



Drainage Strategy for 3 PSPs in South East Melbourne

Hydrogeological Desktop Assessment

Melbourne Water Corporation

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Executive Summary

The City of Casey is a rapidly growing municipality in Victoria, Australia and has a number of Precinct Structure Plans (PSP) in place to manage the transition of rural and agricultural land use to intensified urban land use. As part of a PSP, the planning and provision of new drainage infrastructure is required to support greenfield development, which is managed using a Development Services Scheme (DSS). This report provides a conceptual hydrogeological characterisation of the Devon Meadows, Five Ways Road, Clyde Township and Moores Road DSS areas to inform drainage infrastructure options as part of development of Melbourne Water's (MW) drainage strategy.

Historically, the City of Casey municipality supported widespread heathlands, swamps, grasslands and grassy woodlands as the area formed part of the Koo Wee Rup Swamp prior to historic land use changes. The study area is within the Koo Wee Rup Water Supply Protection Area (WSPA), in which the water table aquifers are primarily represented by the Upper Tertiary Aquifer (fluvial) (UTAF), and to a lesser extent, the Quaternary Aquifer (QA). Soils across this area are unlikely to exhibit Potential Acid Sulfate Soils (PASS).

Groundwater flow is likely to be radially towards Western Port, however influence from regional groundwater pumping likely alters the flow regime through development of seasonal drawdown cones.

Depth to groundwater is likely to generally be shallow (<5 m below ground surface) and water table salinity is likely to be range from fresh to saline and has been inferred as Segment C of the Environmental Reference Standard (ERS), within the *Environment Protection Act 2017*. Relevant groundwater values include Groundwater Dependent Ecosystems (GDEs), which are identified across the study area and groundwater users, which primarily relates to stock and/or domestic purposes.

As part of Melbourne Water's drainage strategy, a number of drainage infrastructure options have been explored and presented within this report. Due to the shallow water table and its potential salinity, the following factors have been identified and require further consideration:

- The intersection of the water table by drainage structures and its potential to facilitate or impede groundwater recharge/discharge or interactions with surface water
- The intersection of saline water by drainage structures
- Changes to groundwater flow regimes
- Potential changes to groundwater levels and/or quality from drainage infrastructure
- The material of drainage infrastructure in the context of the saline soil and groundwater setting

Gaps identified during the hydrogeological assessment include limited site specific groundwater level, quality and flow data and characterisation, particularly at locations where drainage infrastructure is proposed.

To further assess the hydrogeological impacts of the proposed drainage infrastructure within the DSS areas, GHD recommends that at key drainage infrastructure locations, such as wetlands and retarding basins, further ground investigations are undertaken as part of the design phases to assess site-specific hydrogeological parameters, and the potential impact on groundwater flow regimes, levels and quality. If ground investigations conducted as part of the design phase identify shallow and or saline groundwater at the infrastructure site, consideration should be made for groundwater level and quality monitoring of the water table aquifer, to establish background/baseline conditions and to assess impacts of the drainage infrastructure on the receiving environment. A groundwater risk assessment should also be conducted to identify and rank groundwater related risks.

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1. Introduction

1.1 Background

As part of the background data review for the Devon Meadows and Clyde Five Ways Road Development Services Schemes (DSS), GHD conducted a review of SKM's 2012 report entitled *Groundwater and Groundwater Dependent Ecosystem (GDE) assessment*. The report focused on potential hydrogeological impacts as a result of urban development in the Casey Growth Area (CGA).

From the review, GHD identified a number of data gaps and provided recommendations to address the data gaps and increase robustness of the assessment. This report forms the response to recommendation 1 within GHD's *Devon Meadows and Clyde Five Ways Road DSS Main Report (GHD, 2022)*. The Devon Meadows, Clyde Five Ways Road, Clyde Township and Moores Road Development Services Schemes (DSS) are herein termed as 'the DSS areas'.

1.2 Purpose of this report

The purpose of this report is to provide conceptual hydrogeological characterisation of the DSS areas to inform drainage infrastructure options as part of development of their drainage strategy.

1.3 Scope

The scope of works includes a review and desktop assessment of current hydrogeological information within the Devon Meadows, Five Ways Road, Clyde Township and Moores Road DSS areas for the items specified under recommendation 1 within GHD's *Devon Meadows and Clyde Five Ways Road DSS Main Report (GHD, 2022)* except for a review of potential sources of groundwater contamination. The assessment includes:

- Groundwater extraction from the Koo Wee Rup WSPA, the distribution of extraction and the current groundwater management requirements in the DSS areas
- Groundwater elevations, level trends and groundwater flow in the DSS areas
- Groundwater quality in the DSS areas
- Environmental values in the DSS areas (including GDEs) that need to be protected. It is noted that the legislation that covers the protection of groundwater has been updated since the original assessment was completed
- Potential Acid Sulfate Soils (PASS)
- Aquifers present and their hydraulic parameters
- Assessment of current monitoring conducted and potential changes to the hydrogeological regime during or after the implementation of the drainage strategy and urbanisation
- Recommendations regarding additional work to close hydrogeological data gaps

1.4 Limitations

This report has been prepared by GHD for *Melbourne Water Corporation* and may only be used and relied on by *Melbourne Water Corporation* for the purpose agreed between GHD and *Melbourne Water Corporation* as set out in section 1.2 of this report.

GHD otherwise disclaims responsibility to any person other than *Melbourne Water Corporation* arising in connection with this report. GHD also excludes implied warranties and conditions, to the extent legally permissible.

The services undertaken by GHD in connection with preparing this report were limited to those specifically detailed in the report and are subject to the scope limitations set out in the report.

The opinions, conclusions and any recommendations in this report are based on conditions encountered and information reviewed at the date of preparation of the report. GHD has no responsibility or obligation to update this report to account for events or changes occurring subsequent to the date that the report was prepared.

The opinions, conclusions and any recommendations in this report are based on assumptions made by GHD described in this report (refer to section 1.5 of this report). GHD disclaims liability arising from any of the assumptions being incorrect.

GHD has prepared this report on the basis of information provided by *Melbourne Water Corporation* and others who provided information to GHD (including Government authorities), which GHD has not independently verified or checked beyond the agreed scope of work. GHD does not accept liability in connection with such unverified information, including errors and omissions in the report which were caused by errors or omissions in that information.

1.5 Assumptions and data sources

A key limitation of this hydrogeological assessment is the use of regional geological and hydrogeological datasets to conceptualise the hydrogeological setting. This investigation has relied on a number of data sources including:

- Published geological and hydrogeological mapping
- State drilling records
- Government produced literature including land use planning information, meteorological, and topographical data
- Victorina Government water resource data
- Australian Government climate data

These data sources have been referenced, where relevant, throughout this report. A complete list of references is provided in section 7 of this report. This report does not incorporate information or data obtained through site investigations.

2. Desktop hydrogeological assessment

2.1 Site setting

The Devon Meadows, Five Ways Road, Clyde Township and Moores Road DSS areas are located approximately 50 km south-east of Melbourne, within the City of Casey and covers a combined area of approximately 1,500 ha. The overall site is bounded by Craig Road in the west, Ballarto Road in the north, Manks Road in the south and Yallambee Road in the east. The South Gippsland Highway intersects the boundary of the Devon Meadows and Five Ways Road DSS.

The DSS areas occur within the Gippsland Plain Bioregion. Historically, the area supported widespread heathlands, swamps, grasslands and grassy woodlands. The area formed part of the Koo Wee Rup Swamp prior to historic land use changes which led to the draining of the swamp in the 1800s (SKM, 2012). Consequently, remnant native vegetation is known to be highly fragmented across the area.

2.2 Surrounding land use

The existing land use within the Devon Meadows DSS is a mixture of low-density residential development and naturally vegetated areas. Land use within the Five Ways Rd, Clyde Township and Moores Road DSS is predominantly pasture and market gardens. Surrounding land use to the north and south of the site area is a mixture of residential and agricultural, to the east is predominantly agricultural, and to the west is residential and the Royal Botanic Gardens.

2.3 Climate

Climate information was obtained from the Scientific Information for Land Owners (SILO) portal¹ for climate station Cranbourne Botanic Gardens (86375). A summary of the long-term average rainfall and temperatures at this station between 1990 and 2022 is shown in Table 1. The monthly rainfall along with the cumulative deviation from the mean (CDFM) monthly rainfall is shown in Figure 2-1. Historically, the month of September shows the highest rainfall, while March shows the lowest.

The analysis of observations of actual evaporation from the Cranbourne Botanic Gardens (86375) climate station indicates that average daily evaporation per month ranged from 1.6 mm/day (June) to 6.3 mm/day (January) (Figure 2-2). The months of December, January and February show the highest evaporation rates, while May, June and July show the lowest evaporation rates.

¹ <https://www.longpaddock.qld.gov.au/silo/point-data/>

Table 1 Average monthly rainfall and temperature (1990 - 2020) – Cranbourne Botanic Gardens (86375)

Row Labels	Average of minimum temperature (°C)	Average of maximum temperature (°C)	Average of monthly rainfall (mm)
January	13.8	25.6	53.8
February	14.1	25.5	49.3
March	12.7	23.5	46.5
April	10.5	20.0	70.1
May	8.6	16.4	66.7
June	6.8	13.9	77.9
July	6.3	13.4	69.4
August	6.6	14.4	81.3
September	7.8	16.6	83.3
October	9.0	19.1	76.0
November	10.5	21.2	73.0
December	12.0	23.4	63.1
Annual	9.9	19.4	810.4

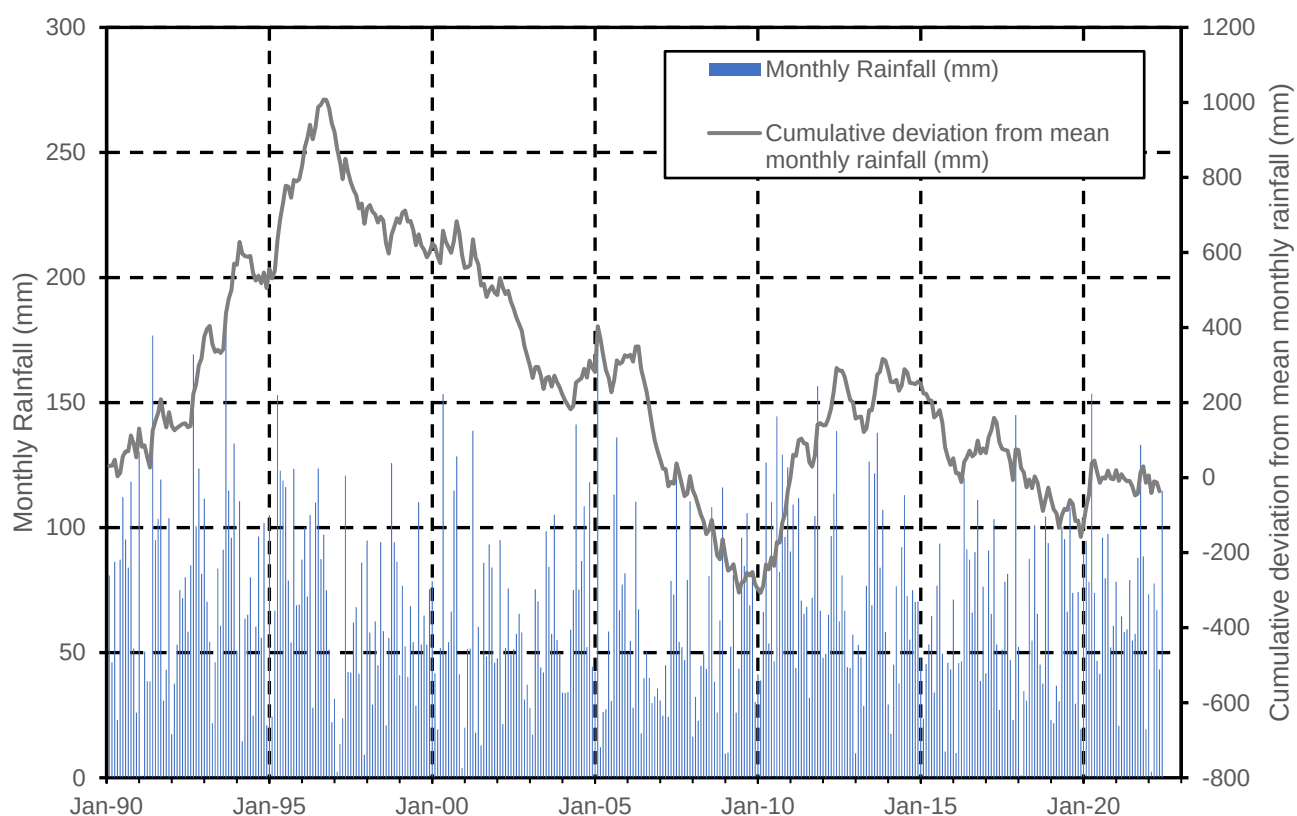


Figure 2-1 Monthly rainfall and CDFM (1990 - 2022) – Cranbourne Botanic Gardens (86375)

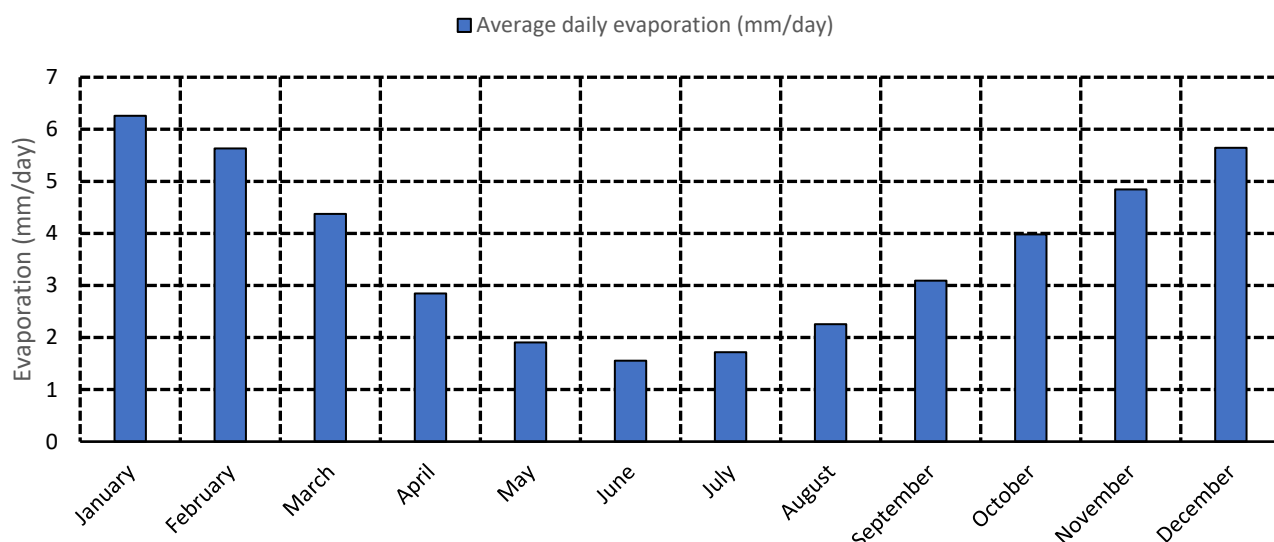


Figure 2-2 Average monthly evaporation (1990 - 2022) – Cranbourne Botanic Gardens (86375)

2.4 Geology

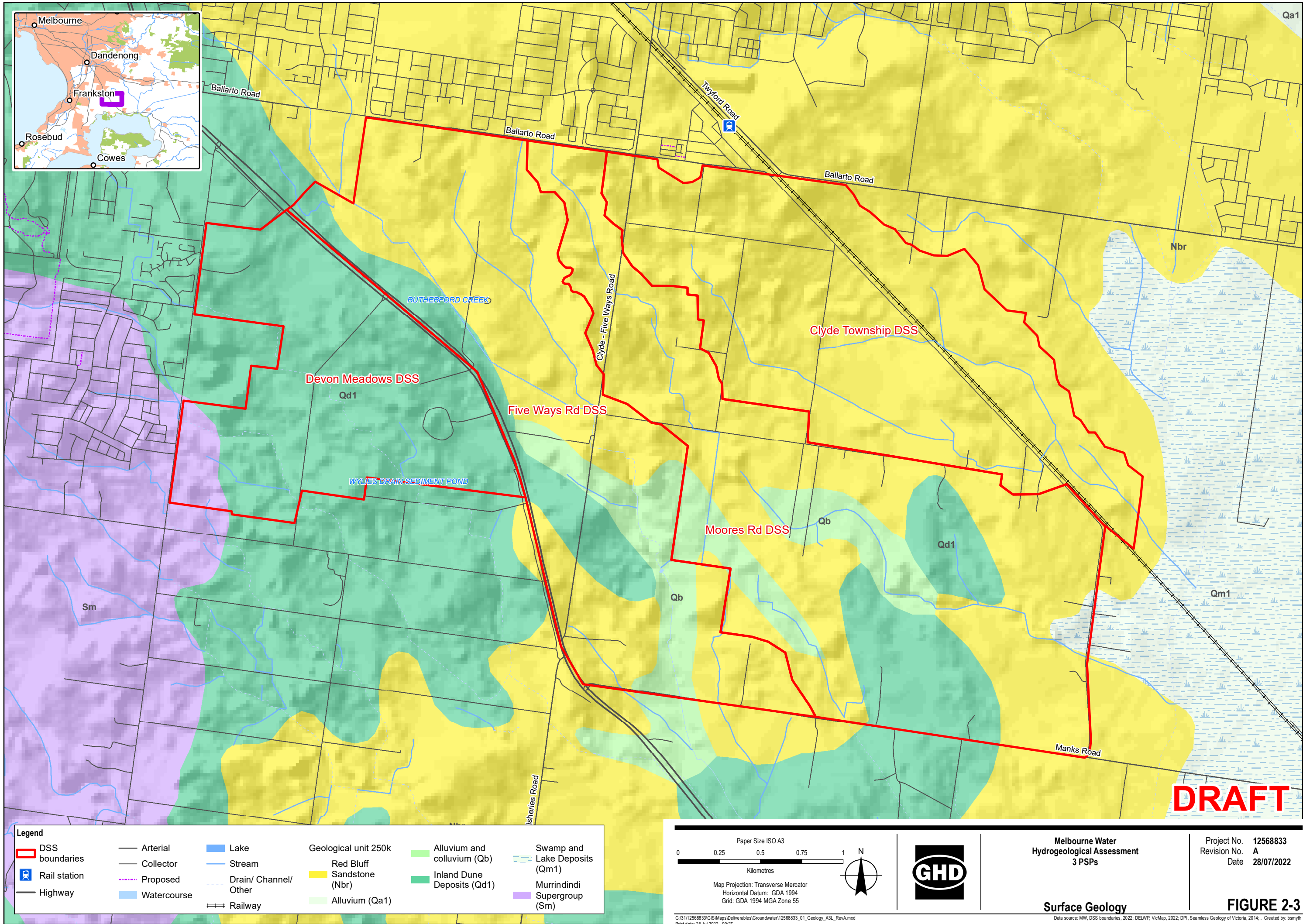
As shown in Figure 2-3, surface geology within the Devon Meadows DSS comprises of costal dune deposits, with a small outcrop of Murrindindi Supergroup marine mudstones and sandstones along the western boundary. The Five Ways Road, Moores Road and Clyde Township DSS areas comprise Brighton Group fluvial sandstone and conglomerate deposits, with outcrops of alluvium and colluvium sand, silt, clay and gravel, and inland dune deposits towards the southern boundary of the Five Ways Road and Moores Road DSS. A generalised regional stratigraphy is summarised in Table 2 based on the Queenscliff Mapsheet (1:250,000).

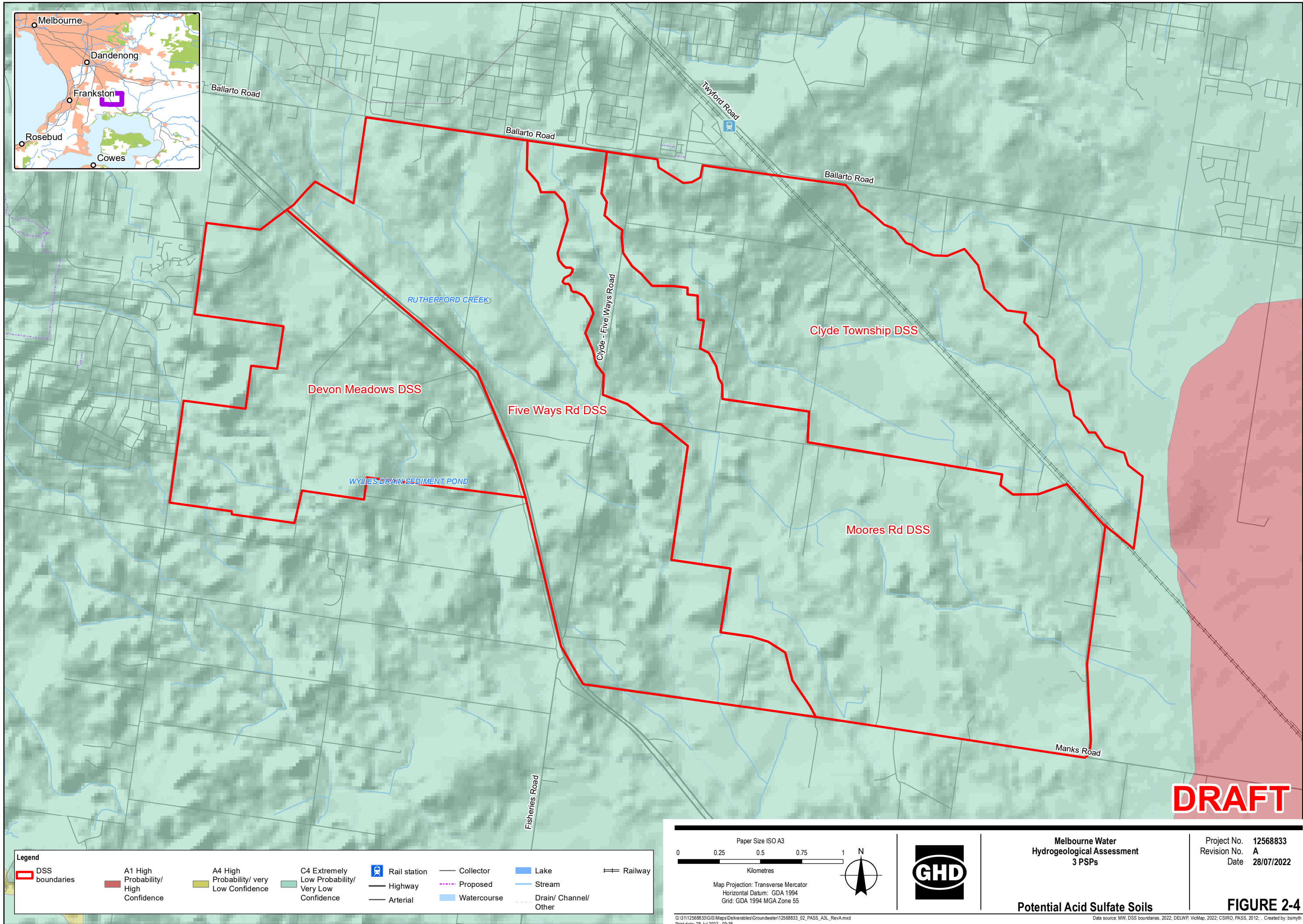
Table 2 Generalised regional stratigraphy

Period	Epoch	Formation / Group	Lithology
Quaternary (Upper)	Holocene	Unconsolidated Sediments	Paludal lagoon and swamp deposits: silt, clay
Quaternary (Lower)	Pleistocene	Unconsolidated Sediments	Aeolian dune deposits, sand, clay, and calcareous sand
Tertiary (Upper)	Pliocene to Miocene	Brighton Group	Fluvial sandstone, conglomerate, siltstone, and ironstone
Tertiary (Middle)	Oligocene	Maude Formation	Marine limestone, calcareous sandstone, sandstone, quartzite, sandy limestone, with intercalated olivine basalt lava
Tertiary (Lower)	Eocene to Oligocene	Older Volcanics	Extrusive tholeiitic and minor alkaline basalts
	Paleocene	Eastern View Formation	Fluvial gravel, sand, clay and brown coal
Pre-Tertiary	Silurian to Devonian	Undifferentiated	Marine mudstone and sandstone

2.5 Potential acid sulfate soils

The Commonwealth Scientific and Industrial Research Organisation (CSIRO) Atlas of Australian Acid Sulfate Soils was interrogated and is shown in Figure 2-4. The figure shows that the soil within the DSS areas is likely to comprise extremely low probability/very low confidence of acid sulfate soils occurring. Of note, roughly 200 to 500 m east of the DSS boundary, there is an area of identified high probability/high confidence of acid sulfate soil occurring. This is due to this area of land being part of the estimated tidal zone.





2.6 Hydrogeological setting

2.6.1 Relevant aquifers

A search of the Department of Environment, Land, Water and Planning (DELWP) Groundwater Resource Report identified the hydrostratigraphy at the site, this is summarised in Table 3.

The Secure Allocations, Future Entitlements (SAFE) project layers were interrogated for the aquifers that form the water table as shown in Figure 2-5. It was identified that the water table aquifer across the majority of the site is the Upper Tertiary Aquifer (UTAF), which consists of fluvial sands, gravels and clay. The exception to this is within the Devon Meadows DSS and along the western boundary of the Clyde Five Ways Road DSS, where the water table aquifer is identified is the Quaternary Aquifer (QA), consisting of sand, gravels, clay and silts. These aquifers are sedimentary aquifer systems in which the groundwater flows between the pore spaces of the sediments.

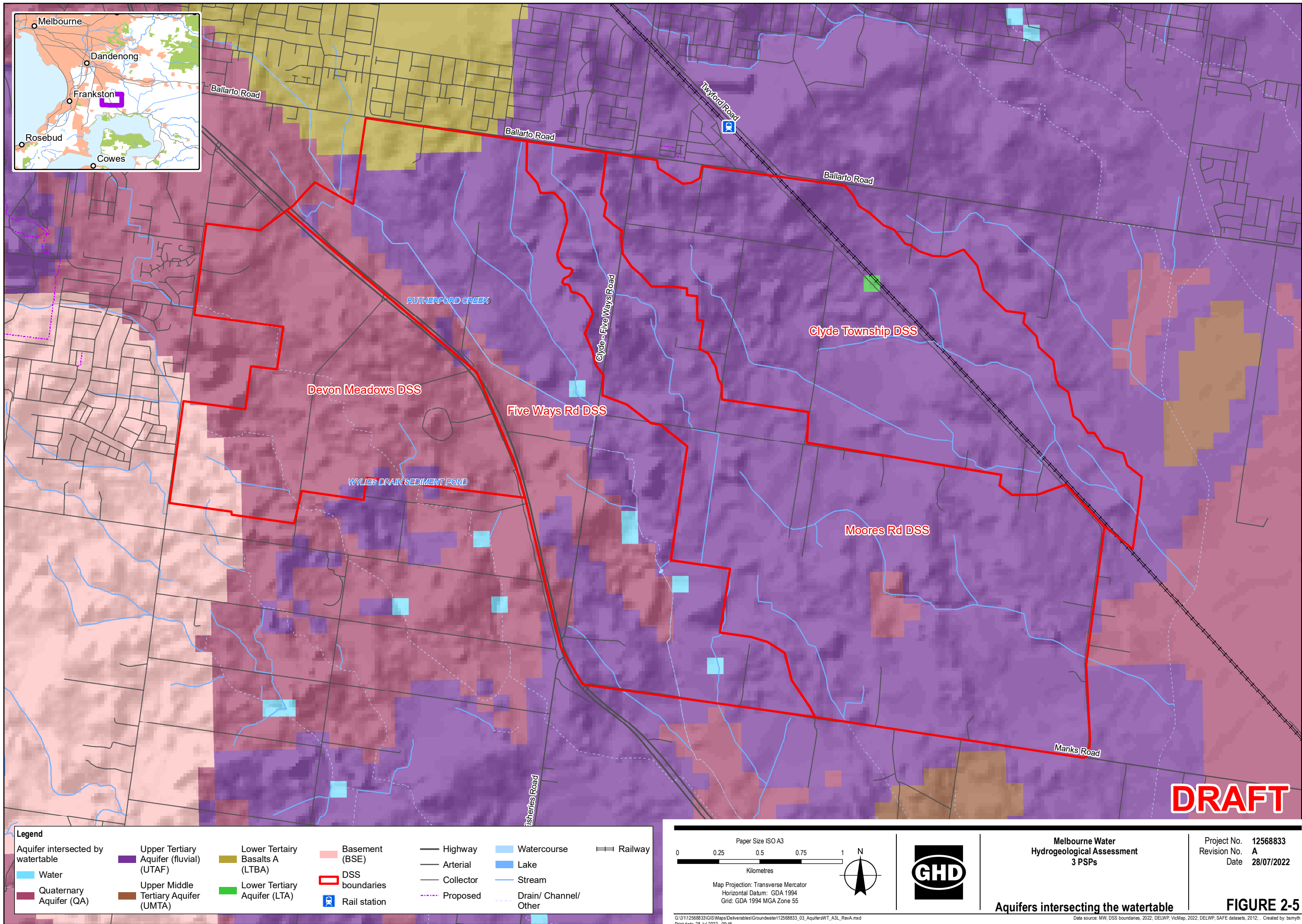
Overall, aquifer depths generally deepen eastwards across the CGA. It is noted that the Lower Tertiary Basalts (LTBA) aquifer is not present within the Moores Road and Clyde Township DSS, instead, the Lower Tertiary Aquifer (LTA) is present.

It is noted that hydraulic conductivity of the aquifer systems is highly variable and bore yields can vary as a result. Data collected from DELWP Water Measurement Information System (WMIS), along with data from Southern Rural Water's Groundwater Management Plan (SRW, 2010) for the Koo Wee Rup WSPA, indicate the following approximate yields:

- Up to 10 L/s within the shallow QA
- 10 to 40 L/s within sand, gravel, limestone, clay, silt and lignite of the UMTA
- 2 to 25 L/s within the older volcanics (LTBA)
- 2.5 to 25 L/s within the bedrock aquifer (BSE)

Table 3 Site hydrostratigraphy

Age	Formation	Aquifer	Lithology	Depth below surface (m)
¹ Pleistocene	Unconsolidated sediments	Quaternary Aquifer (QA)	Sand, gravels, clay, silts	<10
Pliocene to Miocene	Brighton Group	Upper Tertiary Aquifer-fluvial (UTAF)	Sand, gravel and clay	10 to 38
Oligocene	Maude Formation	Upper Mid-Tertiary Aquifer (UMTA)	Limestone (fractured rock), sand, gravel, clay, minor coal	23 to 44
² Paleocene	Eastern View Formation	Lower Tertiary Aquifer (LTA)	Sand, gravel, clay and silt, minor coal	44 to 67
Eocene to Oligocene	Older Volcanics	Lower Tertiary Basalts (LTBA)	Basalt (fractured rock)	25 to 69
Cretaceous onwards	Metamorphic and Igneous rock	Mesozoic and Palaeozoic Bedrock (basement) (BSE)	Sedimentary (fractured rock): Sandstone, siltstone, mudstone, shale. Igneous (fractured rock): includes volcanics, granites, granodiorites.	> 47
1. Identified within the Devon Meadows DSS only 2. Identified at depth within the Moores Road DSS Clyde Township DSS only				



2.6.2 Groundwater management arrangements

The principal management unit for groundwater resources in Victoria is the Groundwater Management Unit (GMU). A GMU may be a Groundwater Management Area (GMA), a WSPA or an Unincorporated Area (UA). Of these administrative boundaries, only WSPAs are declared under the *Water Act 1989*, to ultimately provide sustainable management of groundwater resources.

Under the *Water Act 1989*, the Minister for Water may declare the total volume of groundwater (and/or surface water) which may be taken in an area. This is termed the Permissible Consumptive Volume (PCV). The total volume of water allocated under the PCV became a trigger for declaration of a GMA (or WSPA).

The *Water Act 1989* requires that all persons who wish to extract groundwater (except domestic and stock users) apply for a groundwater licence. Groundwater licences are issued to protect the rights of licence holders, ensure that water is shared amongst users, and to ensure that environmental requirements are protected. The Victorian Water Register was established as a public register of all water-related entitlements. Within WSPAs, caps or moratoriums on the issue of additional extraction licenses are often present. Within WSPAs, caps or moratoriums on the issue of additional extraction licenses are often present.

LMPs are incorporating smaller GMUs into larger groundwater catchments for management purposes, but local rules have been retained to address specific issues and water trading arrangements. LMPs are considered to be more responsive than statutory management plans as they can be revised and updated with changing (local) groundwater conditions.

The site falls within the Koo Wee Rup WSPA (DELWP, 2019) and thus is subject to specific plans and rules. The Koo Wee Rup WSPA has a PCV of 12,915 ML/yr which is the total volume of groundwater that may be taken from the area (regardless of depth below surface). When the PCV volume is reached, no further groundwater extraction licences can be issued within the area unless it is traded with another user (DELWP 2019).

The relevant groundwater licensing authority throughout the study area is Southern Rural Water (SRW)

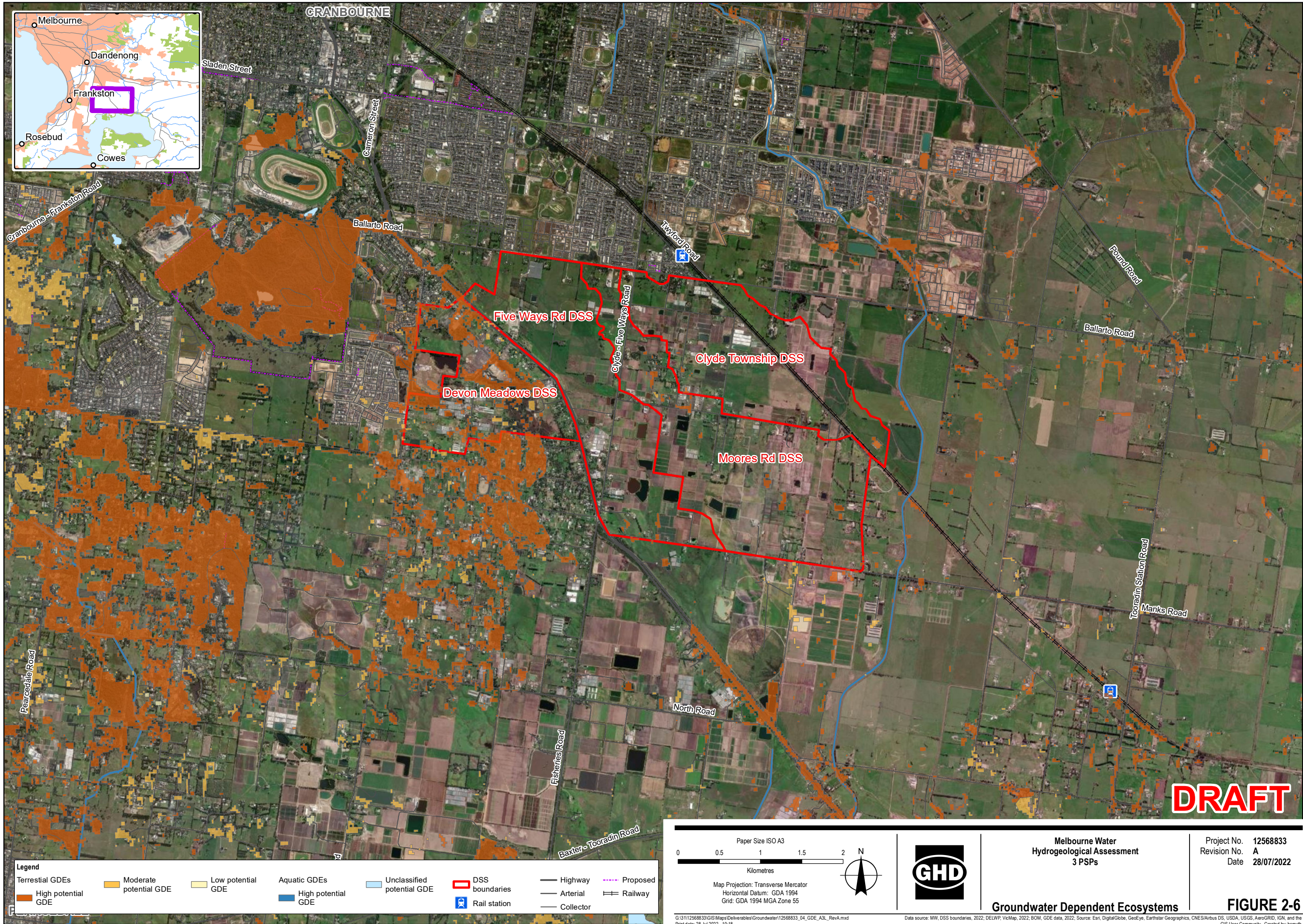
2.6.3 Groundwater dependent ecosystems

The Bureau of Meteorology's GDE Atlas identifies several GDEs within or in close proximity to the site, as shown in Figure 2-6. Specifically, the following ecosystems are identified as moderate or high potential GDEs:

- Aquatic high potential GDE - Western Outfall Drain running north to south, approximately 500 m east of the Clyde Township DSS and Moores Road DSS
- Terrestrial high potential GDE – scattered swamp scrub within the Moores Road DSS, and at the southern boundary of the Five ways Road, Moore Road and Clyde Township DSS
- Terrestrial high potential GDE – scattered heathy woodland located throughout the Devon Meadows DSS
- Terrestrial high potential GDE – patch of swampy riparian woodland within the Devon Meadows DSS
- Terrestrial moderate potential GDE – scattered grass woodland and heathy woodland within the Devon Meadows DSS
- Terrestrial moderate potential GDE – patch of swamp scrub within the Moores Road DSS

Note that the Royal Botanic Gardens Cranbourne is located 900 m west of the Devon Meadows DSS and contains a large area of heathy woodland. Further afield to the south of the site, roughly 5 km is the North Western Port Nature Conservation Reserve.

Lastly, the Western Port Ramsar site is located within 5 km south of the DSS areas.



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Print date: 28 Jul 2022 - 10:18

Data source: MW, DSS boundaries, 2022; DELWP, VicMap, 2022; BOM, GDE data, 2022; Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community. Created by: bsmth

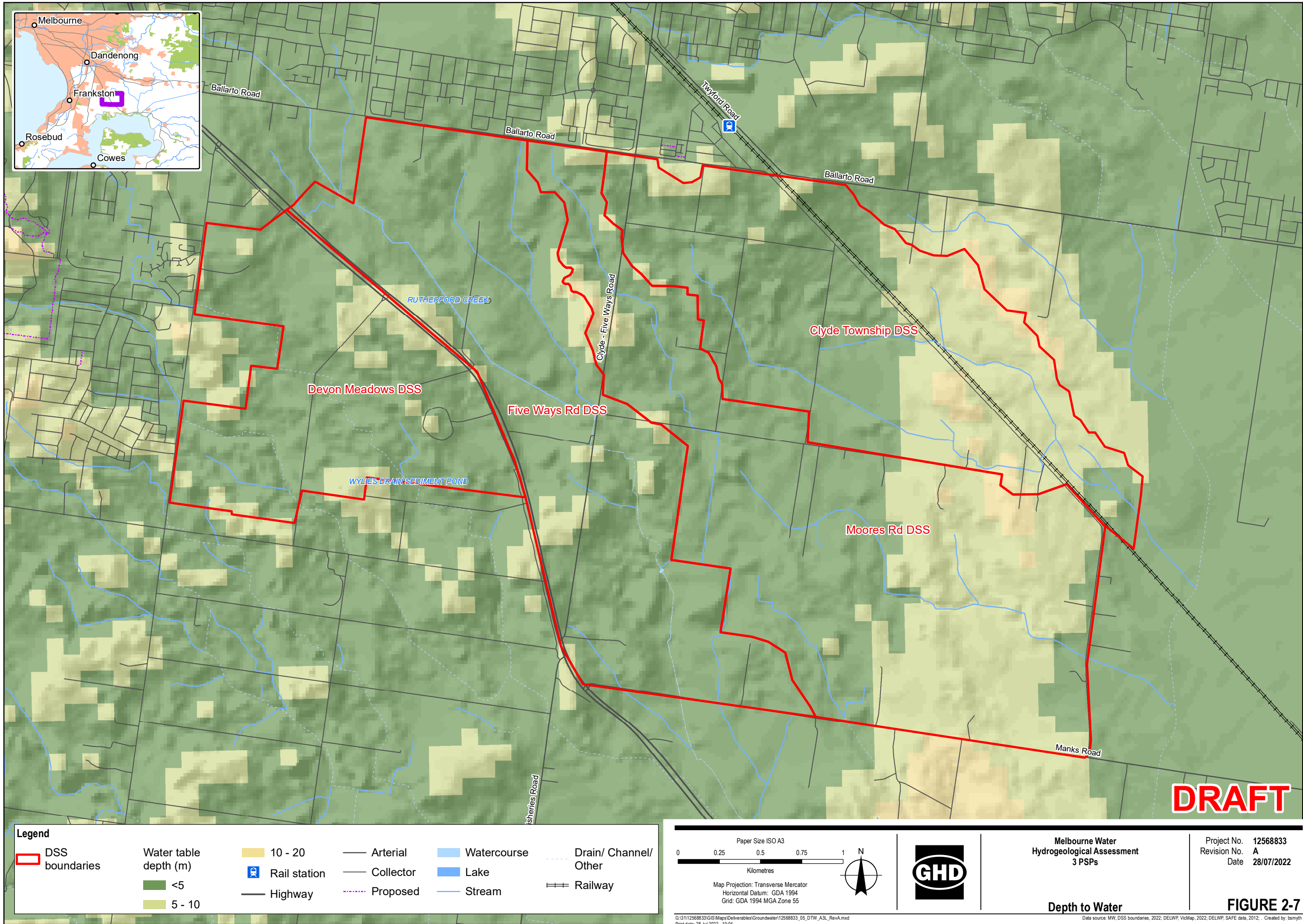
2.7 Regional groundwater levels

Figure 2-7 shows DELWP SAFE layers for depth to groundwater. The figure indicates that the water table across the majority of the site area is <5 m. The exception to this is within the eastern boundary of the Clyde Township DSS and Moores Road DSS, where the water table depth is up to 10 to 20 m below ground surface.

A search of DELWP's WMIS identified that there are no State Observation Network (SON) bores within the DSS boundaries. However, five SON bores within a 3 km radius of the DSS boundary were identified. SON bores 76210 and 91081 are screened within the QA, and 91076 is screened within the UTAF, which are likely to be the water table aquifer in their respective areas. SON bores 126975 and 91029 are screened at depth in the LTBA and UMTA/LTA respectively. Of note, groundwater depths in these two bores do match with the DELWP SAFE layers for depth to groundwater. The groundwater levels for the five SON bores are plotted in Figure 2-8. A residual mass curve for the mean monthly rainfall has also been plotted, which has been used to help characterise the influence of climate on groundwater levels.

Groundwater levels within the water table SON bores typically range between 1 to 4 m below the ground surface. Average groundwater elevations recorded for SON bores 91076, 76210 and 91081 are 18.7 mAHD, 68.6 mAHD and 72.3 mAHD respectively. There is a subtle overall declining trend from 1998, before increasing in 2011 and then stabilising. This subtle trend correlates with the residual mass rainfall curve and the Millennium Drought (1996 and 2010). Seasonal fluctuations in groundwater levels are most pronounced in borehole 91076 (roughly 2 m magnitude), and less pronounced in boreholes 91081 and 76210 (roughly 1 m magnitude).

Deeper boreholes (126975 and 91029) that develop deeper aquifers, show a more pronounced match when compared against the residual mass rainfall curve e.g. they are generally responding in unison.



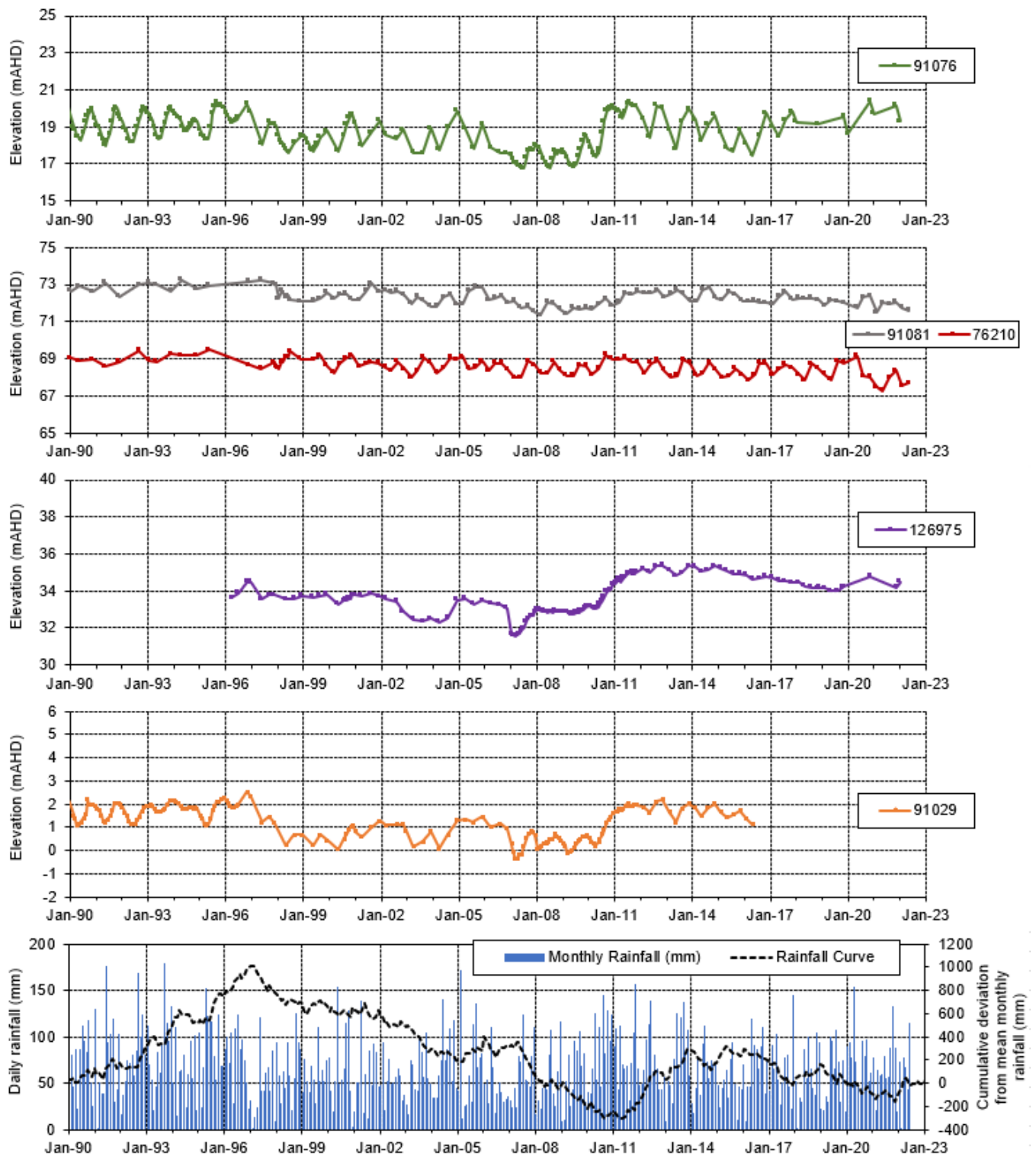


Figure 2-8 State observation network groundwater monitoring borehole hydrographs – mAHD

2.8 Groundwater flow

Historically, groundwater within the Koo Wee Rup WSPA flows in general agreement with the topography, recharging in areas at the edge of the Basin and flowing radial towards Western Port Bay. A number of boreholes within the centre of the Koo Wee Rup plain were reported as artesian prior to extensive pumping of the area (SKM, 2012). A cone of depression formed under the Koo Wee Rup Plain by the 1970s due to groundwater pumping. This resulted in altered groundwater flow regime across the plain.

In regard to the CGA, groundwater flow is likely to be towards the coast, with minor localised influences from pumping that may be exacerbated during the irrigation season (October to March), resulting in a seasonally variable groundwater flow regime.

2.9 Groundwater salinity

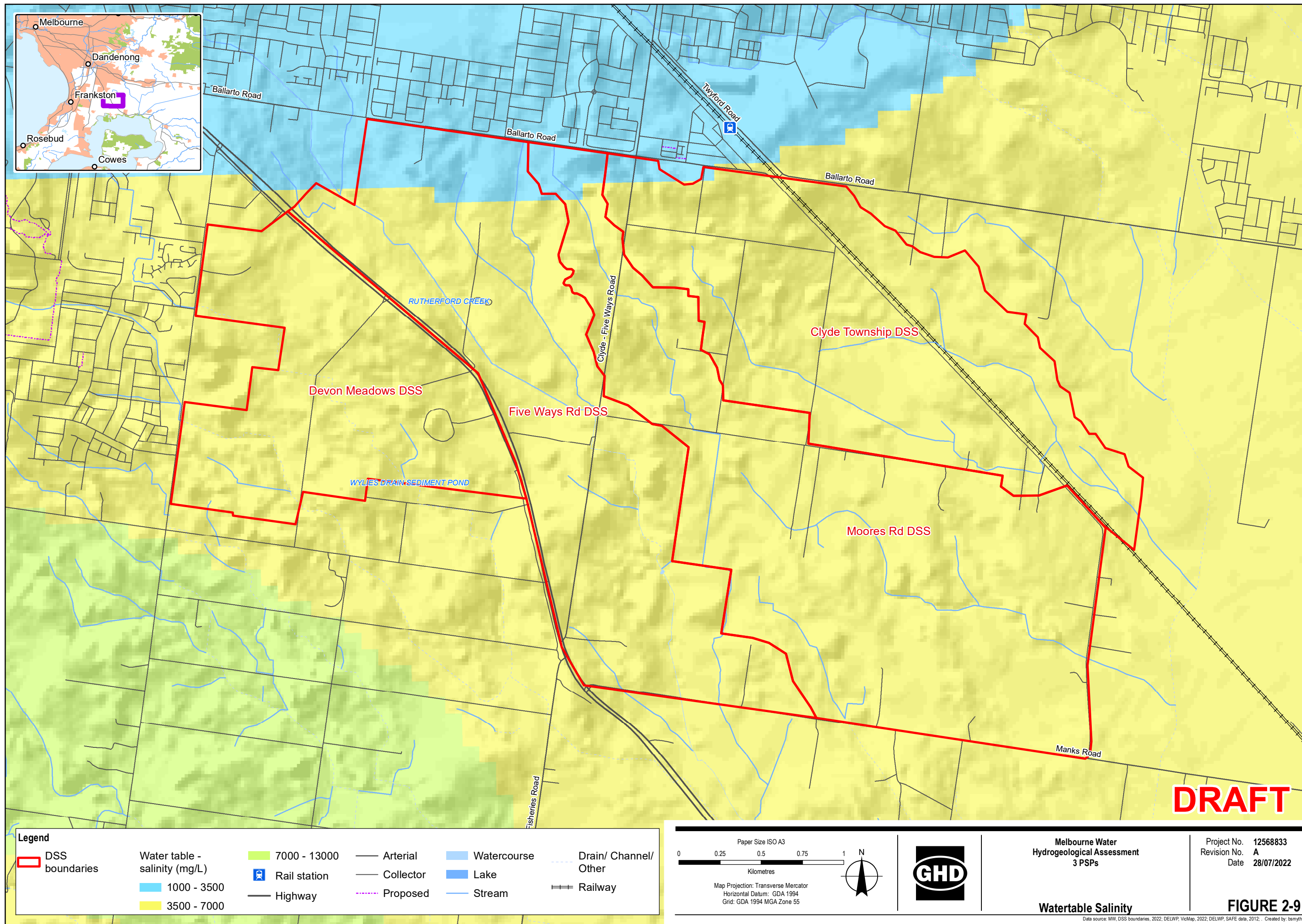
DELWP's Groundwater Resource Report indicates that at the Devon Meadows DSS, the water table salinity in the QA and the UTAF is between 1,001 to 3,500 mg/L Total Dissolved Solids (TDS). DELWP's SAFE mapping (Figure 2-9) indicates a higher salinity range of 3,500 to 7,000 mg/L TDS across the majority of the DSSs, except for a small area within the northern extent the Five Ways Road, Moores Road and Clyde Township DSSs. Within this area the salinity is 1,000 to 3,500 mg/L.

DELWP's WMIS showed limited groundwater quality information for the SON bores, with the most recent available data being from the 1990s. The three SON boreholes screened within the water table (76210, 91081 and 91076) had average salinity values of 62 mg/L, 167 mg/L and 2,860 mg/L respectively (based on limited data). While SON boreholes 126975 and 91029 (screened within deeper aquifers) showed average salinity values of 9,466 and 901 mg/L respectively (based on limited data).

DELWP's WMIS had limited recent groundwater quality information available for bores within the 3 km of DSS boundaries (including within the DSS boundary). In the available data, 53 bores had TDS data, and 125 bore had electrical conductivity (EC) data that was converted to TDS using a conversion factor of 0.65. Of these, 123 bores had depths less than 30 m. Table 4 summarises the salinity information for these 123 bores. Generally, the average TDS values are similar to that described in DELWP's Groundwater Resources Report. Note that a number of the bores had limited sample results, with the most recent data starting from the 1990s and earlier in some cases (the sampling method is not known for some of the bores and the quality of the data has not been verified).

Table 4 Summary of DSS bore salinity

Lithology	Number of bores	Range in TDS (mg/L)	Average TDS (mg/L)
Basalt	22	404 – 4,006	1,523
Clay	12	360 – 7,605	2,785
Coal	1	-	539
Gravel	1	-	561
Ironstone	1	-	270
Limestone	2	1,716 – 2,860	2,288
Mudstone	3	233 – 8,190	2,966
Not known	28	62 – 5,324	1,120
Sand	50	101 – 4,550	1,163
Sandstone	3	162 – 2,295	884



2.10 Groundwater quality

DELWP's WMIS was interrogated for groundwater quality data for bores in the area with depths less than 30 m. Table 5 summarises some key groundwater quality information available. Note that a number of the bores had limited recent sample results (i.e. some bores only having data from the 1990s and earlier) and the sampling method is not known for some of the bores.

Table 5 Regional water quality

Lithology	Range in TDS (mg/L)	Range in EC (µS/cm)	Range in Nitrate as N (mg/L)	Range in Chloride (mg/L)
Basalt	404 – 4,006	622 – 7,400	0.23 – 18.06	137 – 2,400
Clay	160 – 7,605	590 – 11,700	0.23	115 – 3,960
Coal	539	829	-	205
Gravel	561	863	-	207
Ironstone	270	415	-	100
Limestone	1,716 – 2,860	2,640 – 7,567	0.23	700 – 2,470
Mudstone	233 – 8,190	358 – 12,600	0.23 – 0.90	78 – 4,370
Not known	62 – 5,324	119 – 9,000	0.01 – 24.61	24 – 2,500
Sand	101 – 4,550	211 – 7,000	0.23 – 1.35	48 – 2,260
Sandstone	162 – 2,295	300 – 3,530	-	43 – 1,024

2.11 Regional groundwater use

A search of DELWP's WMIS database was undertaken to identify and characterise groundwater use within the DSS areas and surrounding region. The following comments are made regarding the WMIS data:

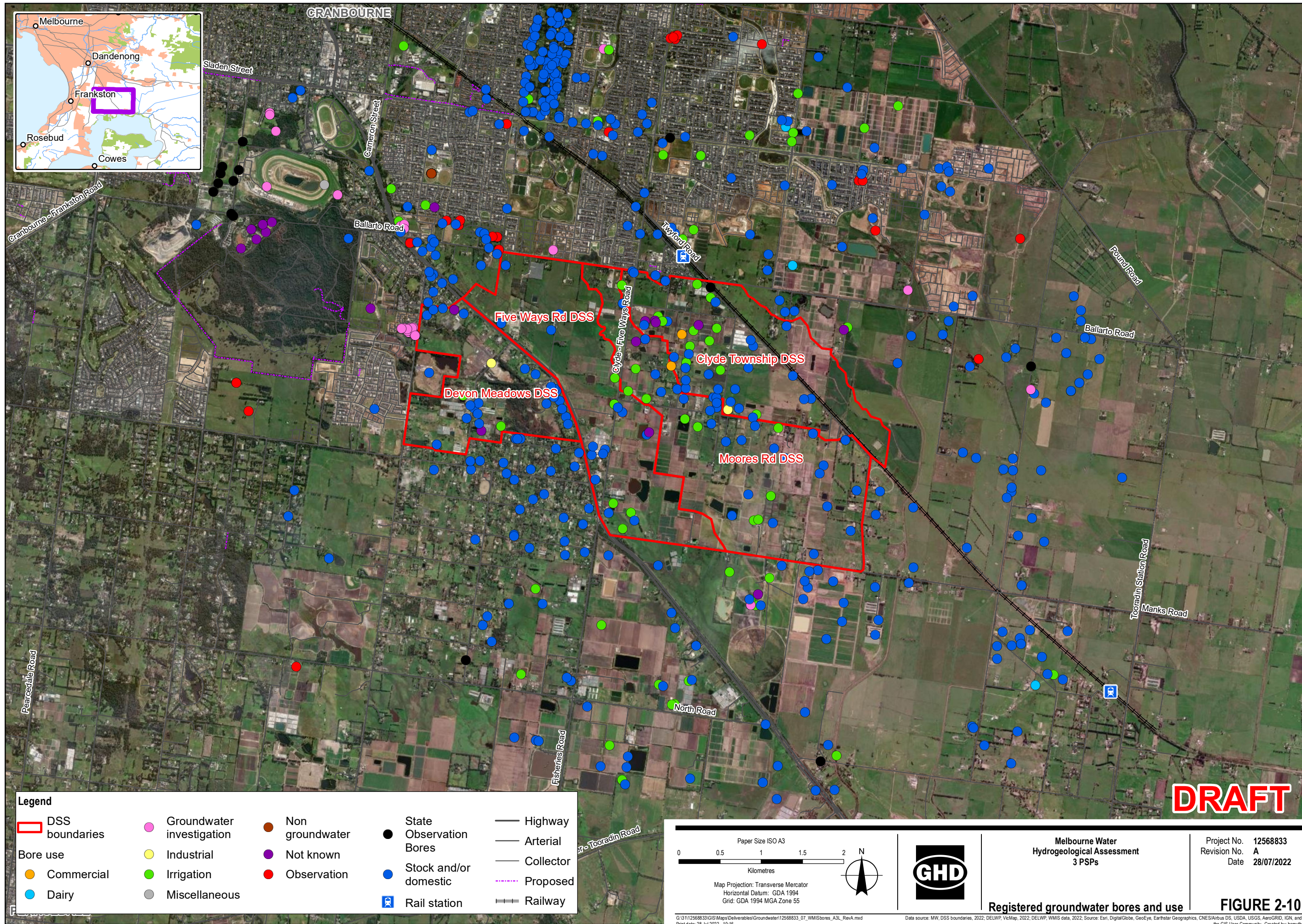
- Bores installed prior to the proclamation of the original Water Act 1969 may not be registered as there was no mandatory requirement to licence bores prior to this date
- Bores installed without a bore construction licence are unlikely to be registered on WMIS (unless detected by later audits)
- Many bores have not been surveyed for location. Bore locations registered were often those initially proposed on the bore construction licence application. In many instances drilling contractors could not gain access to these sites and final locations often have a positional accuracy greater than 250 m.
- The information registered on the WMIS is subject to the accuracy of the bore completion reports submitted by drilling contractors
- Information registered on WMIS is subject to change since the completion of the bore e.g. water level information, pump setting depth, groundwater quality
- Some information is not available on WMIS e.g. pump setting depth and bore ownership

The search identified 668 bores within 3 km from the site boundaries (this includes boreholes located within the DSS site boundaries). Of these, a total of 65 bores were identified as being decommissioned or not used. A breakdown of the users for the 603 bores (excluding decommissioned/not used bores) is presented in Table 6.

Table 6 *Regional groundwater uses*

Bore use type	Number of bores	Percentage of total bores identified (%)	Number of bores within site boundary
Irrigation	63	10	29
Commercial	2	<1	2
Industrial	2	<1	2
Dairy	3	<1	-
Stock and/or domestic	392	65	89
State observation bores	14	2	1
Observation bore	24	4	-
Groundwater investigation	33	6	-
Non groundwater	51	9	-
Miscellaneous	1	<1	-
Not known	18	<1	8

As shown in Figure 2-10, the majority of the bores within the DSS site boundaries are used for stock and/or domestic use, with a number of bores also used for irrigation purposes. This is similar down gradient of the site boundary, with the majority of the bores being used for stock and/or domestic purposes, followed by irrigation purposes.



2.12 Surface water quality and levels

A search of DELWP's WMIS river and stream flow monitoring database did not identify monitoring stations within a 3 km radius of the DSS site boundaries.

2.13 Regulatory framework for groundwater classification

2.13.1 Relevant legislation

The *Water Act 1989* is the principal legislation with respect to how groundwater is allocated for consumptive use in Victoria. Section 9 of the *Water Act 1989* sets out rights of water corporations to water.

The *EP Act 2017* is the principal legislation with respect to the environment in Victoria; significant changes to the *EP Act 2017* came into force on 1 July 2021.

2.13.2 Background groundwater salinity

EPA takes a conservative approach and classifies groundwater as per the lowest TDS identified to protect all potential environmental values. This assessment adopts EPA's conservative approach and as such, the water table aquifer relevant to the project area is considered **Segment C** (based on regional TDS concentrations up-gradient/westward of the site area) for the purposes of this assessment, and in identifying environmental values of groundwater to be protected (refer to section 2.13.3). Within Segment C, groundwater quality needs to be maintained to protect all the environmental values listed in section 2.13.3.

2.13.3 Groundwater environmental values

The environmental values to be protected for each groundwater segment are defined in the Environmental Reference Standards (ERS) under the *EP Act 2017*. The ERS supersede the State Environment Protection Policy (Waters) 2018. Water of higher quality (lower salinity) has more environmental values than low quality (higher salinity) groundwater. Environmental values to be protected for each segment are marked by a tick in Table 7.

Table 7 Protected environmental values of groundwater segments

Environmental value	Segment (TDS mg/L)						
	A1 (0-600)	A2 (601-1,200)	B (1,201-3,100)	C (3,101-5,400)	D (5,401-7,100)	E (7,101-10,000)	F (>10,000)
Water dependent ecosystems and species	✓	✓	✓	✓	✓	✓	✓
Potable water supply (desirable)	✓						
Potable water supply (acceptable)		✓					
Potable mineral water supply	✓	✓	✓	✓			
Agriculture and irrigation (irrigation)	✓	✓	✓				
Agriculture and irrigation (stock watering)	✓	✓	✓	✓	✓	✓	
Industrial and commercial use	✓	✓	✓	✓	✓		
Water-based recreation (primary contact recreation)	✓	✓	✓	✓	✓	✓	✓
Traditional Owner cultural values	✓	✓	✓	✓	✓	✓	✓
Buildings and structures	✓	✓	✓	✓	✓	✓	✓
Geothermal properties	✓	✓	✓	✓	✓	✓	✓

The EPA may determine that an environmental value may not apply to groundwater if:

- There is insufficient aquifer yield to sustain the environmental value, having regard to variations within the aquifer and reasonable bore development techniques to improve yield; or
- The application of that groundwater, such as for irrigation, may be a risk to the environmental values of land or the broader environment due to the soil properties; or
- The background water quality level exceeds (or is less than, in the case of indicators such as pH, dissolved oxygen and many biological indicators) the relevant objective specified in Table 5.4 of the ERS and as a result the environmental value cannot be achieved; or
- The background level of a water quality indicator other than TDS precludes a beneficial use; or – A Groundwater Quality Restricted Use Zones (GQRUZ) has been declared

2.13.4 Protected environmental values

Within Segment C, groundwater quality needs to be maintained to protect all the environmental values listed in Section 2.13.3.

3. Drainage infrastructure options

Table 8 summarises the drainage options selected by Melbourne Water for further modelling of the Devon Meadows and Five Ways Road DSS areas (drainage options for Clyde Township and Moores Road DSS areas will be covered in a future report). The table describes the options' approach to flood attenuation, flow conveyance and water quality. A map of the proposed layout of options 1, 3 and 6 is provided in Figure 3-1, Figure 3-2 and Figure 3-3 respectively. A map is not shown for Option 10 as all flood attenuation and water quality assets are on-site. For Option 12, a large harvesting pond is proposed outside of the Urban Growth Boundary (UGB), between South Gippsland Highway and Fisheries Road. The inclusion of the collection harvesting system could provide a water source close to potential water uses and remove excess stormwater volume from the Devon Meadows area, alleviating the current nuisance flooding.

Table 8 Summary of options to be modelled

Option	Flood Attenuation	Flow Conveyance	Water Quality
Option 1A (Regional Assets)	Regional Retarding Basins (RBs) located at DSS boundary on main waterways	Pipes and waterways	Regional Water Quality (WQ) measures located at DSS boundary on main waterways
Option 3 (Distributed Assets)	Distributed RBs located upstream of each major waterway confluence and at DSS boundary	Pipes and waterways	Distributed WQ measures located upstream of each major waterway confluence and at DSS boundary
Option 6 (On-site attenuation and WQ by developers)	No attenuation as part of DSS. Each developer must provide their own on-site attenuation.	Pipes and waterways	No WQ measures as part of DSS. Each developer must provide their own on-site WQ measures.
Option 10 (Flow Diversions)	Divert flows within DSS catchment to optimize asset sizing. RBs as per Option 1A or Option 3	Pipes and waterways	As per Option 1A or Option 3.
Option 12 (Large harvesting pond downstream of PSP)	RBs in similar locations to Option 1 or Option 3. Harvesting downstream of the PSP/outside UGB to alleviate nuisance flooding.	Pipes and waterways	As per Option 1A or Option 3.
Note – For each option above, IWM options such as rainwater tanks and storage/harvesting will be assessed			

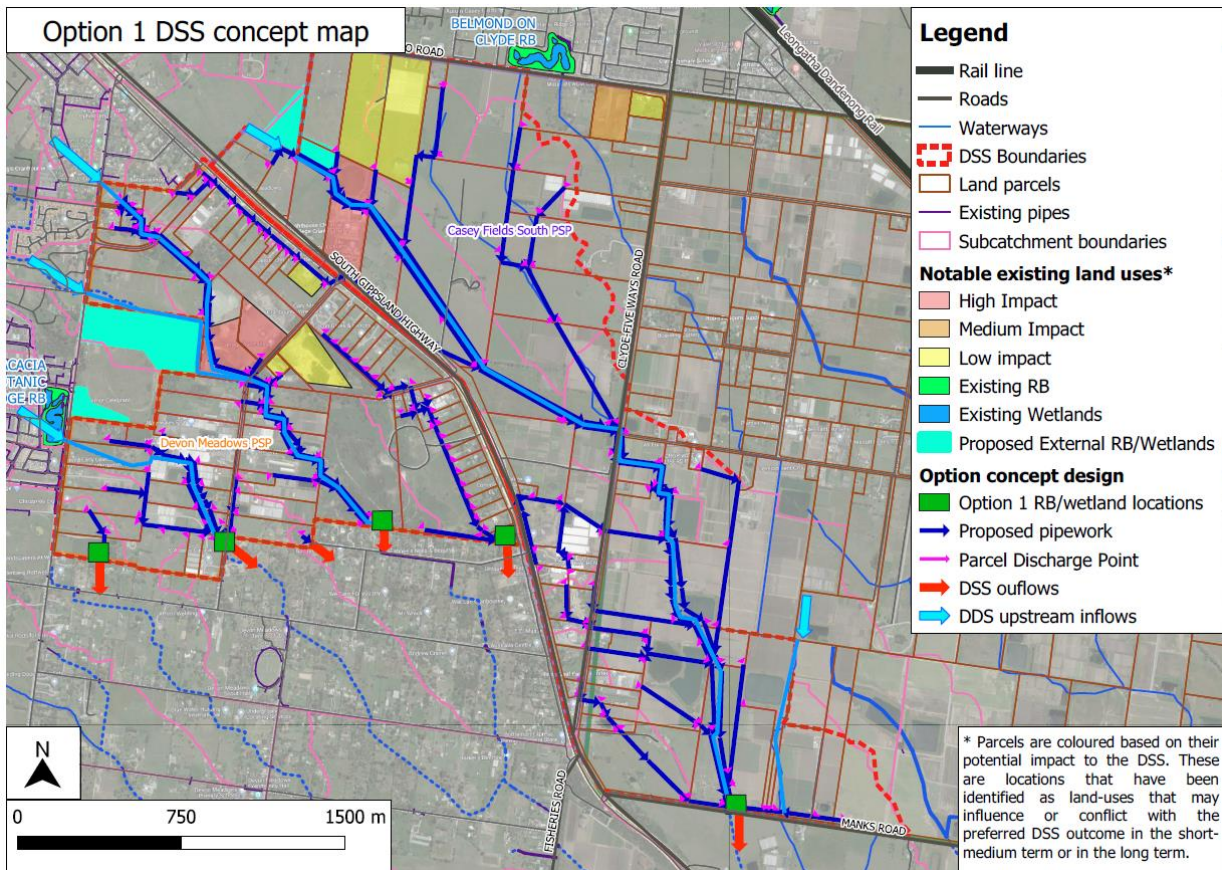


Figure 3-1 Option 1 concept map

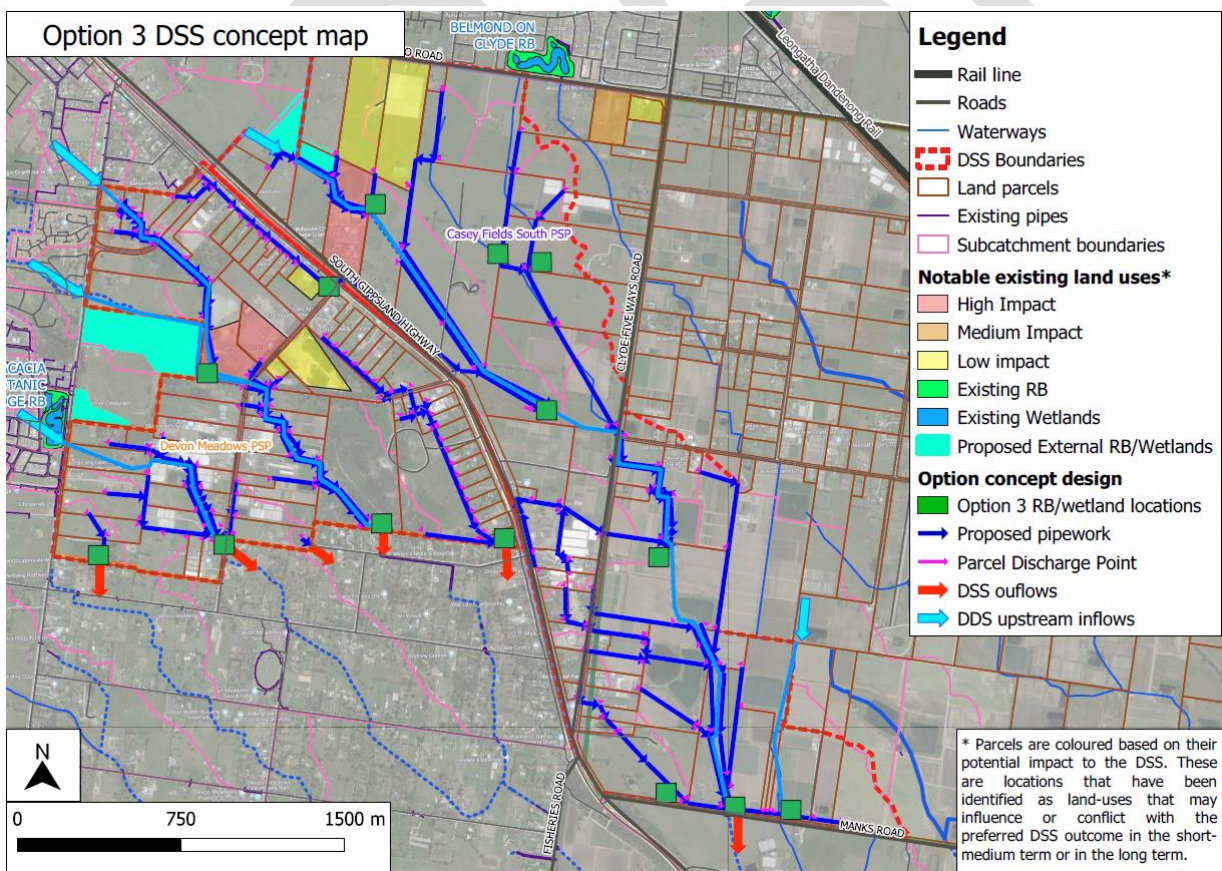


Figure 3-2 Option 3 concept map

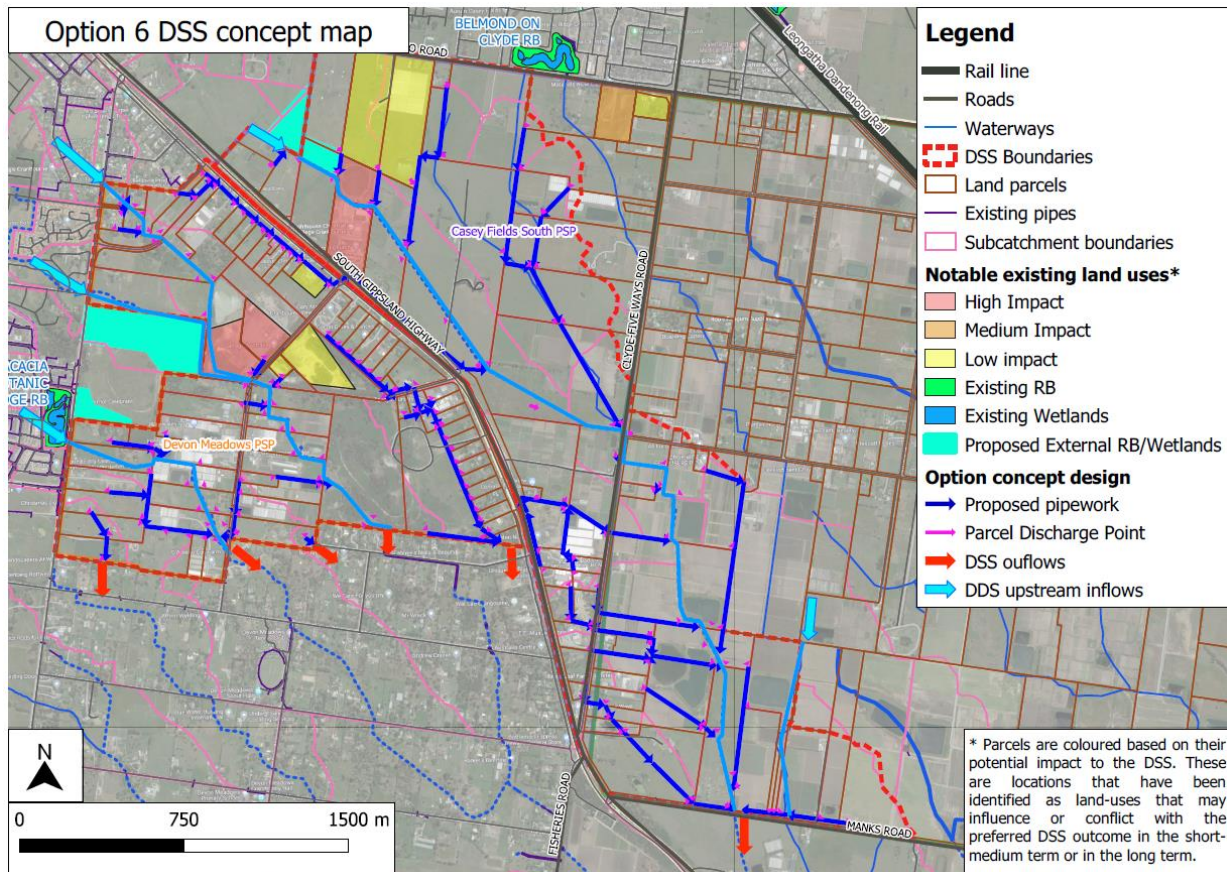


Figure 3-3 Option 6 concept map

3.1 Considerations for drainage infrastructure on groundwater

As part of the proposed drainage infrastructure options outlined in section 3, the following factors should be considered with regard to groundwater:

- The intersection of the water table by drainage infrastructure
- The intersection of saline water by drainage infrastructure
- Changes to groundwater flow regimes
- Potential changes to groundwater levels from drainage infrastructure
- Potential changes to groundwater quality from drainage infrastructure

As outlined in section 2.7, depth to the water table in the Devon Meadows and Five Ways Road DSS areas is likely to be <5 m. It is therefore possible, that if shallow excavation is required for the construction of some drainage infrastructure, groundwater may be intersected. Depending on the type of wetlands constructed, hydraulic connection to the water table is possible, which could either recharge or discharge groundwater. The impacts of groundwater flow changes as a result of this should be assessed prior to construction.

If dewatering is required during drainage infrastructure construction, consideration of groundwater disposal options should be explored. The type of groundwater disposal option would be dependent on the volume and quality of the groundwater. Groundwater salinity within the Devon Meadows and Fiveways Road DSS is likely to range from 1,000 to 3,500 mg/L (refer to section 2.9), however, site specific testing should be carried out in areas of the proposed drainage infrastructure if groundwater is encountered.

As drainage infrastructure can alter the natural distribution of water within the DSS area, the effects of drainage infrastructure to the natural groundwater flow regime, levels and quality need to be considered. In general, these can alter when:

- There are changes made to surface water storage areas (i.e. wetlands, retention basin)
- Construction activities intersect the water table
- Changes occur within, and downstream of drainage channels

Changes to the natural flow regime can have environmental impacts to surrounding flora and fauna. In particular to water dependent ecosystems and species, along with other environmental values such as agricultural and irrigation (stock watering). Changes to the natural flow regime as a result of drainage infrastructure will likely modify the areas that groundwater recharge and discharge occur. Which in turn can alter groundwater levels and groundwater quality. This change is difficult to quantify due to its complexity, both at a local and regional scale. In general, the drainage infrastructure itself can become a point of groundwater recharge due to leaks and cracks.

If shallow groundwater is confirmed, consideration could be made to using the network of subsurface stormwater and sewerage drainage constructed to service residential developments to intercept and drain groundwater. This would require further investigation and modelling to confirm feasibility.

Regarding water quality, the altered flow regime that may occur due to the drainage infrastructure, along with increased run-off into the drainage system as urbanisation of the area occurs, can result in adverse impacts to the quality of the groundwater and needs to be taken into consideration.

3.2 Considerations for groundwater on drainage infrastructure

The proposed drainage infrastructure is likely to interact with the water table, acting as both areas of recharge and discharge, as outlined in section 3.1. Consideration of potential impacts that groundwater can have on the materials used as part of the drainage infrastructure should be taken into consideration. Although based on regional data, water table salinity (refer to section 2.9) is unlikely to have an adverse effect on drainage material. It should be noted that salts can be concentrated up to levels that could affect buildings, infrastructure and flora if the site is not managed to control the concentration of salt. In view of the process for salt to concentrate by migration within water (seepage/runoff) and through evaporation, drainage and water management form important aspects of salinity management at the sites.

Drainage infrastructure across the sites would receive water from both run-off and the water table aquifer and therefore can act as a hydraulic connection between the two. Consideration of materials used should be made, where this connection is likely, i.e. retention basins using clay linings to prevent infiltration. Therefore, depending on the level of interaction between drainage infrastructure and surface water and/or groundwater, the material used will either facilitate or impede recharge/discharge within the water table and should be taken into consideration during the design process.

4. GAP analysis

GHD has identified the following gaps in available data:

- Limited recent site specific groundwater quality data, specifically at the proposed drainage infrastructure locations
- Limited aquifer parameters data (specifically hydraulic conductivity) in water table aquifers relevant to drainage infrastructure locations
- Limited understanding of groundwater flow paths within the study area
- Limited understanding of surface water quality within the study area and infiltration rates

5. Conclusion

This report provides a conceptual hydrogeological characterisation of the DSS areas to inform drainage infrastructure options, as part of development of Melbourne Water's drainage strategy.

The study area is within the Koo Wee Rup WSPA, in which the water table aquifers are primarily represented by the UTAF, and to a lesser extent, the QA. Soils across this area are unlikely to exhibit PASS.

Groundwater flow is likely to be radially towards Western Port, however influence from regional groundwater pumping likely alters the flow regime through development of seasonal drawdown cones.

Depth to groundwater is likely to generally be shallow (<5 m below ground surface) and water table salinity is likely to be range from fresh to saline and has been inferred as Segment C of the ERS. Groundwater values include GDEs, which are identified across the study area and groundwater users, which primarily relates to stock and/or domestic purposes.

The following factors should be considered with regards to drainage infrastructure and groundwater:

- The intersection of the water table by drainage structures and its potential to facilitate or impede groundwater recharge/discharge or interactions with surface water
- The intersection of saline water by drainage structures
- Changes to groundwater flow regimes
- Potential changes to groundwater levels and/or quality from drainage infrastructure
- The material of drainage infrastructure in the context of the saline soil and groundwater setting

Gaps identified during the hydrogeological assessment include limited site specific groundwater level, quality and flow data and characterisation, particularly at locations where drainage infrastructure is proposed.

6. Recommendations

Based on the desktop hydrogeological assessment, GHD recommends that:

- For key drainage infrastructure locations such as wetlands and retarding basins, further ground investigations are undertaken as part of the design phases to assess the site-specific water table elevation, groundwater level variability, groundwater quality, aquifer hydraulic properties at these locations, and the potential for proposed infrastructure to impact groundwater flow regimes and groundwater quality
- If ground investigations conducted as part of the design phase identify shallow and or saline groundwater at the infrastructure site, consideration should be made for groundwater level and quality monitoring of the water table aquifer, to establish background/baseline conditions and to assess impacts of the drainage infrastructure on the receiving environment
- If the above investigations are undertaken, a groundwater risk assessment should be conducted to identify and rank groundwater related risks. This could be used as a basis for consideration of engineering mitigation options to reduce potential for impact to drainage infrastructure and/or the groundwater environment

7. References

Australian Soil Resource Information System (ASRIS). National soil data provided by the Australian Collaborative Land Evaluation Program ACLEP, endorsed through the National Committee on Soil and Terrain NCST (www.clw.csiro.au/aclep)

Bureau of Meteorology: GDE Groundwater Dependent Ecosystems Atlas

Department of Environment, Land, Water and Planning (DELWP) 2017. Victorian Aquifer Framework (VAF) Secure Allocation Future Entitlements (SAFE) project data

DELWP VicMap spatial data

DELWP Groundwater Resource Report tool. Accessed online @ <https://www.water.vic.gov.au/groundwater/groundwater-resource-reports>

DELWP Water Measurement Information System (WMIS). Accessed online @ Water Measurement Information System

SKM (2012) Casey Growth Area impact assessment: groundwater and GDE investigation

Southern Rural Water (SRW) 2010. Groundwater Management Plan Koo Wee Rup Water Supply Protection Area. Accessed online @ [KWR-GMP-Final_signed_med_res.pdf](#) (srw.com.au)

VandenBerg, A.H.M. (1997) Queenscliff SJ 55-9 Edition 2, 1:250 000 Geological Map Series. 1:250 000 geological map. Geological Survey of Victoria



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