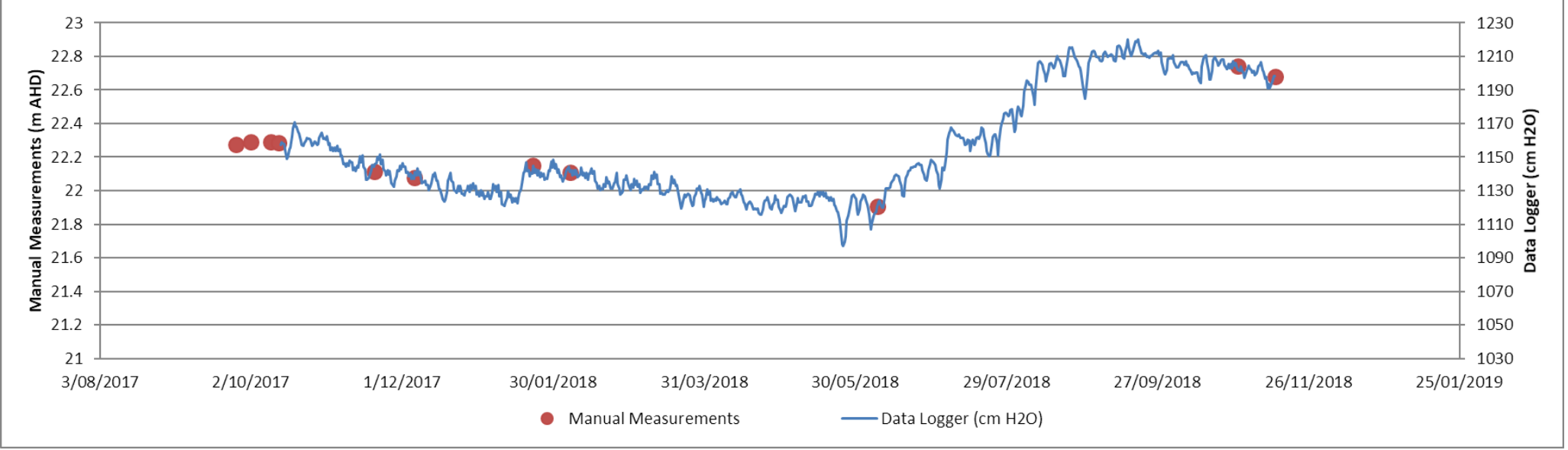
1. The annual water year for water taken under this licence is defined as 1 June to 31 May.
2. The licensee shall not use water for sprinkler irrigation between 9 am and 6 pm except for the establishment of newly planted areas. For newly planted areas water may be used within these hours for a period of up to 28 consecutive days, commencing from the date of planting.
3. Between 1 June and 31 August in any year, the licence-holder must not water a lawn, garden, or grass-covered area ("turf") by reticulation, provided always that this restriction shall not apply to watering with a hand held hose; or watering, by way of reticulation: newly planted areas for a period of up to 28 days from the date of planting; for renovating turf; or for maintenance of reticulation systems.

End of terms, conditions and restrictions

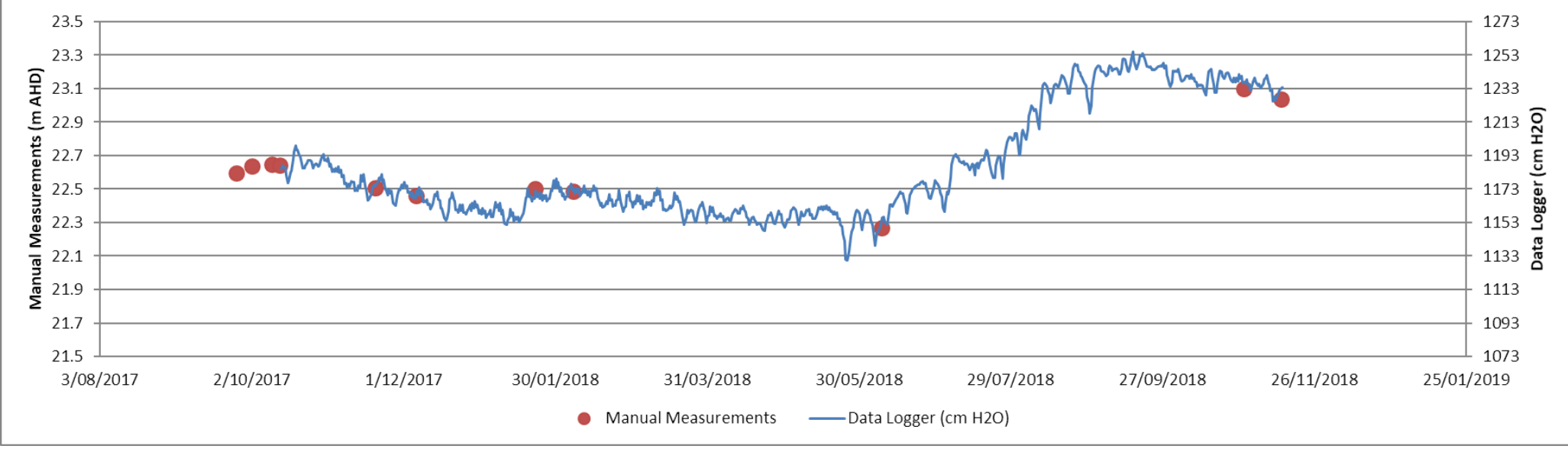
APPENDIX E –

- **RECORDED GROUNDWATER MONITORING DATA AND BORE RECORDS**
 - **DWER BORE RECORDS AND RECONCILIATION**

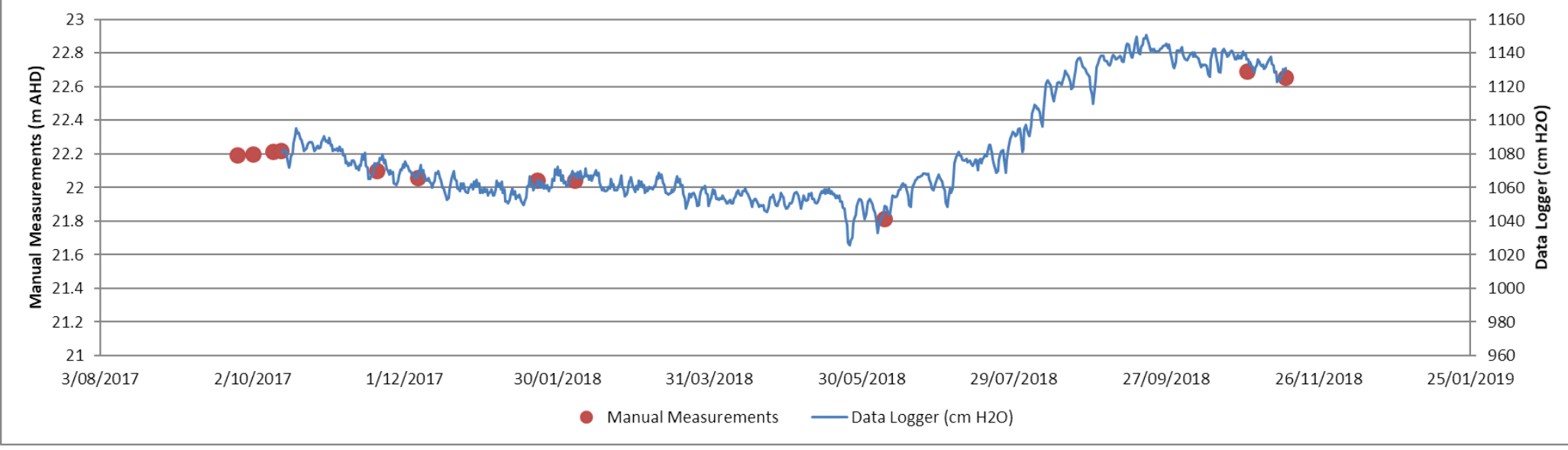
E-MB01



E-MB02

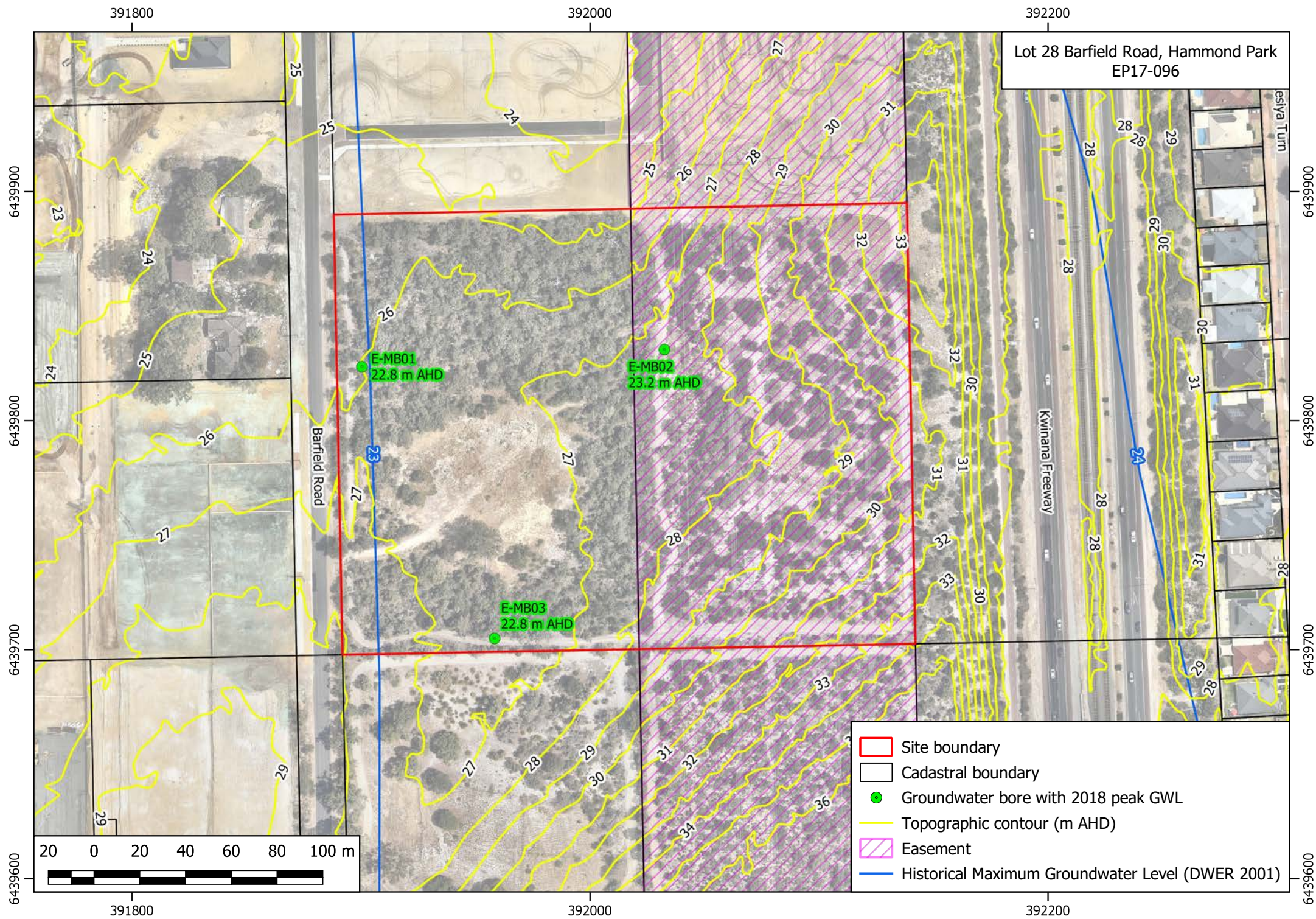


E-MB03



Summary of manual groundwater level measurements:

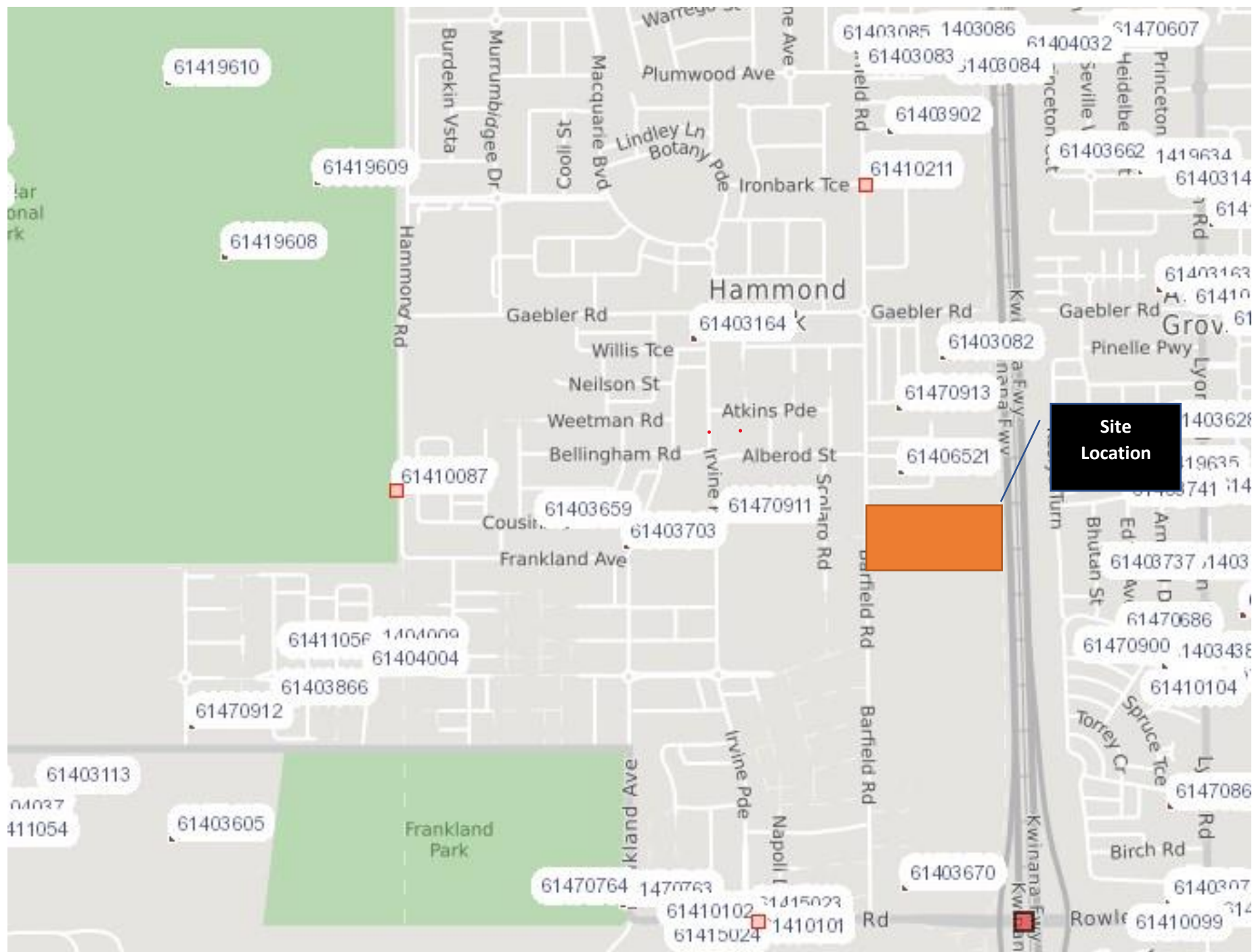
Date	E-MB01		E-MB02		E-MB03	
	m AHD	m BGL	m AHD	m BGL	m AHD	m BGL
26/09/2017	22.273	3.517	22.596	4.504	22.195	4.275
2/10/2017	22.290	3.500	22.639	4.461	22.198	4.272
10/10/2017	22.291	3.499	22.650	4.450	22.213	4.257
13/10/2017	22.284	3.506	22.643	4.457	22.219	4.251
20/11/2017	22.116	3.674	22.507	4.593	22.098	4.372
6/12/2017	22.077	3.713	22.462	4.638	22.059	4.411
22/01/2018	22.151	3.639	22.500	4.600	22.044	4.426
6/02/2018	22.110	3.680	22.488	4.612	22.045	4.425
8/06/2018	21.906	3.884	22.271	4.829	21.813	4.657
29/10/2018	22.740	3.050	23.099	4.001	22.694	3.776
13/11/2018	22.679	3.111	23.036	4.064	22.655	3.815



Groundwater Quality -2017/2018

Site Name	Date of Sampling	Field Chemistry						Nutrients and Nutrient Species					
		Temperature	Electrical Conductivity	Dissolved Oxygen	Dissolved Oxygen	pH	Oxidation-Reduction potential	Ammonia (NH ₃) as N	Oxides of Nitrogen (NO _x) as N	Total Kjeldahl Nitrogen (TKN) as N	Total Nitrogen (TN) as N	Total Phosphorous (TP) as P	Reactive Phosphorous (ORP) as P
		°C	mS/cm	mg/L	% sat	pH units	mV	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
E-MB01	10/10/2017	20.5	0.488	1.90	21.1	4.45	-60.3	0.10	<0.01	1.4	1.4	0.04	<0.01
E-MB01	22/01/2018	20.0	0.644	0.34	3.9	4.42	63.1	0.14	<0.01	1	1.0	0.02	<0.01
E-MB01	29/10/2018	18.2	0.965	0.42	4.5	5.13	-214.0	0.05	<0.01	1.2	1.2	0.01	<0.01
E-MB02	10/10/2017	19.2	0.246	1.76	18.9	5.15	-51.2	0.02	1.81	0.40	2.2	0.03	<0.01
E-MB02	22/01/2018	21.7	0.223	0.48	5.5	5.32	54.1	<0.01	0.58	0.30	0.9	0.01	<0.01
E-MB02	29/10/2018	20.5	0.444	0.79	8.7	5.69	-263.0	0.03	5.13	1.00	6.1	0.03	<0.01
E-MB03	10/10/2017	18.2	0.601	1.31	13.8	5.67	-106.4	0.15	<0.01	0.6	0.6	0.03	<0.01
E-MB03	22/01/2018	20.4	0.493	0.28	3.1	5.88	-80.9	0.01	0.35	0.3	0.6	0.01	<0.01
E-MB03	29/10/2018	18.5	0.810	0.36	3.9	5.87	-286.0	0.10	<0.01	0.4	0.4	0.01	<0.01

Minimum	18.2	0.223	0.28	3.10	4.42	-263.0	0.01	0.35	0.30	0.6	0.01	0.00
10th Percentile	18.2	0.239	0.32	3.66	4.44	-228.7	0.02	0.42	0.30	0.6	0.01	0.00
Median	20.2	0.491	0.64	7.10	5.24	-70.6	0.05	1.20	0.80	1.1	0.03	0.00
90th Percentile	20.9	0.740	1.80	19.56	5.75	56.8	0.14	4.13	1.26	3.4	0.03	0.00
Maximum	21.7	0.965	1.90	21.10	5.88	63.1	0.15	5.13	1.40	6.1	0.04	0.00
Average	19.84	0.513	0.91	9.94	5.21	-82.3	0.07	1.97	0.78	1.8	0.02	0.00
Standard Deviation	1.22	0.236	0.66	7.11	0.55	114.5	0.06	2.20	0.43	1.8	0.01	0.00



DWER BORE RECORDS SURROUNDING SUBJECT SITE

