DISTRICT WATER MANAGEMENT STRATEGY

TO SUPPORT THE PICTON SOUTH DISTRICT STRUCTURE PLAN

PREPARED FOR DEPARTMENT OF PLANNING

AUGUST 2017
17-000073
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COMMERCIAL IN CONFIDENCE

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DOCUMENT CONTROL
15023

Issue	Date	Issue details	Author	Checked
A	18.05.2017	Draft to client	Sarah Carr	Brendan Oversby
B	23.08.2017	For Submission	Sarah Carr	Brendan Oversby

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1. EXECUTIVE SUMMARY

This District Water Management Strategy (DWMS) has been prepared to support the future development of the Picton South District Structure Plan (DSP) area.

The objective of this DWMS is to detail the best management practices approach to water management that will be undertaken for this future development, while recognising some areas are already being used for industrial purposes. This will include managing, protecting and conserving the total water cycle of the DSP area and the greater catchment. These strategies respond to the area's drying climate, lack of easily accessible water resources, general site characteristics of fully and partly developed industrial lands and natural ecosystems while also incorporating new technology and water management systems. It will also reflect some of the design works being undertaken on the adjoining Waterloo District Structure Plan area.

The District Structure Planning process is being led by the Department of Planning, in consultation with the Shire of Dardanup and City of Bunbury ('local authority'). They 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 local authorities, future developers and relevant regulatory authorities. Through this collaboration, the strategies will allow the water management on site to complement the proposed industrial use, 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.

1 . 1 EXISTING SITE CONDITIONS SUMMARY

The DSP area is located within the Shire of Dardanup and City of Bunbury. The northern boundary of the subject land is the South Western Highway. The south western boundary is mainly north of the Boyanup Picton Road and the eastern boundary roughly aligns with Martin Pelusey Rd. The exact area can be seen in Figure 1.

The subject area is currently predominately farmland in the north eastern portion. The exception is the existing rail yards. The southern/western portions are mainly used for industrial uses, with large lot sizes. A more densely developed industrial estate is located in the south eastern corner.

The site is also crossed with existing roads and rail lines.

The site contains numerous wetlands on the flat plain areas. There are also lines of low sand dunes with generally low to medium slopes. The Ferguson river crosses the southern portion of the site and flows in a north westerly direction. It is generally incised into the surrounding plain.

The soil type is predominately duplex in nature, with a thin layer of sand over clay/loam, except for isolated low sand dunes, and river sediment deposits. These soil types contribute to the wetland nature of the site. Related to this, the site is relatively flat, with some steeper grades associated with the Ferguson River system and sand dunes within the eastern portion of the subject land.

The Ferguson River forms a natural drainage line that receives water directly from a large section of the subject land along the southern boundary. A small portion of the north eastern section of the site flows northward under the South West Highway. The rest of the site sheets water to constructed drains, which enter the Ferguson River near the western edge. These drains allow what were most likely previously trapped lows, to drain off the subject land.

The majority of the subject area is cleared. There is some limited native vegetation including remnants of wetland and riverine dependent vegetation, most of which is degraded to some extent. Native vegetation covers portions of the land, predominately within private lots. There has also been some revegetation of the Ferguson River within the south eastern industrial development.

The site currently is not serviced with a potable water supply or a mains wastewater.

PLANNING SUMMARY

The DWMS, in conjunction with the Picton South DSP, supports the proposed rezoning of the subject land from Rural to Industrial (where it is not already zoned as such) as well as reserve areas along the Ferguson River. The rezoning and subsequent development of the DSP area reflects the need to continue to plan for the growth of the greater Bunbury area.

As outlined in the DSP, it is proposed the subject land be developed in 4 Stages, known as industrial precincts. The precincts will form more succinct and coherent development areas in line with the ideals of the DSP. The precinct boundaries generally bypass industrial areas that are currently established, with the exception of Precinct 4 (Figure 1). Precinct 4 consists of the subdivided and established 'Golding Crescent' industrial precinct, which already has sustainable water servicing and stormwater design in place.

Precincts 1 to 3 will subjected to Local Structure Plans, with corresponding Local Water Management Strategies. It should be noted that Precinct 2 currently includes the approved Lot 105 Columbus Drive LWMS, shown on Figure 1.

Alternatively, LWMSs will be completed for individual lots as they are developed. All LWMS's are to be in accordance with this DWMS with drainage management to be on a pro-rata basis. They will need to considers the storage requirement of the entire catchment and provide the relevant storage as a percentage of the portion being developed within the relevant LWMS.

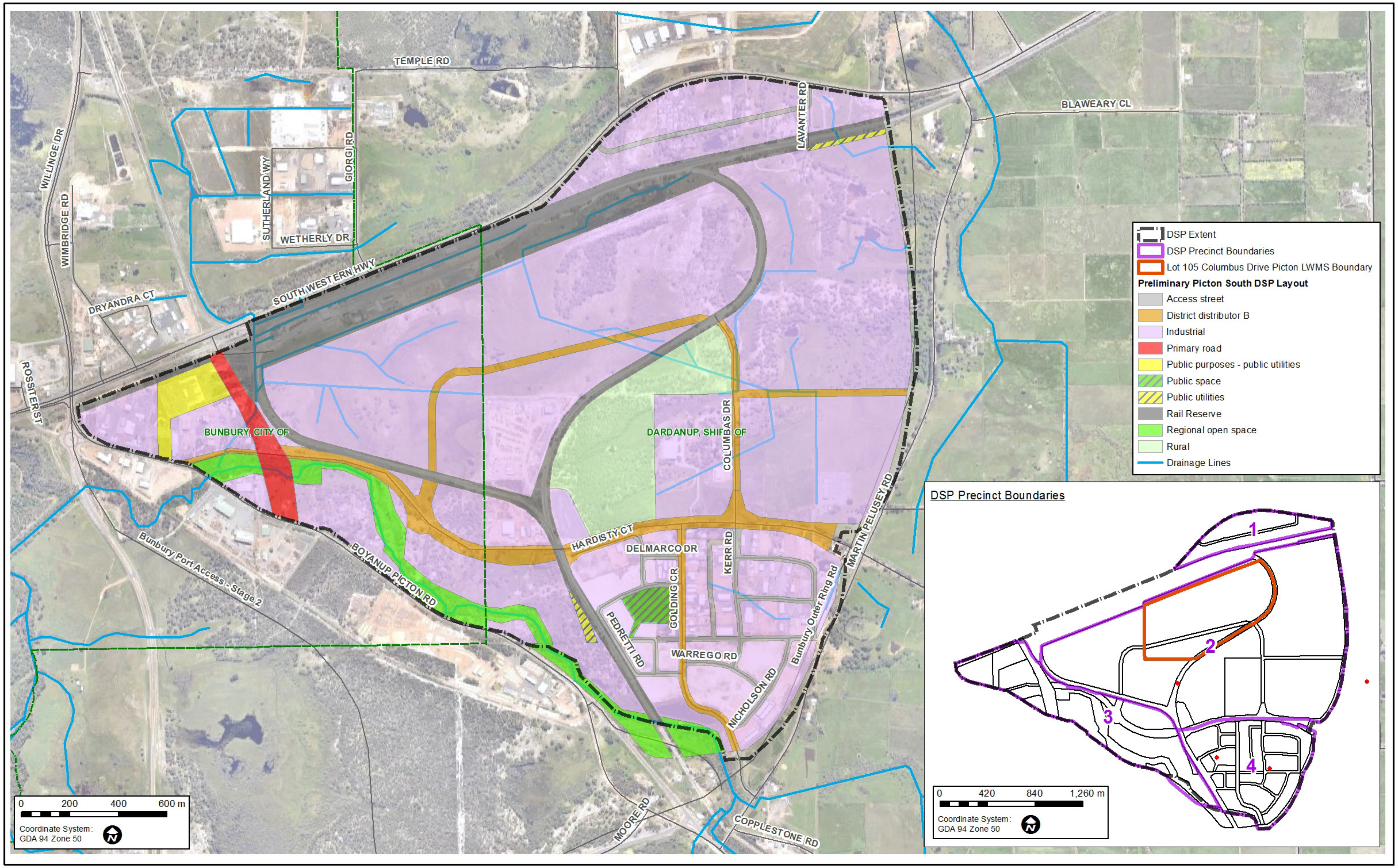


Figure 1 - Picton South District Structure Plan

2. KEY ELEMENTS

The water management strategies for the DSP area are based on best practice water sensitive urban designs that integrate sustainability and the provision of functional industrial areas. The strategies will be achieved through the synthesis of planning and designs, with long-term collaborative management of the total water cycle. The plans and designs for the development are appropriate for the subject land's development constraints, surrounding environment and land use and current developed areas.

A summary of the Water Sensitive Urban Design (WSUD) elements that will be implemented within the development to achieve best management practices are outlined below, and visually represented in Figure 2.

2.1 DRAINAGE MANAGEMENT STRATEGY

- On lot and off lot detention systems, combined with treatment systems such as bioretention gardens will capture and treat stormwater flows. All flows leaving the site up to the 1% AEP event are generally to match the pre development rate.
- Lots will have a direct connection to the road network storm water system, after storage is exceeded on the lot.
- On lot storage is to be in accordance with the local authority guidelines.
- All finished floor levels will be designed to maintain a clear separation of 300mm between the habitable floor levels and the 1% Average Event Period (AEP) event flood level, generated on site.
- All finished floor levels will be designed to maintain a clear separation of 500mm between the habitable floor levels and the 1% Average Event Period (AEP) event flood level of the Ferguson River.
- Upstream flows, detailed in the Preston Industrial Park (Northern Precinct) drainage study, will be accounted for within the Preston Main Drain, as intended.
- Upstream flows within the Ferguson River will remain consistent with the Department of Water's flood modelling , which will be reported in the Drainage and Water Management Plan (DWMP).

2.2 GROUNDWATER AND ACID SULPHATE SOIL MANAGEMENT STRATEGY

- Inflows to the groundwater are to be treated through bioretention media and plants within the basin and swales, to improve the quality of water prior to it entering the groundwater.
- A subsoil drainage system, interconnected with the swale network, will be used to control groundwater levels around buildings and roads.
- All groundwater level management is to focus on fill minimisation.
- Subsoil drainage systems are to incorporate amended filter media around them to treat groundwater prior to it entering the subsoil pipe.
- All groundwater discharged from sub-soil drains will be further treated through the vegetation within the receiving drainage system.
- An Acid Sulfate Soils (ASS) investigation is required within each Local Structure Plan (LSP) area. ASS soils will be handled in accordance with an ASS Management Plan at subdivision stage.

2.3 SUSTAINABLE WATER SERVICING

- Industrial buildings are to be encouraged to incorporate rainwater storage devices where practical. These are to be plumbed to provide a source of internal and external non potable water.
- All lots are to be connected to a potable reticulated water main to provide security of supply.
- Lots to be connected to mains sewage unless detailed planning shows a portion is suitable to dry industry or onsite effluent management, using Alternative Treatment Units (ATUs).
- Non potable water may come from a variety of sources including some stormwater harvesting and treated wastewater. Detailed investigations are to be undertaken to determine suitable solutions prior to development beginning.
- Provision of awareness raising material on water saving measures to business developers.
- Landscaping on private lots to be in accordance with waterwise landscaping principles as directed by the local authority.

2.4 WATER DEPENDENT ECOSYSTEM MANAGEMENT

- New waterway habitat will be created within upgraded and new swales.
- Bioretention systems and detention basins will provide riparian wetland habitat.
- Existing native wetland vegetation is to be retained wherever possible, by incorporating it into Public Open Space (POS) areas, reserves or left as its existing rural land use. These areas will also be enhanced as appropriate with revegetation and weed control.
- The Ferguson River to be protected within foreshore reserves where possible. The reserve area is to be rehabilitated to enhance the ecological functioning of the waterway.
- Foreshore Management Plans are to be produced for the Ferguson River as adjoining lot areas are developed. Foreshore Management Plans must be completed at the LSP stage and developed concurrently with Bushfire Management Plans to avoid uninentended consequences.
- The WSUD elements used on site will treat stormwater and groundwater, improving the water quality prior to it entering downstream ecosystems.
- A Wetland Management Plan should be developed for the Resource Enhacement Wetland at the LSP stage.

2.5 MONITORING AND MAINTENANCE

- Pre development monitoring of surface water and groundwater is to build on the works currently undertaken by the Department of Water and private lot owners/developers. It is to include both level and quality. This is either to be done as part of each relevant LWMS or as part of a separate overall study.
- Monitoring is to be undertaken through the construction phase of each stage for surface water, groundwater and acid sulphate soil disturbance.
- Post development monitoring is to consider surface and groundwater quality, ecosystem enhancement and WSUD structural performance

2.6 IMPLEMENTATION AND GOVERNANCE

- Developers are to undertake detailed LWMSs and UWMPs for their relevant stage to provide the necessary information for management of water across the site.
- Servicing agreements and a service provider are to be established prior to development beginning.
- The local authority, Department of Planning and Department of Water are to continue to provide guidance, direction and assistance so that the targets outlined in this report are able to be realised.

2.7 FILL MANAGEMENT

- Fill minimisation is to be a key consideration in all developments within the DSP area
- Utilisation of techniques such as a close network of subsoils and swales are to be investigated to minimise groundwater mounding and control groundwater rise.
- Infrastructure that can be built within and on top of minimal fill are to be preferentially used to reduce fill requirements.

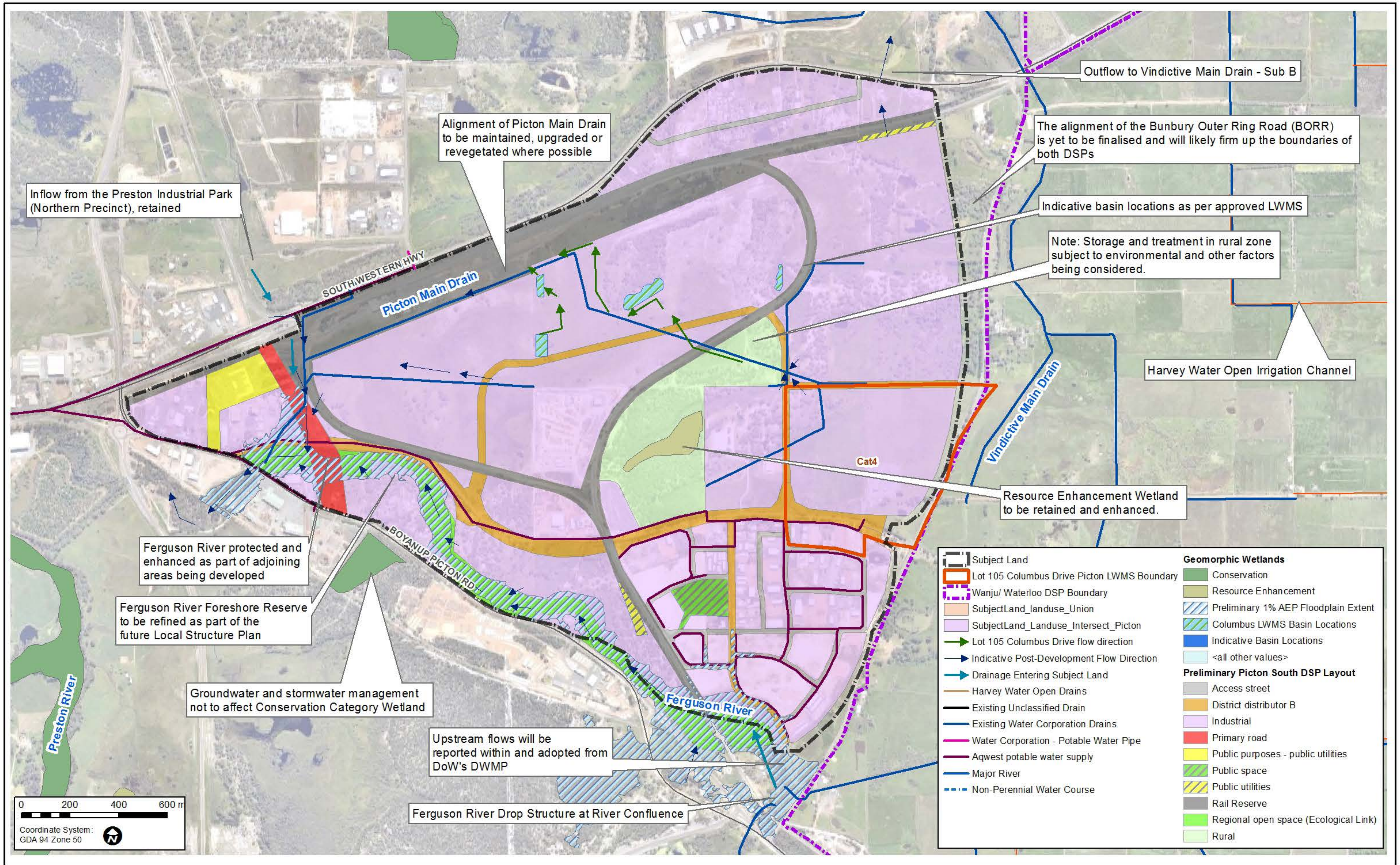


Figure 2 - Key Elements

3. ENVIRONMENT

The following is a summary of the environmental characteristics of the site. This information is taken mainly from desktop assessments by Calibre.

3.1 CLIMATE

The subject area is within a temperate Mediterranean climate of cool wet winters and hot dry summers. The mean rainfall is approximately 734mm/annum (median 698mm/annum). Winter temperatures range between a minimum of 7^{0}C and 17.3^{0}C maximum on average, with summer ranging from a minimum of 15.4^{0}C and a maximum average of 30.1^{0}C. There are regular extremes outside of these temperature ranges.

Groundwater also responds to this seasonality of rainfall and temperature. There is commonly a 1.3m+ variation in vertical groundwater levels, as water either moves towards the subject land's surface drains and waterways or is evapotranspired over summer, without new water entering the soil profile from rainfall.

3.2 LANDFORM

The subject area is predominately composed of a gently sloping plain that falls in an east to west direction. The plain falls from 22m AHD in the south eastern corner, grading through to 8m AHD on the western boundary. There is a small section along the northern boundary of the site which falls south to north, 16 mAHD to 12 mAHD respectively. There are several peaks and depressions as the site falls towards the west with many trapped lows. Due to heavier soils and high groundwater levels, several trap lows are considered to have wetland characteristics, which is supported by the Geomorphic Wetland Database (see Section 3 for more details).

The slopes in southern plain area, south of Ferguson River are generally around 1:100 to the river bank. North of the Ferguson River and south of South Western Hwy slopes are flatter with slopes generally reaching 1:500.

There are some small, low sand rises located along the eastern edge of the site. These rise approximately 2 to 5m above the surrounding plain. The slopes are between 1:20 and 1:60 on the sand dune sides.

The Ferguson River within the southern portion of the site cuts into the surrounding flood plain, with the river channel falling approximately 5 to 7m from the surrounding plain, with slopes in the order of 1:10. A side channel linking the portion of the site to the Ferguson River is located in the western portion of the site, namely the Picton Main Drain. The Main Drain slopes from 12mAHD in the North West to 5mAHD on connection to the Ferguson River.

North of the South Western Hwy the subject land discharges into a side channel of the Invictus Main Drain. The side channel flows south to north, falling from 11.5 mAHD to 10.5mAHD at the connection to the Main Drain.

The sites landforms can be seen in Figure 3.

Landform: Low lying area in front of small sandy dune

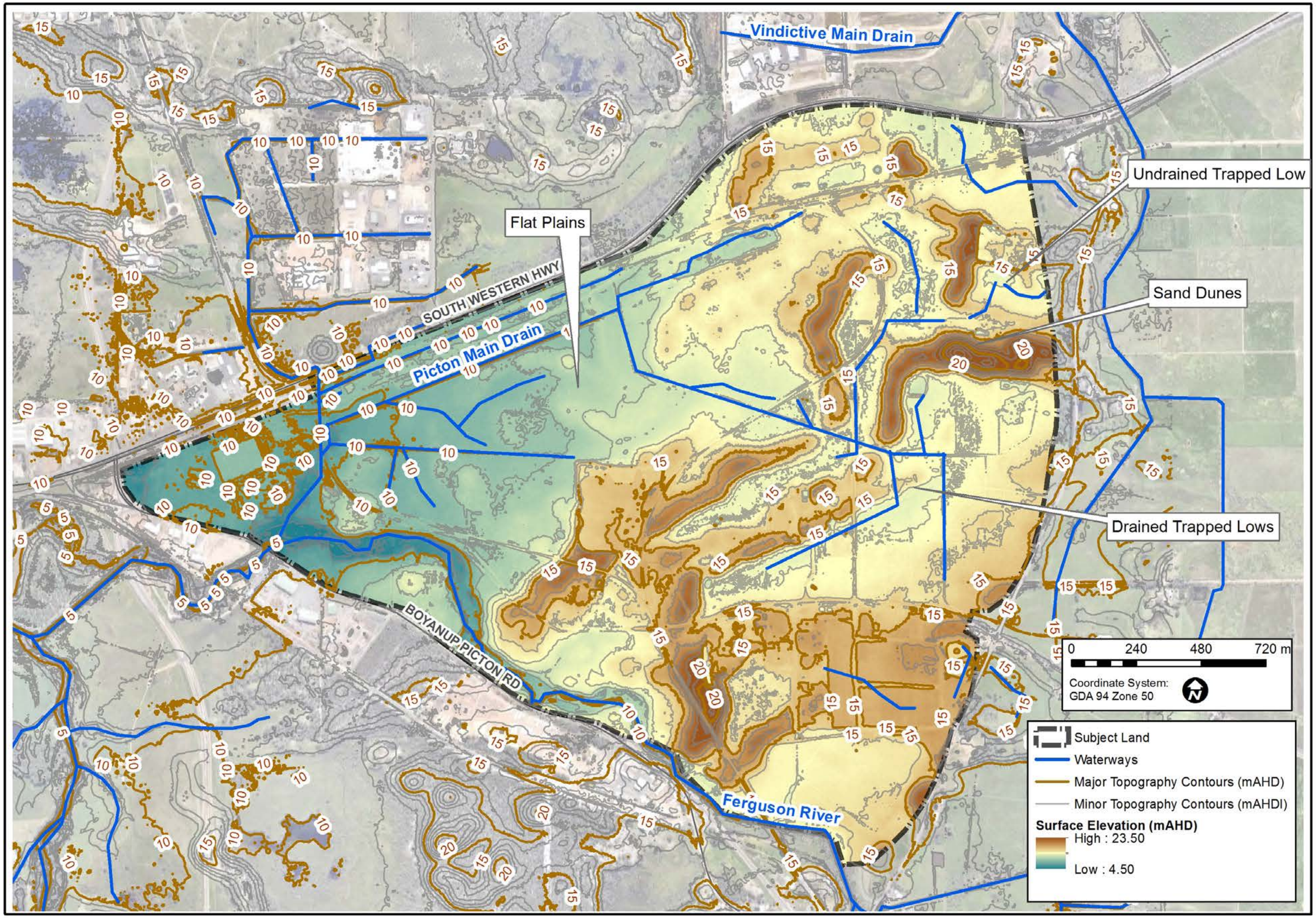


Figure 3 - Landform

3.3 SURFACE GEOLOGY AND ACID SULPHATE SOIL CHARACTERISTICS

3.3.1 Local and Regional Geology

The geology of the area is composed predominately of Guildford Formation (Qpb), with Bassendean Dune systems (Qpa) on the eastern edge. Portions of the site contain Bassendean Sands overlying Guildford Formation (Qpb/Qpa) and there is also some more alluvial sediments associated with the Ferguson River system (Qhao).

3.3.2 Soil types

In general the soil type is a thin layer of Bassendean sand over Guildford loams and clays (or Pinjarra soils), commonly known as duplex soils. Repeated wetting and drying at this boundary has resulted in gravel or mottled layers at this interface. There are also areas of yellow earthy soils associated with the major drainage lines such as the Ferguson River. In isolated patches, more peaty soils may be found associated with the areas of more permanent wetlands. As part of the Lot 3 Harris Rd geotechnical investigation (Figure 4), four test pits were constructed using a back hoe. The soil profile found was sand overlying sandey clay, which is consistent with soil/geology mapping shown on Figure 4.

Phosphorus Retention Index

The Phosphorus Retention Index for the sites soils is likely to be low to moderate in the thin Bassendean sand and high in the Guildford soils.

3.3.3 Infiltration/Permeability

The saturated permeability of the surficial sands, where they exist are generally in the order of 1 – 10 m/day. The underlying clays are 1 – 2 orders of magnitude lower (i.e. 0.1 to 0.01 m/day). This lower permeability would also occur at the surface, where the loamy soils of the Guilford complex occur at the surface.

Where there is sand over loam/clays, the major change in permeability creates the observed perched groundwater conditions. Given the low porosity and total water storage capacity of the surface sands, the surficial profile often exceeds field capacity (and may approach saturation) over its entire depth; hence the surface profile is considered saturated.

3.3.4 Acid Sulfate Soils

The Acid Sulfate Soil (ASS) Risk Mapping shows that there is an area of High to Moderate Risk within 3m of the surface, associated with the Ferguson River (Figure 4). The remainder of the site is mapped as a Moderate to Low Risk. Future detailed studies may be needed to determine the status of the soils in particular areas, especially in any peaty wetland systems or where coffee rock/iron hardpan is found. The sand dune rises are unlikely to have an ASS risk, however this has not been delineated in the broad scale mapping. Figure 5 shows the current ASS mapping (DER, 2016).

ASSs do occur in deeper sediments in similar soil types, and should be considered if deep excavation is envisaged as part of future development.

3.4 CONTAMINATED SITES

A detailed contaminated site analysis has not been undertaken. There is the potential for some contamination due to agricultural and industrial uses, especially around sheds and work sites, this should be investigated as part of future detailed design phases.

A review of the Department of Environment Regulation's(DER) Contaminated Sites Database (accessed 8 May 2017) showed the portion of the subject land within Lot 512 Boyanup-Picton Road and Lot 7 Wimbridge Rd is classified as 'Remediated for restricted use'(Figure 4). This site was historically used as a power pole treatment site and for the storage of associated chemicals. Due to the potential presence of hydrocarbons, creosote and dieldrin in the soil, a site-specific health and safety plan is required before any disturbance to soil is undertaken.

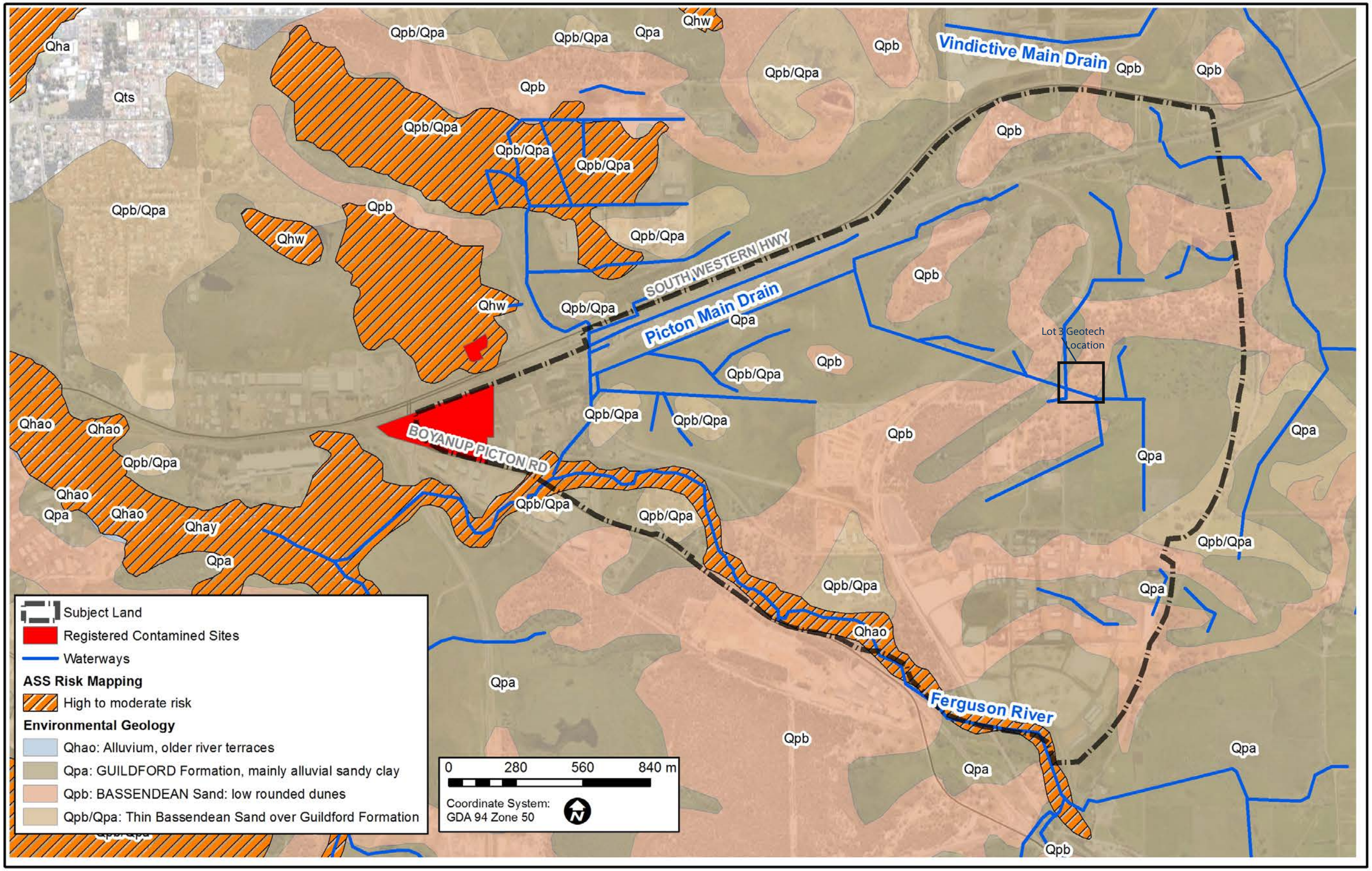


Figure 4 - ASS, Surface Geology and Contaminated Sites

3.5 WETLANDS

The Geomorphic Wetland database has identified the majority of the subject land as dampland, sumpland or palusplain with a Multiple Use classification. The Multiple Use classification does not preclude future urban development.

There is also a small Conservation Category Wetland (CCW) south of the Ferguson River and a Resource Enhancement Wetland (REW) in the centre of the subject land. Both wetlands are associated with sections of better quality vegetation, which have not been disturbed through agriculture or development. Wetlands are shown on Figure 5 and described in Table 1.

Downstream of the subject land runs the Preston River, which is identified as a CCW palusplain.

Wetland Number	Wetland Type	Classification	Approximate location
1389	Sumpland	Multiple Use	South- Western corner, south of Boyanup-Picton Rd
1404	Dampland	Resource Enhancement	Centre of Subject Land
1405	Sumpland	Not Assessed	Between Harris Rd and Boyanup-Picton Rd
1406	Sumpland	Multiple Use	Within developed portion between Harris and Boyanup-Picton Rd
1554	Sumpland	Multiple Use	Between Columbas Dr and Martin-Pelusey Rd
1555	Dampland	Multiple Use	Between Columbas Dr and the Picton East rail line
14329	Palusplain	Multiple Use	Scattered across the full extent of the subject land
14330	Palusplain	Multiple Use	Between Boyanup-Picton Rd and the Picton rail line
14331	Palusplain	Conservation	Abuts wetland 14330

Table 1: Wetland Summary

There are no Ramsar listed sites or Wetlands of National Importance within the site or immediate surrounds. The site does drain to the Leschenault Estuary however, which is located approximately 6km to the north west. This is a known as an important bird habitat and is recognised under JAMBA and CAMBA (Japan and China – Australian migratory bird agreements).

3.6 NATIVE VEGETATION

The majority of the site has been cleared of native vegetation, especially in the wetland areas, and is now predominately agricultural pasture or industrial uses. There are some areas that retain isolated native overstorey species, with an understorey of pasture, as well as isolated areas where the native understorey is relatively intact.

Along the Ferguson River there is generally an overstorey of Eucalyptus rudis and Melaleuca rhaphiophylla with a weed dominated understorey, composed of watsonia, kikuyu, cotton bush, annual grasses and general pasture species. There are also some isolated willows and false bamboo. Just outside the main channel there are also occurrences of Corymbia callophylla and Agonis flexuosa.

In the flat plain areas, the remaining native wetland vegetation is sparse and consists of the above native tree species along with some Juncus pallidus, other juncus species and Gahnia trifida and Xanthorea sp. There also some other Melaleuca species around the edge of some of the sandhill seeps. A detailed flora and vegetation assessment will need to be undertaken as part of future assessments.

These vegetation associations and conditions can be seen in Figure 5.

3.6.1 Fauna

The fauna habitat on site is closely linked to the small areas of native vegetation. The value of these areas as habitat relates closely to their current condition. Some of this vegetation also performs an ecological linkage function for fauna movement, such as the riverine systems. The cleared area provide little habitat for native fauna species

In line with increased land clearing within the Ferguson River catchment in the early 1900's, the river channel was widened via cutting and explosive charges. Further widening was undertaken in 1964 after major floods devestated the area. Works included significant clearing of river snags and vegetation. Historical modifications to the river have had a negative impact to the degree of native vegetation found on site.

As part of the Leschenault Water Quality Improvement Plan (DoW, 2012), the lower Ferguson River was deemed to have low habitat value and no ecological value for aquatic birds. Extensive land clearing and surrounding agricultural land uses have also impacted the overall water quality within the river, as detailed in Section 3.7.2.

Wetland vegetation showing native overstory and weedy understory.

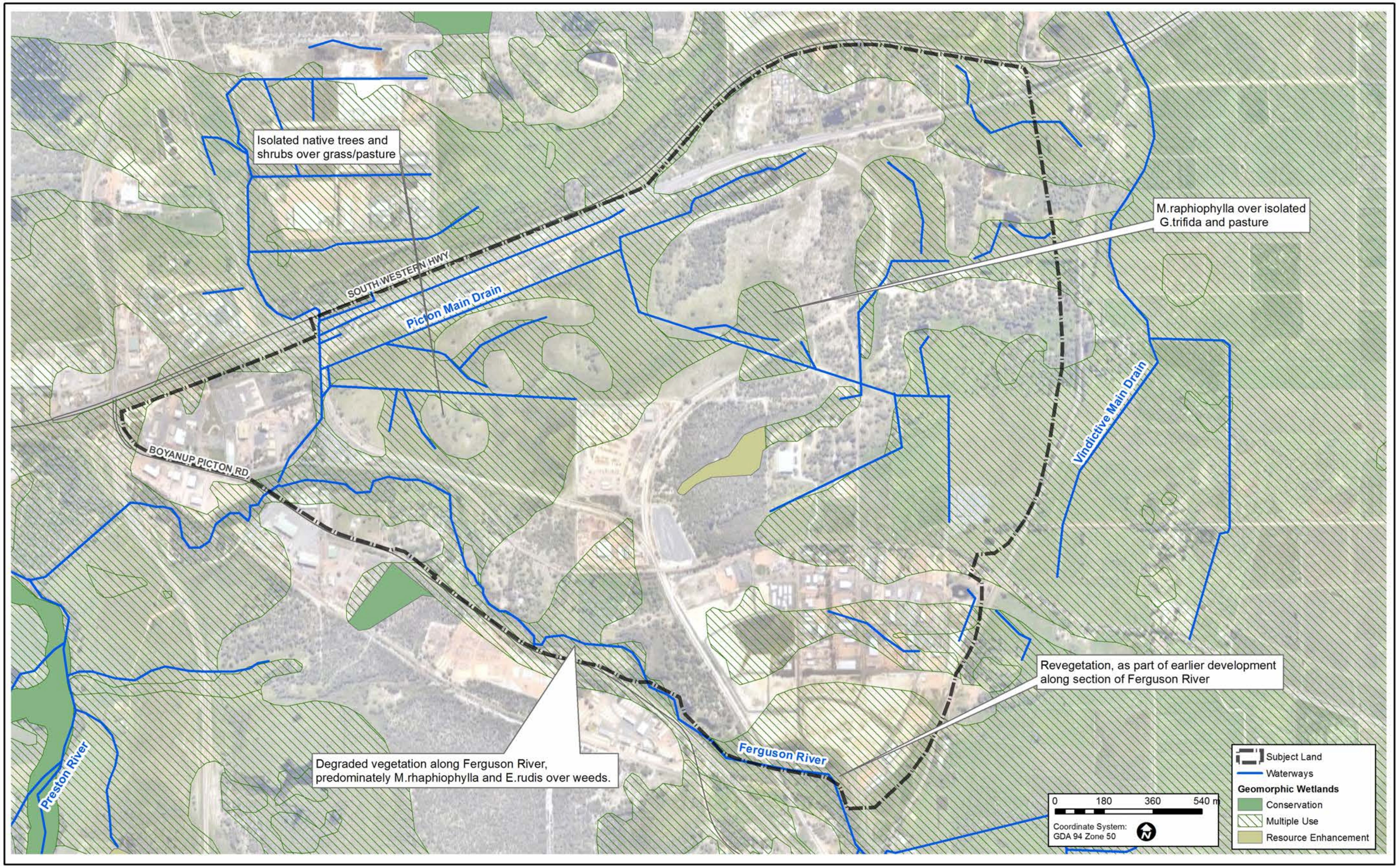


Figure 5 - Wetlands, Waterways and Vegetation

3.7 PRE-DEVELOPMENT SURFACE WATER HYDROLOGY

3.7.1 Surface Water Features

The existing major surface water features found within the subject land includes the Ferguson River, the Picton Main Drain, several unidentified rural drains, an REW in the centre of the subject land and a CCW south of the Ferguson River. Major drainage features are shown on Figure 6.

3.7.2 Surface Water Quality

The DSP area sits within the Leschenault Estuary Catchment and as such is covered by the Leschenault Estuary Water Quality Improvement Plan (WQIP). The Estuary and its tributaries are also a Management Area proclaimed under the Waterways Conservation Act 1976 and a catchment included in the stage government's Regional Estuary Initiative.

The majority of the subject land discharges towards the Ferguson River with a small portion discharging to the Vindictive Main Drain. The main drain runs north and discharges into the Collie River.

No surface water quality monitoring has been undertaken specifically for this project. There has been some water quality recorded as part of the Leschenault Estuary WQIP. A summary of the average winter water quality within the waterways are presented in Table 2 and summarised as follows:

- The Ferguson River Catchment has a TN export per unit area of 1.67 to 2.54kg/ha/year and a TP of 0.06 to 0.08kg/ha/year. These are considered moderate and low levels respectively.
- The Lower Collie River Catchment has a TN export per unit area of 2.55 to 3.82kg/ha/year and a TP of 0.09 to 0.33kg/ha/year. These are considered high and moderate levels respectively.

In general the elevated nutrient levels, for the waterways linked to the site are due to the current farming practices (beef and dairy). Both of the catchments are considered Recovery catchments in the WQIP, due to the elevated nutrient levels. This classification specifies a Total Nitrogen and Total Phosphorus target concentration of 1.0 mg/L and 0.1 mg/L respectively.

Waterway	Total Nitrogen -TN (mg/L)	Total Phosphorus - TP (mg/L)
Lower Collie (Vindictive Main Drain)	1.5	0.1
Lower Ferguson	1.5	0.11

Table 2: River water quality

Although there has not been a flora and fauna report completed over the Ferguson River, it is likely to have a moderate to High Ecological Value. This is due to the native overstorey, semi permanent flow and the link it provides to other areas of natural significance. The understorey is predominately weeds including dense stands of Watsonia, where it is near the subject land.

As detailed in the Wanju and Waterloo Intergrated Water Management Strategy (IWMS), the Collie River is considered to be tidal, within the reach of the Vindictive main Drain. Although the river is degraded due to weed encroachment and historical grazing, it does provide insitu habitat as well as a link for both aquatic and riparian fauna. This contributes to it being rated as having a High Ecological Value (Calibre Consulting, 2016).

Ferguson River channel

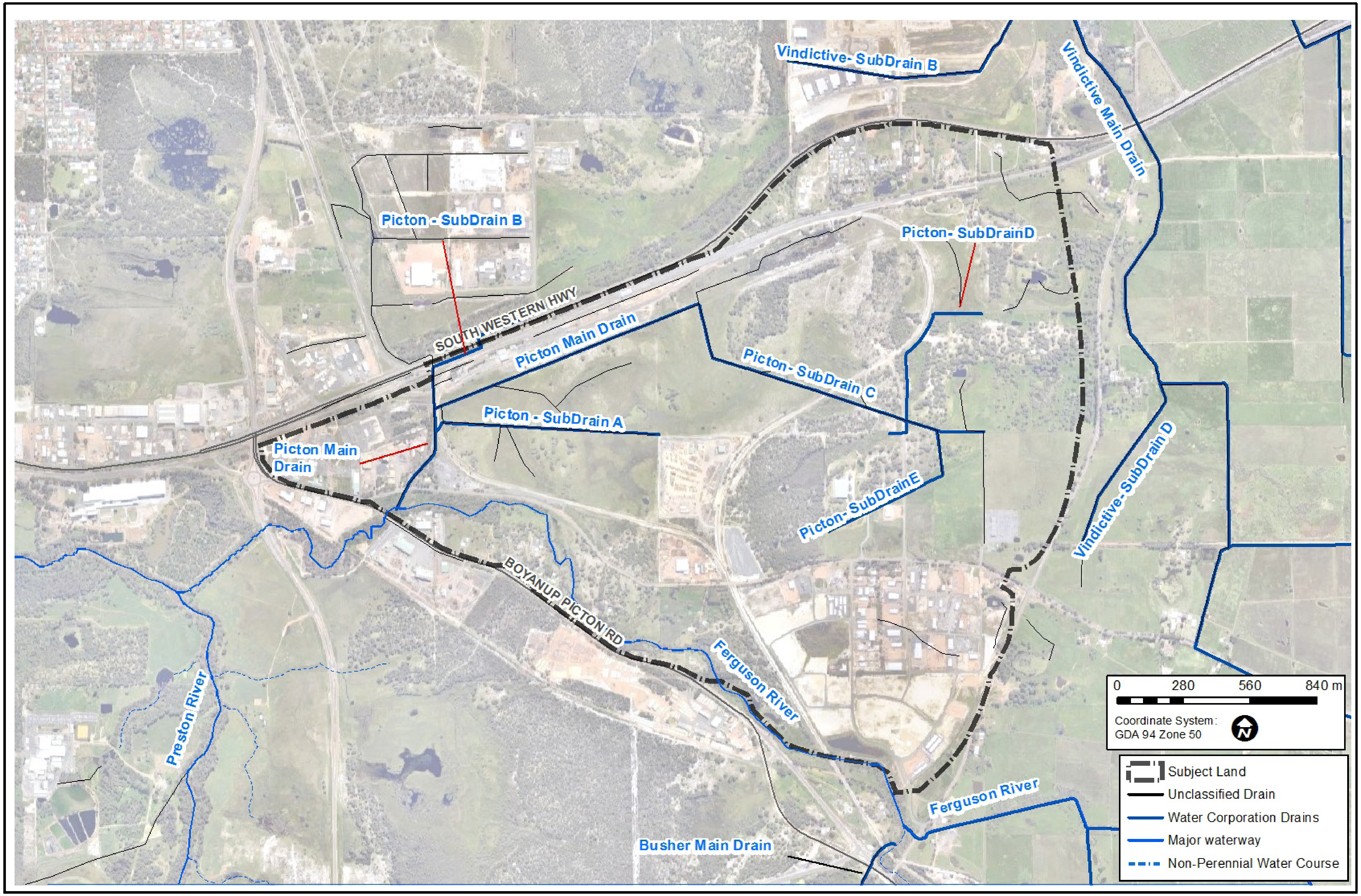


Figure 6 - Surface Water Features

3.7.3 Pre-Development Design Flows

Internal

Estimated pre-development design flows for the 1% AEP (Annual Exceedance Propobability) storm event was calculated using the XPSWMM modelling package. LiDAR and site information were used to determine the boundaries of 12 catchments for the subject land (See Figure 7). Table 3 presents the design flows from each catchment and Figure 7 shows the drainage across the subject land. A detailed assessment with refined model assumptions and inputs will be required at the LWMS and UWMP stages.

Modelling assumptions include:

- A roughness coefficient ('n') of 0.4 for pervious areas, based on land cover and high responsiveness of groundwater to rainfall.
- Catchment grade determined by LiDAR data.
- Impervious area % determined by aerial photography.
- An initial loss of 10 mm assumed for all catchments to account for initial infiltration within the catchment.
- Based on LiDAR analysis, Catchments A, B and E were found to have no outlet. Stormwater generated within these catchments is currently retained on site.
- Predevelopment modelling for Catchment L was not completed as the catchment is currently constructed to final design.

Catchment	Area (ha)	1% AEP Impervious Area (%)	1% AEP Design Flow (m^3/s)	Receiving Waterway	Total Flow (m^3/s)
A	15.00	No outflow from Catchment			
B	9.05				
C	13.50	15	0.129	Vindictive Main Drain	0.300
D	20.75	30	0.171		
E	19.90	No Outflow from Catchment			
F	176.80	30	1.091	Picton Main Drain	2.051
G	155.40	30	0.960		
H	41.70	50	0.744	Ferguson River	2.542
I	36.85	50	0.690		
J	17.20	30	0.622		
K	36.70	35	0.486		
L	63.70	Excluded from model as catchment is constructed to final design			
Total	606.55	-	4.893	-	4.893

Table 3: Catchment Areas and 10% and 1% AEP flow rates

External

The estimated inflow from the Preston Industrial Park (Northern Precinct), north of the South Western Hwy is 0.384 m^3/s in the peak 1% AEP storm event. The report is included in the CD of Attachments.

The peak 1% AEP upstream flow from the Ferguson River will be reported in the DoW's DWMP. As part of the Picton South DSP, some development is proposed within the preliminary floodplain extent shown on Figure 7. However, at the LSP stage proponents will have to demonstrate that the flood regime of the general area is not detrimentally impacted. A review of the proposed stormwater management design will need to be completed as part of any future LWMSs fronting the Ferguson River.

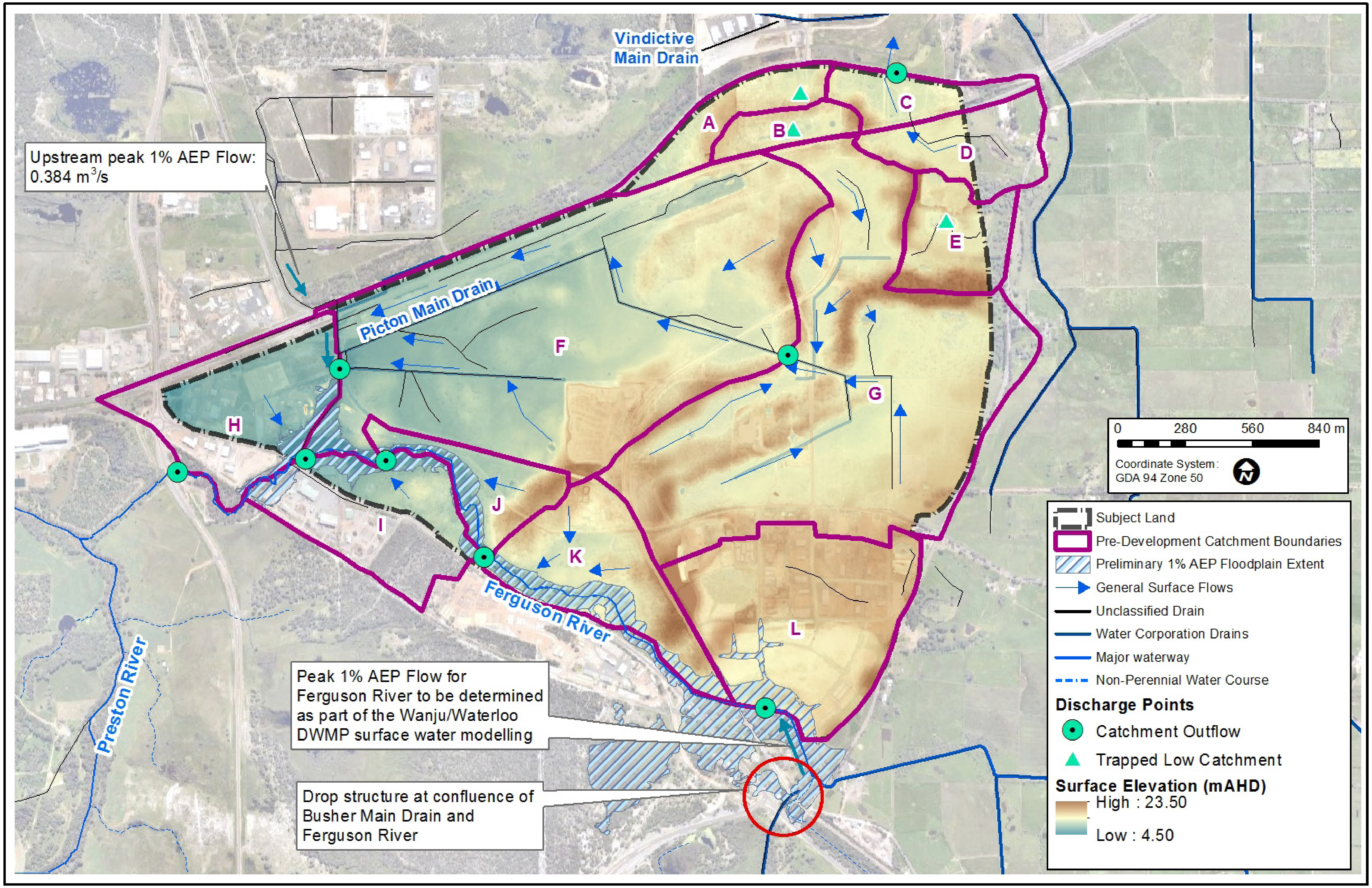


Figure 7 - Pre-Development Stormwater Modelling

3.8 GROUNDWATER HYDROLOGY

3.8.1 Shallow superficial Aquifer

The Department of Water has been monitoring the Superficial Aquifer in the Bunbury area since 2013 to determine groundwater levels in the Bunbury groundwater area. As part of the monitoring program, there are two monitoring bores located within the subject area extent, namely DMP33 and DMP39. Monitoring is taken quarterly with the peak groundwater level occurring in 2014, as shown on Figure 8.

In 2008 and 2009, Calibre Consulting completed three separate monitoring programs along both the eastern and western boundary of the subject area. Peak groundwater levels across all three projects occurred in 2008 with above average rainfall measured for the same year.

Monitoring results for the above mentioned bores have been used to determine basic groundwater contours across the subject area (Figure 8). Groundwater contours are assumed to be above average, in line with measured rainfall depths. To be conservative the groundwater contours should be referred to as Average Annual Maximum Groundwater Levels (AAMGL). The groundwater levels largely follow the general slope of the land with contours falling in a westerly direction from 14mAHD to 8mAHD towards the Preston River.

The rate of horizontal groundwater movement is unknown, although the soil type of most of the site would suggest that it is low during summer, when the levels drop into the underlying heavier soils. In winter and early spring the rate of horizontal movement is likely to increase, as groundwater will travel through the superficial sands near the surface. Localised rainfall is the most likely influence on groundwater depth. The seasonal change in depth is usually in the order of 1-3m vertically.

Using the groundwater contours in comparison to LiDAR elevation data, a depth to groundwater map has also been produced (Figure 8). This information is preliminary and should only be used to help guide decision making and not for detailed design. Over much of the site, the groundwater is likely to be at the surface to 1m below in the winter/spring peak, due to the clayey/loamy nature of the underlying soil and flat landform. Some small sand rises are likely to have over 1.5m of separation to groundwater with the biggest separation to the Maximum recorded groundwater depth being 2.46m. The draw down effect on groundwater from the Ferguson River means that the land close to this system will have areas with more than 1.5m of separation to groundwater.

Minimum and maximum groundwater levels recorded for each bore are shown on Figure 8.

3.8.2 Quality

Groundwater quality has been measured within the eastern portion of the subject land between Harris Rd and the Picton East train line. Monitoring results suggest both Total Nitrogen and Total Phosphorus exceeded the Leischenault Estuary WQIP target values of 1.0 mg/L and 0.1 mg/L respectively. Aluminium and iron concentrations were also found to exceed ANZACC guideline values. Other pollutants may be present, as outlined in Section 3.4, due to current land uses. The poor groundwater quality measured is likely due to current agricultural activities (e.g. high nutrients)taking place in the subject land as well as the actual soil types (e.g. high metals). Water quality was not recorded for DoW monitoring bores DMP33b and DMP39b.

3.8.3 Allocation

The subject area is located within the Bunbury groundwater area and the Dardanup groundwater sub area. As of May 2017, both the Superficial Aquifer and the deeper confined Leederville Aquifer have licence availability. There is no availability within the Perth- Yarragadee South Aquifer.

The potential groundwater yield within the Superficial Aquifer is quite low and may not be viable as a non-potable water source. There is minimal availability within the Leederville Aquifer with several applications currently being processed by DoW. It is unlikely there will be available allocation within the Leederville Aquifer in the near future.

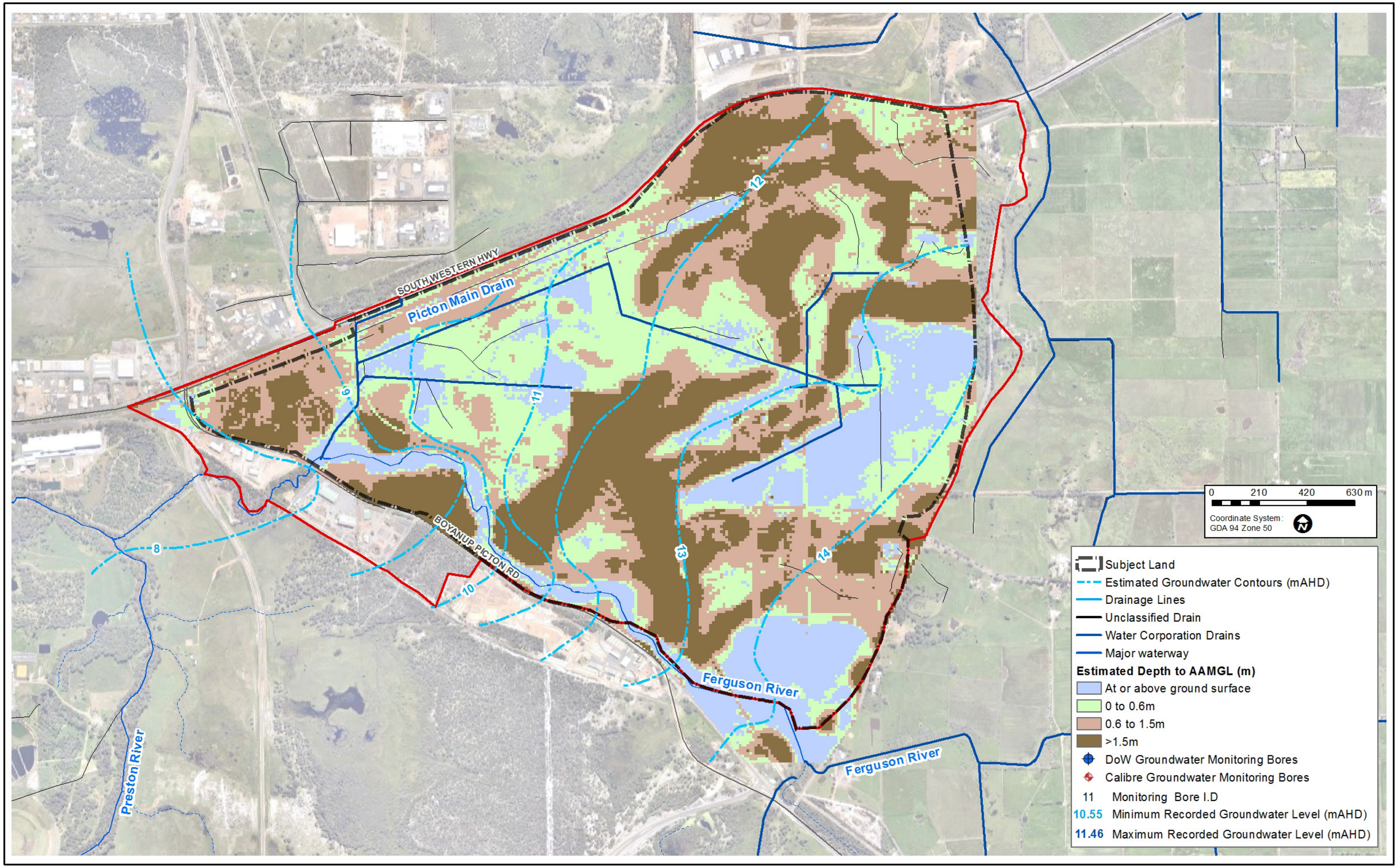


Figure 8 - Indicative Pre-Development Groundwater Levels

3 . 9 ETHNOGRAPHICAL AND SOCIAL SUMMARY

3 . 9 . 1 ETHNOGRAPHICAL CHARACTERISTICS

The following information is a summary of the information mapped by the Department of Aboriginal Affairs (DAA). The summary is focussed on the aspects of the mapping that relate to water management.

The main ethnographical feature is the Ferguson River (DAA Site ID 19796) with mapping covering the Ferguson River channel itself. The site type is consider Mythological and was recently be demoted from a 'Registered Site', however this ruling is currently being disputed (Figure 9).

There are a number of scatter sites, mainly associated with the small sand rises and floodplain adjacent to the Ferguson River. The locations can be seen in Figure 10. These are not closely related to water management on the subject land.

3 . 9 . 2 OTHER SOCIAL CHARACTERISTICS

The Ferguson River contains a thick vegetation layer around it which excludes boating and most fishing activities. There is some seasonal marroning.

The large expanse of private holdings means that the majority of the rest of the site is not used for public social activities associated with water.

3 . 10 EXISTING WATER SERVICES

3 . 10 . 1 POTABLE WATER SUPPLY

The subject land is currently partially serviced with a reticulated potable water source from Aqwest in the developed portions of the Subject Land. A general network can be seen in Figure 9.

Water Corporation also operates the system that supplies the town of Dardanup to the south east.

Existing residents and businesses, not connected to the Aqwest system, rely on their own individual systems to provide potable water.

3 . 10 . 2 WASTEWATER TREATMENT

The subject land is currently not serviced with a reticulated sewage system. Water Corporation operates schemes to the west of the site. This wastewater is sent to the Dalyellup treatment plant.

Existing residents and businesses within the subject land rely on their own individual systems to provide wastewater treatment.

3 . 10 . 3 AGRICULTURAL IRRIGATION WATER SCHEME

The site is not serviced through the Harvey Water Irrigation Scheme, which delivers untreated water for agricultural irrigation.

3 . 10 . 4 GROUNDWATER USAGE

Some groundwater allocation is required for domestic and stock use. However, there is currently no effective furthe rallocation available within the 3 main aquifers in the subject land (Section 5). There may be some opportunities for water trading in the area, however this requires further investigation.

Irrigation is not required for the Precinct 4 Public Open Space (POS).

3 . 10 . 5 OPPORTUNITIES AND CONSTRAINTS SUMMARY

Table 4 provides a summary of the water management related constraints and opportunities for the Picton South DSP area. The table provides a framework from which the management strategies have been written. It carefully considers the existing characteristics of the site and surrounding areas and how each can be best incorporated into making the DSP area sustainable form a water management aspect. It also provides a summary that will assist with informing more detailed studies at the appropriate stage of planning.

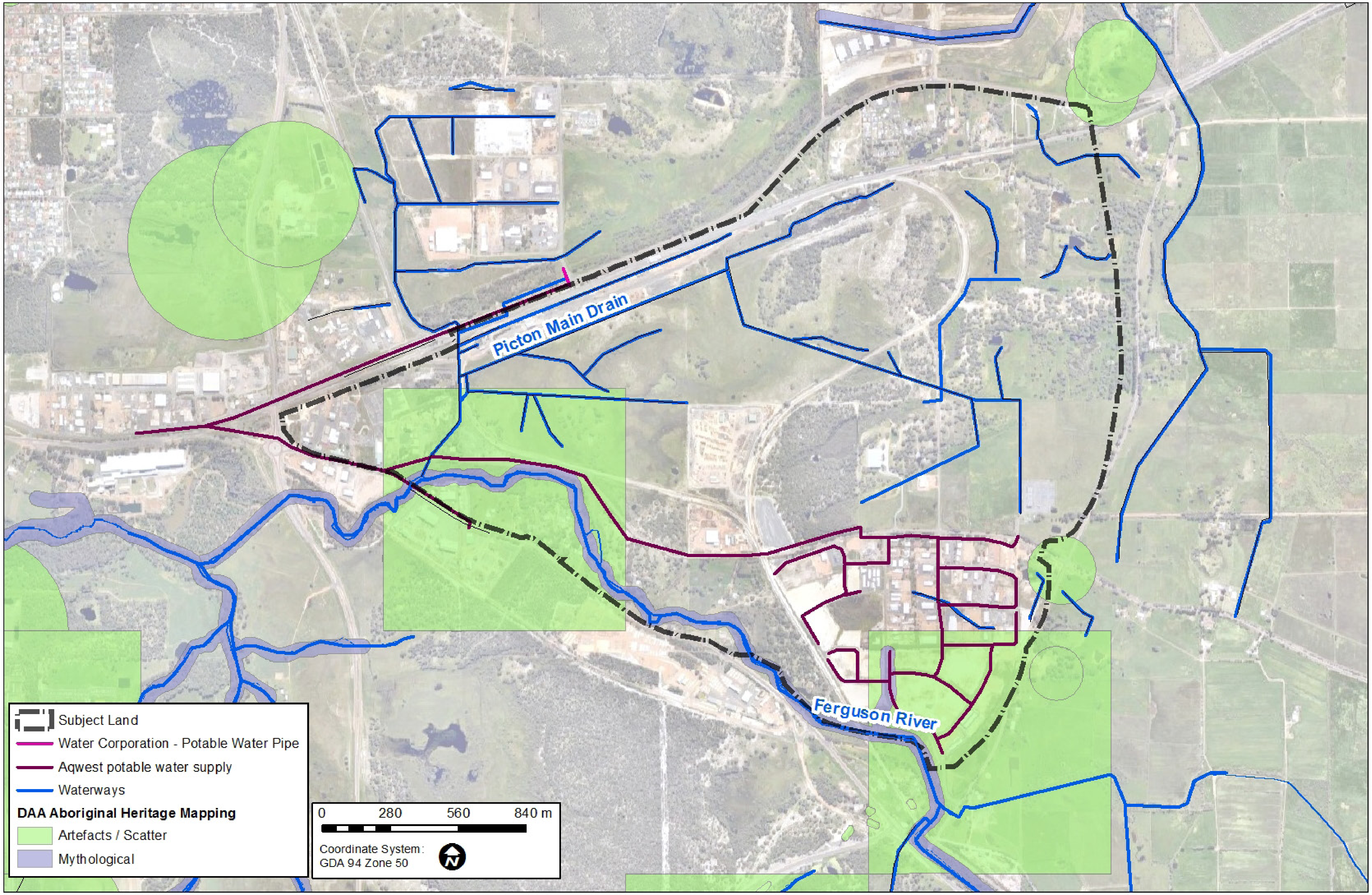


Figure 9 - Aboriginal Heritage Mapping and Water Servicing

Constraints/Threats	Additional information	Ref	Opportunities and Management Options
Aboriginal Heritage Site/ Cultural values	Heritage sites and high cultural value areas associated with wetland and waterways	A	Heritage Sites that relate to water are to be within foreshore reserves, where possible.
		B	Potential interpretive signage/relevant art within foreshore walking network, with linkage back to how overall water management on the site assists with protecting the waterways heritage and cultural values
Low grade/slope of land	Grade may be less than the minimum for a traditional pipe drainage network	A	Utilise swales spaced at design intervals to minimise pipe lengths. Swales able to transport flows at lower grades then pipes.
		B	Utilise wetland systems for treatment to make use of low grade (as appropriate)
Wetlands (and associated buffers)	Conservation Category / Resource Enhancement wetlands	A	Creation of buffers around applicable wetlands, a 50m minimum buffer should be considered the default for the CCW and REW in the 'Wedge' area. Other than on northern boundary, there are no CC or REW in Industrial area.
		B	Preparation and implementation of a wetland management plan for appropriate wetlands, including advice on protection and rehabilitation management strategies.
		C	Enhancement of wetlands and their functional areas.
		D	Provide refuge for fauna between the large areas of native vegetation reserved on-site and to natural wildlife corridors by including in ecological linkages.
		E	Encourage planting of locally appropriate native plants in public and private areas to provide linkages between wetlands, reserved native vegetation and wildlife corridors.
		F	Use of Water Sensitive Urban Design (WSUD) techniques to treat and improve water quality that enters wetlands.
		G	Maintenance of existing flow rates via appropriately designed stormwater and groundwater management designs.
		H	No treatment within the wetland area with some flood storage within buffer area. These structures/basins designed to mimic seasonal wetlands to provided additional habitat.
	Multiple Use wetland areas	I	No ecological constraint. Need to manage high groundwater (see below).
Waterways - (and associated foreshore reserves)	Ferguson River	A	Creation of foreshore reserves (or buffers), which are included within ecological linkages.
		B	Preparation and implementation of a ecological linkages management plan, including advice on protection and maintenance management strategies.
		C	Encourage planting of locally appropriate native plants in public and private areas to provide linkages between swales and waterways.
		D	Use of WSUD to treat and improve water quality that enters waterways.
		E	Maintenance of existing water flow rates via appropriately designed stormwater and groundwater management designs.
		F	Potential construction of footpath (or interpretative trail) along and through ecological linkages to improve recreational facilities and provide an educational resource for the greater community.
	Minor Waterways	G	Enhancement of drainage lines so that they both transport the required volumes and flow rates while providing habitat for fauna through appropriate design. Link in with swale system. Can also be used as 'celebrations of water' and key landscaping features throughout the development.
Flooding	Waterway flooding	A	No development allowed within the 1:100 floodway of the drainage system, unless demonstrated filling of floodway has no adverse impact to upstream or downstream environment.
		B	Use of fill where necessary to achieve the required separation from appropriate flood levels.
		C	Use Multiple Use Corridors, Oval etc. for flood storage and flows during large events.
	Water Corporation Rural Drainage Network design parameters	D	Drainage service providers engaged earlier in the planning process to investigate drainage management options within the area during the staged development.
		E	Work with stakeholders to identify and agree optimal drainage and associated infrastructure governance.
	Internal Flooding	F	Utilise stormwater infrastructure to store and convey runoff during a flood event that protects both infrastructure and receiving water bodies. Post development release flow rates from the subject land will be designed to match pre-development flow rates.
	Unknown flood level/widths	G	Indicative drainage corridor alignments, widths and water levels; pre development flood detention volumes; assessment of adequate land being set aside for flood management will be provided by the LWMS.

Table 4: Opportunities and Constraints

Constraints/Threats	Additional information	Ref	Opportunities and Management Options
Stormwater Flow Rate Runoff	Changes to flow regimes of natural systems	A	Post development outflow rates to generally match pre-development rate.
		B	Use of WSUD to temporarily store and control the flow rates of stormwater runoff and discharges from the development both on private and public land.
		C	Drainage lines to be maintained as close as possible to existing inverts and locations, unless environmental investigations show changing them will be beneficial.
Stormwater Nutrients, Contaminants and Pollutants	Need to manage historical and new pollutants including salinity	A	Use of WSUD (e.g. bioretention units, wetlands, overland flow etc.) to reduce total pollutant loads entering groundwater and leaving the subject land as surface flow.
		B	Structural separation practices applied at a lot level to minimise pollution from industrial activities.
		C	Introduction of non-structural best management practice, including educational of lot owners regarding responsible disposal and use of water from their business.
		D	Landscaping to utilise strategies that will not produce excessive fertiliser requirements and potential leaching of nutrients.
		E	Removal of potentially high nutrient loading agricultural practice currently on the land.
		F	Monitoring of water quality post development to improve treatment strategies, if required.
Groundwater Levels	Depth to groundwater in relation to infrastructure	A	Use of suitable fill where necessary. Suitable fill should be stipulated in future geotechnical investigations, and should include appropriate permeability requirements and a provision for soil amendments to improve nutrient retention while having a permeability which minimises mounding.
		B	Use of suitable fill, roadside swales and sub-soil drainage pipes where necessary to obtain adequate separation between controlled groundwater levels and infrastructure.
		C	Ensure development has no negative impact on groundwater resources, significant wetlands and waterways influenced by site.
	Protection of groundwater dependent ecosystems	D	Infiltration of stormwater wherever possible on both private and public lands.
		E	Monitoring of groundwater levels pre development to increase the accuracy of the site's specific peak levels.
		F	Monitoring of groundwater levels post development to improve management strategies, if required.
Groundwater Quality	Mobilisation of historical pollutants (Nutrients, metals, salinity)	A	Provide treatment wrap around subsoil system or end of pipe treatment
	Potential new pollutants (nutrients, metals, salinity, hydrocarbons)	B	Minimise changes in post development groundwater levels (especially reducing them)
		C	Use of WSUD (e.g. bioretention units) to reduce total nutrient loads entering groundwater.
		D	Treatment of groundwater, including bioretention gardens, filters around subsoil pipes and other nutrient attenuation mechanisms.
		E	Landscaping to utilise strategies that will not produce excessive fertiliser requirements and potential leaching of nutrients.
		F	Removal of potentially high nutrient loading agricultural practice currently on the land.
		G	Monitoring of groundwater quality post development to improve treatment strategies.
Acid Sulphate Soils (ASS) Risk		A	Undertake ASS risk investigation of the site at appropriate stage of development.
		B	Keep groundwater levels at similar levels to minimise mobilisation of Acidic groundwater from ASS.
		C	Use of fill, WSUD and minimising the disturbance to the existing soils to reduce the risk of disturbing ASS.
Heavy soil type	Low infiltration rate/ perching	A	Undertake geotechnical investigations to determine infiltration rates to assist with localised stormwater design.
		B	Utilise stormwater management structures that do not rely on infiltration
		C	Incorporate high permeability fill as appropriate

4. SURFACE WATER DRAINAGE MANAGEMENT STRATEGY

The key objectives for surface water management are:

- Protection of key wetlands and waterways from the impacts of industrial runoff
- Protection of infrastructure , human life and assets from flooding and inundation

4.1 SURFACE WATER QUANTITY MANAGEMENT

Urbanisation results in increases impervious area. Increased rates and volumes of stormwater rurnoff must be managed to protect infrastructure, environment and assets from flooding and inundation. Stormwater management must also provide water treatment measures to prevent contamination of the downstream environment.

Surface water quantity design objectives are as follows:

Stormwater Flows

- Management of post-development flows to match the pre-development scenario up to the critical 1% AEP storm event.
- identified external flows to be managed within the subject land. Upstream flows within the Ferguson River will be reported with DoW's DWMP for the area. Preliminary floodplain mapping has been provided by DoW, as shown on Figure 10.
- In the post-development scenario, all trapped low catchments will merge with catchments that have an outflow connection. The peak outflow at this point will not increase as a result of the merge and will be detained to the pre-development peak 1% AEP flow rate at this point. Storages and flows across each cathcment will be sized on a pro-rata basis, determined by modelling results presented in Table 5.

Stormwater Detention and Conveyance

- A combination of detention swales and basins may be used throughout the DSP area, with outflows controlled to peak pre-development flow rates. Indicative locations are shown on Figure 10, however these may be modified or split depending on how individual lots are developed.
- The internal road network will be used to convey peak 1% AEP flows throught he subject land via overland flow, in conjunction with the pipe and swale network.
- Piped drainage within the road network will be used to convey the 10% AEP storm event.

Infrastructure Protection Measures

- Should any proportion of the proposed industrial lots be used for floodplain storage, local authorities will have to monitor and regulate surface levels as the planning process progresses.
- All finished flood levels are to be set a minimum of 300mm above the adjoining road level and flood levels generated within the LSP areas. Building pad levels are to also be a minimum 500mm above the 1% AEP flow level of the subject land's major waterways and flow channels/swales, such as the Ferguson River and Picton Main Drain.
- Industrial lots are required to retain 2m^3 of storage per 65m^2 of hardstand area. A piped lot connection trickle outlet may be provided to the street drainage network, with the rate of discharge assumed to be inline with maximum emptying presented in the DoW's stormwater manual, roughly 1L/s/ha. Where possible the storage area can also form part of the on lot landscaping. Local authority guidelines are provided in the CD of attachments.

Waterway and Wetland Management

- The Ferguson River consists of a small defined channel and flat surrounding floodplain with the current modelled flood extent shown on Figure 10. Final upstream peak flows within the Ferguson River will be reported in DoW's DWMP for the area.
- Modifications may be made to the Picton Main Drain and internal swale/ drainage channels, provided all modifications can be demonstrated to have no adverse impacts to the upstream or downstream environment.
- Critical wetlands (Identified in Section 3) and the Ferguson River foreshore will be retained and rehabilitated. as part of the Picton DSP development. The extent of revegetation will be defined further in corresponding foreshore management plans. A conceptual Foreshore Management Plan has been completed and is described in Section 7.3.2.

4.1.1 Post-Development Stormwater Modelling

Indicative post-development catchment boundaries, discharge points and basin areas are shown in Figure 10. Catchment boundaries were estimated using the Picton South DSP layout, in conjunction with pre-development catchment boundaries.

Post-development modelling was completed using the XPSWMM modelling package. The peak 1% AEP allowable discharge rates presented in Table 5 were estimated based on pre-development catchment boundaries and a pro-rata analysis of interesected post-development catchments. The Columbus Drive development (Figure 10) has utilised the approved peak 1% AEP outflow rate of 0.511 m^3/s.

Indicative Detention basins for each post-development catchment were sized based on the peak 1% AEP allowable discharge rate. Subsequently the peak 10% AEP outflow rates were calculated as a result of sizing the detention storage basins.

Modelling assumptions are as follows:

- The assumed post-development land use breakdown for each catchment is 20% roads, 75% Industrial Lots and 5% drainage/ other.
- The overall peak 1% AEP flow rate has increased by 0.217 m^3/s which is wholly within the Picton Main Drain Catchment. This is due to the higher flows used within the approved Columbus Drive LWMS.
- Industrial lots are assumed to consist of 90% hardstand area.
- Industrial lots modelled with a 13.8mm initial loss, which roughly equates to 2m^3 of storage per 65m^2 of hardstand area.
- Roads assumed to be 90% impervious and drainage/other assumed to be 30%. Both land uses are not assumed to have an initial loss.
- Detention basins have been sized based on 1:6 side slope, 1% AEP water depth of 1.0m with the basin outlet set at the base of the basin.
- Modellling was not completed for Precinct 4 as the area has been subdivided and constructed to final design. Outflow from Precinct 4 is currently directed towards the Ferguson River and does not impact other Precincts.
- The peak 1% AEP outflow from Catchments Cat3, Cat4 and Cat5 are detained to match design inflows identified in the Lot 105 Columbus Drive LWMS of 1.16 m^3/s. This peak outflow is slightly higher than the prorata outflow identified in Section 3.

Catchment	Area (ha)	1% AEP Flow (m^3/s)	1% AEP Required Storage Volume (m^3)	10% AEP Flow (m^3/s)	10% AEP Required Volume (m^3)	Receiving Waterway	Total 1% AEP Flow (m^3/s)
Cat1	37.50	0.128	20,460	0.091	13,960	Vindictive main Drain	0.300
Cat2	21.90	0.172	11,245	0.113	8,790		
Cat3	72.80	0.473	30,985	0.457	19,665	Picton Main Drain	2.270
Cat4	45.15	0.295	22,660	0.231	15,740		
Cat5	60.05	0.391	27,565	0.362	17,470		
Cat6	63.35	0.465	As per approved Lot 105 Columbus Drive LWMS				
Cat7	22.35	0.140	10,620	0.119	7,175		
Cat8	81.65	0.506	39,170	0.433	25,725		
Cat9	47.00	0.776	12,330	0.624	7,715	Ferguson River	2.54
Cat10	18.50	0.348	4,365	0.316	2,660		
Cat11	18.35	0.342	6,900	0.309	2,430		
Cat12	15.95	0.576	8,610	0.218	2,430		
Cat13	37.90	0.502	9,225	0.445	5,260		
Cat14	63.60	Constructed to final design					

Table 5: Post-Development Stormwater Management

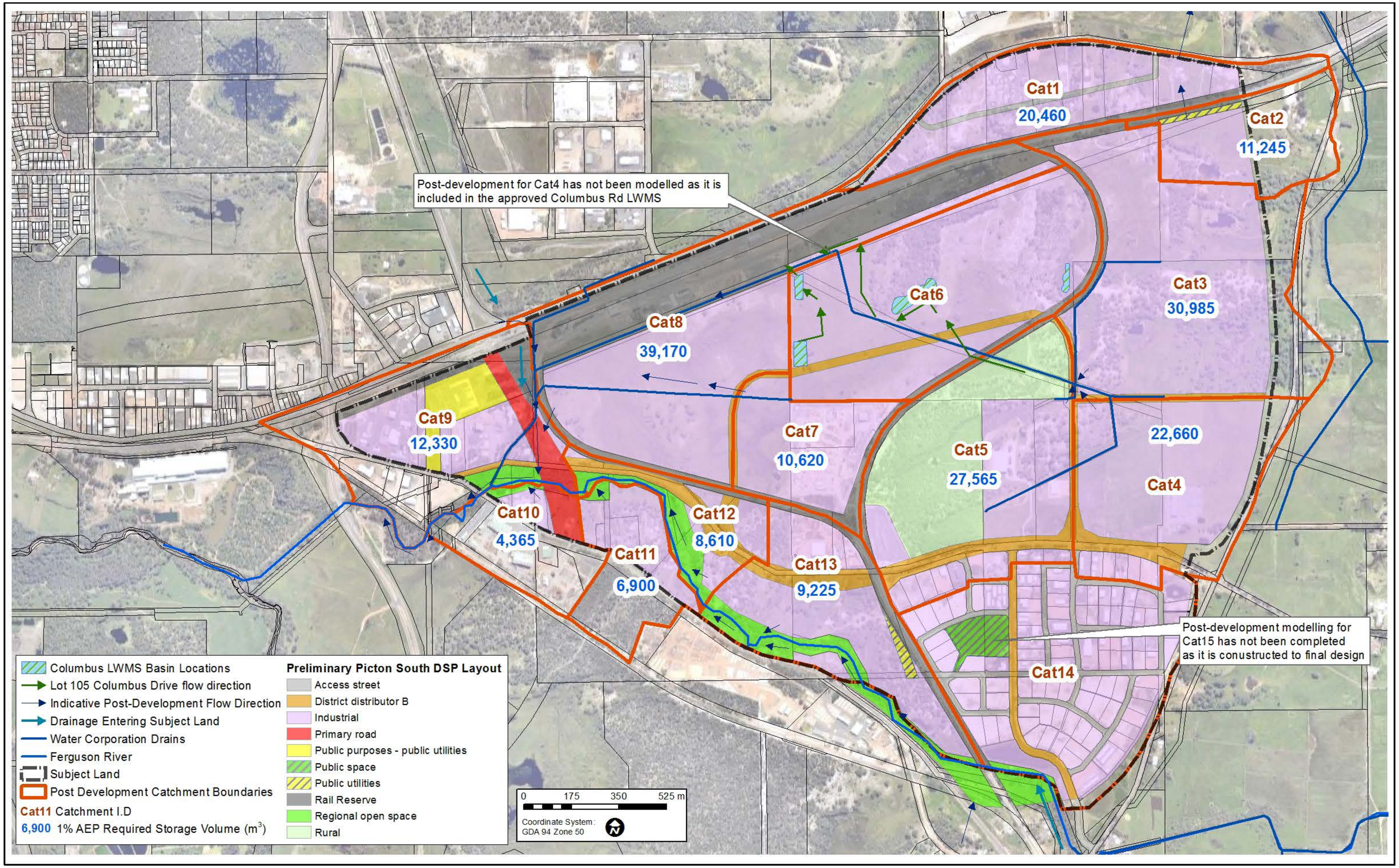


Figure 10 - Post-Development Stormwater Management

4.2 SURFACE WATER QUALITY MANAGEMENT

Detention and treatment for small (approximately the 1 EY events/ first 15mm) will involve a variety of on-lot and road systems. This combined system will focus on both flow control and water quality management.

The development will utilise a range of best management practices to manage water quality across the site and a treatment train approach is likely to be employed for many areas. By using a treatment train approach, (eg multiple points where water is managed and or receives treatment as it moves through the development), there is a greater chance that the quality of water leaving the DSP area will be suitable for the receiving water body. The methods outlined will assist the development area to meet the guidelines set out in the Leschenault Estuary Water Quality Improvement Plan for water quality improvement of this catchment. The relevant guideline is for discharging water to have a Total Nitrogen content of 1.00mg/L or less and Total Phosphorus to be 0.10mg/l or less.

4.2.1 Lot Based Practice

On-Site Lot Treatment

It is proposed that individual industrial and commercial lot owners will provide treatment options for the 1 EY event and attenuation at a rate of $2m^3$ for every $65m^2$ of impervious area. The on-site flows can be detained with a variety of methods including shallow landscaped bioretention basins, rainwater tanks and on-site soak wells, where separation to groundwater exists. The Shire is to enforce this treatment and storage as part of the building construction phase.

The most effective method in implementing best practice in industrial precincts is to ensure that pollution sourced from work areas does not discharge into the stormwater infrastructure (the concept of structural separation is displayed in Figure 15). Practices that land managers and owners can undertake involve roofing work areas, directing wash-down water to storage or onsite effluent systems, and controlling activities undertaken in areas that link with the stormwater infrastructure. The guiding principles and practices in the construction and management of industrial lots should be an intention to separate areas subject to pollutants and contaminants from paths that would transport water to the stormwater infrastructure. The developer will encourage structural separation, and the local government agencies will be encouraged to ensure elements are included for building application approvals.

This control and treatment of stormwater includes the carparks and outside storage/laydown spaces with each business. In general, the treatment and storage facilities are to be located within the landscaping areas of the site and towards the front of the lots. Some storage may also happen in areas close to subsoil networks, to assist with infiltrating the stormwater and potential impacts on groundwater rise.

Education

Education of businesses and their employees is very important to ensure that they are knowledgeable about the different systems and potential impacts on the environment that their industrial and commercial practices could have. As part of the future development of individual lots there is the opportunity to provide education focused on individual on-lot water quality management. It is essential for the overall management of water quality within the subject land that employees are educated on the following:

- The difference between the stormwater and on-site treatment systems for each business;
- Do not sweep or dispose of litter or waste into gutters or drains, and keep the footpath, gutter and outside areas near their business free of litter. This includes providing adequate refuse storage for litter and cigarette butts;
- All waste skips and bins should be stored in a designated area with a roof and surrounded by toe walls to prevent any leakage entering the stormwater system;
- Lids on bins and skips should be kept closed to stop loose litter being blown away. This also stops rain getting in which can wash oils, solvents and chemicals out of rags and into the stormwater;
- Spills from loading and unloading operations are a common source of stormwater pollution. Where possible conduct all activities with the potential to pollute water (e.g. loading and unloading, transfer of materials) within roofed and bunded areas or indoors;
- Storage of potential pollutants, including precautions in case of leakages, should be in secured areas. The storage may require roofing, a physical barrier for leaks to leave the storage (e.g. a lip at openings) and possibly a bund if appropriate.
- When moving, pumping, loading or unloading liquids make sure that a spill kit is available for use in case of a spill. Depending on the type of liquid, spill kits can be as simple as a drum full of sand or sawdust and a shovel; and
- How to handle materials to reduce waste and prevent spills.

This may be achieved through the provision of education material during the Development Application phase. This should be supported by the land developer and the Local Authority.

Industrial and Commercial Contaminant Risk Management

The greatest risk to contamination of the natural environment from the development will be industrial waste, which can include petroleum hydrocarbons, heavy metals, surfactants, toxins and/or salts (DoW, 2009b).

As previously mentioned, structural separation and education will be paramount to minimising the risks of contamination from any of the lots within the subdivision. The Western Australian Business and Environment Manual developed by the WA Chamber of Commerce and Industry and the Centre of Excellence in Cleaner Production provides an online resource. The manual is designed to assist WA businesses to successfully manage their environmental issues together with their business operations. Importantly it provides information relating to environmental legislative requirements and obligations at local, State and Commonwealth level for a range of industry practices.

Statutory requirements, approvals and managing agencies are outlined in environmental guidelines, codes of practice and Water Quality Protection Notes for a range of businesses and activities in Western Australia. Generally the Department of Environment and Regulation, Department of Water and Department of Health are the three major State government agencies involved in waste management and contaminated sites.

Contingency plans and emergency responses should also be developed where appropriate for the industry on the lot. The DoW's Water Quality Protection Note 10: Contaminant Spills – Emergency Response is a useful reference for lot owners.

4.2.2 Treatment Structures

The following section highlights the treatment systems to be used within the DSP areas. It is worth noting that the type of development proposed will influence the likely location of treatment systems. The high percentage of impervious area used within industrial lots means opportunities for large bioretention basins are low. The water is more likely to be directed to small pocket bioretentions where space allows. There may be opportunities for some tree pit bioretention systems or bioretention gardens on the non-active frontages. On larger streets, water may be directed to the central medium for treatment. These can be considered at the detailed design stage.

Bioretention Systems

In general, flows will initially be directed from the road surface to the kerb line and into either roadside bioretention systems or side entry pits, which would discharge to bioretention basins or swales. This will depend on the location and design of each catchment.

Bioretention systems are designed according to the latest FAWB Adoption Guidelines for Filter Media in Biofiltration Systems and the Stormwater Management Manual for WA design guidelines. The bioretention gardens are to be sized to a minimum 2% of each connected impervious catchment. Plant species are to be as per the Vegetation guidelines for stormwater biofilters in the south-west of Western Australia.

The bioretention areas should only require irrigation during the initial 2 to 3 years of establishment, depending on the seasons. They should require no fertiliser application and irrigation demands after establishment should be predominately met by stormwater alone. In summer, some top up irrigation will assist with plant survival and reduce the chance of nutrients leaching from the system. For this reason it is recommended that the bioretention systems are irrigated. This can also be complemented with a saturated zone built into the bioretention system, which will allow for longer storage of stormwater and irrigation water.

The gardens will be designed to assist in the removal of nutrients, sediments and other potential contaminants from stormwater as the water infiltrates through to groundwater or is directed to the pipe network.

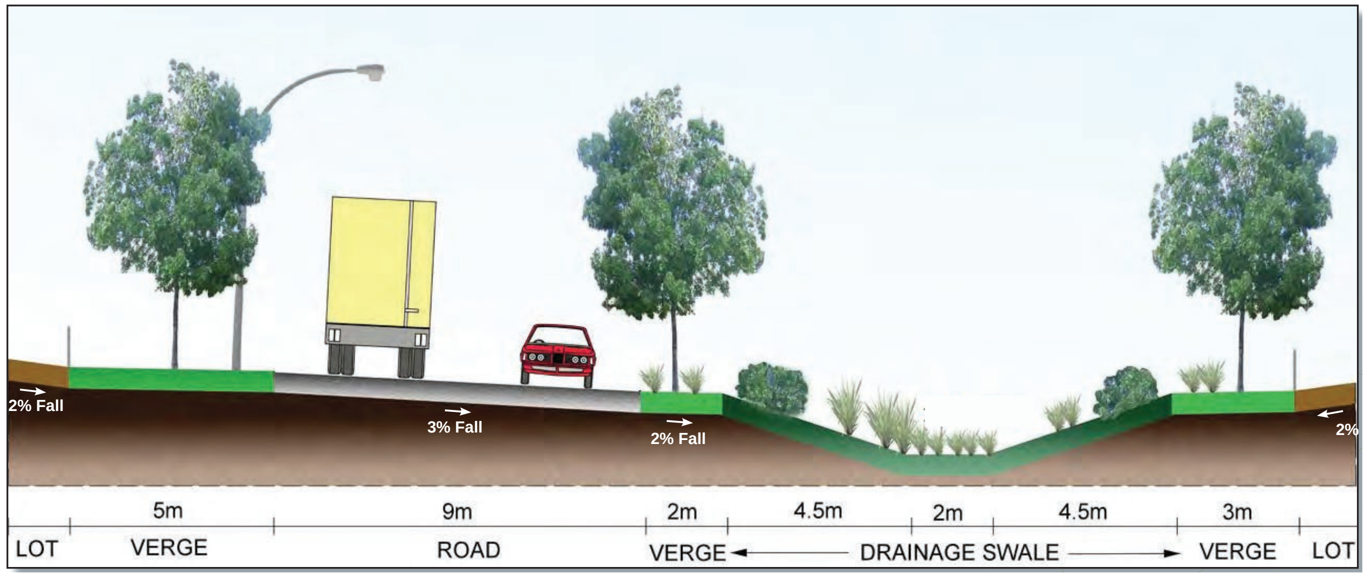
Bioretention gardens have been demonstrated to achieve a 50% decrease in nitrogen, 80% decrease in phosphorus and a 90% decrease in total suspended soils (Department of Water's Stormwater Management Manual).

Swales

The vegetated swale network will also form part of the treatment train. Some of these may function as bioretention swales, especially where flows are small. The swales will slow water down, and in combination with the biological functioning of the plants and associated biofilms, this will allow for sediment and litter settling and nutrient absorption. The swales will mainly be planted with locally native species and suited to riparian habitats. Vegetated swales typically have a capacity for a 25-50% reduction in nutrients. Indicative swale locations in relation to industrial and residential lot layouts can be seen in Figures 11 and 12.

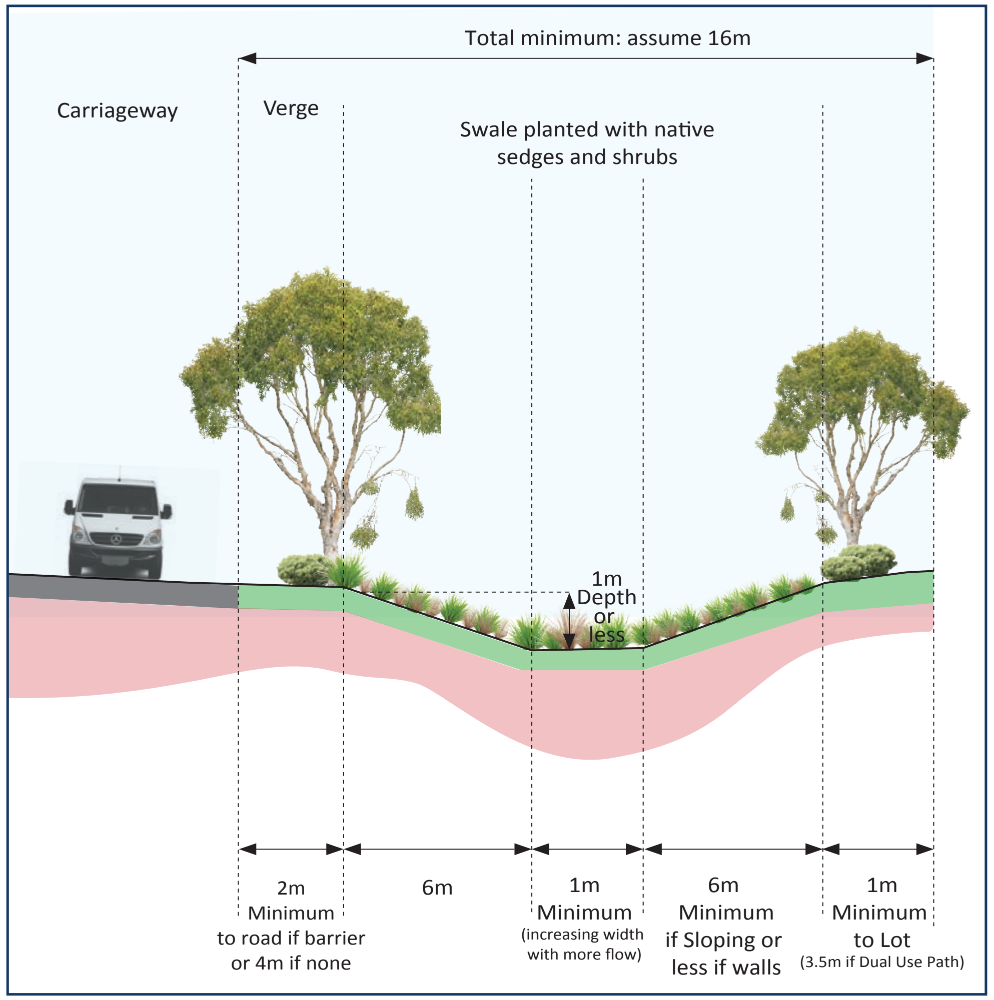
Example of small roadside constructed swale

Example of bioretention in carpark



Note: All widths shown are indicative and subject to detailed design

Figure 11- Road and Swale Cross-section Typical Arrangement for Major Drainage Lines



Note: All widths shown are indicative and subject to detailed design and landscaping treatment

Figure 12 - Road and Swale Cross-section Typical Arrangement for Minor Residential Street Swale

4.2.3 Construction Phase Controls

A key aspect of managing water quality for the development will be involved in the construction of the subdivision. At the subdivision stage of development there will be a requirement to prepare and implement erosion and sediment control plans. Management options should also focus on minimising potential pollutants during the construction phase. The management options may include:

- Assessment of erosion risks;
- Stabilisation of stock piles;
- Minimise the exposure times for disturbed areas;
- Sediment curtains, fences, and filters at inlets and other control points;
- Cut off drains;
- Temporary sediment basins;
- Stone mattresses; and
- Hydro-mulching and interim plantings.

4.2.4 Landscaping

Landscaping of public areas (including road reserves, Multiple Use Corridors and drainage reserves) is to have a focus on utilising native species that will require minimal watering and fertiliser application. By implementing this strategy, the landscaping will not contribute to the pollution of the groundwater or surface water generated on the site. Furthermore, by utilising native plants with a high ability to absorb excess nutrients, the landscaping can help remove nutrients within the swale and basin systems, as well as take up nutrients from the groundwater. This can help reduce the overall load of nutrients leaving the site.

Some other landscaping areas will be highly formalised, with significant areas for people movement. This means the amount of area for garden beds may be reduced. Water features are also likely to play a part. Evaporation and infiltration from these features will need to be considered in any water balance modelling undertaken,

Landscaping concept plans produced as part of the LWMS and more detailed landscaping plans at the subdivision stage are to show how they are managing nutrients and other pollutants as well as overall water usage.

4.3 STAGING

Due to the staged process of development of the subject land (Precincts 1 to 4), appropriately detailed drainage designs will need to be completed for each Precinct area, in support of the corresponding LSP. LSPs should be detailed over the full extent of each precinct. Precinct 4 will not require detailed drainage designs as this area is already subdivided and constructed to final design. Where possible, storage requirements is generally to be sized on a pro-rata land area basis. Exceptions may be made where an LWMS covers an entire catchment and an agreement can be made between all land owners for water to be stored in a more suitable location. Each of these stages will need to consider the movement of water into, across and out of the stage in relation to the overall drainage strategy. This may include pror-ata storage (and basins) on a particular development area, should a whole precinct not be developed concurrently. Drainage within Precincts 1 to 3 will be documented within corresponding LWMSs and UWMPs.

Where there are existing drainage and irrigation networks within the development stage, as the overall function of these will need to be retained until the entire upstream and downstream area within the subject land is developed. This is covered in more detail as part of the Governance section (Section 9).

5. GROUNDWATER AND ACID SULFATE SOIL MANAGEMENT STRATEGY

The focus of groundwater management for the subject land is to maintain groundwater as close as possible to existing levels, while maintaining adequate separation from infrastructure. Furthermore groundwater will be managed to achieve a high water quality.

5.1 INFRASTRUCTURE SEPARATION

A suitable vertical separation between necessary infrastructure surface levels and the final groundwater level, including potentially a Controlled Groundwater Level (CGL) is to be implemented within relevant areas of the subject land. The CGL is to be set in accordance with the water resource considerations when controlling groundwater levels in urban areas (DoW 2013). The guidelines provide for a flexible approach that take account of the rigour of the data available and local conditions that influence the appropriate level at which the CGL may be placed, which has been assumed to be effectively at the current natural surface for areas of clay loams. This is due to the perching that is likely to occur on top of this layer, wherever sand fill is used. The actual separation will depend on the landuse, associated infrastructure and its sensitivity to groundwater.

Where separation is required, this will generally be achieved through the use of clean fill, subsoil piping and open swales. The level of separation has not been set to allow for proven innovative options for fill reduction. All final separation distances will need to be proven to not adversely affect infrastructure or receiving environments. They will also need to be approved by the local authority.

Where the development's groundwater is directly influencing sensitive ecological systems, groundwater levels are to be managed to minimise any potential impacts. This is covered in more detail within Section 15. In general, groundwater will be controlled at a level similar to the current average maximum levels, so as to achieve this goal of minimal impact on the groundwater dependent ecosystems. Groundwater will still feed into the wetland systems and the receiving rivers through the swale drainage system, as well as direct ground flow.

5.1.1 Subsoil system

Subsoil placement will influence the CGL directly. In general subsoils will be laid in conjunction with and adjacent to the pipe drainage network. Further subsoils may also be used within lots, where there is a need to minimise mounding. This is likely to be the case for industrial areas, where the lot size is large. The final distance between sub-soil pipes will be determined by the permeability of the soil within that section of the development and the sensitivity of the infrastructure and landuse above. The subsoil discharge points (if separate to the drainage network) will generally be set 100mm above the base of the swale or basin.

5.1.2 Swales

The base of the swales will be used to control groundwater directly, as well as provide a free flowing outlet for the subsoil network. By using the swale network, with its ability to have free draining outlets, mounding of the groundwater is minimised. This will result in the minimisation of fill across the site.

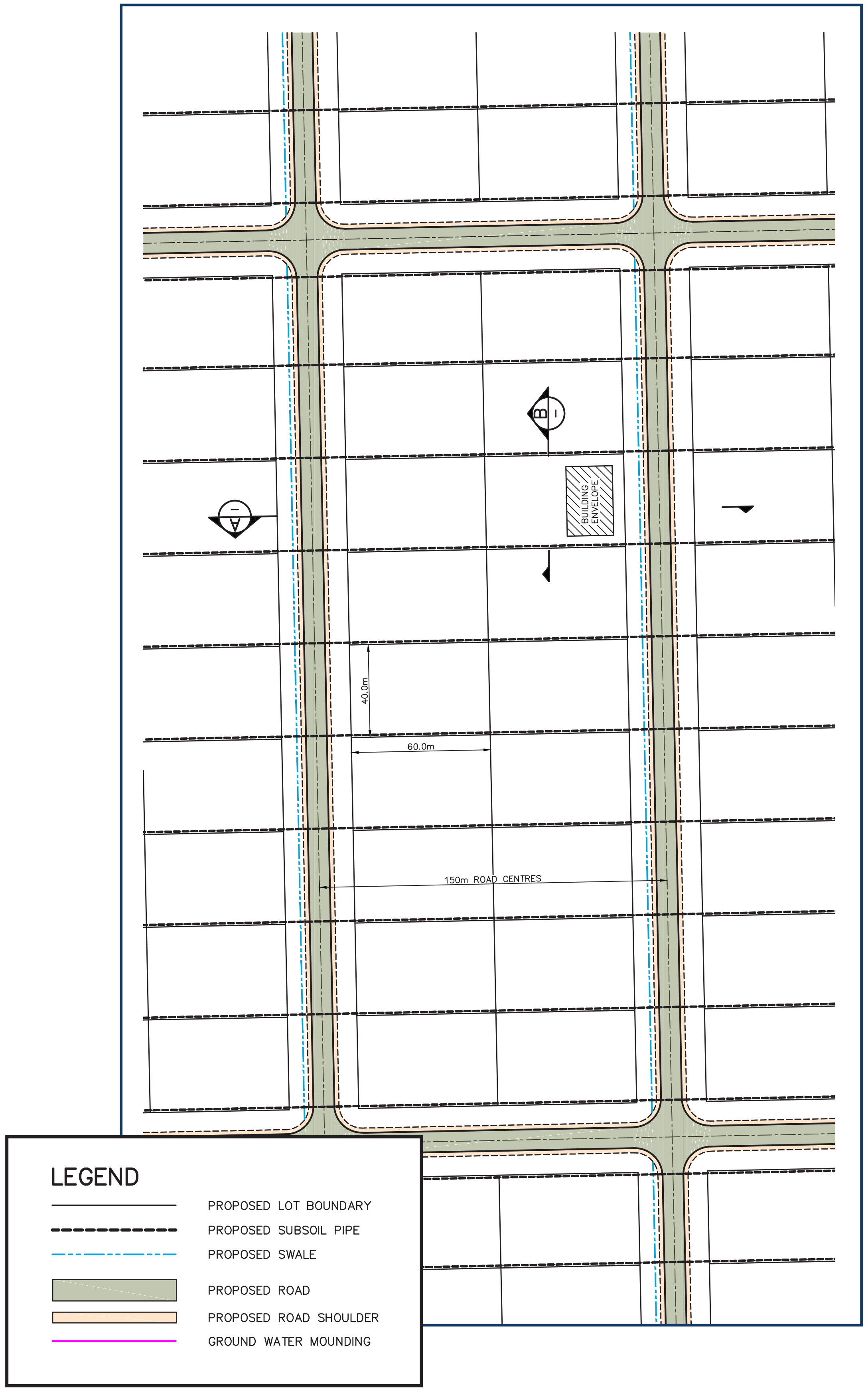


Figure 13 - Typical Subsoil Detail for Industrial Lots - Plan View

5.1.3 Fill

It is likely that much of the site will require importation of fill material to achieve the minimum separation to groundwater level. Fill requirements should be kept to a minimum as a more sustainable use of scarce fill resources. More information on the utilisation of fill can be found in Section 10. The information below provides a summary of fill in relation to groundwater levels.

Some fill is likely to be clean sand, due to its high porosity. The high porosity means that the mounding between subsoils/swales is minimised, allowing for further distances between these controlling structures. Any fill of imported sands will require compaction to relevant standards.

The clean sand also allows for direct infiltration and potentially shallow soakwells , minimising surface run off. For this reason it is most likely to be used in areas where on lot infiltration is able to be achieved. Where soakwells are to be used, their sizing is likely to impact the required separation distances to groundwater. This means that the CGL (including mounding) will need to be below the invert of the soakwell. By utilising surface or above ground storage, as well as sealed below ground systems with a trickle outlet to the road drainage network, instead of soakwells, fill levels may be able to be reduced. The minimization of fill is a critical component of achieving a sustainable development within the DSP area.

Clay fill may also be used. This will need to take into account increased runoff, reduced infiltration and potential impacts on buildings and road construction. This may be a suitable option for higher density areas, where the level of impervious surfaces is already high, and the land available for soakage within each lot is reduced.

Within industrial lots, there is the possibility to have a variety of fill levels across each lot. Certain areas of industrial lots require less fill to actually function without being impacted upon, or adversely impacting the groundwater. These are areas that don't contain significant infrastructure, such as buildings. These areas of lower fill requirements include, parking areas, laydown areas and general vehicle movement areas. The drainage basin areas are also able to utilise less fill, provided they are designed to have their bases close to groundwater. By being close to groundwater, the basins can actually function similar to an ephemeral wetland. By using basins, rather than soakwells, fill levels are likely to be minimised. Above ground storage, or sealed below ground systems with a trickle outlet may also be used to minimize the fill requirements

The building envelopes within industrial areas should require a maximum of 1.0m of fill/separation to the groundwater. The surrounding lot will generally only requires 0.3m of fill above the maximum groundwater mound (in the middle of the lot). On the edges of the lot, where the subsoils (and at the front of the lots, near the roadside swales) the depth to groundwater will be less than the middle, due to the typical mounding curve. For this reason, the front of the lot and potentially the sides is where stormwater basins/soakwells and buildings etc. should preferentially be located.

A diagrammatic representation of a typical industrial lot and development subsoil configuration can be seen in Figure 13.

5.2 LOWERING OF GROUNDWATER LEVELS

Lowering of groundwater to below the existing pre-development groundwater regime, can assist with minimising fill. This may be an option for areas away from significant natural environments such as the Ferguson River and any areas of significant wetland vegetation.

Lowering water away from these sensitive ecosystems will minimize any potential ecological impacts.

The risk of Acid Sulfate Soils (ASS) will need to be carefully considered as well, although if the levels are only slightly reduced below the maximum and don't impact the minimum levels, then there is unlikely to be significant impact on both the production of ASS and the mobilisation of acidic groundwater and pollutants mobilised by the increase in acidity. Due to the area being identified as moderate ASS risk, an ASS management plan, including on site geotechnical investigations, will need to accompany any investigation into options for lowering groundwater. This will assist with managing any potential risks and should be comleted as part of the LWMS and UWMP.

The potential to lower groundwater levels will be limited on the subject land, due to the land's flat nature and the invert of the existing drainage points, which currently control peak groundwater discharge. Groundwater discharge is controlled by existing on site drains and the swale drain along the boundary roads.

To achieve significant reductions in groundwater very close subsoil pipes or swales are required, which may not be feasible.This is due to the low lateral permeability of much of the site,

In general, when setting the Controlled Groundwater Level, due consideration is to be given to the report titled water resource considerations when controlling groundwater levels in urban areas (DoW 2013).

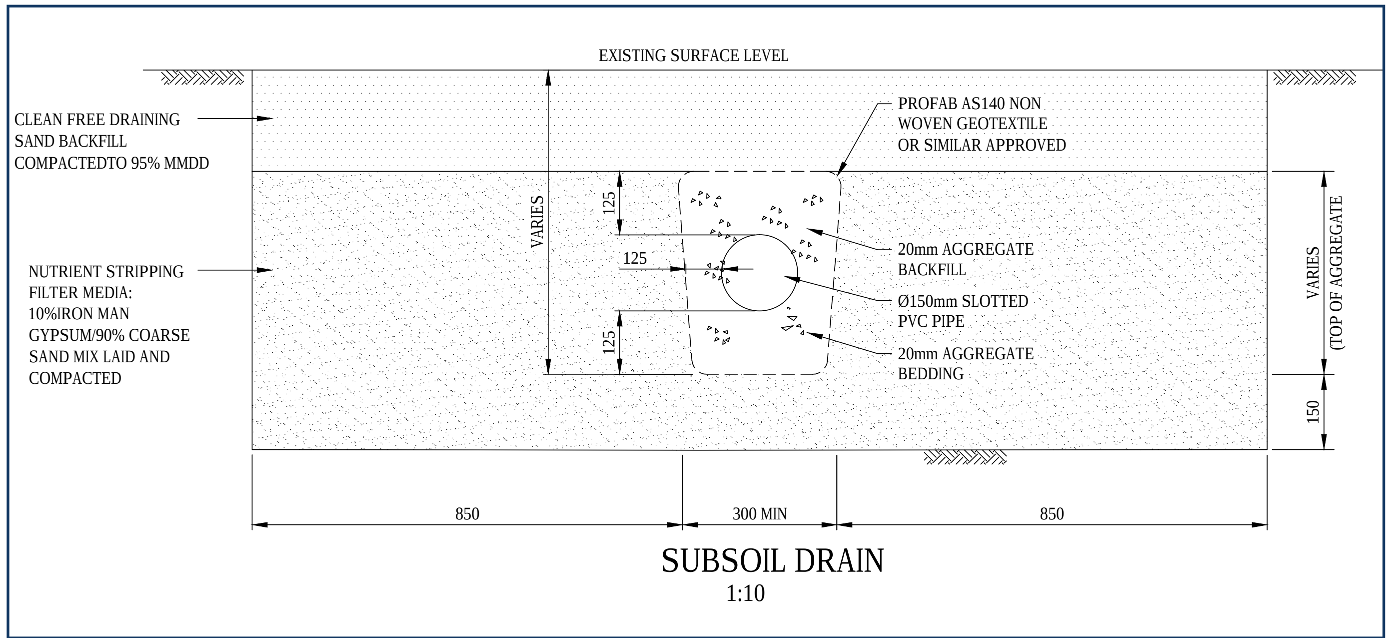


Figure 14- Indicative subsoil cross section detail with treatment media

Figure 15 - Guide Plan for Industrial Development

5.3 PUMPING AND REUSE OF GROUNDWATER

Pumping of superficial groundwater for potential reuse is assumed to not impact the peak groundwater level as the system may fail during critical periods of heavy rain. It may however provide an option for generally controlling groundwater flows through late spring to early autumn. The scheme would generally utilise trickle flow from subsoil pipes as an irrigation source for nearby Regional Open Space areas. Any use of this water will require licencing through the Department of Water as it is within the Dardanup groundwater sub area of the Superficial Swan.

Another option is to use horizontal bores for collection of the superficial aquifer's water. This water can then be pumped and either treated and disposed or resued.

5.4 GROUNDWATER QUALITY MANAGEMENT

Groundwater quality will be improved through the use WSUD structures, subsoil treatment and appropriate landuse management. This includes both management of existing groundwater quality and long term groundwater generated as part of development of the DSP area.

The treatment of stormwater via infiltration through WSUD structures, is covered in Section 4. The general philosophy is to treat stormwater prior to its infiltration into the soil profile, which will result in groundwater receiving minimal new pollutant loads. This includes treating water through bioretention gardens, wetlands and swales.

The Department of Water's website also contains information on the trialling of amended soils under subsoil systems. The information can be found at: http://www.water.wa.gov.au/water-topics/waterways/managing-our-waterways2/soil-amendments

Subsoil systems may also incorporate amended soil filter media to manage nutrients and other pollutants moving into the subsoil system. One potential product that may be used is 'Ironman Gypsum' mixed with sand. This product is shown to be effective in removing nutrients from water filtering through it. An indicative cross section of this is shown in Figure 14.

Treatment may also be used at the discharge point of subsoil systems. This may include vegetated wetlands or structures specifically designed to treat the contaminants contained within groundwater being discharged. Sizing of any type of treatment structure at the discharge point will need to consider flow rates, seasonality of flows, pollutant levels and whether stormwater will also enter the system. The Department of Water is undertaking a trial using an amended soil blanket under subsoil piping to determine how this may affect nutrient movement into the subsoil. Details on this trial can be found on the Department's website.

Both the treatment around the subsoil network and the end of pipe treatment options can be used to treat legacy nutrients. Due to historical farming practices, it is likely that the subsoil network will discharge nutrients and other pollutants that are currently held in the soil matrix and groundwater aquifer. This is based on groundwater quality testing on nearby areas, with similar historical land uses and soil types, which show elevated nutrient and other pollutant levels. Any treatment system will need to be designed to accommodate treatment of the pollutants likely to be present and the likely timeframe over which these legacy pollutants are likely to be flushed from the system.

5.5 MONITORING

Monitoring of groundwater levels will be required for each area of development to determine the setting of any proposed CGL. This will need to be undertaken in conjunction with the LWMS.

Monitoring will also be needed post development to ascertain the effectiveness of the groundwater strategies and assist with determining any remedial works. This is covered in more detail in Section 8.

5.6 ACID SULPHATE SOILS MANAGEMENT AND DEWATERING STRATEGIES

Based on the fact that the majority of the site is mapped as being of a low to moderate ASS risk, further investigations and sampling should be undertaken as part of detailed development design. All investigations and management options are to be undertaken in accordance with the latest Department of Environmental Regulation processes and requirements. This is especially relevant in areas where groundwater levels are likely to vary from current levels, or if water is to be fast tracked via subsoil systems and swales, to natural waterways. The provision of deep sewers are another process that may disturb ASS if any are present on the site. Vacuum or pressure sewer systems may be used to avoid this issue, subject to future detailed design. It is expected that any potential ASS issues that may occur on-site will be able to be managed through conventionally used methods such as liming and minimising exposure to air.

6. SUSTAINABLE WATER SERVICES STRATEGY

The sustainable development ethos for the development has led to investigation into a variety of potential water servicing models. These will require more detailed economic assessments and general feasibility as the development is progressed.

The Water Corporation and Aqwest have provided preliminary information that they may service the development, if required, using traditional methods. Other operators have also expressed interest in providing some or all of the services described below.

The Water Services Act (2012), allows any entity to potentially become a water service provider, where it meets the licencing requirements of the Economic Regulatory Authority (ERA) as set out by the Act.

A single entity to oversee all aspects of water servicing is likely to assist with the implementation of sustainable water management across the development. However, under the Act, each service could be provided by a different operator and there is also the possibility of multiple operators providing similar services in close proximity. Small scale operators may also play a role in localised areas e.g. localised sewer mining and reuse schemes for irrigation.

There has also been a rapid development in economically feasible water service provision over the last 10 years. It is likely that this trend will continue. Given the longer timeframes associated with the development of the subject land, alternative options, not viable at the moment, may prove to be more suitable at the time of actual development.

With this in mind the following information is to be taken as a framework and list of options for the servicing of the subject land. When the site is closer to being developed, these options can be revisited to determine the most suitable path based on the available technology and type of development being undertaken.

6.1 POTABLE WATER SUPPLY

Due to existing development within the subject land, much of the site is currently serviced with a potable water supply. Future development within the subject land will need to utilise the existing or be supplied with a mains potable water supply. The Water Corporation has outlined that it has considered a range of technically feasible options and it is yet to commit to a particular option. The supply would most likely be partially stand-alone, with header tanks to provide a reliability of supply and pressure. The exact location of the infrastructure has not been set.

Aqwest has also expressed interest in being a supplier of water to the subject land and have indicated a willingness to undertake a detailed assessment at the appropriate time.

Other suppliers may also choose to supply all or part of the development area with potable water. The final operator or potentially, operators will need to be determined as part of the LWMS's.

The Department of Water has undertaken an assessment of the projected demand and estimated timeframe that demand may exceed current licensed entitlements for town water supply schemes in the South West. (South West Region Town Water Supply – March 2015). The assessment determined that demand can just be met for the Bunbury, Dalyellup, Eaton-Australind and Boyanup schemes to 2060 from current licensed entitlements and the groundwater reserved for future public supply. This assumes that residential water use is reduced to meet a water use efficiency target of 100kL/person/year by 2030, and that the groundwater resources are available in the future. However, the addition of the Picton South expansion areas, in conjunction with the existing schemes, will likely exceed current entitlements and the water that is reserved for future public water supply by 2060. The groundwater from the Bunbury-Yarragadee and Kemerton North groundwater sub areas, is the most likely source to meet future demands. Groundwater availability, and demand from all water sectors, will be further evaluated by the Department of Water using groundwater modelling and the development of a local water supply strategy for Greater Bunbury over the next few years.

There is also the possibility of obtaining water from non groundwater sources. This may include the existing seawater desalination plant and potentially surface runoff dam supply. Although these are not part of current Department of Water planning, given the long term nature of this development, these source may prove to be viable options. As an example, if the proposed desalination project for Wellington Dam goes ahead, this may be a viable future water source.

Any detailed planning of servicing needs to consider the option to obtain water from a variety of sources to provide longterm supply resilience. As technology improves and the climate changes, alternative water supply options may become more viable for the DSP area.

6.2 NON POTABLE WATER SUPPLY

Non-potable water may be utilised within the DSP area, predominately for individual on lot uses. This is likely to be sourced from groundwater obtained through DoW's water trading scheme. Other larger schemes may be utilised in conjunction with potential schemes in the adjoining Waterloo area. The Wanju and Waterloo IWMS should be consulted as to possible options in this space. Any regional open space areas are unlikely to be irrigated.

Rainwater tanks

As part of the sustainable development ethos of Picton, industrial buildings will be encouraged to install rainwater tanks, wherever practical, to reduce the quantity of water consumption from the water mains. Owners, developers and builders will be encouraged to install fittings to ensure the captured rainwater can service indoor and outdoor purposes. This is to be driven by the local authority, with relevant direction provided to the developer.

Encouraging the installation of rainwater tanks can provide a distributed capture system throughout the development that may also be used to control stormwater discharge.

Greywater

Another potential water conservation measure that can be adopted is by reusing greywater on lot by lot basis.

If lot owners wish to install greywater systems, they are to follow acceptable greywater reuses practices (see Code of Practice for the Reuse of Greywater in Western Australia, Department of Health, 2005). All greywater systems must be approved by the Department of Health, Western Australia.

6.3 WASTEWATER TREATMENT

As the Picton South DSP area is outside of the current Water Corporation treatment scheme area, there is the potential to explore a variety of wastewater treatment options. These can also be managed by other entities.

Water Corporation has provided advice that it is able to provide treatment of wastewater from the adjoining Waterloo area, with this being sent to the Bunbury Waste Water Treatment Plant (WWTP), in Dalyellup. This system expansion would require infrastructure in the Picton South DSP area. Should this scheme happen, the Picton South DSP may be able to connect. There is a need for considerable new and upgrading of existing piping and pumping infrastructure to achieve this, especially to service the entire area. It may be decided that at least a portion of the industrial area remains unsewered, which will influence the type of industrial usage. Dry industries, which have minimal water usage and discharge requirements may be concentrated in one area of the Industrial Park to facilitate their development, while minimising overall sewer implementation costs. Currently however, it is likely that any development will rely on each lot treating its own wastewater.

The wastewater treated at the Bunbury WWTP is currently discharged via ocean outfall. Options to bring back the treated wastewater for use within the adjoining Waterloo area were considered by Water Corporation. This is a physically viable option, however the cost is considered very high at this point in time.

There is also the potential for a separate treatment and reuse system within or adjoining the subject land. This may involve a higher level of treatment so that the water can be used as a non potable source within businesses and industrial facilities. Additionally, this water could be used for park irrigation within the Wanju area, however this would most likely require large scale storage, with associated construction and maintenance costs.

Another potential option is a hybrid system using localised sewer mining, to treat water for fit for purpose. This could then be run on a needs basis eg seasonally for watering of localised parks and playing fields. This would negate the need for storage. The same system could also provide a year round non potable source to buildings/ businesses.

The onsite and sewer mining treatment options are likely to use membrane filtration, bioreactors and potentially reverse osmosis. These systems require only small treatment areas and are able to be held entirely within buildings. This makes them suitable for urban spaces.

6.4 SUSTAINABLE WATER USAGE

6.4.1 Waterwise Garden and Other Outside Usage

Planning and implementing Waterwise gardens and practicing other outdoor waterwise techniques as part of industrial lot landscaping can produce significant water savings per annum. Some of the options for implementing waterwise landscaping include, reduced lawn areas, use of locally native species, overall reduction in irrigated area, hydrozoning of a garden, efficient irrigation methods such as drip systems, incorporating stormwater runoff and storage into the landscaping and the use of soil amendments to hold water.

Natural rainfall alone should be sufficient to maintain Waterwise gardens once established. However the installation of rainwater tanks could be used to supplement or possibly even substitute for the use of mains potable water for any additional outdoor requirements.

Waterwise gardens will be encouraged through various landscape information packages. Educational material raising awareness of waterwise practices will be provided to lot owners and employees. The local authority may apply guidelines as to suitable landscaping types and areas to assist with overall water usage on residential, commercial and industrial lots.

6.4.2 Regional Open Space and Streetscape Landscape Plan

The objective of Regional Open Space landscaping, if any is required, is to implement strategies that prevent the need for irrigation all together. This includes the retention of native vegetation where possible, revegetation using native species and utilising stormwater for irrigation. A portion of the Regional Open Space areas will also incorporate detention basins which will be planted with native vegetation designed to survive in the cycle of wet and dry periods that the basin will experience. These areas will require minimal to no irrigation.

Landscaping of streetscape areas, including lot frontages, should focus on waterwise gardening which includes reduction of turfed areas, use of locally native species, use of hydrozoning practices and efficient irrigation methods. All verge landscaping should be approved by the relevant local authority.

Revegetation along Ferguson River/ Drainage basin

7. WATER DEPENDENT ECOSYSTEMS MANAGEMENT

There are two main focuses for the management of water dependent ecosystem (WDE) as part of the subject land's future development: firstly protection and enhancement of onsite ecological systems and secondly to treat water prior to discharge into the onsite downstream significant environments. There will also be the creation of new WDE habitat across the site. This includes the swales/living streams, as well as bioretention gardens and basins within the streetscape and Regional Open Space areas.

The following explains each of these further.

- Offsite WDE Protection. The main ecosystems effected directly from the development's runoff are the downstream sections of the Ferguson River. The eventual discharge points of the Leschenault Estuary could also be potentially impacted.
- The utilisation of WSUD, including groundwater and surface water management, throughout the development will improve water quality either flowing off site as surface water to the above systems or joining the superficial groundwater aquifer. By undertaking this treatment, the water that leaves the site will minimise the nutrient, sediment and other pollutants which have the ability to cause environmental harm. The measures proposed are likely to lower the nutrient levels moving through the site's waterways. This is in keeping with the WQIP recommendation. These management techniques, as outlined in previous sections, include both management of pollutants produced as part of the new land use, as well as the potential mobilisation of legacy nutrients and other pollutants through groundwater control systems (eg swales and subsoil pipes). UNDO modelling will also need to be undertaken at the LWMS stage to prove there is no downstream impact from a nutrient point of view.

Furthermore, flow rates are to be managed so that the post development rates that enter ecologically sensitive areas are either similar to the pre development rate, or are shown to be beneficial to the receiving environment. This will be for minor and major rainfall events.

The actions being used to manage water quality entering these systems has been outlined in more detail within the surface and groundwater management sections.

7.1 ON SITE WATER DEPENDENT ECOSYSTEM CREATION

7.1.1 Swale network

Swales are to be designed to act as ephemeral streams and provide habitat values for fauna, especially avifauna and herpetofauna. This can be achieved through the use of native species for the plantings and the creation of a variety of habitat types such as floodplains, high flow side channels, meanders, pools and riffles.

7.1.2 Detention and Infiltration Systems

The detention basins and bioretention gardens constructed as part of this development will provide some ephemeral wetland type habitat to generalist wetland and riparian species. The construction and planting of these basins, can maximise this effect through shaping to create various zones and the use of locally native plants. This can be complemented by utilising utilising native plantings in surrounding streetscape areas.

As such these areas can act as areas for future colonisation by a variety of small fauna and assist with fauna movement between larger natural systems. The basin and bioretention garden areas are to include both an understorey of sedges and rushes as well as an overstorey of wetland shrubs. In larger systems, tree may also be incorporated. Species should be chosen from the Vegetation guidelines for stormwater biofilters in the south west of Western Australia, or similar publications.

7.2 MOSQUITO MANAGEMENT

To ensure that the proposed drainage system does not hold standing water over the spring and summer months, all bioretention gardens and detention basins created for each subdivision will be designed to ensure that drainage flows will be infiltrated within 96 hours in accordance with the design objectives for WSUD.

No permanent water bodies are currently proposed for the project. The final water bodies and treatment systems to be used may hold semi-permanent water. Potential mosquito issues will need to be managed and outlined as part of detailed design.

7.3 ON SITE ECOSYSTEM PROTECTION AND ENHANCEMENT

7.3.1 Localized Wetlands

Some small, relatively degraded wetlands may be enhanced and incorporated into the urban area of the development. These will form part of the POS and drainage areas.

The small area (2.7ha) of Very Good to Good quality vegetation within the centre of the Subject Land is to be retained as a resource enhancement reserve (with due consideration undertaken as to its current usage). Water flows into and out of this area is to be carefully considered as part of detailed design so that the vegetation is not negatively affected. Groundwater levels should also be controlled to minimize any potential impacts to the seasonal rise and fall of the existing groundwater regime in this location. A wetland management plan for the resource enhancement wetland will be required at local structure plan stage.

Some revegetation and weed control may be undertaken. This is to be considered as part of future detailed planning and subject to the final vesting of the individual land parcels.

7.3.2 Ferguson River

Regional Open Space will be implemented along the foreshore areas of the Ferguson River where possible which is shown on Figure 16. The Regional Open Space will mainly be composed of native revegation with some ares set aside for low impact recreation.

Department of Planning have completed a conceptual foreshore management plan for Ferguson river. The final foreshore areas are to be determined prior to completion of the relevant LWMS. The buffer distance to the river, and the appropriate activiities and structures for the foreshore will need to be determined by this time. The buffer distance will also be partly determiend by the immediate landuses surrounding the area, the direction of groundwater flow and the types of practices and infrastructure employed i nthe surrounding area to maximise the quality of water that will enter the area.

A Foreshore Management Plan is to be undertaken as part of the detailed development of the area, with the boundaries set as part of the LWMS. Operational policy 4.3: Identifying and establishing waterways foreshore areas (DoW 2012) is to be used to guide the production of these reports. The management plans are to detail strategies, practices and an implementation schedule that will provide protection and enhancement opportunities for these waterways. In general the management plans will review revegetation, weed control, erosion control, public access management, fire management and appropriate infrastructures. The foreshore management plans are to be undertaken in conjunction with Bushfire Management Plans to make sure they are complementary. They should also reflect the approved works outlined in the FMP for the south eastern portion of the river (Lot 51 Martin Pelusey Road, Dardanup Foreshore Management Plan). A copy of this report can be found in the CD of Attachments.

The conceptual foreshore management plan has separated the indicative foreshore boundaries into 4 sections, shown on Figure 16. Suggestive widths and general comments have been extracted from the report and are provided in Table 6. The conceptual foreshore management report is included in the CD of attachments.

Section	Foreshore Widths	General Comments
Section 1 Confluence of the Preston and Ferguson Rivers to Willinge Drive.	• Foreshore average width of 80 m • Revegetation average of 60m (30m either side from the centre line of the river)	• Current foreshore reserve width should be increased to 80m wide as opportunity arises. • This section of the Ferguson RIver has an incised channel and carries the highest flows. • This section also links into the Preston River vegetated corridor that is part of the greater Preston to Ocean Regioanl Park.
Section 2 Willinge Drive to Boyanup Picton Road.	• Foreshore average width of 100 m • Revegetation minimum of 50m (25m either side from the centre line of the river) • Scope to have larger aeras vegetated due to the odd shape of the area.	• Odd shaped area, the foreshore is already confined to a degree by industrial developments on the Boyanup Picton Road that back onto the Ferguson River and adjacent easements. • This section of the Ferguson River has an incised channel and carries the highest flows. • Option to use some of the foreshore areas and easements for drainage management.
Section 3 Boyanup Picton Road to Lot 5.	• Foreshore average width of 80 to 100m • Revegetation minimum of 60m (30m either side from the centre line of the river). • Scope to have larger areas vegetated due to the odd shape of the area.	• This section of the Ferguson River again has an incised channel, but not as deep as downstream. Large sections of lower floodplain bounded by roads leaving odd shapes of land that may not be economically suitable for development. Opportunity for drainage management sites. • Sections of remnant, intact upper canopy on the floodplain that should be considered for inclusion within the foreshore revegetation area (see map for section 3). • Some houses have been historically built too close to the waterway within this zone. Therefore long term foreshore restoration opportunities should be sort after as development progresses within the area.
Section 4 Lot 5 to Martin Pelusey Road	• Foreshore average width of 60m • Revegetation minimum of 50 to 60m (25/30 m either side from the centre line of the river). • Scope to have larger foreshore area and vegetated areas due tot he odd shapes adjacent to roads.	• This section of the Ferguson River again has an incised channel, but not as deep as downstream. Large sections of lower floodplain bounded by roads leaving odd shapes of land that may not be economically suitable for development. Opportunity for drianage management sites or larger foreshroe vegetated areas (Possibly future offset sites for Dept. of Main Roads).

Table 6: Foreshore Width Suggestions for Ferguson River

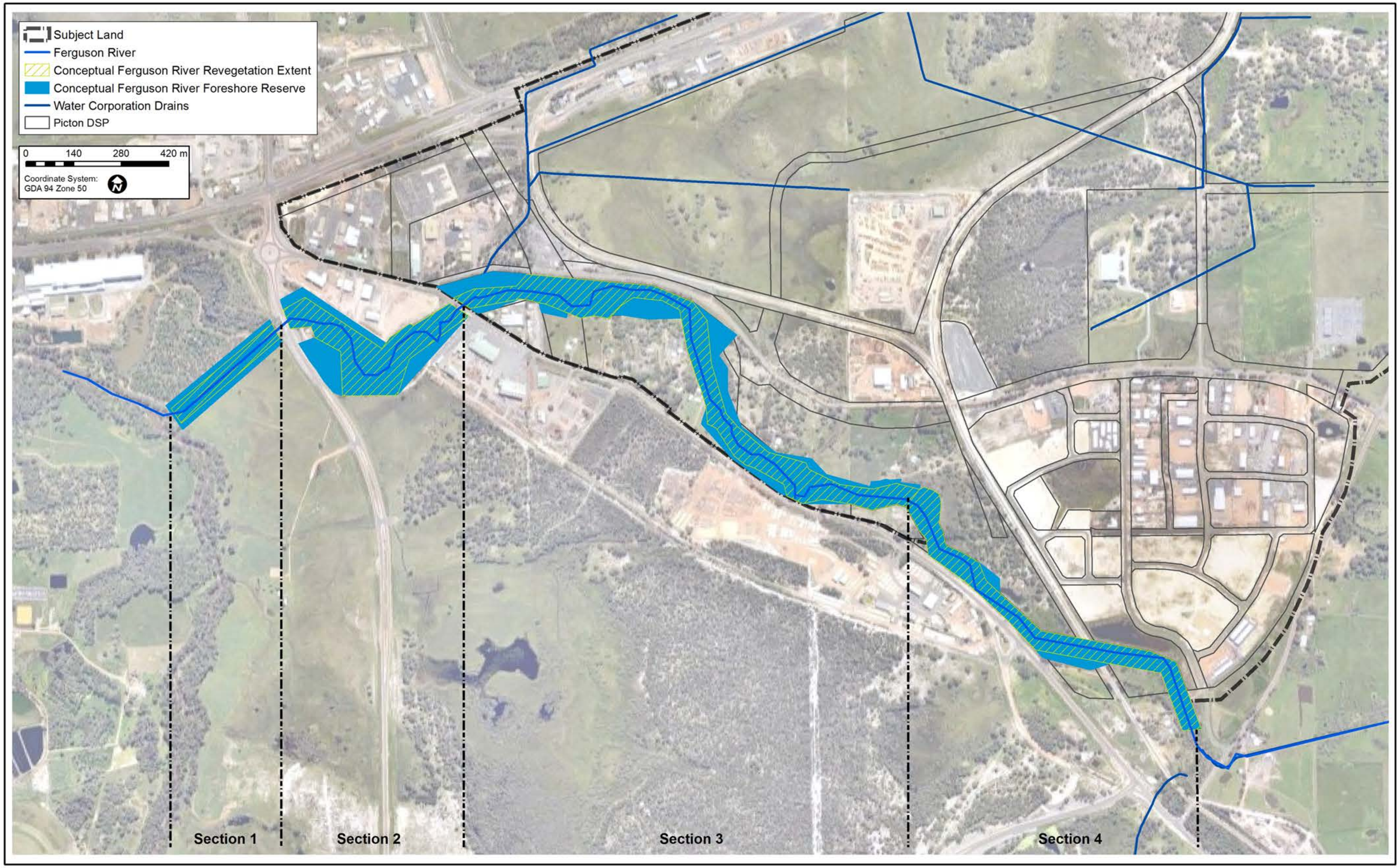


Figure 16 - Conceptual Ferguson River Foreshore Resrve

8. MONITORING & MAINTENANCE

8.1 PRE-DEVELOPMENT

8.1.1 Groundwater

Pre-development monitoring for the subject land has involved some large scale monitoring of groundwater levels by individual landholders. The locations of these bores can be seen in Figure 17. A likely groundwater movement model is shown in Figure 9. Groundwater quality data is not currently available for most of the DSP area. Based on sampling from nearby areas with similar soil types and past agricultural practices, it is likely that nutrients and other pollutant levels are likely to be high.

Additional detailed, localised groundwater level and quality monitoring is likely to be required as part of Precincts 1 to 3. This will provide the finer detailed information to assist with determining the likely pre-development groundwater regime. This will then be used to determine a suitable Controlled Groundwater Level post development or requirements for separation. Furthermore the water quality data will assist with determining the potential treatment requirements for any groundwater discharge. It will also provide base line data so that future post development monitoring has a reference line to work to. Future monitoring is to be undertaken in accordance with the water resource considerations when controlling groundwater levels in urban development (DoW 2013).

This information should be collected as part of the LWMS process and potentially the UWMP.

8.1.2 Surface Water

Surface water monitoring for water quality is to be undertaken as part of the LWMS. This is to provide a base line of information for future post development monitoring as well as identify potential issues. The monitoring should include nutrients, mobile sediments, algal levels, heavy metals, pH and hydrocarbons in areas where it is relevant (eg within Picton Main Drain).

All major inflow and outflow points should be sampled. Given the size of the development area and likelihood of a staged development process, the monitoring may be undertaken in discrete areas relevant to that particular development. Alternatively an overall monitoring program may be developed for the site that is then funded by future developers. This would likely be managed by the local authority and associated partners such as the Leschenault Catchment Council and Department of Water. Indicative locations for monitoring of the major sites can be seen in Figure 17.

The monitoring process and parameters sampled should be in accordance with Water monitoring guidelines for better urban water management strategies and plans (DoW, 2012).

8.2 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 basins 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 roads 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. The systems should be stabilised with geofabric or similar in the interim. Once the risk has passed, the accumulated sediment and geofabric should be removed and the system vegetated.

In areas where it is required, further monitoring of ASS is also to be undertaken as outlined in the relevant ASS Management Plan.

Construction monitoring and maintenance regimes are to be developed as part of the LWMS and finalised within the UWMP.

8.3 POST DEVELOPMENT

The post development monitoring and maintenance regimes will depend on the treatment trains incorporated into the development and likely risks to on site infrastructure and nearby ecosystems. The following provides guidance on the targets and likely process to be undertaken. Full details are to be included in the relevant UWMP. There is an opportunity for a development wide post-development monitoring scheme, coordinated by the local authorities, with assistance from the Department of Water. This will allow a consistent monitoring process to be undertaken and will be more efficient then multiple small-scale systems by separate developers. Funding from developers towards this scheme would allow this overall coordinated approach to be implemented. The same approach could be used for some aspects of the pre development monitoring that is currently not available.

Furthermore the monitoring could focus on key better management practices to test their effectiveness to a high level of accuracy, rather than broader monitoring of all systems. This will allow the development to act as a trialling place for innovative water management options.

Any monitoring program should seek guidance from the local authorities and Department of Water, so that it considers all relevant aspects and requirements.

8.3.1 Water Quality Monitoring

The Swan Coastal Plain water quality criteria of 0.1 mg/L for total phosphorus and 1.0 mg/L for total nitrogen will be adopted for monitoring of all water discharged from the development area. This criteria has been set as the targets for lowland tributaries in the Leschenault Estuary Water Quality Improvement Plan (DoW, 2011). For other parameters, ANZECC guidelines should be used in determining safe discharge levels of potential pollutants, taking into account the natural levels of some metals in the region's soils. Surface water monitoring will review samples against these levels to determine how the development's WSUD processes are working. This will also allow for adjustments to the required treatment trains to be made for later stages. Where systems include flow from upstream areas, pre development water quality may also influence the targets to be achieved

The surface water monitoring points are to be determined as part of the relevant LWMS and UWMP. In general they should be at key points within the treatment train and include subsoil discharge points, basin outfalls and discharge locations to the natural environment.

Groundwater bores will be placed as close as possible to the pre development bores, to allow for a more accurate comparison between pre and post development results. Should the pre-development bores exist in the post-development environment, these can continue to be monitored during the post-development monitoring programme.

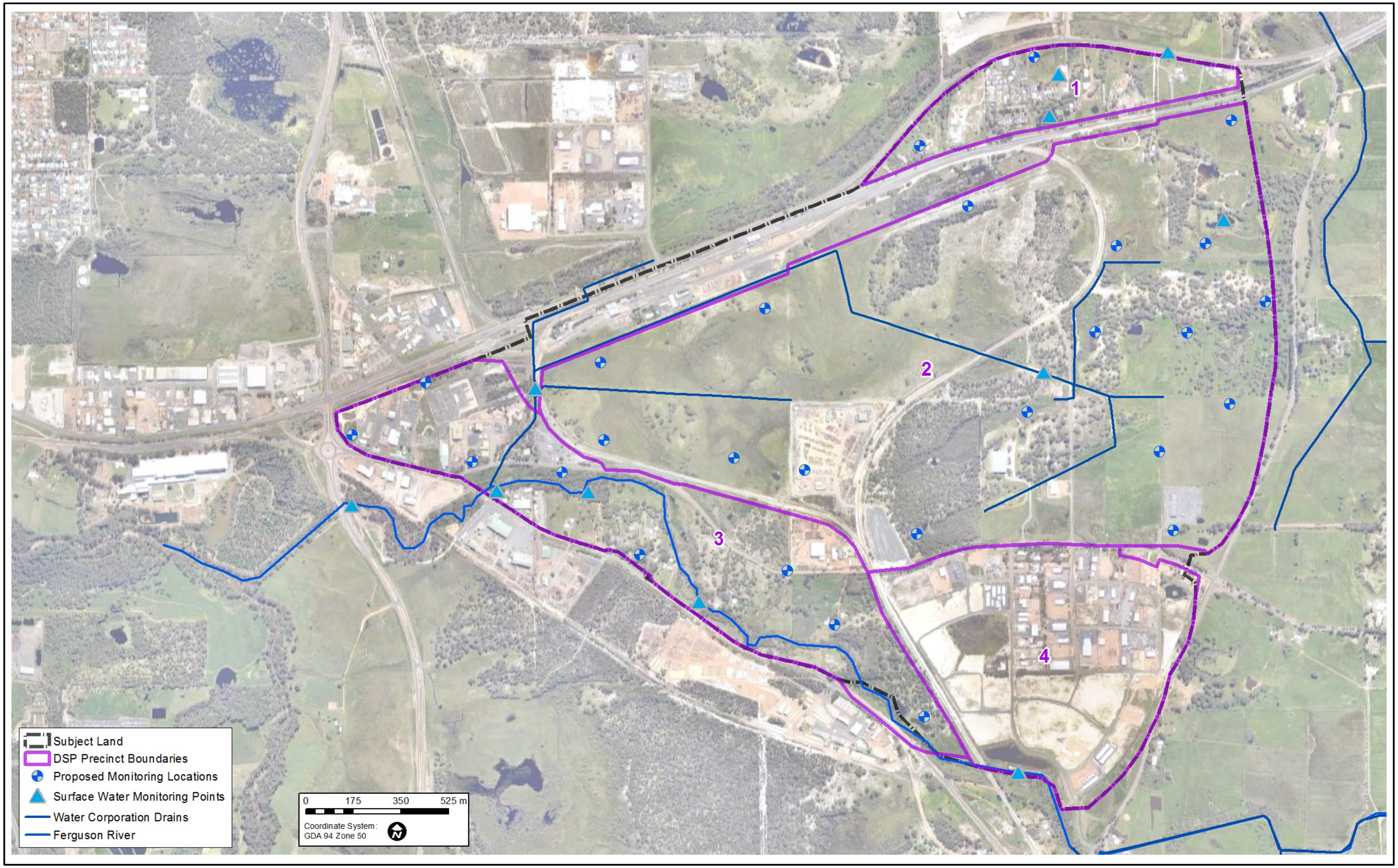


Figure 17 - Indicative Monitoring Location Plan

8.3.2 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 through regular removal of material and control of catchment generated debris eg. street sweeping, leaf removal, appropriate locating of rubbish bins to reduce rubbish;
- Vegetative cover of the systems is maintained;
- Sediment build up is not impeding the functionality (note, design vegetated systems so that excessive short term sediment in early stages is not an issue eg do not plant until high risk sediment movement has passed);
- Erosion is not present;
- Soils are not compacted;
- Litter is removed;
- Excessive hydrocarbons are not present in the system;
- Weeds controlled;
- Infiltration of stormwater is maintained to reduce standing water (in non-wetland systems);
- Flows are not excessively detained;
- Stormwater pipes are flowing freely;
- Gross Pollutant Traps are functioning and are not blocked; and
- 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.

It is recommended that vegetated WSUD elements are monitored by personnel with floristic knowledge and/or qualifications and be capable of identifying evasive species within the natively vegetated WSUD systems. Furthermore, personnel in charge of monitoring should have a good understanding of principles and the functional design of the WSUD elements and the treatment system. The maintenance activities prompted through monitoring activities will generally require coordination between landscape and civil services.

The pit and piped network (stormwater and subsoil) 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. This is especially relevant for Gross Pollutant Traps (GPT).

A key focus should also be on the control of litter and sediment that is often generated during the house/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. Compliance aspects will need to be discussed with the Local Authority, so that rectification of the source problem can be achieved.

8.4 REPORTING

All information collected from the monitoring programs should be recorded and provided in a report, prepared by the developer, to the Department of Water and local authority in a structure and format to be agreed upon. The report will compare monitoring results with target design and performance criteria to ascertain what, if any, actions may be required, and will provide ongoing assessment of the suitability of monitoring and reporting strategies. If a trigger value for a contingency action is reached, a more detailed report on the occurrence, its impact and proposed action to prevent recurrence is to be compiled by the developer and submitted to the Local Authority and DoW. After 2 years of monitoring for the relevant Stage by the developer, the local authority will become responsible for any further monitoring they wish to undertake.

9. 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.

They will also be influenced by the staged approach of the development, shown on Figure 1.

The following is a summary of the process to achieve implementation.

9.1 DRAINAGE SYSTEM GOVERNANCE

Due to the presence of multiple Water Corporation Drains combined with a staged approach to the development of the subject land, there is a need to have a governance framework around surface drainage. The general philosophy is that the drainage processes happening on site need to be retained upstream and downstream of any new development, while the current agricultural pursuits continue in parts of the DSP area not yet developed. Linked to this is the costs of installing future drainage and who is responsible for the construction and maintenance. Overarching this, is the governance requirement that any works do not significantly increase the flooding regime of the DSP area and surrounds.

The following points have been set out to assist with providing direction to these aspects.

- Capital costs for localised drainage systems will be borne by the developer directly
- For the broader arterial systems, a contribution scheme will need to be developed. This will include associated structures such as regional drainage and crossings.
- As development occurs the drainage governance may take a variety of forms, including input from the local authorities, Water Corporation and Main Roads. There may be a need for:
    - Temporary medium term diversion infrastructure to be installed to allow irrigation servicing to continue downstream of development areas.
    - Downstream drainage systems to be upgraded to accept post development flows, which will also require a review of management arrangements to ensure historical and future drainage needs are met.
    - Detailed water movement strategy for the localised development to show how the existing flows can be safely managed post development and are in accordance with the governance framework.
- In the long run after full development is completed, drainage governance should be transitioned from Water Corporation to a single drainage service provider (eg Shire of Dardanup or City of Bunbury).

9.1.1 Individual Developer Requirements

- As part of the local structure plans, complete LWMS and UWMP for the relevant subject land area.
- Undertake detailed drainage assessments in accordance with the agreed governance arrangements, including impacts on the existing Water Corporation drainage system. The drainage assessment also needs to consider the pro-rata storage and detention of water on the area being developed. This means each lot being developed needs to store its own water within its boundary as a percentage of the catchment and the catchment storage requirement. Alternatively, a LWMS/UWMP may detail alternative arrangements for storage on other land parcels, where the storage is within the LWMS/UWMP area and is approved by all relevant parties.
- Determination of localized groundwater levels and quality.
- Determination of localized surface water quality.
- Geotechnical assessments and Acid Sulphate Soil investigations.
- 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 where required.
- The planting of vegetation within the bioretention gardens, basins and foreshore areas with appropriate locally native plants and maintenance of the plants until handover to the Local Authority. Plant species are to be in accordance with their standard list or as approved by the relevant Local Authority.
- Water sensitive landscaping of the streetscape. Plant species are to be in accordance with their standard list or as approved by the local authority.
- Provide industrial lot owners with information regarding Waterwise practices relevant to the development landscape and servicing strategy.
- Undertake post development monitoring as required
- Undertake monitoring WSUD infrastructure to assess their performance and respond accordingly for the required monitoring period.
- Produce and implement the Foreshore Management Plan for each section of the Ferguson River.
- Produce and implement a Wetland Management Plan for the Resource Enhancement Wetland.

9.1.2 Department of Water Requirements

- Assess each LWMS and provide support to local authorities in assessing UWMPs, as required.
- Finalise and release the Ferguson River Flood Study.

9.1.3 Department of Planning Requirements

- Provision of necessary layouts and guidance on landuse planning for the subject land.
- Finalisation of the LWMS using the DWMS information and other information
- Provide assistance where possible with developing suitable water servicing options

9.1.4 Shire of Dardanup and City of Bunbury requirements

- Responsibility for the maintenance of the internal stormwater system installed post-development, after a mutually agreed upon handover period (or as outlined in the Governance framework).
- Ongoing encouragement of Waterwise and nutrient wise practices for industrial lot owners.
- Maintain water management strategies within the Regional Open Space area after handover.
- Undertake compliance at industrial lot development stage to reduce impact to constructed subsoil and stormwater systems.
- Develop and implement a development contribution plan.

9.1.5 Service Provider Requirements

- Develop workable service strategies suited to the DSP area and potential works for the adjoining Waterloo DSP.
- Have the Servicing Strategies approved through the Economic Regulatory Authority in line with the Water Services Act.
- Implement and run the required services as required by legislation

10. IMPLICATIONS ON FILL AND INFRASTRUCTURES DUE TO DEPTH TO GROUNDWATER AND SOIL TYPE

In order to set a sustainable water management strategy for the DSP area, an investigation into minimizing fill as part of the development of the subject land was completed. Potential water impacts considered included possible ways to minimize fill and what implications this may have on the site classifications for buildings, other infrastructure construction and maintenance and more.

Clean sand fill has commonly been used in high groundwater sites and clayey soil areas on the Swan Coastal Plain, to provide either separation to groundwater and/or a more favourable site classification to reduce building costs. The increasing scarcity of easily accessible clean sand resources has meant that the cost of sand has risen significantly. This is leading to other alternative options being sought, so that this scarce resource is managed sustainably into the future.

Within the subject land there is a high perched groundwater table, which is assumed to be within 0.5m of the surface at its annual peak across most of the site. The majority of the site also has loamy to clayey soils at or close to the surface. The combination of these two characteristics are interlinked, as the heavier soil (with its associated low permeability/ hydraulic conductivity) reduces the chance for rainwater to infiltrate quickly, resulting in groundwater building up within the shallow aquifer. This is further compounded by the very flat nature of the majority of the site. This means that surface water doesn't readily run off, rather it to slowly infiltrates into the shallow groundwater or pools at surface before evaporating.

Due to these specific site characteristics, the main driving factor for fill is the high groundwater. While buildings could be designed so that they are able to be built for the heavy soil types present, there is still a requirement for adequate groundwater separation. This is fundamentally driven by a required separation to road pavements from groundwater as pavements are likely to fail if they are too close to groundwater. Partly linked to this is the requirement for adequate drainage infrastructure within the road reserve. To make sure that the drainage system is above the groundwater, while still having adequate cover over the pipes means that roads typically need to be a minimum of 0.7m above the groundwater. Using a heavier duty pipe (eg class 4 or similar) can reduce the required cover, however the cost of the pipe is more. The street network also provides safe flow paths for extreme storm events (eg 1% AEP events). For this reason, the finished floor levels for buildings are usually set 300mm above the kerb line. Generally this requires an additional 200mm of fill above the road, unless the building is raised on stumps or similar.

Groundwater is also typically controlled via subsoil systems within the road. Between the subsoils on each road, the groundwater will rise in a mound. The height that the groundwater rises to is influenced by the hydraulic conductivity of the soil between the subsoils and the distance between subsoil lines. To minimize the mounding, a free draining media (eg sand) and minimizing the separation between subsoils can be used. This may mean installing a secondary subsoil network within the lot itself. This is most applicable in large lots eg industrial areas and commercial zones.

Having places where the subsoils can freely drain to also minimise the length of subsoil piping and drainage piping. This is usually a basin or swale. The invert of the basin or swale sets the height of all surrounding levels and infrastructures, especially in areas with minimal slope. In a flat site such as the subject land, artificial slope will need to be created to allow the drainage network to function. This can be achieved by using drainage swales throughout the development.

Soakwells can also impact on the amount of free draining fill required. For soakwells to function as designed, they generally require a minimum of 300mm of free draining sand at their base. Soakwell types may be modified so that they are shallow in nature (eg 600mm deep), allowing reduced fill. Alternatively they may be designed so that they have a trickle outlet to the street drainage, rather than relying on full infiltration. Furthermore, stormwater may not be infiltrated through soakwells and instead sealed below ground systems with a trickle outlet to the street drainage or above ground systems may be used. These are less impacted by the depth to groundwater. The stormwater modelling must take into account the final concepts used, so that the street drainage (and downstream drainage infrastructure) take into consideration the added flow.

In summary, all development within the DSP areas are to investigate options for the minimization of fill, so as to manage this scare resource into the future and provide a long-term sustainable development for Picton South.

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