Lot 9501Gaebler Road, Hammond Park

LOCAL WATER MANAGEMENT STRATEGY





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Appendix A Supporting reports contained within full Development Appliication

1 EXECUTIVE SUMMARY

This Local Water Management Strategy (LWMS) has been prepared to support the future development of Lot 9501 Gaebler Road, Hammond Park.

The objective of this UWMP is to detail the best management practices approach to water management that will be undertaken for this future development, while considering its current onsite features. This will include managing, protecting and conserving the total water cycle of the subject land and the greater catchment.

The developers are committed to the concepts and outcomes outlined within this report. This includes providing a framework to assist with the future implementation, monitoring and maintenance of the best management practices designed specifically for this development.

The effectiveness, efficiency and benefits provided by the best management practices outlined, require a long-term collaborative effort between the landowners, City of Cockburn and other relevant regulatory authorities. Through this collaboration, the strategies will allow the water management on site to complement the proposed Commercial land uses, by providing sustainable water servicing, stormwater management and manage the environmental attributes of the site and nearby. The practices utilised are summarised in more detail in the Key Elements Section.

SITE SUMMARY

The subject land area is located within the City of Cockburn (Hammond Park). The site is approximately 3.8193 hectares of which approximately 1.4488 hectares is proposed to be developed. It is bordered by residential properties to the north east and east. A school is located immediately north of Gaebler Road. The western boundary is shared with Hammond Road (including its further widening) with a bush reserve on the western side of Hammond Road. Immediately to the south is bushland that contains a wetland. This area (Lot 9008) is to be developed for residential purposes. It will retain the wetland with a 15m buffer.

The site location can be seen in Figure 1.

The area is predominately covered in intact bush. On the higher country this is banksia woodland, while in the depression there are a range of wetland species. There is some weed encroachment on the eastern wetland side.

The soil type is generally sand. The slopes are generally gentle.

Surface water is present in the wetland areas during periods of extended rainfall.

PLANNING SUMMARY

This LWMS has been prepared to support the Development Application for the subject land. 1.4488ha of the western portion of the site is proposed to be developed for commercial mixed use. This includes a range of restaurants, fuel station, carwash and medical centre. The remaining eastern 23705ha is to remain as regenerating native bush and wetland.

The developed portion will be a divided into 5 separate lots. These are accessed off either Gaebler or Hammond Road.

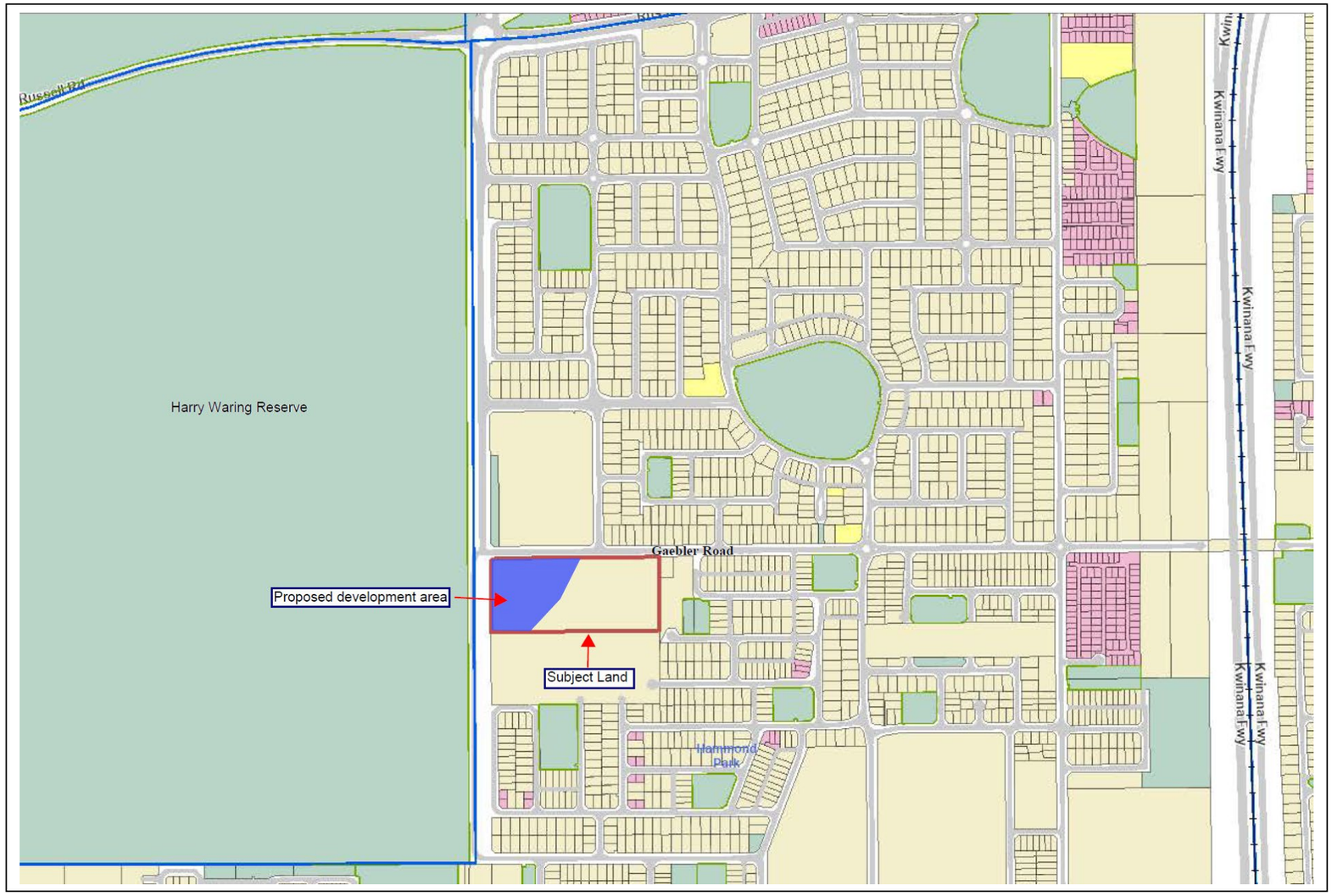
The layout can be seen in Figure 2.

MAIN REFERENCING DOCUMENTS

This document has been compiled from the following reports. These reports should be referred to where more detail is required.

- PGV Environmental (2023), Lot 9501 Gaebler Road Hammond Park Environmental Assessment Report
- WML Consulting Engineers (2022) Geotechnical Investigation Lot 9501 Gaebler Road Hammond Park
- Peritas (2023) Lot 9501 Gaebler Road Hammond Park 6164 Engineering Services Report

Figure 1 Location on plan



2 KEY ELEMENTS PLAN

Water management strategies for the subject land are based on best practice water sensitive urban designs that integrate sustainability into commercial developments. The strategies will be achieved through the synthesis of planning and designs to manage, protect and conserve the total water cycle. The plans and designs for the development are appropriate for the subject land's commercial development, surrounding environment and local drainage characteristics.

A summary of the WSUD elements that will be implemented within the development to achieve best management practices are outlined below:

Water Conservation and Servicing

- The site is to be serviced with potable water by the Water Corporation.
- Sewer is to be gravity fed to the Water Corporation sewer main.
- Landscaping is to be partially watered via direct stormwater runoff.
- Summer landscaping irrigation requirements are to be provided from Water Corporation Mains supply.

Stormwater Management

- 1Event per Year (1EY) storm treatment off carparks and roads is achieved through bioretention gardens with excess water infiltrated using below ground storage.
- Specialist systems will be utilised within service station area to collect and treat hydrocarbons.
- Specialist systems will be utilised within the carwash area to treat on site pollutants.
- Underground detention systems are to be installed to detain and infiltrate the entire 10% annual exceedance probability (AEP) storm event.

Flood Protection

- All finished floor levels will be designed to be above the internal road and path network, with a 1% AEP low flow pathway through the development to the surrounding bushland to mimic the current flow direction.
- Post development flow rates off site will be below the predevelopment flow rates in the 1% AEP.

Ecosystem Protection

- Water sensitive urban designs (WSUD) will utilise bioretention gardens to capture sediments, large debris and nutrients from all water runoff from impervious surfaces, reducing impacts on downstream wetland and estuarine systems.
- Specialists' treatment systems are to be utilised within the service station and carwash land use so no pollutants are released to the groundwater.
- The landscaping will utilise nutrient and waterwise practices to minimise contamination of the groundwater.
- The landscaping of the bioretention systems will act as ephemeral wetland systems, providing habitat for generalist species.
- Suitable access management will be installed to control access into the wetland area.
- All commercial landuses are outside the wetland footprint.
- Water infiltrated on site at similar to pre development rates to replenish groundwater, which feeds downgradient wetland system.

Groundwater Management

- Inflows to the groundwater will be treated through bioretention gardens.
- All water infiltrated on site in events up to and including the 10% AEP, to mimic the pre development infiltration.
- Subsoil may be installed to control groundwater rise to 21mAHD, with discharge to the Gaebler Road drainage network.
- Fill used to maintain 1.5m separation to groundwater from buildings.

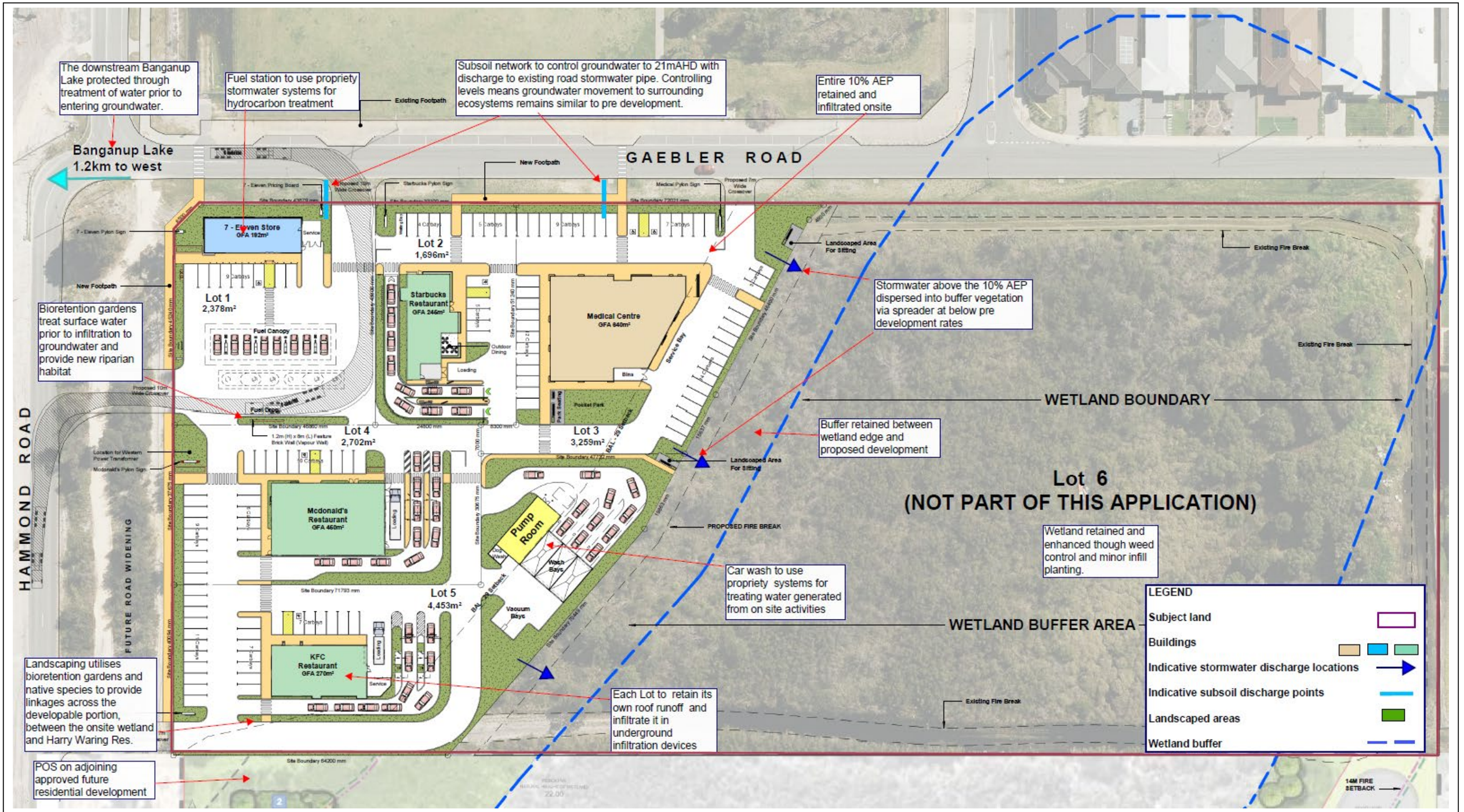


Figure 2 Key Elements Plan

3 LANDFORM PLAN

The subject land is composed of a low sand dune in the west grading to a trapped sandy flat in the centre and east, that exhibits wetland characteristics.

The site generally falls from 23.1mAHD in the north west corner to approximately 21mAHD within the eastern wetland. The developable portion is generally 21.5m or higher. Grades are generally around 1:50 on the western sand dune through to 1:200 for the wetland portion.

Figure 3 shows these landforms diagrammatically.

3.1 WATER FEATURES.

The only water related landform within the subject land is the central/eastern wetland. This extends in a south westerly direction to the neighbouring lot and is effectively an interdunal depression with no surface discharge point. It is noted as having surface water (as an expression of groundwater) in late winter of wet years.

There are no waterways or drains within the boundary of the subject land.



Low sandune on western side



Sand flat wetland

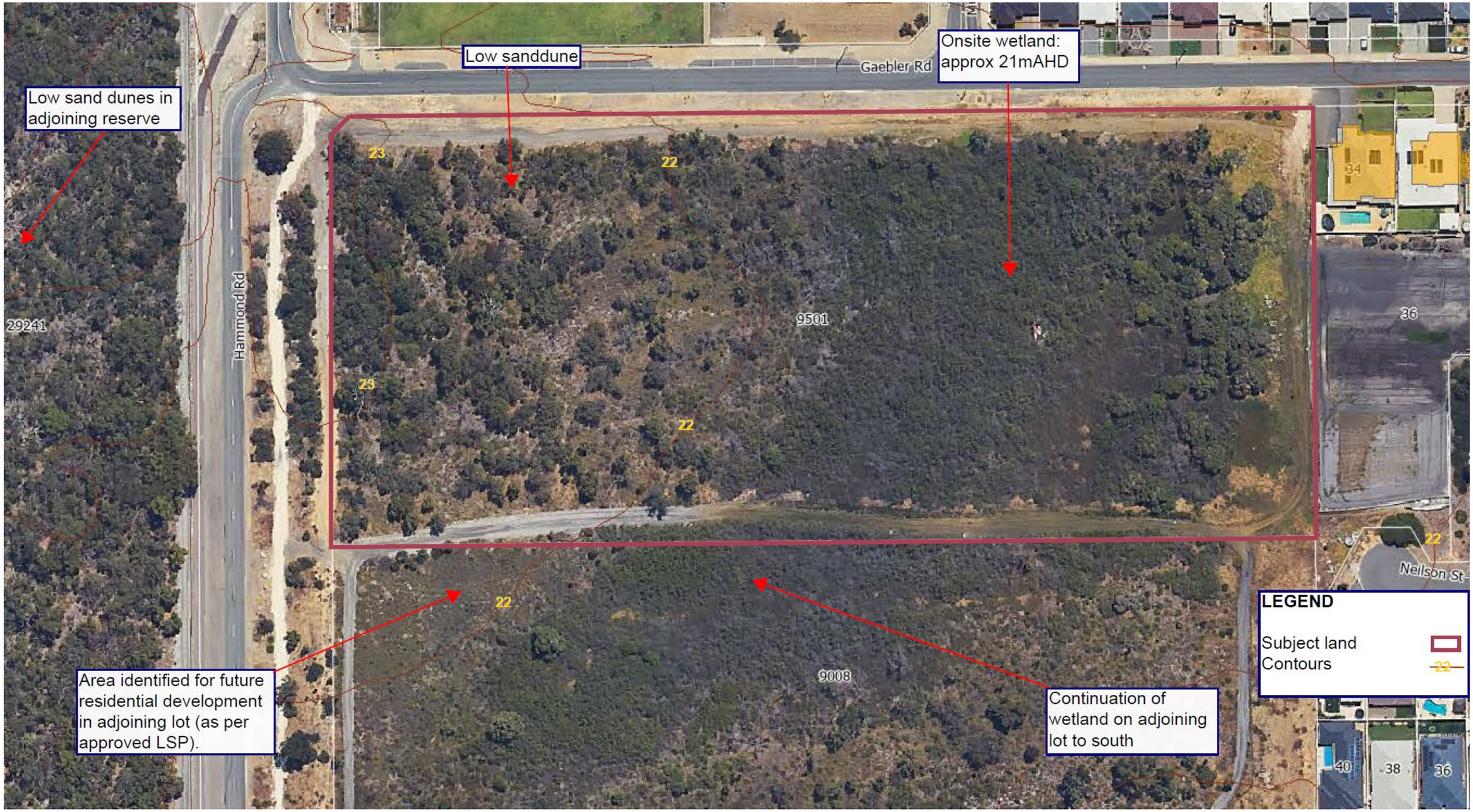


Figure 3 Current Landforms

4 GEOTECHNICAL PLAN

A geotechnical assessment was undertaken by WML in 2022 with the results recorded in the report titled; Geotechnical Investigation Lot 9501 Gaebler Road Hammond Park. The following is a summary of the findings.

The site works were undertaken in June 2022 and included excavating 3 bore holes to 5m with monitoring wells installed, 5 further bore holes and 4 in situ permeability tests. The Test pit locations can be seen in Figure 4.

4.1 GENERAL SOIL CONDITIONS

The subject site is located on the Swan Coastal Plain within the Bassendean landscape systems. The 1:50,000 scale Geological Map 'Fremantle' indicates that the site is SAND – very light grey at surface, yellow at depth, fine to medium-grained, sub-rounded quartz, moderately well sorted, of Eolian origin

A summary of the soil profile from the site's test holes can be seen in Table 1.

Table 5 Soil profile

Depth (m)	Description
0.0 – 0.30	**TOPSOIL: SAND (SW)**, fine to medium grained, dark grey; trace silt; moist; very loose.
0.3 – 5.2	**SAND (SW)**, medium to coarse-grained, subrounded to subangular, dark/pale cream, dark grey, trace silt; moist; medium dense.

4.2 PERMEABILITY

Four in-situ permeability tests were undertaken using the constant head Talsma-Hallam method in accordance with AS/NZS 1547:2012. All of the permeability tests consisted of 100mm diameter. They were designated as HA4 650mm deep with pipe 400mm below the ground, HA5 550mm deep with pipe 300mm below the ground, and HA6 and HA7 700mm deep with pipe 450mm below the ground, were excavated and filled with water to saturate the surrounding soil. A constant head of water was then applied, and a known volume of water was timed to dissipate. Table 2 presents the results of the in-situ testing.

Table 6 Permeability results

Location ID	In-situ Permeability Test	
	m/s	m/day
HA4	1.29E-04	1.11
HA5	1.53E-04	1.32
HA6	2.60E-04	2.25
HA7	1.31E-04	1.13

4.3 ACID SULPHATE SOILS

No onsite Acid Sulphate soil (ASS) testing has been undertaken to date. ASS mapping (DWER) of the site suggests that there is a moderate to high risk of ASS within 3m of the surface within the wetland area. In the higher portions the risk is recorded as low. The mapping may not match the actual wetland area and further testing may be needed to confirm actual risk in any development areas. This can be appropriately addressed as a condition of development approval.

4.4 GROUNDWATER

Groundwater was encountered in all three (3) monitoring wells, MA1, MA2 and MA3 that were installed at the end of June 2022. Groundwater was also found at HA2 at depths of 1.55 m below ground level. A summary of the groundwater levels recorded at the site 28th of June 2022 is presented below in Table 3.

Table 7 Groundwater levels June 2022

Location ID	Depth Below Ground (m)
MA1	1.47
MA2	2.50
MA3	2.50
HA8	1.55

Notes: All depths are relative to the existing ground surface

4.5 PHOSPHORUS RETENTION INDEX

No onsite testing for phosphorus retention has been undertaken to date. Due to the presence of Bassendean sand throughout, the Phosphorus Retention Index (PRI) is likely to be low (0-0.5).

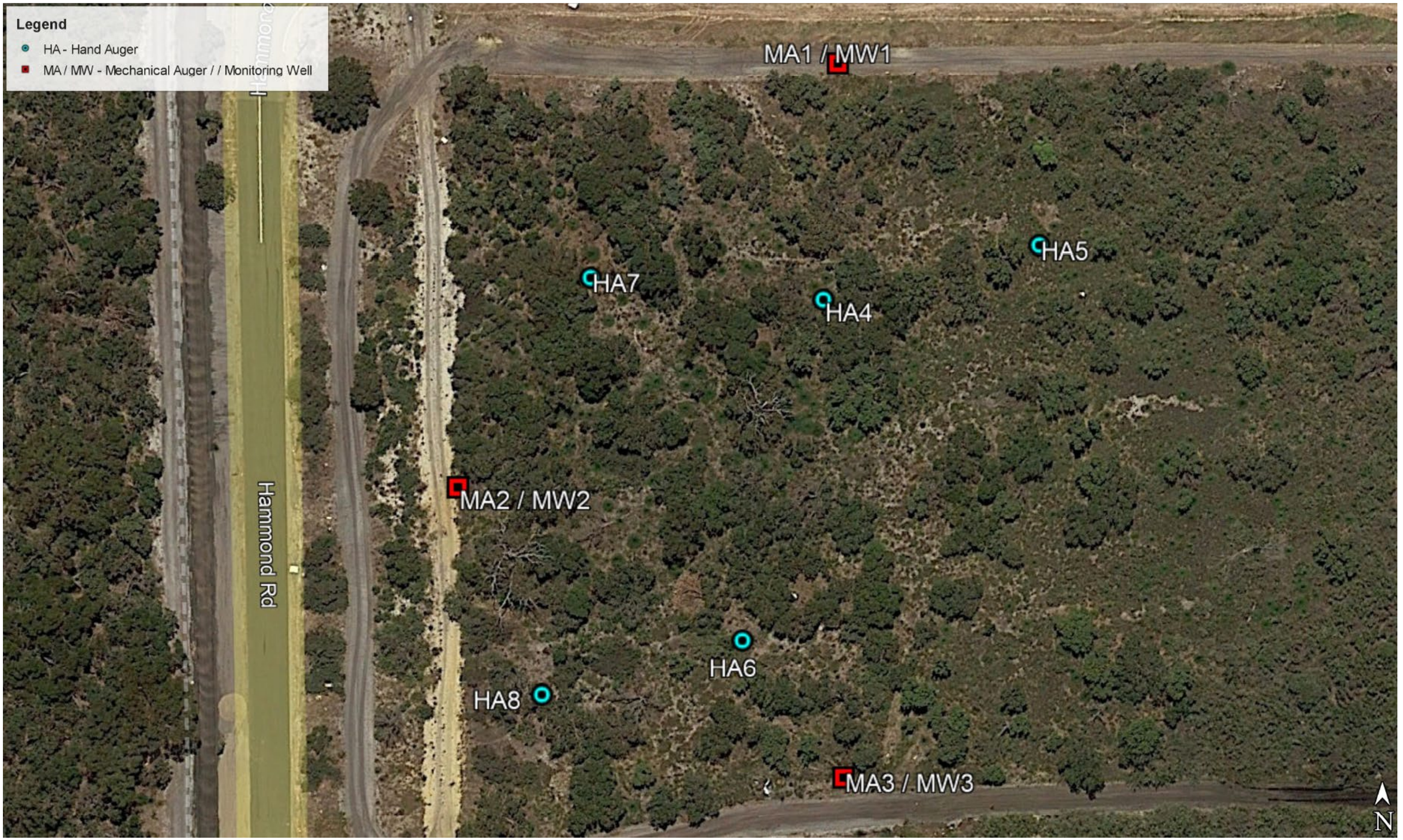


Figure 4 Geotech test locations

5 ENVIRONMENTAL CONDITIONS

An environmental assessment was undertaken for the subject land in 2023 by PGV Environmental. The findings were outlined in the report titled in the Lot 9501 (41) Gaebler Road, Hammond Park Environmental Assessment Report. The following is a summary of the water related environmental values, which can also be seen visually in Figure 5 and 6.

5.1 GENERAL

The site has been previously cleared (between 1961 and 1974) and used for horticulture. The majority of the site has since regrown native vegetation, with evidence of regrowth by 1995.

5.2 WETLANDS

The northern of wetland UFI 14104 occurs on most of the eastern half of the site. The wetland extends onto the Lot to the south. The wetland is classified as a Conservation Category Wetland.

The site is also located approximately 1.5kmn south-east of the RAMSAR listed wetland Thomsons Lake. Thompson's Lake is not downstream from the proposed development area as the groundwater flows to the south-west. The Lake is also not linked to the proposed development area by surface water flows.

Banganup Lake is the closes downstream wetland that is fed by groundwater flow from the direction of the subject land. This is located approximately 1.2km to the west.

5.3 WATERWAYS AND DRAINS

There are no natural waterways or drains within the site.

5.4 VEGETATION

The vegetation types mapped on the site are described below:

1. *Eucalyptus marginata* (Jarrah)/*Allocasuarina fraseriana/Banksia attenuata/B. menziesii* Low Woodland over a diverse Open Low Heath;
2. *Banksia attenuata/B. ilicifolia/Kunzea glabrescens* Low Woodland over *Scholtzia involucrata/ Patersonia occidentalis* Open Low Heath;
3. *Kunzea glabrescens* (Spearwood) Closed Tall Scrub over *Hypocalymma angustifolium* Open Low Heath;
4. *Banksia ilicifolia* Open Low Woodland over *Kunzea glabrescens* Tall Open Scrub over *Hypocalymma angustifolium* Open Low Heath;
5. *Melaleuca preissiana* Low Woodland over *Astartea affinis* Shrubland over *Dielsia stenostachya* Sedgeland.

Of these, vegetation Types 3 is the main type found within the wetland. Type 4 is found in the northern section of the wetland where it adjoins Gaebler Road, while Type 5 forms the eastern boundary of the wetland.

The condition of the vegetation on the site is mostly in Very Good to Excellent condition with the eastern margins in Good to Degraded condition due to a high number of weeds, particularly Pigface (*Carpobrotus edulis*).

5.5 Fauna

The site contains two fauna habitats. The vegetation dominated by Banksia is described as Open Woodland habitat. The area associated with the wetland is Wetland Woodland Habitat.

Fauna habitat was assessed as being Good due to the Vey Good Condition of the vegetation and that it has some connectivity to the Harry Waring Nature Reserve to the west.

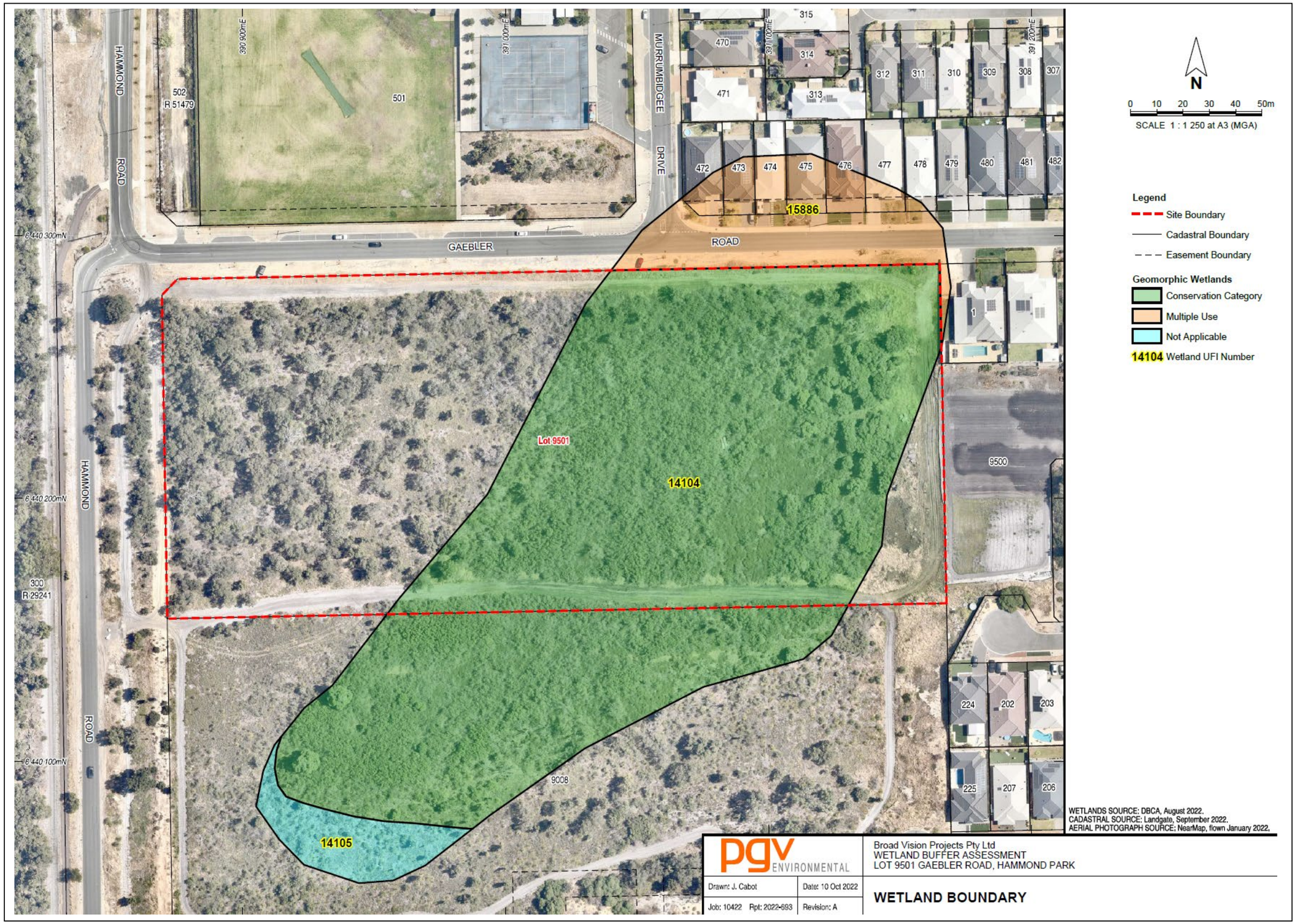


Figure 5 Geomorphic Wetland Boundary (*PGV 2019*)

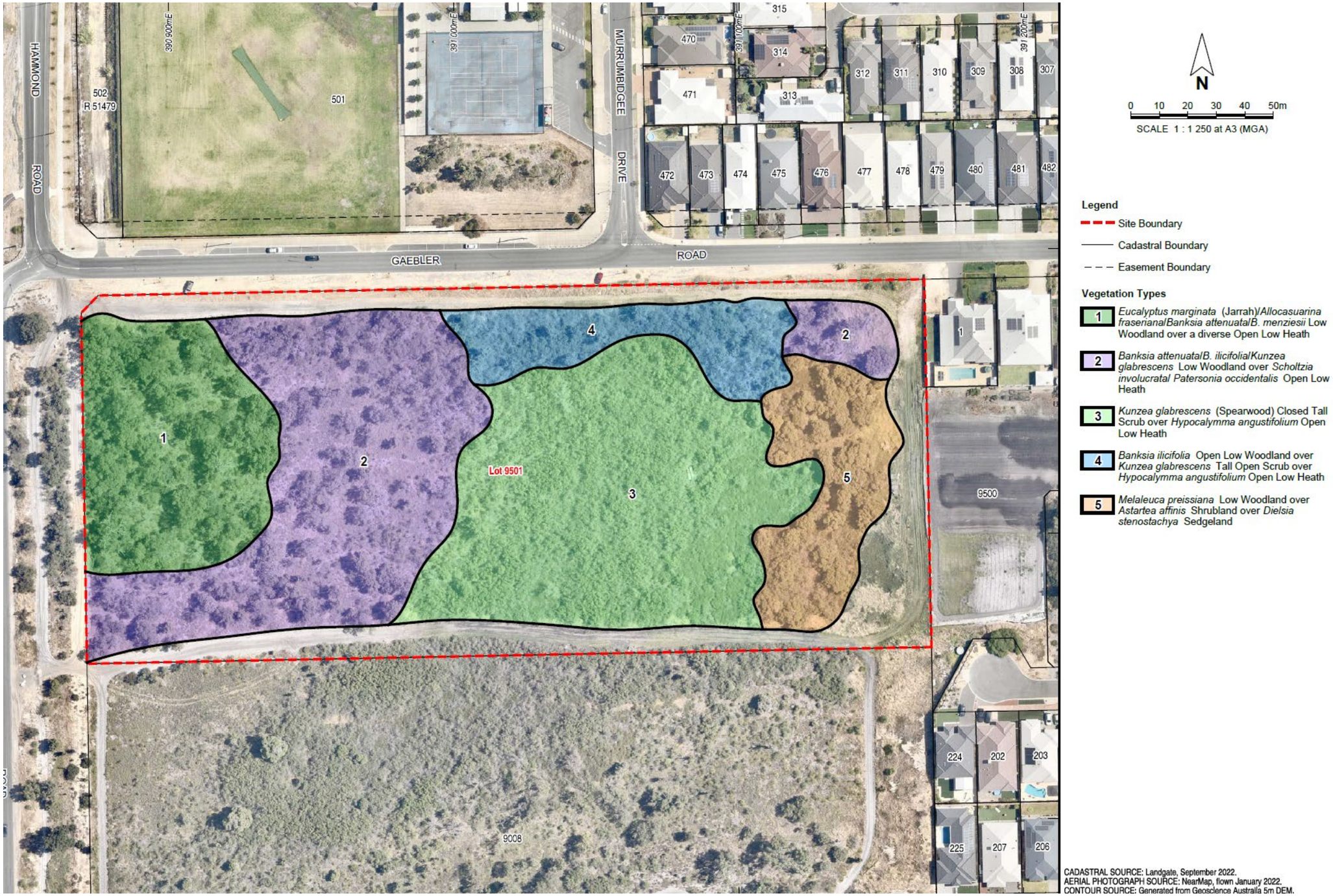


Figure 6 Vegetation types (*PGV 2019*)

6 SURFACE WATER PLAN (PRE-DEVELOPMENT)

6.1 Existing drainage infrastructure.

There is no existing constructed drainage within the subject land.

Stormwater drainage within the existing Gaebler Road reserve drains the road and catchments to the east but does not take water from the subject land. The pipe is a 525 and falls from approximately 20.37mAHD to 19.61mAHD where it adjoins the subject land. This road drainage falls to the west and discharges into the sump located between the school and Hammond Road. Hammond Road has no pipe drainage adjacent to the subject land, with water sheeted into the sandy verges.

A layout of this drainage network can be seen in Figure 7.

Relevant External Catchments

For the western portion that is likely to be developed there is no significant external flow onto the subject land. The portion of Hammond Road reserve that is currently unmade (set aside for future widening) has an area of approximately 500m2 which may shed to the subject land in extreme events. As this is minor in nature and is unlikely to sheet onto the subject land once the road has been upgraded, it has not been modelled as part of the site's drainage assessment

Internal flows

The western developable portion generally sheets water eastward and south eastward to the onsite wetland via further bushland. This area was assumed to be 1.4488ha. The remainder of the subject land also falls towards the wetland. The wetland has no surface outlet, so any flows that reach the wetland will infiltrate into the groundwater system. Due to the relatively flat grades and sandy soils, along with dense vegetation, there is minimal surface flow.

6.2 Modelling

The western developable portion was modelled using DRAINS modelling software.

The modelling included the following parameters and assumptions:

a) Horton/ ILSAX drainage modelling method used.
b) ARR 2016 methodology and rainfall figures used.
c) The entire area was assumed to be pervious bushland.
d) To reflect the deep sandy soils, a soil factor of 1 was applied.
e) A retardance factor of 0.2 was applied to reflect the native bush vegetation.
f) The storms modelled for the 10% AEP and 1%AEP were the 5min,10min,15min,20min, 25min,30min, 45min,1 hr,1.5hr, 2hr, 3hr, 4.5hr, 6hr, 9hr, 12hr, 18hr and, 24hr events. Longer storms were not run as there was a consistent drop it flows as the length of storm increased.

The results reflect the low grades, pervious sands and vegetated nature of the external catchments. This means there is no to minimal runoff in the 10% Annual Event Probability (10% AEP). In the short duration 1% Annual Event Probability (1% AEP) storms, there was some flow generated that is to be taken into account as part of the development of the subject land. The results can be seen in Table 4.

Table 8 Predevelopment External Catchment Summary

Catchment	Area(ha)	10% AEP (m^3/sec)	Critical Storm	1%AEP (m^3/sec)	Critical Storms	Discharge Location / Comments
Western developable area	1.4488	0	NA	0.073	10min *(with other high peaks storms to 2hr)*	Currently vegetated low sand dune. Sheet flow to wetland within subject land.



Figure 7 Current surface water and drainage characteristics

7 GROUNDWATER (PRE-DEVELOPMENT)

7.1 SHALLOW SUPERFICIAL AQUIFER

The subject land is within the Jandakot – Success Perth Superficial Swan aquifer area. Groundwater levels were recorded as part of the geotechnical investigation (Section 4). Groundwater was generally recorded between 1.47m and 2.5m below the natural surface in June 2023. The bore locations can be seen in Figure 3.

DWER groundwater mapping shows the general fall of groundwater is in a westerly direction, with maximum levels dropping from approximately 21mAHD to 20mAHD across the subject land. This can be seen in Figure 8.

An analysis of aerial photography of the site shows that the wetland experiences shallow surfaces water as an expression of high groundwater during wet years. An example of this can be seen in Figure 9. There also appears to be a trend to higher groundwater in recent years that corresponds to the establishment of residential development in the surrounding catchment.

As of September 2023, there was allocation available in the superficial aquifer.

7.2 DEEPER CONFINED AQUIFERS

The subject land is within the Jandakot confined Perth Leederville and Perth Yarragadee North aquifer areas. As of September 2023, the Leederville is fully allocated, while the Yarragadee has limited information on availability.

7.3 QUALITY

Groundwater quality was not investigated due to the site deemed to be of a low risk of a groundwater quality that would differ significantly from previous farming and residential uses on the Swan Coastal Plain. The site is likely to have moderate nutrient levels along with likely elevated aluminium and iron levels, which are common through this area. The proposed landuse is also unlikely to change the current groundwater quality significantly.

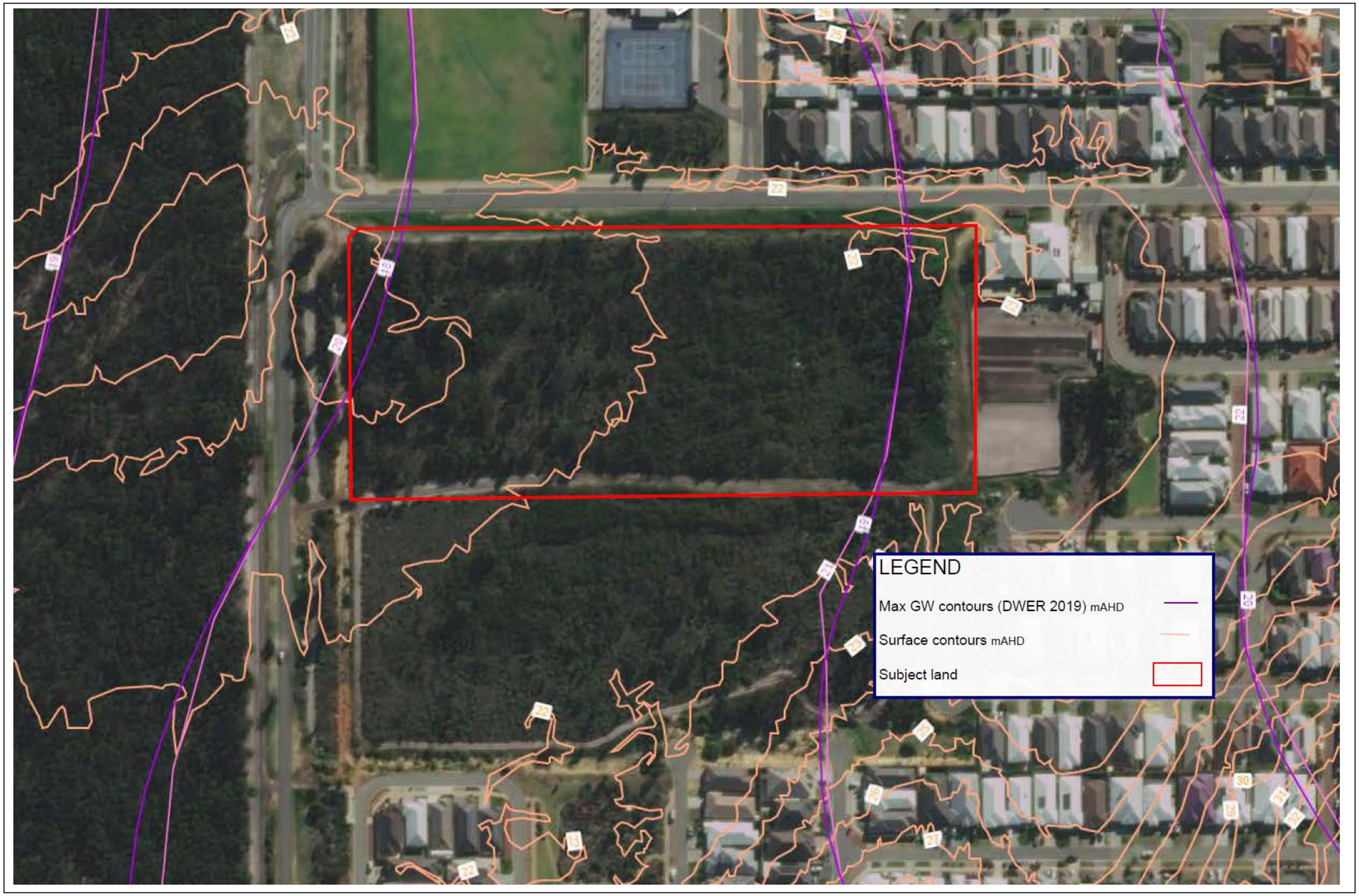


Figure 8 DWER Groundwater contours



Figure 9 Review against spring high groundwater aerial

8 DRAINAGE MANAGEMENT STRATEGY

The aim of Surface Drainage Management for the subject land is to generally manage the water flows so that water treatment happens on site for minor events and that the 10% AEP is infiltrated either within each lot, with larger events discharging to the onsite wetland. The system has been designed so that it achieves these outcomes while also sitting above the controlled groundwater level of 21mAHD.

Figures 10 shows the sub catchment boundaries, general flow directions and indicative discharge points.

The following sections show in more detail how water is treated and conveyed in three different AEP scenarios and management of external catchment flows,

8.2 – 1 Exceedance per year event (1EY)

8.3 – 10% AEP

8.4 – 1% AEP

8.1 MODELLING

Modelling of the post development layout was undertaken in DRAINS.

The post development modelling for the development has been split into 5 internal sub catchments representing the 5 lots. The catchments can be seen in Figure 9.

Outflow has been modelled as heading eastward to the buffer of the wetland where it is to be discharged as sheet flow in events above the 10% AEP.

Each catchment takes into account the presence of roof runoff, hardstand (eg roads/paths/carparks) and pervious garden areas.

Ground surface stormwater is initially directed to bioretention gardens within each lot. The bioretention gardens are assumed to be 0.15m deep to the invert of the outlet structures (sump pits), with a total depth of 0.2m. They are located throughout the landscaping areas. In large events, overflow from the bioretention gardens is then directed to the Underground storage underground storage via an internal pipe network. The storage has been modelled as 1m deep structures with impervious sides and a pervious base.

Roof runoff is to be piped directly to the underground storage. The combined storage volumes and infiltration have been sized to completely infiltrate the 10% AEP event. The storage breakdown for each catchment can be seen in Table 5.

Each lot deals with its stormwater independently of the surrounding lots. Above the 10% AEP, there may be some surface water discharge across neighbouring lots to the wetland.

The modelling considered the 1EY, 10% AEP and 1% AEP. The following is a summary of the assumptions and parameters used:

- Impervious areas were assumed to have a retardance coefficient of 0.01(eg asphalt/concrete/rooves)
- Pervious areas were assumed to have a retardance coefficient of 0.1 (eg short grass, landscaped gardens).
- The storms modelled for the 10% AEP and 1%AEP were the 5min,10min,15min, 20min, 25min, 30min, 45min,1 hr,1.5hr, 2hr, 3hr, 4.5hr, 6hr, 9hr, 12hr, 18hr and, 24hr events. Longer storms were not run as there was a consistent drop in flows as the length of storm increased.
- Catchments were designed to be logical areas of stormwater capture and discharge.
- The catchments were split into paved surfaces and pervious surfaces, and where relevant, roof surfaces.
- Bioretention basins are assumed to be 0.15m deep to the invert of the overflow. A further 0.1m is assumed to be available until it floods into adjoining carpark/hardstand. The sides are assumed to be vertical and not be pervious. The initial overflow is assumed to be directed by pipe to the underground storage (via a silt pit). Overflow into the carparks is directed as an overland flow to the downstream capture point, which was modelled as the underground storage.
- Bioretention gardens were assumed to have a permeability of 0.2m/hour (4.8m/day) in keeping with industry standards.
- The underground storage was assumed to have vertical sides and be 1m deep and 0.2m below the surface. This provides 0.3m of separation to the maximum groundwater level of 21mAHD.
- Underground storage was conservatively assumed to have impervious sides and a pervious base with an infiltration of 1m/day. This is slightly under the lowest infiltration rate determined as part of the geotechnical investigation.

Table 5 Catchment and storage summary

Catchment	Total area (m^2)	Ground area (m^2)	Roof area (m^2)	Soft landscaping area (m^2)	Bio area (m^2) *	Bio depth (m)**	Bio volume (m^3)	Underground storage area (m^2) #	Underground volume (m^3) ##	Notes
Lot 1 7 Eleven	2378	1826	552	267	186.9	0.2	37.38	11	11	Roof area includes undercover fuelling area
Lot 2 Starbucks	1696	1451	245	222	155.4	0.2	31.08	5	5	
Lot 3 Medical Centre	3259	2691	640	532	372.4	0.2	74.48	13	13	
Lot 4 McDonalds	2702	2252	450	302	151	0.2	30.2	9	9	
Lot 5 KFC & Carwash	4453	3953	500	674	337	0.2	67.4	10	10	Roof area includes carwash bays and pump house

*

* *Bio areas assumed to be 70% of soft landscaping area for Lots 1-3 and 50% of Lots 4-5.*
** *Bio areas assumed to be 0.2m deep on average and 0.15m to pit.*
Underground storage assumed to be $1m^3$ of storage for $50m^2$ of roof area
Underground storage assumed to be 1m deep

8.2 1EY MANAGEMENT

The Drainage Management system is designed to manage contaminants within the stormwater for the 1EY.

There are two main directions that drainage water will take; infiltration to groundwater and surface run off. To deal with these different flow paths, two separate treatment trains have been designed.

DIRECT INFILTRATION TO GROUNDWATER

The majority of water that fall on pervious surfaces (eg lot landscaping) in the subdivision will infiltrate through to the groundwater, due to the permeability of the insitu and fill sand within the subject land. Any potentially polluting activities are to take place on hardstand areas so that water can be effectively treated prior to infiltration. Garden beds are to use nutrient wise practices and predominately native species to minimise and nutrient leaching.

SURFACE FLOW

For the majority of the ground surface stormwater, water flowing off impervious surfaces such as roads, pathways, driveways etc will be directed to the bioretention gardens located in the landscaping strips within each lot. This may be through landscaped vegetated systems in combination with soakwells or similar. The exact design is to be determined on a lot-by-lot basis as part of each relevant building application.

The entire 1EY is able to be infiltrated in the bioretention gardens from the ground surface flows. The volume and area of bioretention for each lot can be seen in Table 5.

Clean roof runoff is directed by pipes to the underground infiltration systems. These are able to infiltrate the entire 1EY event. The modelled volume and assumed surface area for each lot are detailed in Table 5.

POLLUTING LANDUSES

The potentially polluting uses of the fuel station and carwash are to be designed so that they capture the entire 10% AEP event for the possible polluting areas and treat it within their own specialist equipment (which will capture the entire 1EY). The exact treatment system is to be determined as part of the detailed design for each lot, with propriety systems to be used. This is to be approved as part of the building licence application.

8.3 DRAINAGE MANAGEMENT PLAN – 10%AEP

As the entire site is a commercial development, a 10% AEP detention volume has been applied to the entire development area.

Storage is via a combination of bioretention gardens and subsurface storage units. With the base of the storage units sitting approximately 1.2m below the surface, they will be located within free draining sand and above the water table.

The system has been designed so that there is no direct discharge of stormwater in a 10% AEP event. Water will only flow out via the subsoil network, when the groundwater level has reached the subsoil pipe network.

The storage volumes shown in Table 5 were filled to between 90% and 98% in the 10% AEP.

Quality

It is not an objective of managing 10%AEP events to treat for quality, but the bioretention gardens and detention systems will allow for trapping and settling of suspended sediments, especially after the flood peak has passed. All water infiltrating through the soil profile during the 10%AEP event will receive treatment as it moves through the bioretention media or soil profile.

8.4 DRAINAGE MANAGEMENT PLAN – 1%AEP

The subject area has been designed to safely manage the 1%AEP flood event so that impacts on the subject land and downstream infrastructure, the environment and people's safety are minimised.

All floor levels are to be set a minimum of 500m above the assumed 1% AEP flood height of the wetland of 21.5mAHD. Floor levels are also to be 300mm above the low point flow lines through the development to the wetland, to protect against internal flood risks.

In agreement with the City, events greater than the 10% AEP can be discharged to the buffer vegetation, with water then traveling overland to the wetland. The wetland area therefore provides storage for larger events. Due to the significant on-site capture and infiltration of stormwater, the flow rate from the development area is less than the predevelopment 1% AEP flow rate. A comparison can be seen in Table 6.

The flood peak for the subject land has been modelled as occurring at 1 - 2 hours.

Flows have been modelled as coming to the surface from the underground storage infiltration, and then flow overland to the wetland buffer area. Designated discharge points will be determined, that assist with spreading any flows across the ground surface, allowing for further infiltration and dissipation.

Table 6 Pre and post flow comparison

Scenario	10% AEP (m^3/sec)	Critical Storm	1%AEP (m^3/sec)	Critical Storms	Discharge Location / Comments
Pre development	0	NA	0.073	10min *(with other high peaks to 2hr)*	Currently vegetated low sand dune. Sheet flow to wetland within subject land.
Post development	0	NA	0.008	1-2 hours	Multiple discharge points and spreaders into bushland buffer, with overland flow to wetland.

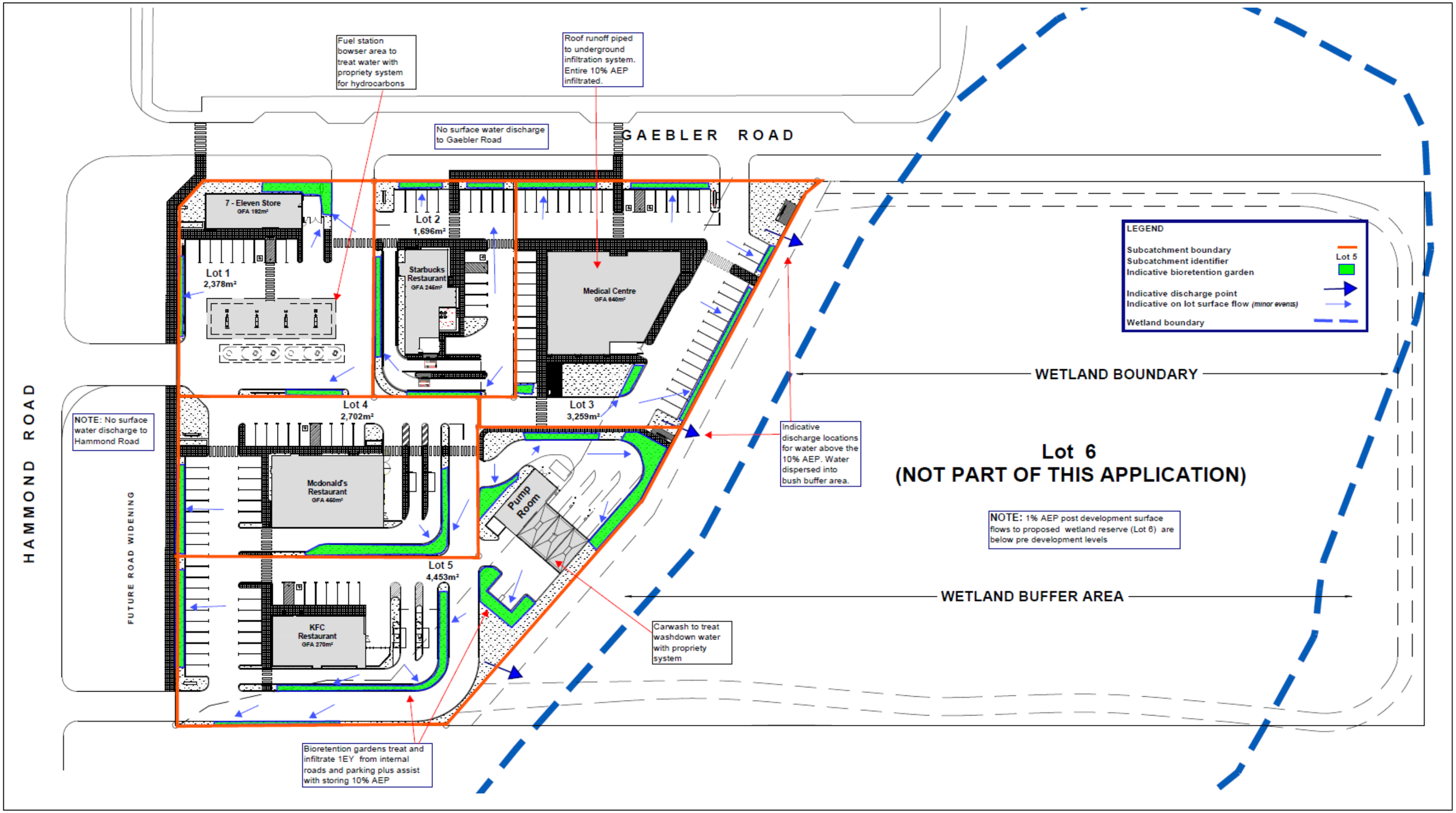


Figure 10 Post-development surface water management summary

9 GROUNDWATER MANAGEMENT STRATEGY

9.1 GROUNDWATER LEVEL MANAGEMENT

The focus of groundwater management for the subject land is to maintain groundwater as close as possible to existing levels, while maintaining separation from infrastructure. Maintaining suitable separation between buildings and the road pavement from the maximum groundwater level will be achieved through two main methods.

The first method involves using porous, clean fill/insitu soils for the proposed developable portion. This will allow ground levels to be set at approximately 1.5m above the assumed historical maximum groundwater level of 21mAHD.

The second strategy is to install a subsoil network that controls water that may rise above 21mAHD. This water is proposed to be discharged into the existing drainage pipe network on Gaebler Road. As the invert of this pipe network is generally 1m or more below the assumed control level of 21mAHD, this provides a workable option for longterm protection against groundwater level rise in high rainfall years. This proposed link points can be seen in Figure 11 and match the existing pits.

9.2 GROUNDWATER QUALITY MANAGEMENT

Groundwater will be managed to improve water quality. This will be achieved through the use of bioretention gardens to treat surface flows prior to infiltration. The use of nutrient wise strategies within the landscaping areas will also reduce the potential risk of nutrient leaching.

The potentially polluting uses of the fuel station and carwash are to be designed so that they capture the entire 10% AEP event and treat it within their own specialist equipment. The exact treatment system is to be determined as part of the detailed design for each lot. This is to be approved as part of the building licence application.

9.3 USE OF GROUNDWATER

There will be no POS irrigation or other public places using groundwater drawn from the subject land. There is the possibility of bores being used on some lots for non-potable uses such as landscaping, however the small areas mean it is more likely that Water Corporation Mains water will be used.. The use of these will be subject to DWER groundwater guidelines at the time of application.

9.4 MONITORING

Groundwater levels have been determined via test pits during winter and with aerial photography. This is considered sufficient for determining groundwater levels within the subject land.

Quality monitoring is not deemed necessary due to small area of development and the fact that the site is likely to be typical of historical agricultural and current residential areas with elevated nutrients. As the groundwater is not being lowered below the historical maximum level, these contaminants are not likely to be mobilised significantly beyond the current transfer rate through the ground profile.



Figure 11 Groundwater management

10 WATER SERVICING STRATEGY

10.1 POTABLE WATER

Preliminary information from DBYD and Water Corporation indicates that there is a potable water supply network in the area. There is a 100mm diameter potable water reticulation pipe approximately 150m south of the proposed development on Serventy Crescent, and a 250mm diameter potable water reticulation pipe approximately 200m east of the proposed development on Gaebler Road.

The requirements of the subject site will need to be confirmed prior to development to ensure that the current existing water infrastructure is sufficient to accommodate the proposed development without any required upgrades, however, it is unlikely upgrades will be required.

Further details can be found in Appendix A (Servicing Report).

10.2 LOT GROUNDWATER BORE

There is the possibility of on lot bores from the superficial or Leederville aquifer for onsite uses only. These will be subject to DWER licencing procedures and availability at the time of application.

10.3 WASTEWATER MANAGEMENT

Preliminary information from DBYD and Water Corporation indicates that there is an existing 300mm diameter gravity sewer main that traverses the northern and western boundary of the subject site, in the verge of Gaebler Road and Hammond Road respectively, that can service the proposed development. Proposed finished floor levels have been checked against the existing sewer main invert levels and it is recommended that fill is placed on approximately 61% of the site to raise the site and be able to achieve sufficient gradients and cover for any proposed sewer infrastructure located within the development. of groundwater separation. In the instance that sewer gravity connections to the existing main is uneconomical, then individual rising pumps and rising main would need to be supplied for lots that cannot achieve a gravity connection.

11 WATER DEPENDENT ECOSYSTEMS MANAGEMENT STRATEGY

There are three main focuses for the management of water dependent ecosystem (WDE) as part of the subject land's future development. These are:

- Retain the onsite wetland and its vegetated buffer
- Treat water prior to infiltration to the groundwater, where it may feed downstream wetlands
- Creation of riparian habitat in the bioretention gardens.

The overall ways in which the WDE impacts will be managed can be seen in Figure 12 and 13.

11.1 ONSITE WETLAND PROTECTION

The onsite wetland is to be retained and protected. This is to include the 15m buffer of upland bushland between the wetland and the developable portion. Protection and enhancement works may include weed control and minor replanting in areas that may require it. Rubbish removal is also to be undertaken. Appropriate public access management is also to be determined.

The works will be similar to those undertaken within the retained portion of the same wetland that is located on the adjoining southern lot (Lot 9008). The exact requirements for wetland restoration works will be outlined as part of detailed design.

11.2 DOWNSTREAM WETLAND PROTECTION THROUGH WATER QUALITY MANAGEMENT

The main natural Water Dependent Ecosystem that the site discharges to are the downstream wetland systems that are groundwater fed. While there is no direct connection with these wetlands, the groundwater has the potential to move through the soil profile in the direction of Banganup Lake. This lake is located approximately 1.2km to the west, in the Harry Waring Marsupial Reserve. The surface and groundwater management plans detail out the techniques that will be used to improve the quality of infiltrating surface water into the groundwater. All ground surface flows up to the 1EY will be treated for nutrients and pollutants prior to entering the waterway. This system will also help treat flows above the 1EY as well. The impact therefore on Banganup Lake from the site will be minimal.

Groundwater levels will also be retained post development through the onsite infiltration and control using subsoils, meaning there will be minimal change in groundwater flow rates or direction.

11.3 CREATING NEW WDE

The creation of new WDEs are expected to provide benefits to the overall ecosystem functioning in the natural environment. The bioretention gardens outlined as part of these management systems will serve as ephemeral wetlands and provide some habitat for generalist species. To maximise the potential of the systems for habitat values and migration, the landscaping utilises locally native species, especially within the bioretention systems. The indicative locations of these can be seen in Figure 11. The landscaping also provides some vegetated linkages from the retained wetland and buffer vegetation through to the Harry Waring Marsupial Reserve.

Planting of the bioretention gardens is to also consider bushfire management requirements.

11.4 MOSQUITO MANAGEMENT

The drainage system is designed so that no water is held within the system after the rain has finished. All areas are designed to drain within 72 hours.

The natural wetland inundated areas will remain in their current format, to allow their current ecological functioning to continue.



Figure 12 Wetland and buffer management strategies (*PGV 2023*)

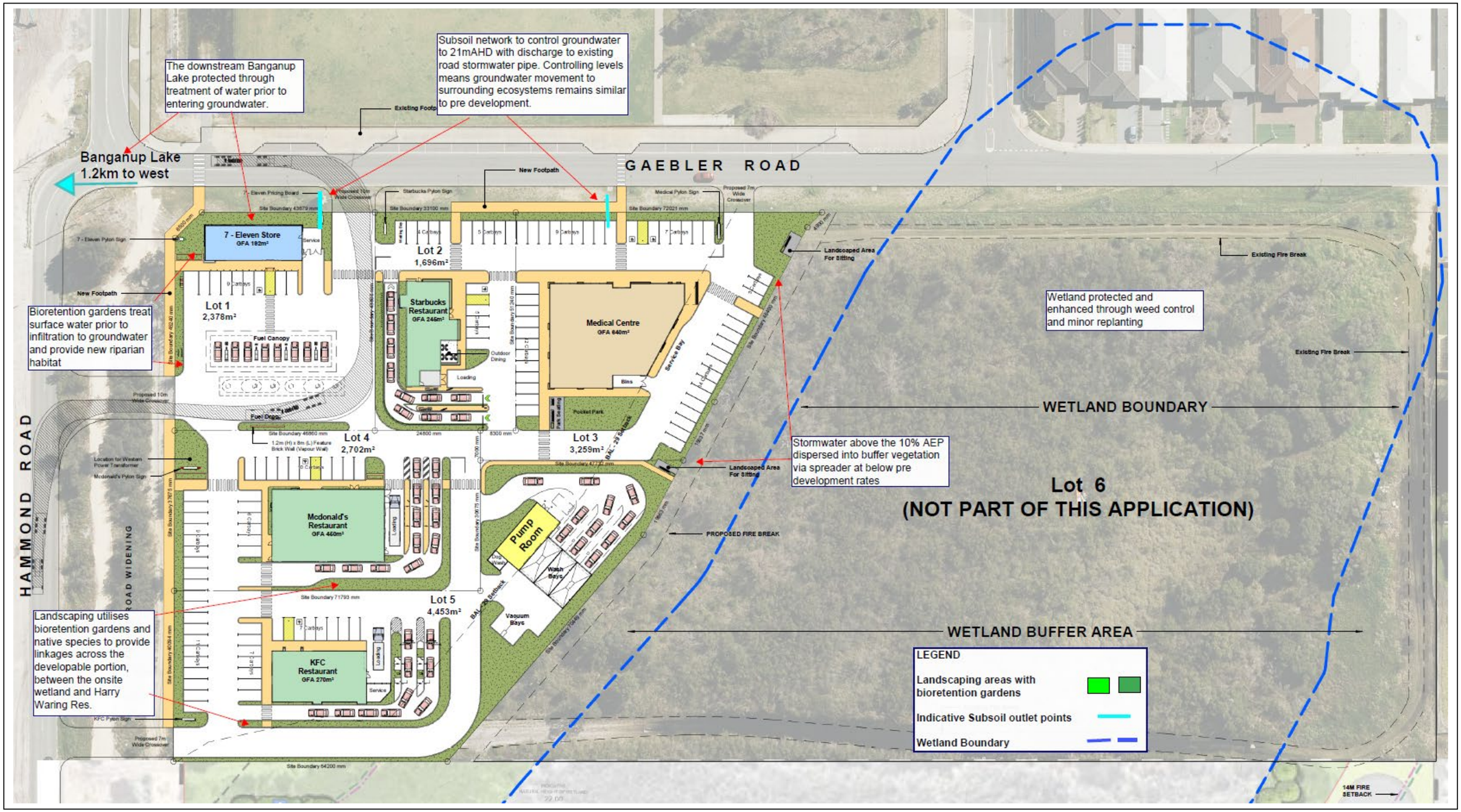


Figure 13 Landscaping and WDE management within developable portion

12 MONITORING & MAINTENANCE

The following section provides information on both pre and post-development undertaken and required. Table 7 also provides a summary of the monitoring requirements.

12.1 PRE-DEVELOPMENT GROUNDWATER

Pre-development superficial groundwater level monitoring for the subject land has been undertaken as part of previous investigations. No further monitoring is deemed necessary as the level to which the groundwater is to be controlled to is deemed to be a conservative historical maximum.

12.2 PRE-DEVELOPMENT SURFACE WATER

Surface water monitoring for water quality is not considered necessary, as the wetland only has water temporarily during periods of extended heavy rainfall over the entire catchment and is predominantly a groundwater fed system.

12.3 CONSTRUCTION PHASE

Installation of drainage control structures ahead of the construction phase of the development will be utilised. This will include the use of water sensitive urban design techniques such as sediment curtains, hydro mulching and temporary detention basins to maintain the quality of the water leaving the development area during construction. The bioretention gardens and detention structures will be monitored for any damage, including compaction, sediment build up, oils, and litter during and at the completion of construction to ensure the structure's effectiveness is not diminished. Sediment and litter on internal roads and parking will be monitored, with removal completed as necessary with street sweeping. To minimise issues with degradation of vegetated treatment systems, it is recommended that planting should be delayed until the risk of high sediment loads has passed.

12.4 POST-DEVELOPMENT

The post-development monitoring and maintenance regimes will focus on easy to observe aspects. The following provides guidance on the targets and likely process to be undertaken.

WSUD Structural Performance Monitoring

Performance monitoring of WSUD elements will be completed to ensure the system is working effectively. Indicators will be used as a cost-effective method to evaluate the adequacies of WSUD performance. It can be assumed that if the WSUD elements operate in accordance to design then the desired management objectives are being met.

The key WSUD elements to be monitored will include:

- Ensuring the inlet and outlet structures are free of debris
- Vegetative cover of the systems is maintained;
- Sediment build up is not impeding the functionality
- Erosion is not present;
- Soils are not compacted;
- Litter is removed;
- Excessive hydrocarbons are not present in the system;
- Weeds are controlled;
- Infiltration of stormwater is maintained to at least the minimum designed rate;
- Stormwater pipes are flowing freely;
- Outlet structures including pipe and dispersers are functional
- Subsoil pipes are flowing freely.

Compared to traditional engineered structures for stormwater runoff management, the WSUD elements require different routine maintenance and these are generally of a landscape maintenance nature. The most common maintenance is the removal of weeds, debris and siltation. The most time intensive period of maintenance for a vegetated WSUD system is during plant establishment (which typically includes two growing seasons), when supplementary watering, plant replacement and weeding may be required. The WSUD elements will be constructed and utilised in different stages so that the functions of the WSUD elements are protected from elevated pollutant loads generated from a developing catchment.

The minor sections of drainage piped network will also require maintenance to make sure they continue to function as designed. This will include rodding, removal of sediments and other debris, as well as the replacement of broken components due to general longterm corrosion and wear.

Maintenance inspections should be conducted after significant storm events (mobilised sediments and coarse material). Inspections should focus on ponding time for the different systems, unequal surface flow distribution and scouring.

A key focus should also be on the control of litter and sediment that is often generated during the building construction phase. This is the most common time when systems are degraded or fail, due to large volumes of pollutants such as non-biodegradable litter, cement fines, direct vehicle compaction, sand movement and other sedimentation issues.

12.1 WETLAND MAINATENANCE

The wetland is to be monitored for weeds, plant deaths and rubbish. Rectification and rehabilitation works are to be undertaken as required and in line with the relevant management documentation. The exact monitoring and maintenance requirements will be determined as part of detailed design.

Table 7 Monitoring requirements

Function	Item to Monitor	Purpose of Monitoring	Trigger for Immediate Action	Maintenance Action Required	Monitoring Frequency	Responsible Authority
CONSTRUCTION PHASE & POST-DEVELOPMENT						
Drainage Management Systems and wetland rehabilitation (includes traditional and WSUD systems)	Structural Design	Systems are constructed to engineer detailed design specifications.	System constructed differs to design specifications.	Remedial work to rectify system to meet design specifications.	During and after construction	Developer
	Structural Effectiveness (inlets, traps and outlets)	Inspection for debris, litter and sediments surrounding structural components.	Debris, litter or sediments causing blockages or impairing functions.	Remove any debris or blockages. Inspect system for any erosion related issues.	Every 3 months	Developer until handover to Local Government
	Erosion	Inspection for erosion.	Presence of severe erosion or erosion impairing functions.	Investigate, identify and rectify the cause of the erosion. Replace filter media as required.	Event based (mobilisation of sediments) and a minimum of every 3 months	Developer until handover to Local Government
	Sediment Build Up	Inspection for sediment accumulation within pits, on the surface of bioretention systems and within basins.	Accumulation of large volumes of sediments and/or silts in pits or on the surface (according to Shire standards).	Investigate, identify and stabilise cause of sediment source. Remove accumulated sediments and replace filter media or plants removed.	Event based (mobilisation of sediments) and a minimum of every 3 months	Developer until handover to Local Government
	Compaction	Inspection of filter media for compaction.	Water remains ponding longer than designed in bioretention system after a storm event.	Investigate cause of compaction. If localised, remove top 500mm of filter media, break up the filter and then return to system without any compaction. If extensive seek expert advice.	Every 3 months	Developer until handover to Local Government
	Weeds	Inspection for the presence of weeds.	Weeds are noxious or highly invasive or if weeds cover more than 25% of area.	Manual removal or targeting herbicide application, with waterway approved products.	Every 3 months	Developer until handover to Local Government
	Plant Condition	Inspection of vegetation health and cover, and presence of dead plants.	Plants dying or a pattern of plant deaths.	Investigate cause of plant deaths and rectify. Infill plantings may be required.	Every 3 months	Developer until handover to Local Government
	Organic Litter	Inspection for the presence of organic litter (e.g. leaves) on surface.	Litter coverage is thick or extensive, or detracting from the visual appearance of the system.	Investigate source of litter and undertake appropriate response, e.g. alter landscaping maintenance practices, community education). Remove litter.	Every 3 months	Developer until handover to Local Government
	Rubbish/Litter	Inspection for the presence of litter.	Litter is blocking structures or detracting from the visual appearance of the system.	Identify source of litter and undertake appropriate responses. Remove litter.	Every 3 months	Developer until handover to Local Government
	Oil/Hydrocarbons	Inspection for the occurrence of oil on surface.	Oil coverage persists for more than 3 weeks, and is thick.	Notify the EPA of the spill and clean up requirements.	Every 3 months	Developer until handover to Local Government
	Filter Media	Check that media is draining as designed	Infiltration rate is outside of the design specifications	Replacement of top layer or all of the filter media (depending on issue)	Every 3 months	Developer until handover to Local Government
	Pipe network	Check that all pipes are free flowing and functioning	Pipes blocked or broken	Clean or repair pipe	Every 3 months	Developer until handover to Local Government

13 IMPLEMENTATION AND GOVERNANCE PLAN

The implementation of the water management strategies outlined in this report will rely on a range of detailed reports being undertaken, governance frameworks being established and implemented and commitments to on ground works, coupled with long-term maintenance/operations. The following is a summary of the process to achieve implementation.

DEVELOPER REQUIREMENTS

- Undertake detailed design of stormwater, groundwater control, potable and wastewater systems as required.
- Updated modelling of all stormwater management systems as part of detailed design
- Produce and implement Construction and Sediment Control reports.
- Implement all servicing and drainage infrastructure in accordance with the overarching strategy for the entire subject land.
- Apply appropriate fill and groundwater control structures on site as required.
- Implementation of the wetland rehabilitation to enhance the onsite wetland.
- Undertake post-development monitoring as required.
- Provide Design Guidance to lot purchasers with regards to their stormwater detention.

WATER CORPORATION REQUIREMENTS

- Approve engineering drawing related to potable water servicing and, provide and maintain a potable waters service.
- Approve engineering drawing related to wastewater servicing and provide and maintain a wastewater service.

CITY OF COCKBURN REQUIREMENTS

- Approval of UWMP and future detailed designs.
- Review and approval of on lot stormwater detention as part of building applications

14 REFERENCES

- Australian and New Zealand Environment and Conservation Council (ANZEEC), 2000, Australian and New Zealand Guidelines for Fresh and Marine Water Quality, Volume 1: The Guidelines
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- Department of Water, 2007, Stormwater Management Manual for Western Australia, Perth Loh, M. and Coghlan, P (2003) Domestic Water Use Study In Perth, WA 1998 – 2001. Water Corporation.
- Western Australian Planning Commission, 2008, Better Urban Water Management. Perth
- PGV Environmental (2023), Lot 9501 Gaebler Road Hammond Park Environmental Assessment Report
- WML Consulting Engineers (2022) Geotechnical Investigation Lot 9501 Gaebler Road Hammond Park
- Peritas (2023) Lot 9501 Gaebler Road Hammond Park 6164 Engineering Services Report

15 GLOSSARY

LWMS: Local Water Management Strategy

LSP: Local Structure Plan

1EY: 1 Exceedance per Year. Refers to the maximum rain fall event that is likely to occur every year.

10% AEP: 10% Annual Event Probability. Refers to their being a 10% probability of rainfall exceeding this value every year.

1% AEP: 1% Annual Event Probability. Refers to their being a 1% probability of rainfall exceeding this value every year.

Appendix A SUPPORTING REPORTS CONTAINED WITHIN FULL DEVELOPMENT APPLIICATION

Appendix B ENVIRONMENTAL ASSESSMENT REPORT

Appendix C GEOTECHNICAL REPORT

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