
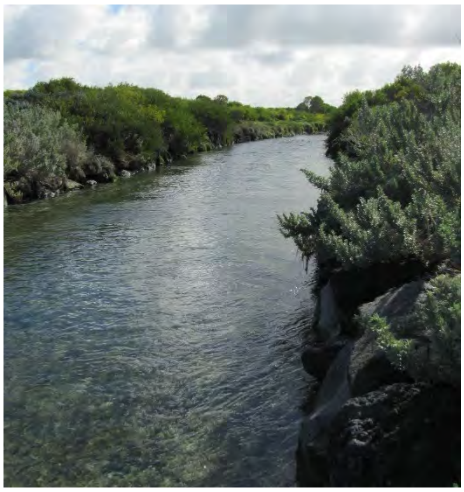


South East Drainage Network Assessment & Managed Aquifer Recharge Feasibility Study

Final Report

A report prepared for the Limestone Coast Landscape Board

26 April 2023

IGS ACE

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by

Innovative Groundwater Solutions

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ACKNOWLEDGEMENTS

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- Sue Botting and Liz Perkins (LCLB)
- Mark de Jong (LCLB)
- All stakeholders who participated in workshops and telephone interviews.

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The information in this report is considered to be accurate with respect to information provided at the time of investigation. IGS has used the methodology and sources of information outlined within this report and has made no independent verification of this information beyond the agreed scope of works. IGS assumes no responsibility for any inaccuracies or omissions. No indications were found during our investigations that the information provided to IGS was false.

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Executive Summary

There has been an ongoing desire for a more integrated surface water – groundwater accounting scheme and management framework in the Lower Limestone Coast (LLC) for many decades, yet the significant impacts of artificial drainage on the regional water balance have not specifically been addressed in the LLC Water Allocation Plan (WAP). Opportunities for retaining water in the landscape to mitigate declines in groundwater levels (some of which are contributed to by drains) as well as to potentially enhance (or restore) groundwater recharge through the installation of regulators have been identified previously, for example by Slater and Farrington (2010).

The present project, initiated by the Primary Producers Sustainable Water Working Group (PPSWWG) and Innovative Groundwater Solutions Pty Ltd. (IGS), with funding secured by the Limestone Coast Landscape Board (LCLB) aimed to assess the availability of water within the South East Drainage Network (SEDN) and investigate the feasibility of holding up or redirecting available water in the landscape to improve water security.

Consultation with stakeholders identified a widespread demand for more strategic and integrated surface water / groundwater / environmental management in the LLC, with the retention of drainage water in the landscape being a critical aspect of this. The view expressed by most was that any surface water that can be harvested should be used to help restore high-value environmental assets in stressed areas, thereby removing the need for blunt policy instruments (i.e., reductions to allocations at the management area scale) and protecting existing industry.

In consultation with stakeholders, three types of scheme to assist with integrated surface water-groundwater management were identified:

1. **Community or on-farm Managed Aquifer Recharge (MAR)**: taking excess surface water at locations and times when it was available in the drainage network and injecting into the shallow water table aquifer near the offtake location for subsequent beneficial (extractive or environmental) use;
2. **Regional water transfer and MAR**: piping water from where it is most available to where it is most needed and can be stored for subsequent beneficial (extractive or environmental) use; and
3. **Holding water up in the SEDN**: holding water up in the drains for passive MAR.

A review of water availability in the SEDN and a desktop assessment of feasible locations for the three scheme types described above identified that the greatest physical constraint on the application of MAR in general is geography, with highest water availability in the west but the greatest demand and potential benefit generally in the east. Numerous feasible areas were identified for community or on-farm MAR to support high water demand by licensed extraction, plantation forestry and high-value GDEs. Notable areas of highest feasibility include areas west of the existing Coles-Short plantation forest estate, around Mount Burr Forest, and south of Mount Gambier associated with the coastal (karst rising spring) creeks.

Even more opportunities were identified for regional transfer of water for MAR, but there are significant costs involved in this option. Highest feasibility areas include the Macdonnell and Donovans groundwater management areas south of Mount Gambier and numerous areas along the SA-Victoria border where relatively deep water tables and high groundwater demand exists.

The simplest and lowest cost option is holding water up in drains for localised recharge to support existing primary production and benefit adjacent GDEs. Potential locations for this were identified, including significant reaches of the Bakers Range watercourse and eastward into Killanoola, Monbulla and Zone 3A management areas. Areas immediately inland of the coastal lakes were also determined to be feasible. However, the current spatial (and to some degree temporal) resolution of flow gauging data in most of these areas is insufficient for confirming feasible locations and decision making around this option.

Potential risks of implementing MAR schemes in the LLC and holding water up in the landscape include localised waterlogging, reduced frequency of moderate and high flows at downstream environmental receptors, impacts to ecological diversity and migration of invasive species caused by more prolonged baseflow to drains, contamination of receiving aquifers with agricultural chemicals, and higher salinity regimes in the northern wetlands due to reduced freshening flows from the south. A preliminary Risk Assessment framework was developed to support future work on the implementation of MAR. This considered the three broad scheme types and regional-scale data and knowledge, resulting in most of the above risks being assessed as low to medium risk levels. Numerical modelling showed that holding water up in the SEDN may present a high risk to current land uses and functionality of private drainage networks from more frequent and/or longer-term inundation of localised areas. The risk framework developed can be used in future as the basis for site specific risk assessment and design of mitigation strategies, with stakeholder input particularly in the development of site specific consequence criteria. Risks of waterlogging caused by any scheme type can be mitigated and reduced during site-specific feasibility assessments using an ensemble of simple decision support models developed during this project.

This project has provided a solid basis for understanding the opportunities and constraints around the feasibility of holding water up in the landscape, including data availability. Recommended next steps include site specific studies to support MAR trials.

1. Introduction

1.1 Background

The South East Drainage Network (SEDN) and southern coastal creeks associated with karst rising springs have a combined average annual discharge of approximately 200 gigalitres (GL) via numerous outlets to the Southern Ocean (SENRMB and SEWCDB, 2019). With a changing climate and regional economy that is highly dependent on groundwater, innovative solutions are needed to retain surface water in the landscape in order to balance the needs of industry, the community and the environment.

An understanding of the potential opportunities offered by available water in the SEDN requires a comprehensive accounting of existing network commitments and discharges. This includes understanding the quantities, quality, location and reliability (seasonality and inter-annual variability) of available water, in the context of a changing climate, and the existing environmental and other commitments and expectations for drainage water. It must also include current authorisations of the South East Water Conservation and Drainage Board (SEWCDB).

One potential use of available drainage water is to supplement existing groundwater resources with managed aquifer recharge (MAR) for primary production use. This has generated strong interest amongst primary producers, particularly in the Lower Limestone Coast Prescribed Wells Area (LLCPWA) where reductions to licensed allocations have recently been applied to address the risk of impact to groundwater dependent ecosystems (GDEs). However, further work is needed to understand the opportunities, risks and benefits of establishing MAR schemes to achieve water quantity and water quality outcomes for consumptive (e.g., irrigation extraction and forest water use) purposes.

The desire for a more integrated surface water – groundwater accounting scheme and management framework in the Lower Limestone Coast (LLC) has been widely debated for many decades. As far back as 1980, when conditions in the region were much wetter than recent times, an environmental impact assessment of the drainage network highlighted there was already too much over-drainage and that there would be a need to hold more water in the landscape (South Eastern Drainage Board, 1980). The significant impacts that artificial drainage have had on the regional groundwater balance have not previously been addressed in the LLC Water Allocation Plan (WAP) (SENRMB, 2019), although the plantation forestry industry and other stakeholders raised the issue during the 2005-2013 review period (pers. Comm. Don Maguire et al., Forestry SA, 2006-2008). Slater and Farrington (2010) also identified the opportunity for retaining water in the landscape to minimise drain induced declines of shallow groundwater, as well as to potentially enhance groundwater recharge through the installation of regulators; the report proposed "*there has never been a more relevant time to construct this infrastructure*".

The Primary Producers Sustainable Water Working Group (PPSWWG) worked with Innovative Groundwater Solutions Pty Ltd. (IGS) in late 2020 and early 2021 to develop a research project proposal to address these knowledge gaps around the SEDN. Then in mid-late 2021, the Limestone Coast Landscape Board (LCLB) was a successful applicant to the Landscape Priorities Fund (LPF – for more information visit https://www.landscape.sa.gov.au) and as part of that 'Making Every Drop Count' grant the Board is supporting IGS to deliver the PPSWG proposal.

1.2 Project Aims

This project will assess the availability of water within the SEDN and investigate the feasibility of holding or redirecting available water in the landscape for the benefit of primary industry.

1.3 Project Scope

The scope of work for this project comprises three parts:

- Stage 1: Drainage Network Assessment
- Stage 2: Managed Aquifer Recharge Feasibility Study
    - Stage 2a – Stakeholder Pre-consultation
    - Stage 2b – Desktop Assessment and Decision Support Models

2. Drainage Network Assessment

2.1 Scope

In accordance with the Project Brief issued by the LCLB, the scope of Stage 1 was to include the following:

- Consult directly with the SEWCDB and SEWCDB management to (i) seek in-principle support to undertake the Drainage Network Assessment for the purposes of identifying available water that may potentially be used for managed aquifer recharge for the benefit of primary industry, (ii) confirm SEWCDB statutory responsibilities, approvals, and authorisations relevant to the Project, and (iii) ascertain agency strategies and policies in relation to management of available water in the SEDN.
- Undertake a desktop review that involves sourcing, reviewing, and analysing contemporary written information relating to the drainage network, including water quality and quantity, locations, relevant infrastructure and existing environmental and user commitments, expectations, and alternate demands to deliver a clear understanding of the location and availability of water in the SEDN.
- Identify potential risks to quality and quantity of water in the SEDN, and its availability for redirection for alternative uses, including consideration of private drainage networks that may have an influence on available water in the public network.
- Deliver a water availability report, with supporting spatial data, which shall focus on, but not be limited to, the South East Drainage Network within the Lower Limestone Coast Prescribed Wells Area.

2.2 SEWCDB Engagement

Prior to IGS being formally contracted by the LCLB to deliver this project, a joint meeting was held between the LCLB and SEWCDB on 23 September 2021 with a technical Expert Panel in attendance. On this occasion, IGS briefed both Boards on the project scope and received positive feedback and a request to keep them updated on progress. A subsequent meeting was held with the Acting Manager, South East Operations on 11 February 2022 at which in-principle support for the SEDN assessment was granted. Information pertaining to existing SEWCDB authorisations and commitments, as well as agency (Department for Environment and Water (DEW)) strategies and policies for managing water in the drainage network was later provided by Mark de Jong (LCLB), who previously worked for SEWCDB and has unparalleled knowledge of the SEDN and associated environmental assets. IGS also presented a project update at the SEWCDB meeting on Thursday 28th April 2022.

2.3 Water Quantity Assessment

2.3.1 Data Synthesis

Historical time-series discharge data for 24 currently active SEDN sites was downloaded from the Water Data SA website (https://water.data.sa.gov.au) for statistical analysis. In most cases the dataset was the 'Best Available', which comprised a mixture of manual and automated/telemetered gauging data over the full period of record. Flow hydrographs were generated within the website and labelled appropriately before being directly exported as images (Appendix A). Two of these sites were subsequently eliminated following statistical analysis due to having no years with at least 335 days of data – this criterion was adopted to avoid biasing statistics towards years with more than one month of missing data (consecutive days or multiple periods). Additional manual gauging data for four coastal creeks associated with the karst rising springs south of Mount Gambier was provided by DEW.

After reviewing the Water Data SA website, it became evident there were at least 36 historical discharge gauging sites across the study area, most of which ceased operation in around 2014. Fourteen of these only had a couple of years of data prior to year 2000, and thus were eliminated, as were two sites with no complete years of data. The remaining 20 sites were deemed to contain a sufficient length of record post year 2000 to warrant inclusion in the project dataset. These provide much greater spatial coverage across the study area (Figure 1). For one of these historical sites (A2390562 – Nalang Creek @ Allendale), data was available for the period 1993 to 2014. However, 1977 to 1993 data from nearby site A2390535 was also available to extend the length of this dataset. Additionally, historical data from sites A2390517 and A2390564 were used to extend the temporal length of the datasets for SEDN sites A2390531 and A2390569 respectively. All sites used in the final statistical analysis to support an assessment of water availability are shown in Figure 1.

Table 1 presents a detailed summary of mean and median annual flow for all selected sites across both the entire period of record and the last 10 years. Mean and median values were only derived from data for years with at least 335 days of data. These statistics are also mapped in Figure 2 and Figure 3, respectively, clearly demonstrating that the greatest water availability is in the western and southern parts of the region near the coast with comparatively insignificant flows in the east.

While annual flow statistics are useful for providing a broad regional perspective, it is arguably more important to understand the seasonal and inter-annual variability in flows at each gauging location. Flow hydrographs are presented in Appendix A for all sites used in this project, grouped according to whether they are for SEDN sites, coastal creeks, or historical sites, and then in order of their Site ID. In order to synthesise all of this data for ease of analysis, we have generated Flow Duration Curves (FDCs) for each site using a Python script. These are also presented in Appendix A, grouped according to whether they are for SEDN sites, coastal creeks, or historical sites, and then in order of their Site ID. Only data from years with at least 335 days of record were used in the generation of FDCs for SEDN and historical sites; in the case of the four coastal creeks, linear interpolation between quarterly manual gauging measurements was used to generate a continuous daily dataset. A selection of FDCs is shown in relation to their location in the region in Figure 4 to Figure 6. Each FDC plot shows separate curves for each year with at least 335 days of record, as well as a curve for the entire dataset comprising these years.

2.3.2 Data Summary

The number of complete years of record (i.e., years with at least 335 days of record) varied between discharge sites, from one year up to 50 years, with 18 of the 46 sites having at least 20 years of data (Table 1). Twelve of the 46 sites had less than five years of data. For the recent ten-year period (2012 to 2021), the number of complete years of record varied between zero and ten, with 21 sites having at least five complete years of data in that recent period (Table 1). Eighteen sites had only one or two years of complete record in the last 10 years. Only site A2391072 had no complete years of record in the last ten years, although it has five complete years of data in the period 2006 to 2012 (Table 1).

Because the focus of this study is on water availability and reliability, this assessment of surface water flow records focuses on median discharge values, although Table 1 also provides mean discharge values. A comparison between Figure 2 and Figure 3 highlights that median discharge for the last 10 years was relatively consistent with long-term median discharge records. The only notable differences are around and inland of Robe (A239505, A239504, A239510 and A239527), where the median discharge for the last 10 years was considerably greater than that for the whole record. Conversely, at site A2390533 (Drain 48 upstream of Lake Bonney), the median discharge for the last 10 years was much lower than that for the whole record. All these sites have at least 20 complete years of data overall. However, all but A2390505 had only two years of data in the last 10 years, so the observed differences in short- and long-term medians may simply be due to this paucity of data for the last 10 years.

Figure 1. All South East Drainage Network (SEDN), coastal creek and historical discharge sites that were used to support the assessment of water availability. Site labels are a shortened form of Site ID, e.g., 512 = A2390512.

Table 1. Summary statistics for all surface water discharge sites used in the water availability assessment.

Site ID	Category	Easting	Northing	Site Name	Date first record	Date latest record	No. years of full annual record (whole record)	No. years of full annual record (last 10 yrs)	Mean annual flow (GL/yr) (whole record)	Mean annual flow (GL/yr) (last 10 yrs)	Median annual flow (GL/yr) (whole record)	Median annual flow (GL/yr) (last 10 yrs)
A2390504		410571	5880328	Bray Drain	4/09/1975	6/05/2014	31	2	3.9	10.6	0.0	10.6
A2390505	SEDN	397828	5885867	DRAIN L @ Boomaroo Park Amtd 7.3 km	16/04/1971	13/01/2022	45	6	33.2	37.8	16.6	52.7
A2390506	SEDN	401871	5927128	BLACKFORD DRAIN @ Amtd 4.0km	16/07/1971	13/01/2022	42	9	20.9	22.5	20.4	18.9
A2390507	Coastal Ck	480872	5789178	Deep Creek	7/10/1970	6/12/2021	50	9	22.7	21.2	22.9	20.6
A2390508	Coastal Ck	482407	5789170	8 Mile Creek	7/10/1970	6/12/2021	50	9	60.2	56.4	61.0	56.3
A2390509	Coastal Ck	495022	5788828	Piccaninnie Pond Outlet	7/10/1970	1/10/2021	50	9	21.1	12.8	23.4	12.7
A2390510	Historical	418671	5895678	Drain L US Princess Hwy	16/07/1971	30/04/2014	23	2	10.8	10.4	7.5	10.4
A2390512	SEDN	417881	5856472	DRAIN M @ Woakwine Amtd 5.1km	14/07/1971	13/01/2022	40	10	38.7	23.9	21.5	14.9
A2390513	SEDN	425379	5848325	REEDY CREEK - MT. HOPE DRAIN @ 7.2km NE South End	14/07/1971	13/01/2022	45	10	20.8	20.5	17.0	20.4
A2390514	SEDN	452918	5878908	DRAIN M @ D_S Callendale Regulator	13/07/1971	13/01/2022	26	10	18.4	9.8	2.6	0.3
A2390515	SEDN	460339	5865550	BAKERS RANGE SOUTH DRAIN @ Robe-Penola Road	13/07/1971	13/01/2022	28	10	1.4	3.9	0.0	3.3
A2390519	SEDN	480092	5894660	MOSQUITO CREEK @ Struan	3/06/1971	13/01/2022	31	9	15.5	7.5	7.4	3.0
A2390523	SEDN	443778	5826883	STONY CREEK @ Woakwine Range	31/05/1973	13/01/2022	25	8	4.0	1.5	3.1	0.2
A2390527	Historical	421321	5886828	Wilmot Drain @ 9.2 km from Drain L	14/03/1973	30/04/2014	32	2	8.2	12.2	4.4	12.2
A2390531	SEDN	469595	5939608	MORAMBRO CK @ Bordertown-Naracoorte Road Bridge with 1971-1975 data added from A2390517	27/06/1973	13/01/2022	12	8	2.2	1.1	0.1	0.0
A2390532	Historical	439721	5832028	DRAIN 44 @ 100m U/S Lake Bonney Rd Bdge	22/07/1976	18/03/2014	17	2	4.3	6.0	3.9	6.0
A2390533	Historical	441921	5829428	DRAIN 48 @ 200m U/S Lake Bonney Rd Bdge	22/07/1976	18/03/2014	24	2	13.5	4.1	14.1	4.1
A2390534	Historical	479713	5981167	Tatiara Ck	9/06/1977	28/06/2018	16	5	1.0	0.3	0.2	0.3
A2390536	Historical	489188	5873638	Drain C US Coonawarra	2/05/1978	5/05/2014	23	2	0.0	0.0	0.0	0.0
A2390541	SEDN	467769	5888378	DRAIN M @ D_S Bool Lagoon Outlet	24/04/1985	13/01/2022	20	10	7.3	9.7	0.0	0.0
A2390542	Historical	476872	5911088	Naracoorte Ck	24/04/1985	7/11/2017	18	5	4.8	0.9	0.8	0.0
A2390556	SEDN	429570	5944150	BAKERS RANGE WATERCOURSE @ G Cutting	10/04/1992	13/01/2022	15	6	3.8	1.7	0.2	0.0
A2390562	Historical	476170	5975469	Nalang Ck @ Allendale with 1977-1993 data from A2390535	8/07/1977	30/04/2014	12	2	0.6	0.2	0.1	0.2
A2390563	Historical	437109	5955102	MARCOLLAT WATERCOURSE @ Rowney Road	22/10/1997	11/07/2013	7	1	1.7	0.1	0.1	0.1
A2390565	Historical	441302	5935484	Fairview @ Pitts	18/06/1998	13/05/2014	12	2	2.6	3.2	2.7	3.2

Table 1 (cont'd)

Site ID	Category	Easting	Northing	Site Name	Date first record	Date latest record	No. years of full annual record (whole record)	No. years of full annual record (last 10 yrs)	Mean annual flow (GL/yr) (whole record)	Mean annual flow (GL/yr) (last 10 yrs)	Median annual flow (GL/yr) (whole record)	Median annual flow (GL/yr) (last 10 yrs)
A2390568	SEDN	378835	6001352	SALT CREEK OUTLET @ Salt Creek	9/08/2000	13/01/2022	19	10	15.5	19.9	13.6	19.3
A2390569	SEDN	424758	5937597	FAIRVIEW DRAIN @ Downstream of Keilira Road with 1998-2000 data from A2390564	23/04/1998	13/01/2022	20	8	6.1	6.3	6.7	5.7
A2390570	Coastal Ck	475023	5788578	Cress Creek	18/03/2004	6/12/2021	16	9	5.3	5.7	5.4	5.6
A2391007	Historical	397745	5993800	BAKERS RANGE WATERCOURSE @ D/S Well & Bridge	28/07/1995	18/06/2014	8	2	2.2	0.0	0.0	0.0
A2391023	SEDN	425514	5964494	MARCOLLAT WATERCOURSE @ Ballater Road Jip Jip	28/08/1991	13/01/2022	15	9	4.0	4.4	0.0	0.0
A2391072	Historical	391041	5999539	Northern Outlet Drain	7/02/2006	18/09/2012	5	0	12.2	NA	2.1	NA
A2391075	Historical	495320	5905325	Yelloch Creek @ Laurie Park	25/08/2006	21/04/2014	7	2	1.8	2.3	0.1	2.3
A2391076	SEDN	503128	5893744	Mosquito Creek at Langkoop Hall	12/09/2006	13/01/2022	11	6	2.6	0.3	0.4	0.0
A2391092	SEDN	412042	5971100	KERCOONDA DRAIN AT PETHERICK ROAD	26/08/2008	14/01/2022	4	2	7.0	0.0	4.2	0.0
A2391104	Historical	419364	5966957	Didicoolum Drain @ Peacock Range	26/03/2009	26/02/2013	2	1	3.0	0.6	3.0	0.6
A2391125	SEDN	454858	5878851	Bakers Range South Drain at 0.85km u_s Callendale Reg with 2002-2009 data from A2391001	2/12/2002	14/01/2022	13	9	3.9	3.4	1.7	2.7
A2391140	Historical	411741	5970966	Bakers Range Watercourse at Petherick Road	27/04/2010	23/07/2014	2	1	0.7	0.0	0.7	0.0
A2391141	Historical	401744	5951997	Taratap Drain at Englands Crossing	28/07/2010	8/07/2013	1	1	0.3	0.3	0.3	0.3
A2391145	Historical	415830	5953276	Wimpinmerit Drain at Bald Hill Road	2/03/2011	23/07/2015	2	2	5.0	5.0	5.0	5.0
A2391146	SEDN	454874	5879940	Bakers Range Watercourse at Callendale	16/05/2011	7/01/2016	3	3	0.0	0.0	0.0	0.0
A2391150	SEDN	416544	5943791	Bald Hill Drain at Ratcliffe Boundary	7/04/2011	9/04/2017	4	4	2.4	2.4	2.1	2.1
A2391151	SEDN	406732	5966120	Bald Hills Drain At McBride Laneway	31/08/2011	23/07/2015	3	3	20.4	20.4	19.5	19.5
A2391187	Historical	428746	5843539	Drain 1B Downstream of the Narrow Neck Weir	14/06/2013	14/05/2016	2	2	4.0	4.0	4.0	4.0
A2391263	SEDN	411031	5931565	Ford crossing D_S Blackford diversion regulator	24/06/2019	24/10/2021	1	1	0.0	0.0	0.0	0.0
A2391264	SEDN	402616	5984244	Cement Ford Crossing at FS13	1/07/2019	31/08/2021	1	1	2.3	2.3	2.3	2.3
A2391279	Historical	472272	5982174	TATIARA CREEK - WRG040 (Poocher Swamp)	16/07/2014	17/03/2019	2	2	1.0	1.0	1.0	1.0

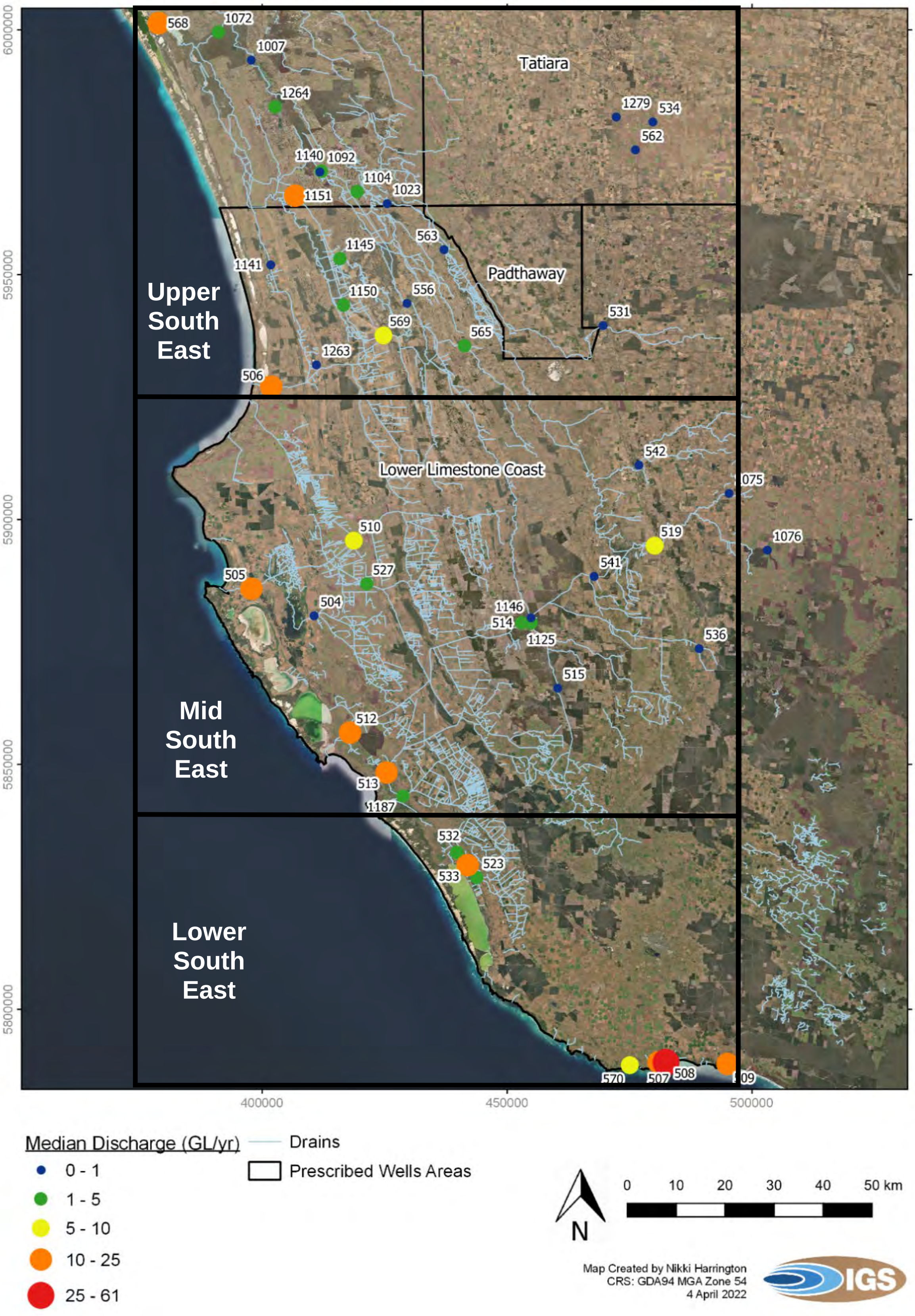


Figure 2. Median discharge (GL/yr) for the whole recorded period at all SEDN, coastal creek and historical discharge sites used in this assessment. Note that only data from years with at least 335 days of data were used. Site labels are a shortened form of Site ID, e.g., 512 = A2390512.

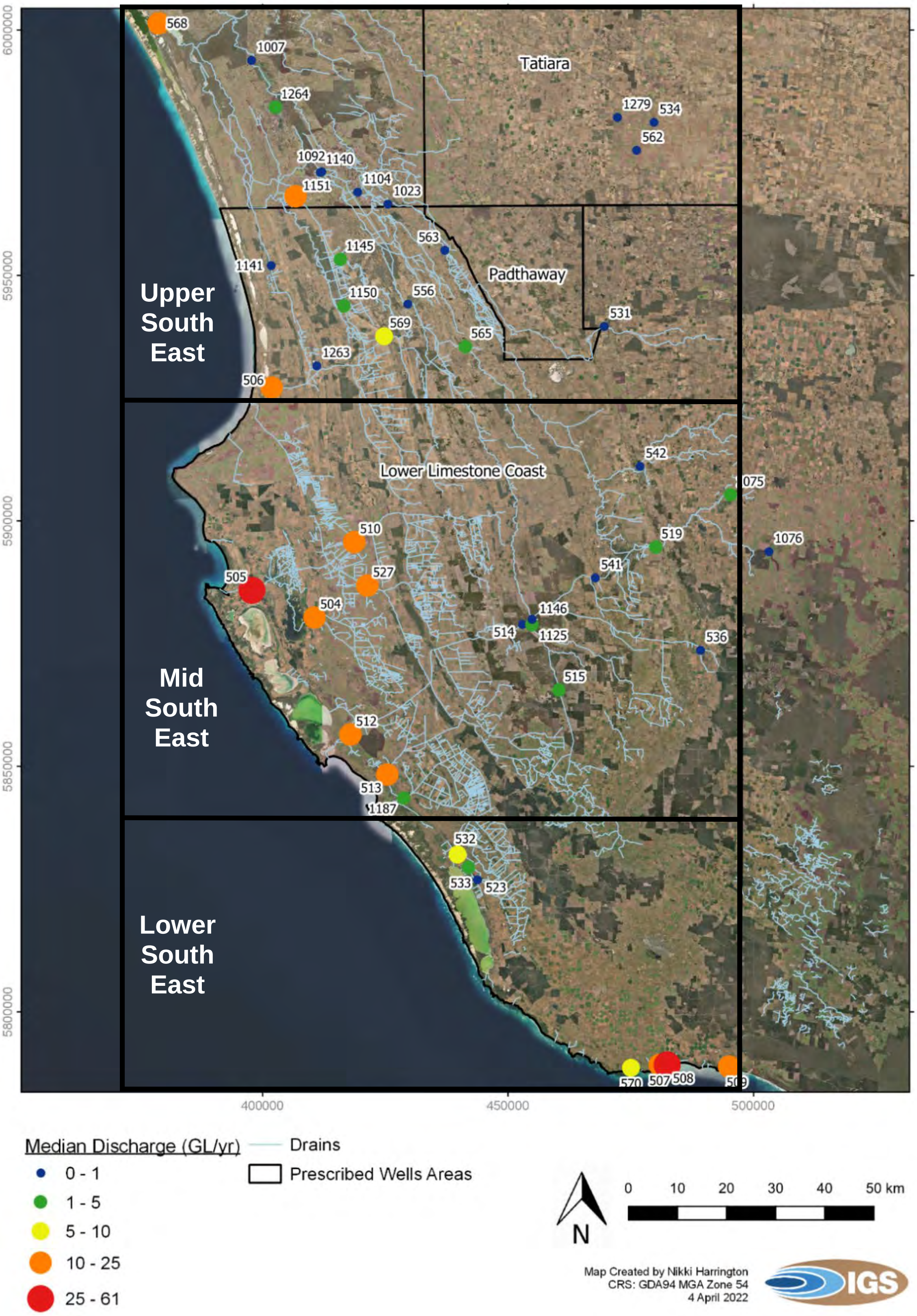


Figure 3. Median discharge (GL/yr) for the last 10 years (1 January 2012 to 30 December 2021) at all SEDN, coastal creek and historical discharge sites used in this assessment. Note that only data from years with at least 335 days of data were used. Site labels are a shortened form of Site ID, e.g., 512 = A2390512.

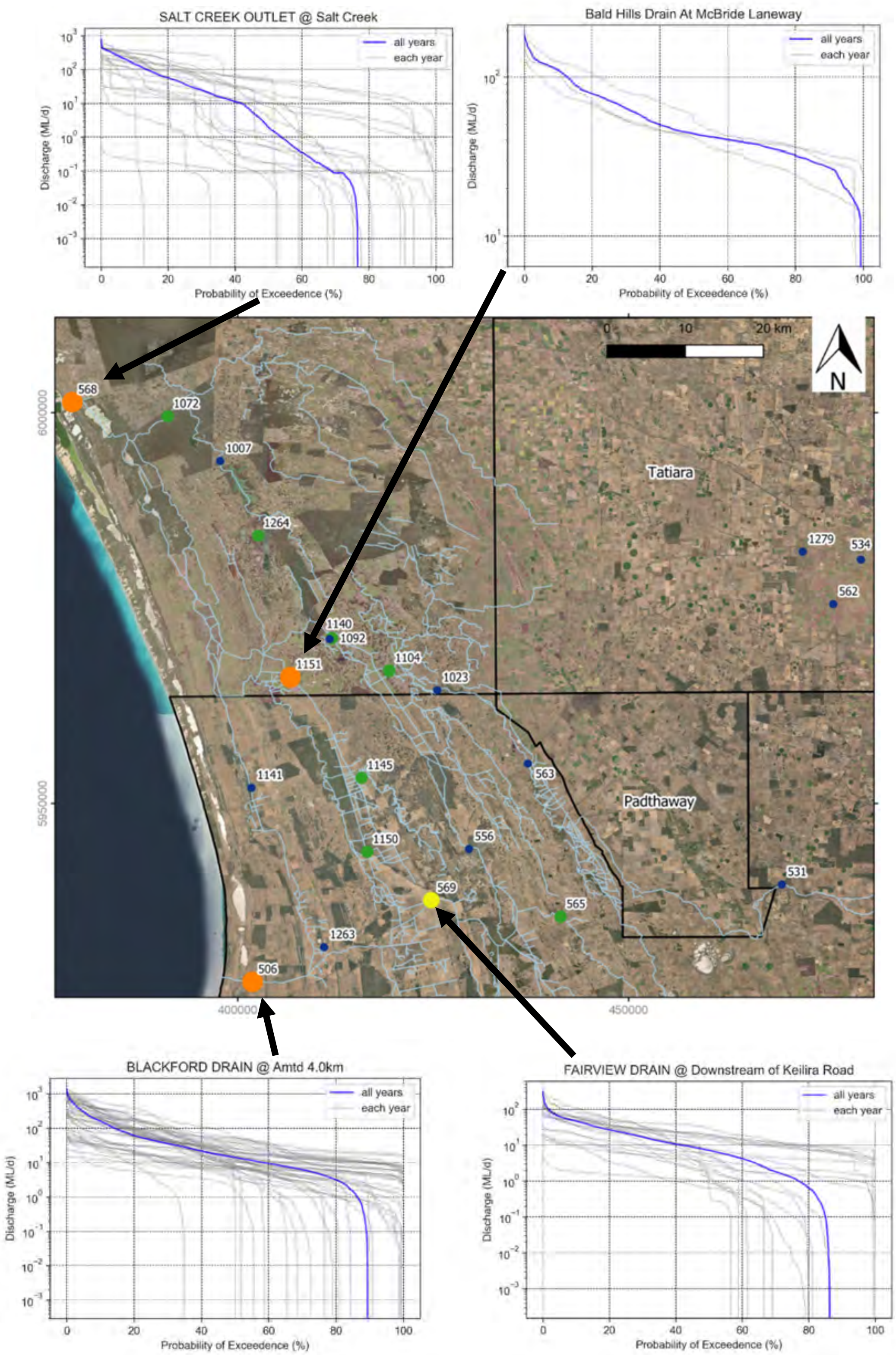


Figure 4. A selection of Flow Duration Curves (FDCs) shown with their locations for the Upper South East. Colour and size of site markers reflect long-term median discharge as shown in Figure 2. Site labels are a shortened form of Site ID, e.g. 1151 = A2391151.

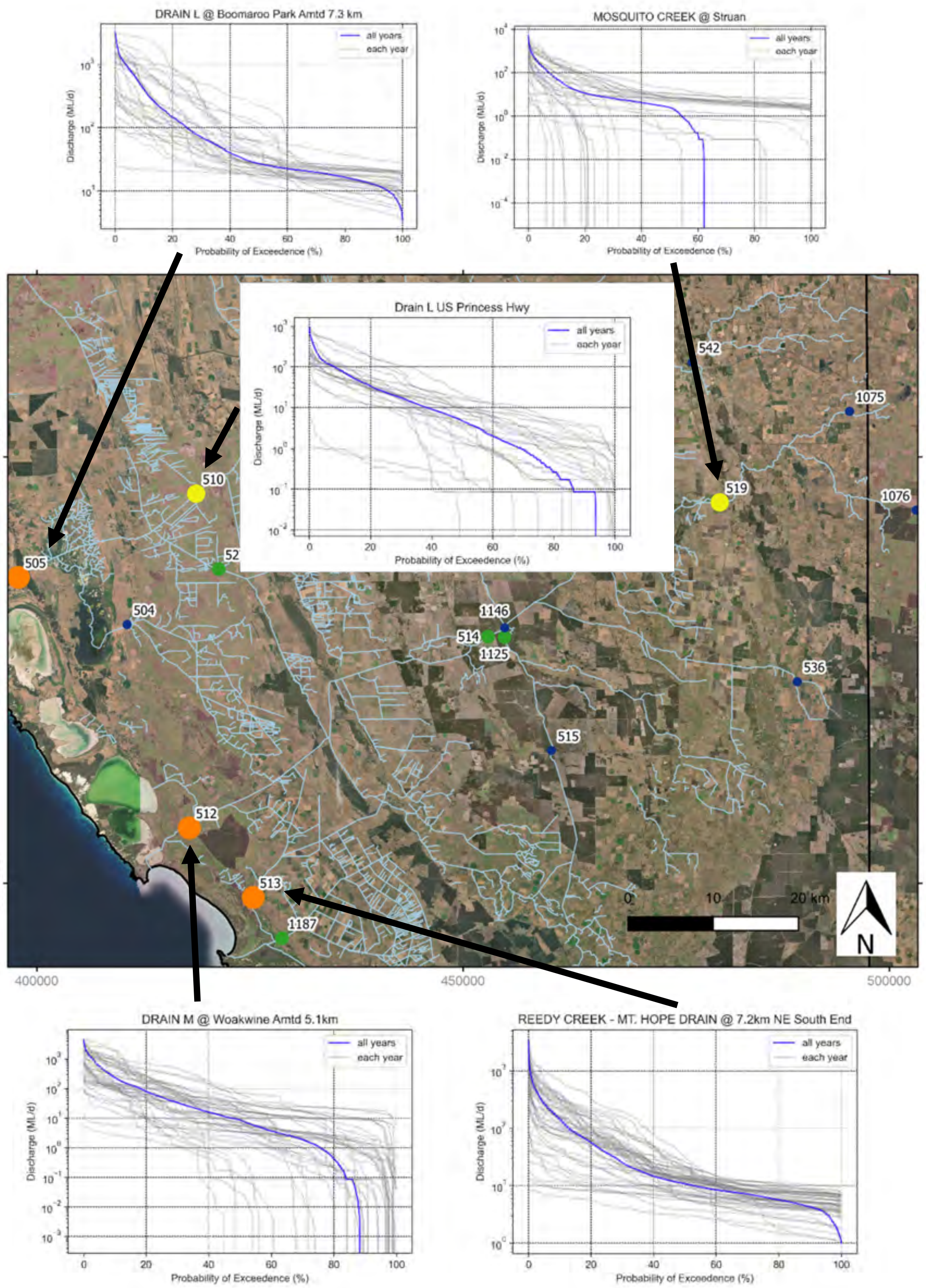


Figure 5. A selection of Flow Duration Curves (FDCs) shown with their locations for the Mid South East. Colour and size of site markers reflect long-term median discharge as shown in Figure 2. Site labels are a shortened form of Site ID, e.g. 512 = A2390512.

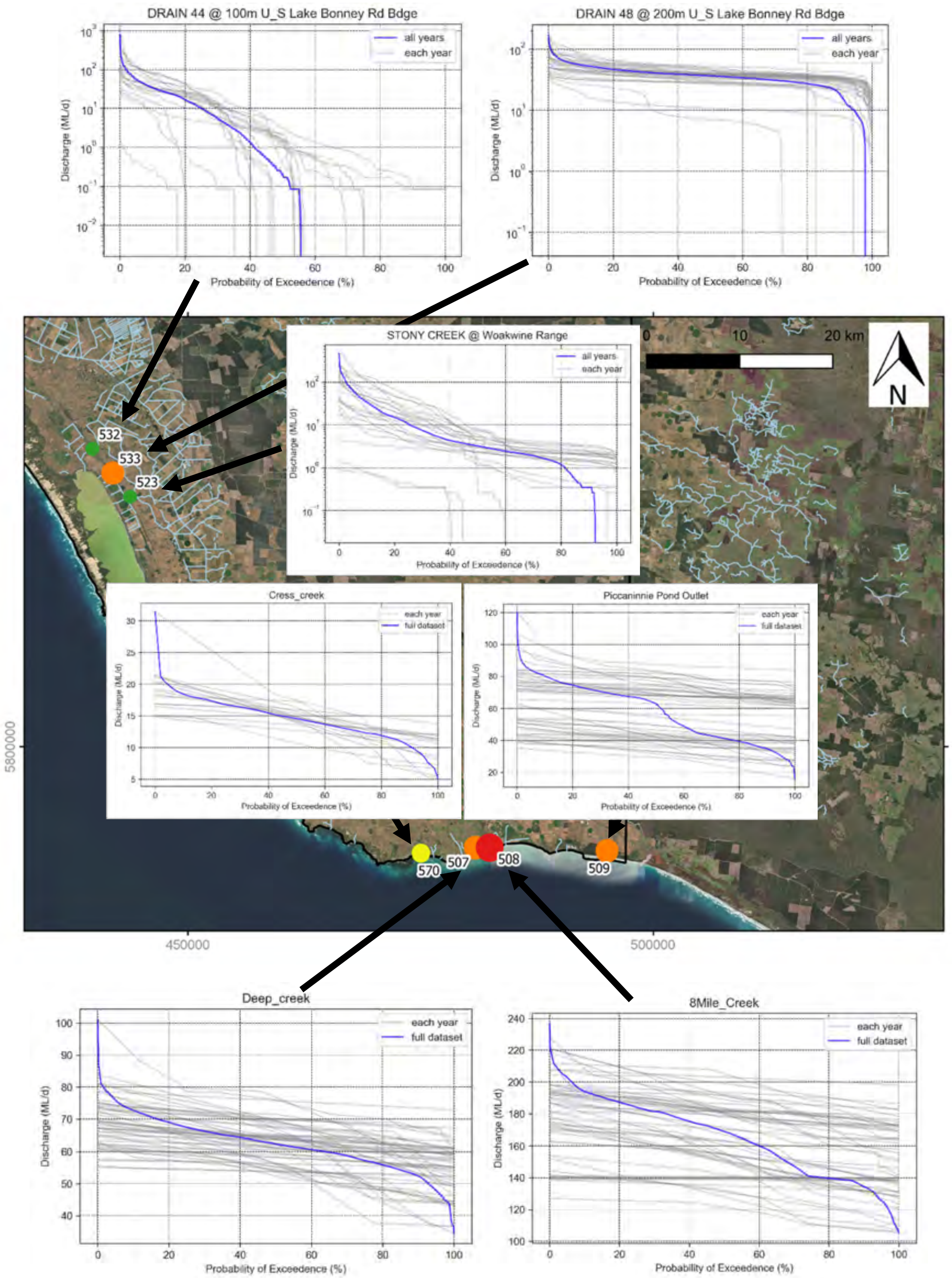


Figure 6. A selection of Flow Duration Curves (FDCs) shown with their locations for the Lower South East. Colour and size of site markers reflect long-term median discharge as shown in Figure 2. Site labels are a shortened form of Site ID, e.g. 509 = A2390509.

2.3.3 Upper South East

The area defined for the purpose of this study as the Upper South East is shown in Figure 4. See Figures 2 and 3 for area defined as Upper South East. Many of the gauging stations in this area have median annual flows in the range 0 to 5 GL/yr. (Figure 2). However, the main outlet stations (A2390568 - Salt Creek Outlet and A2390506 - Blackford Drain) record considerably higher median annual flows of 13.6 GL/yr. and 20.4 GL/yr. respectively as they are at the terminus of the drainage system (Figure 4; Table 1).

For A2390568 (Salt Creek Outlet), the median flow for the last 10 years was 19.3 GL/yr. However, the flow duration curves for each year for this station show that flow is highly variable from year to year, as evidenced by the large spread in FDCs. The curve for all years suggests that flows of at least 3 ML/day occur approximately 50% of the time and flows greater than 0.1 ML/day occur 70% of the time. Conversely, flows less than 0.1 ML/day occur 30% of the time. This gauging station had 19 complete years of data from which to make this assessment, 10 of which occurred in the past 10 years, providing confidence that it is a meaningful assessment.

For A2390506 (Blackford Drain), the median annual flow for the last 10 years was 18.9 GL/yr. Again, flows are highly variable from year to year, however the FDC for all years suggests that flows of at least 4 ML/day occur 80% of the time and flows of at least 10.5 ML/day occur 50% of the time. Flows greater than 0.1 ML/day occur 90% of the time. Conversely, this means that flows less than 4 ML/day occur 20% of the time and flows less than 0.1 ML/day occur 10% of the time. As this assessment is based on 42 years of data, nine of which were from the last 10 years, it is considered meaningful.

Further inland, A2391151 (Bald Hills Drain) and A2390569 (Fairview Drain downstream of Keilira Road) had median annual discharge values of 19.5 GL/yr and 6.7 GL/yr respectively (Figure 2; Table 1). For A2391151, the FDC using the complete years of available data suggests that flows of at least 35 ML/day occur 80% of the time and flows of at least 15 ML/day occur 99% of the time. However, this assessment is based upon only three complete years of data, all from the last 10 years. Hence, the 10-year median is the same as the long-term median and it is difficult to assess the inter-annual variability at this site. Nevertheless, the distribution of the FDCs for each year is narrow, suggesting fairly consistent inter-annual flows (Figure 4).

For A2390569, the median discharge for the last 10 years was 5.7 GL/yr based on eight years of complete data (Table 1). The FDC developed using the complete years of data available suggests that flows of at least 0.8 ML/day occur 80% of the time and flows of at least 8 ML/day occur 50% of the time (Figure 4). Conversely, flows of less than 0.8 ML/day occur 20% of the time. As this assessment it is based on 20 years of data, eight of which are from the past 10 years, it is considered to be a meaningful.

2.3.4 Mid South East

The area defined for the purpose of this study as the Mid South East is shown in Figure 5. See Figures 2 and 3 for area defined as Mid South East. Figure 2 and Figure 5 show a large range in median annual discharge values for gauging stations across this part of the study area. Once again, the largest recorded median discharge values (whole record) occur at the coastal sites, A2390505 (Drain L; 16.6 GL/yr), A2390512 (Drain M; 21.5 GL/yr) and A239513 (Reedy Creek - Mt. Hope Drain; 17.0 GL/yr). Smaller but significant median annual flows are recorded for A2390510 (upstream in Drain L; 7.5 GL/yr) and A2390519 (Mosquito Creek; 7.4 GL/yr).

For site A2390505 (Drain L), the median discharge for the last 10 years was significantly higher than the long-term median of 52.7 GL/yr from six complete years of data (Table 1). The FDCs for this site show comparatively uniform inter-annual flows and the FDC for all available flow data shows that discharge of at least 18 ML/day occurs 80% of the time, and at least 25 ML/day occurs 50% of the time (Figure 5). As this assessment is based on 45 complete years of data, six of which are from the last 10 years, it is considered to be meaningful.

For site A2390512 on Drain M, the median flow for the last 10 years was 14.9 GL/yr for 10 complete years of data, which is lower than the long-term median, and with a little more inter-annual variability than for the site on Drain L (Table 1). The FDC for the whole dataset suggests that flows of at least 0.6 ML/day occur 80% of the time and flows of at least 9 ML/day occur 50% of the time (Figure 5). Conversely, flows less than 0.6 ML/day occur 20% of the time. This assessment is also based on a significant dataset, with 40 complete years of data, 10 of which were from the last 10 years.

For site A2390513 on the Reedy Creek – Mt Hope Drain, the median flow for the last 10 years was 20.4 GL/yr for 10 complete years of data (Table 1). There is comparatively little inter-annual variability in flow for this drain, with discharge of at least 6 ML/day occurring 80% of the time and flows of just over 10 ML/day occurring 50% of the time (Figure 5). Conversely, this means that flows of less than 6 ML/day occur only 20% of the time. As this assessment is based on 45 complete years of data, 10 of which are from the last 10 years, it is considered to be meaningful.

For the two sites with small but significant flows (upstream on Drain L and Mosquito Creek), the yearly FDCs show large inter-annual variability and therefore low reliability of flow.

2.3.5 Lower South East

The area defined for the purpose of this study as the Lower South East is shown in Figure 6. See Figures 2 and 3 for area defined as Lower South East. Median annual discharge values recorded for gauging sites in this area are generally higher than in the Upper and Mid South East regions (Figure 2; Figure 6). This can partially be explained by the fact that the Lower South East receives higher mean annual rainfall, and that all sites are near the coast at the downstream end of the drainage system.

The most northern site of this group with significant flow is A2390533 (Drain 48 upstream of Lake Bonney), with a long-term median annual discharge of 14.1 GL/yr (Table 1). The median discharge for the last 10 years was only 4.1 GL/yr, although this is based on only two complete years of data and may be biased towards years with low flow (Table 1). The FDCs for this site show that flow is relatively consistent from year to year, with flows of at least 35 ML/day occurring 80% of the time and at least 6 ML/day occurring 98% of the time (Figure 6). Two nearby sites, A2390523 (Stony Creek) and A2390532 (Drain 44) have lower long-term median discharge values of 3.1 GL/yr and 3.9 GL/yr respectively and more inter-annual variability (Figure 2; Figure 6).

South of Mount Gambier, the coastal creeks originating from karst rising springs exhibit consistently high long-term median annual flows, i.e. A2390507 (Deep Creek; 22.9 GL/yr), A2390508 (8 Mile Creek; 61.0 GL/yr) and A2390509 (Piccaninnie Pond Outlet; 23.4 GL/yr), with A2390570 (Cress Creek; 5.4 GL/yr) being slightly smaller (Table 1; Figure 2).

The FDCs for these creeks do, however, show considerable inter-annual variability (Figure 6). For A2390507 (Deep Creek), the single FDC for all years of data shows flows of at least 140 ML/day for 80% of the time. For all individual years, flows of at least 110 ML/day occur 80% of the time. For A2390508 (8 Mile Creek), the FDC suggests that flows of at least 56 ML/day occur 80% of the time. For all individual years, flows of at least 38 ML/day occur 80% of the time. For A2390509 (Piccaninnie Pond Outlet), the FDC suggests flows of at least 40 ML/day for 80% of the time. For all individual years, flows of at least 21 ML/day occur 80% of the time. These three sites have 50 complete years of data, including nine years from the last 10-year period (Table 1). However, it should be noted that this data was collected approximately quarterly, rather than daily as for the other gauging stations. Nevertheless, it is thought that the quarterly measurements provide a reasonable approximation of variance in flows throughout each year.

For site A2390570 (Cress Creek), only 16 years of quarterly data is available, nine of which are from the last 10 years (Table 1). However, this is considered to be a representative dataset. The single FDC based on all years of data suggests flows of at least 5 ML/day occur 100% of the time, which appears to be consistent with each individual year of data.

2.4 Water Quality Assessment

Groundwater and surface water in the South East ranges from fresh to brackish. The salinity of a water source is likely to be one of the greatest water quality limitations affecting its suitability for recharge or supplementation of other water resources. The presence of agricultural contaminants has also been identified as another consideration for MAR (Section 4.4.1). However, a search of Water Data SA and discussions during stakeholder consultation indicated there is negligible data currently available on the presence of agricultural contaminants in surface water in the South East. The focus of the Water Quality Assessment presented here was therefore salinity, which is largely measured as electrical conductivity (EC).

Graphs of EC (temperature corrected to 25°C) versus time data for all SEDN and historical gauging stations used in the Water Quantity Assessment (Section 2.3) were downloaded from the Water Data SA website (https://water.data.sa.gov.au) and are presented in Appendix B. The data available on the website is collected via automatic loggers with very few manual measurements recorded. As such, the data presented in Appendix B contains obvious noise that probably reflects common issues with EC loggers, including spurious readings that occur when a logger goes dry. Data grade (or reliability) is indicated in the upper coloured bar at the base of each chart and the key for interpreting the colours is provided at the beginning of Appendix B. It is recognised that the text on the graphs downloaded from Water Data SA is difficult to read. However, it is not possible for guest users of the website to modify this and attempts have been made post-download to improve the readability of the graphs.

Large variations in EC of surface water in drains and watercourses in the South East are common. These reflect temporally and spatially variable inputs of fresh rainfall runoff compared with groundwater inflow, the spatially variable quality of connected groundwater systems, and different degrees of concentration through evapotranspiration of the surface water.

The EC graphs presented in Appendix B summarise the large variability in EC of water across the drainage system in the South East. An example of consistently fresh water (less than 1,000 µS/cm) is A2390534 (Tatiara Creek). In contrast, A2390512 (Drain M) and A2390513 (Reedy Creek – Mt Hope Drain), have EC values consistently in the range 1,000 µS/cm to 2,500 µS/cm and A2390569 (Fairview Drain) has EC values that fluctuate in the range 2,500 µS/cm to 15,000 µS/cm. Others exhibit large temporal variations in EC, e.g. A2390514 (upstream on Drain M) consistently has EC values below 100 µS/cm, with approximately annual spikes in EC up to 2,500 µS/cm. A2391261 (Blackford Diversion Regulator) displays a seasonal cycle of EC, from 5,000 µS/cm to 7,500 µS/cm in winter to 20,000 µS/cm to 25,000 µS/cm in summer.

The EC graphs for the gauging stations identified as having comparatively high median annual flow values in Sections 2.3.3 to 2.3.5 are shown in Figure 7 to Figure 9. All four gauging stations identified in the Upper South East as having large median flow volumes (Figure 4) had EC consistently greater than 5,000 µS/cm and at the main outlets at Salt Creek (A2390568) and the Blackford Drain (A2390506), this is often greater than 10,000 µS/cm (Figure 7).

In the Mid South East, the EC of Drain L at site A2390510 (Princess Highway) fluctuates between 1,500 and 3,500 µS/cm (Figure 8). Unfortunately, EC data for the gauging station further downstream on Drain L, just before it reaches Robe (A2390505), was not available. EC data for Mosquito Creek (A2390519) is patchy but suggests that EC can be below 1,000 µS/cm or as high as 4,000 µS/cm, with this variability consistent with its variability in flow (Figure 8; Section 2.3.4). Drain M, near the coast (A2390512), and the Reedy Creek – Mt Hope Drain, just upstream of the discharge into a small lake associated with Lake Frome (A2390513), both have EC that ranges between 1,000 µS/cm and 2,500 µS/cm with some spikes above and below this range possibly caused by logger malfunction (Figure 8).

In the Lower South East, the EC of Drain 44 upstream of Lake Bonney (A2390532) is patchy and fluctuates considerably, again consistent with its variability in flow (Figure 9; Section 2.3.5). EC ranged between 500 µS/cm and 1,250 µS/cm from 2007 to 2011 and rose slightly to 1,000 µS/cm to 2,000 µS/cm between 2012 and 2013. For Drain 48, also upstream of Lake Bonney, the opposite trend in EC is observed, with values between 1,750 µS/cm and 2,250 µS/cm between 2007 and 2009 (Figure 9). Following a gap in the data in 2010, EC declined in 2011 to 2013 to around 1,000 µS/cm. Finally, the southern-most of these three sites, Stony Creek at Woakwine Range, exhibits EC that fluctuates between approximately 750 µS/cm and 1,750 µS/cm (Figure 9). There was no EC data available on the Water Data SA site for the coastal spring-fed creeks located to the south of Mount Gambier. However, single measurements of water quality for Deep Creek, 8 Mile Creek and Piccaninnie Pond Outlet are available for November 2019 from the EPA Aquatic Ecosystem Condition Reports (EPA Aquatic Ecosystem Condition Reports - Map (waterconnect.sa.gov.au)), with EC values of 1,629 µS/cm, 677 µS/cm and 587 µS/cm respectively.

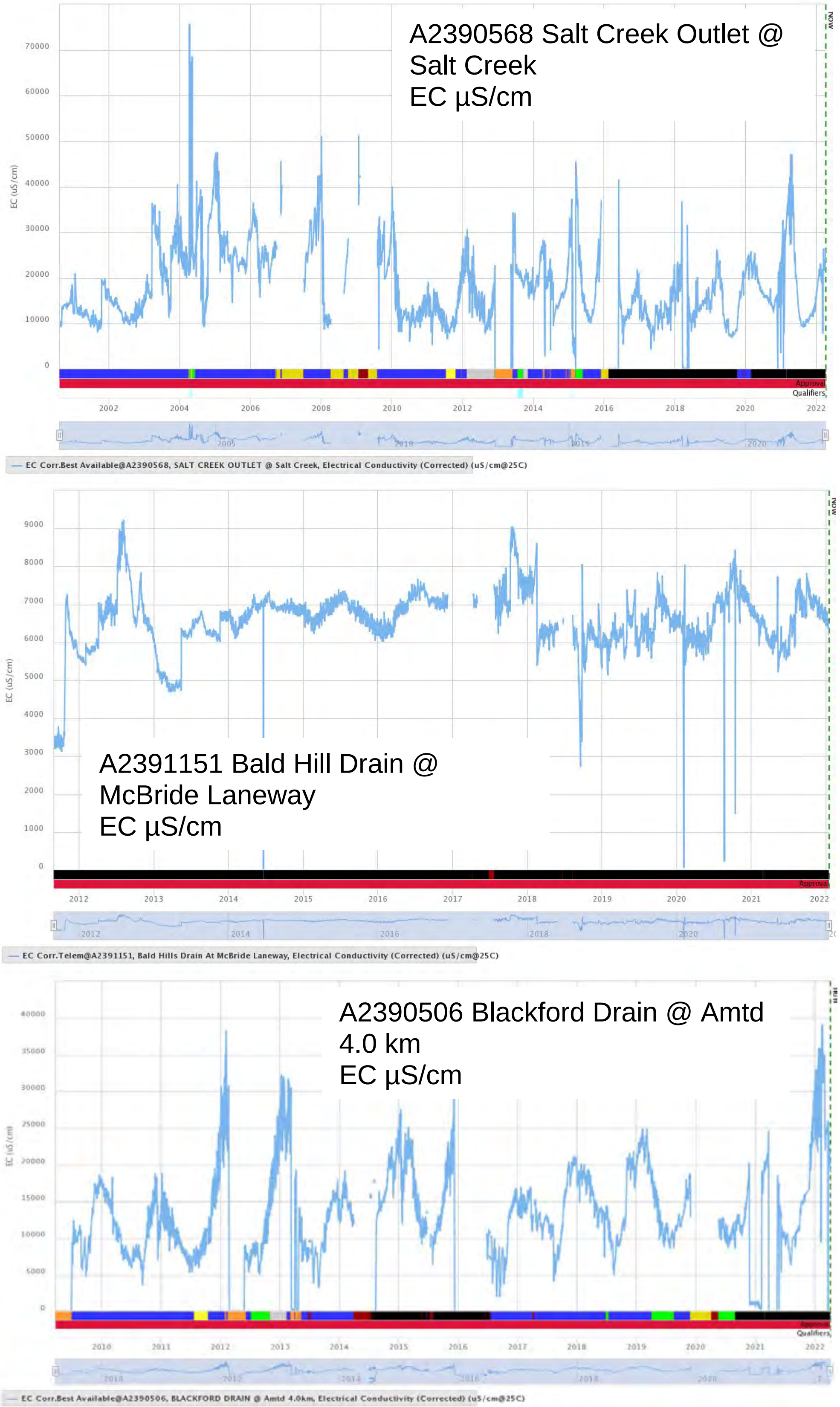


Figure 7. A selection of electric conductivity (EC) graphs for the Upper South East. Note these graphs correspond to the sites of flow duration curves shown in Figure 4. A key for data grade (reliability) and approval status (shown in coloured bars at the bottom of each chart) is provided in Appendix B.

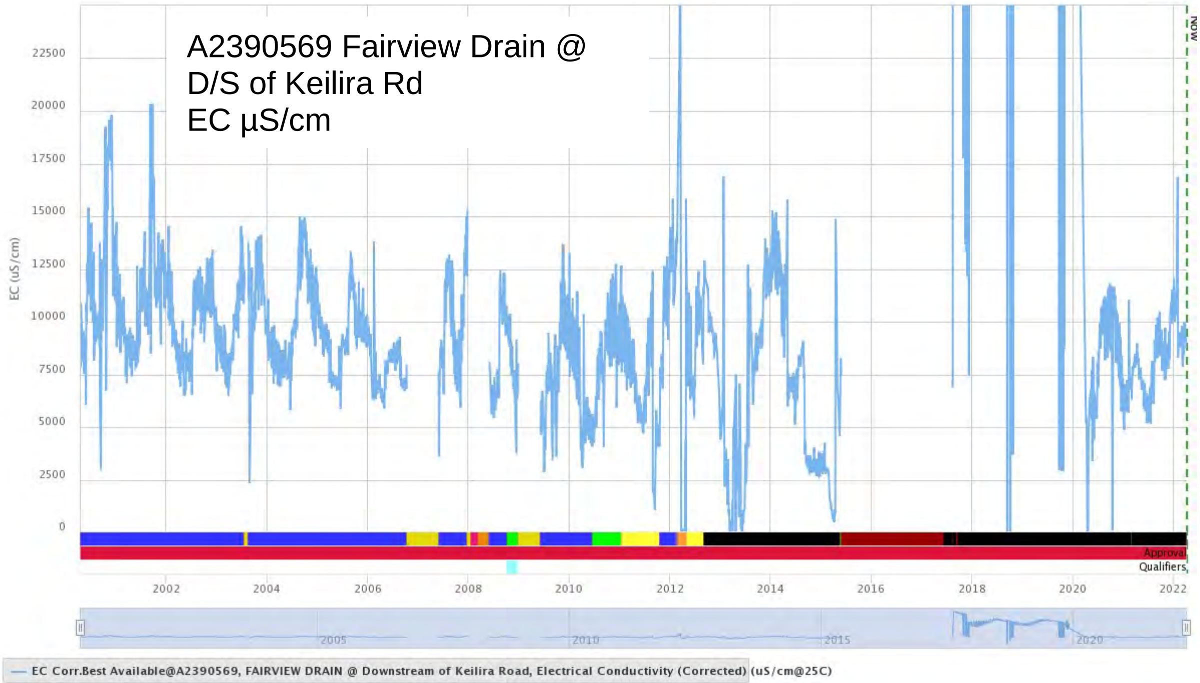


Figure 7 (continued). A selection of electric conductivity (EC) graphs for the Upper South East. Note these graphs correspond to the sites of flow duration curves shown in Figure 4. A key for data grade (reliability) and approval status (shown in coloured bars at the bottom of each chart) is provided in Appendix B.

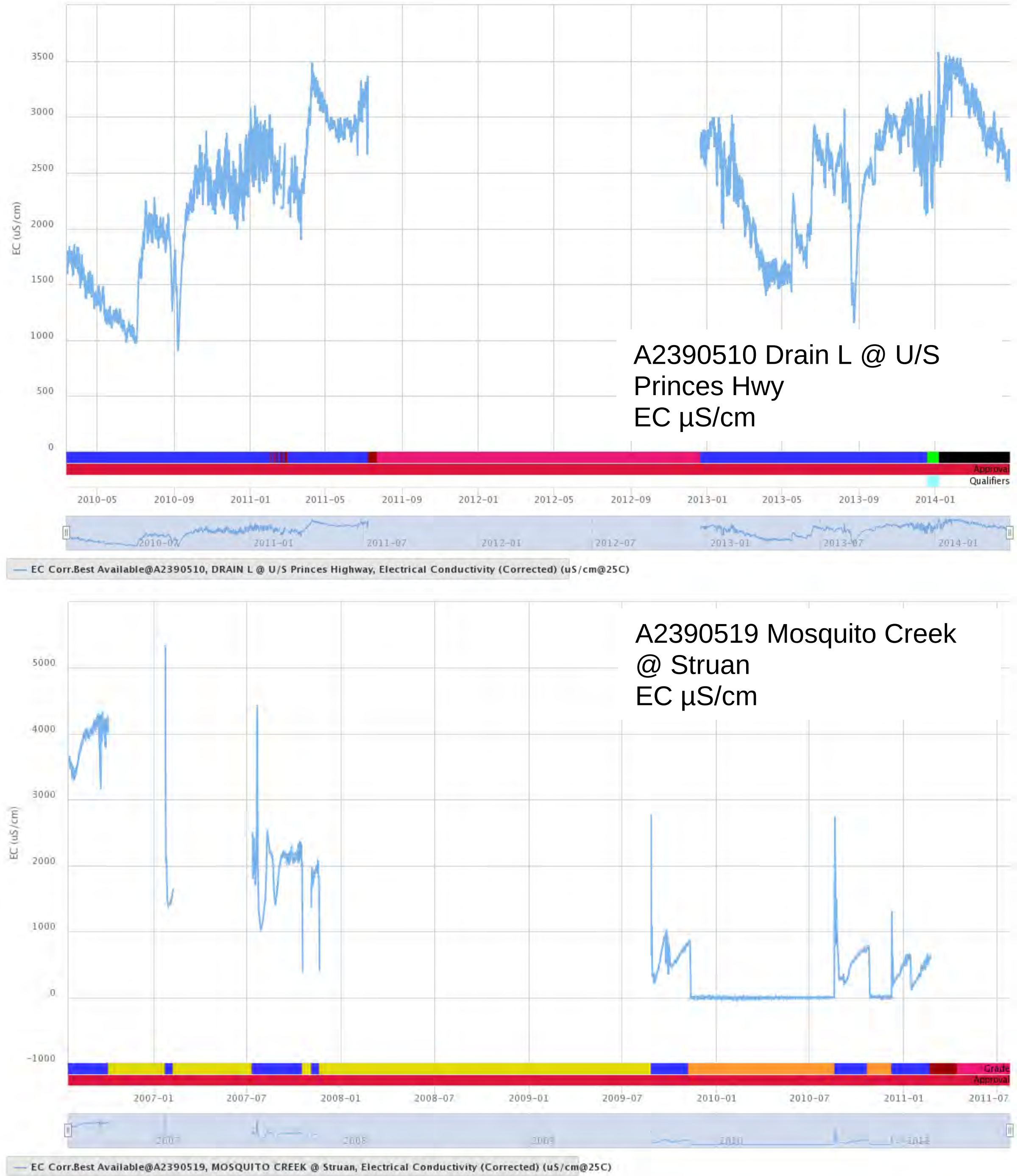
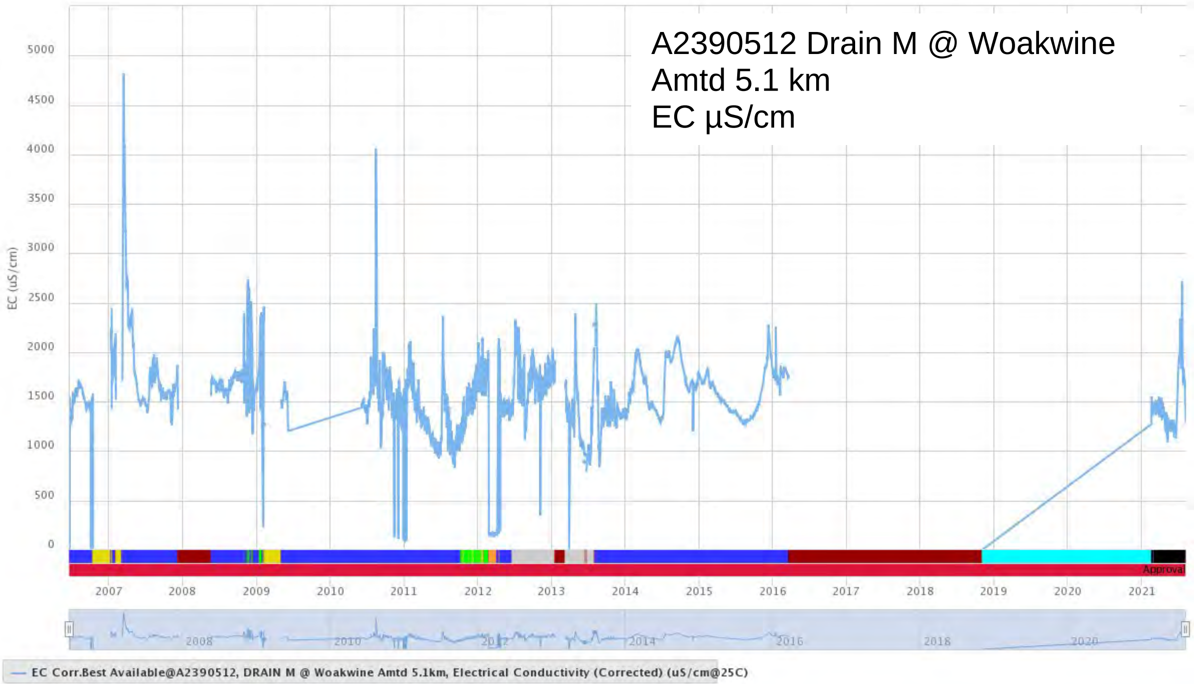


Figure 8. A selection of electric conductivity (EC) graphs for the Mid South East. Note these graphs correspond to the sites of flow duration curves shown in Figure 5, with the exception of site A2390505 for which there is no EC graph available. A key for data grade (reliability) and approval status (shown in coloured bars at the bottom of each chart) is provided in Appendix B.



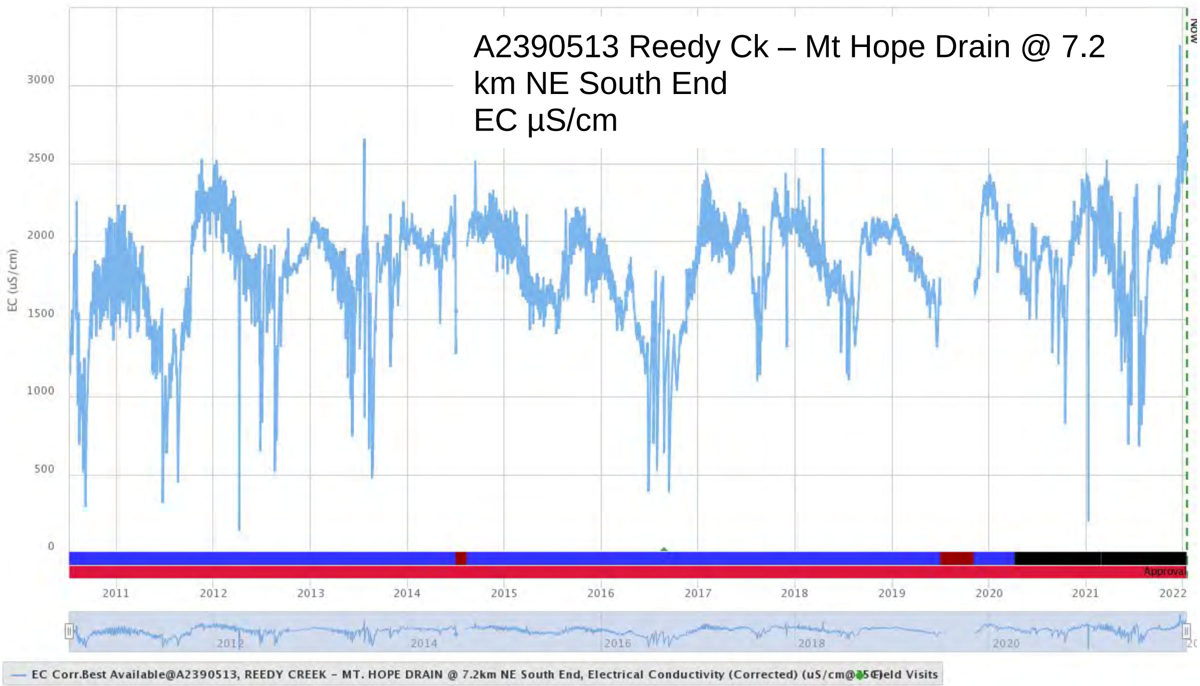


Figure 8 (continued). A selection of electric conductivity (EC) graphs for the Mid South East. Note these graphs correspond to the sites of flow duration curves shown in Figure b, with the exception of site A2390505 for which there is no EC graph available. A key for data grade (reliability) and approval status (shown in coloured bars at the bottom of each chart) is provided in Appendix B.

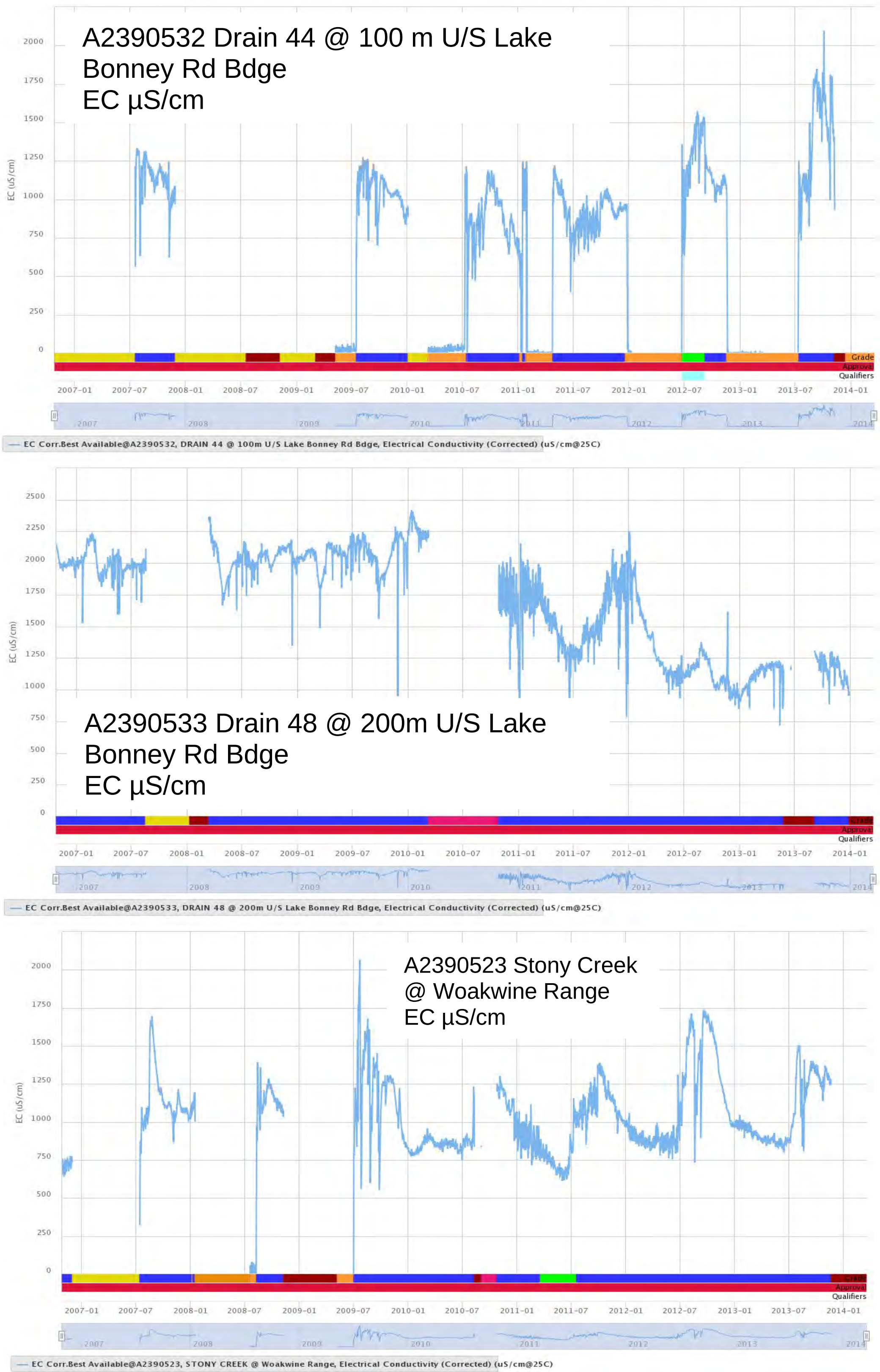


Figure 9. A selection of electric conductivity (EC) graphs for the Lower South East. Note these graphs correspond to the sites of flow duration curves shown in Figure 6, with the exception of the southern coastal creeks (A2390507, 508, 509 and 570) for which there are no EC graphs available. A key for data grade (reliability) and approval status (shown in coloured bars at the bottom of each chart) is provided in Appendix B.

2.5 Existing Infrastructure

A spatial dataset of existing SEWCDB water regulating infrastructure was provided by LCLB on 20 December 2021 and is shown in Figure 10. Each of these regulating structures has an agreed set of operating procedures to achieve target summer levels and/or late autumn-winter levels; and these are tabulated in SEWCDB (2017).

Slater and Farrington (2010) provided a list of weirs and regulators in the Lower South East that were not listed in the Hydstra spatial layer at the time of that report. However, insufficient detail was provided to enable us to determine whether those assets are now included in the latest dataset provided by LCLB. It is therefore assumed that the data presented in Figure 10 is up to date.

Figure 10. Map of existing SEWCDB water management infrastructure.

2.6 Current Authorisations, Commitments, Expectations & Demands

Currently the only drains for which licensed surface water allocations exist are the coastal creeks south of Mount Gambier (Table 2). Eleven individual licences comprise a total licensed volume of 1,380 ML/yr., which is insignificant compared to the historical mean and median annual flows for these creeks (refer table in section 2.3). This suggests there is ample drainage water available for alternative management, whether that be diversion for primary production or retention for environmental benefits such as wetland restoration or mitigation of seawater intrusion.

Table 2. Drainage water licences, as provided by Department for Environment and Water (12 January 2022)

Drain	Allocation (ML/yr.)
8 Mile Creek	194
8 Mile Creek	98
8 Mile Creek	96
8 Mile Creek No. 7	194
9 Mile Creek No. 5	58
Drain 56	1
Drain 56	5
Hitchcox Main No. 1	223
Milsteads No. 2	2
Wild Dog Sub 1	315
Young's Road	194
TOTAL	1,380

There are, however, numerous formalised commitments, informal expectations and aspirational demands for drainage water to meet environmental requirements. These have been compiled by Mark de Jong (LCLB and formerly SEWCDB) and are presented in Table 3. The volumes committed or desired, especially for Drain L and associated Lake Hawdon North, and Drain M and associated Bool Lagoon and REFLOWS through the Baker Range watercourse, are remarkably similar to the historical median annual flows through these areas (Figure 2 and Figure 3). This suggests the environment has already been allocated (albeit not formally) all of the available drainage water, and that little is left for alternative management or beneficial use. The only exception would be during above average/median flow years.

Table 3. South East Drainage Network Commitments to Wetlands, as provided by LCLB (29 March 2022).

Target Area	Location / Source	Volume required (ML)	Authority	Information Source / Comments
SEDN water volume commitments related to Callendale Regulator on Drain M				
Lake George		40,000	Ministerial commitment to Lake George Management Committee as part of REFLOWS initiative	Minister letter to Lake George Management Committee
Mid Baker Range Wetlands	Fairview Rd to Petherick Rd	7,066	Part of REFLOWS initiative	Spreadsheet: Mid Bakers Range Wetland Volumes - Hydrologically Linked Wetlands.xls
Mid Baker Range Wetlands	Callendale to Fairview Rd	4,259	Part of REFLOWS initiative	Spreadsheet: Wetland Volumes - Southern Bakers Range_SAWID_130707.xls
Northern Baker Range Wetlands	Petherick Rd to Messent Conservation Park	30,000	Includes Mandina Marshes, Mandina Lakes Cortina Lakes and Bonneys Camp - commitment via Management Agreement	USE Program Decision Support System Volume-Depth-Area tables; derived from AWE Bakers Range Risk Assessment
West Avenue Watercourse - sumps	Fairview Drain diversion, Parkhill to Henry Creek	5,414	Part of REFLOWS initiative, condition of Bald Hills Drain Construction	Spreadsheet: West Avenue Wetland Volumes.xls
West Avenue Watercourse - floodplain	Fairview Drain diversion, Parkhill to Henry Creek	9,332	Part of REFLOWS initiative, condition of Bald Hills Drain Construction	Spreadsheet: West Avenue Wetland Volumes.xls
Southern Baker Range	South of Callendale	800	Includes en route wetlands, Sheepwash Swamp, Oschar Swamp	Estimate
Bool Lagoon		20,000	The accepted volume to support the EWR's of the Bool and Hacks Lagoon Ramsar Site	Operating rules set to fill Bool Lagoon first, before water flows through Drain M system.
Coorong	Discharge at Salt Creek	56,000	Minister has the ability to use REFLOWS and SEFLOWS to deliver water to the Coorong when required - part of SA Gov SDL offsets	

Table 3 (cont'd)

Target Area	Location / Source	Volume required (ML)	Information Source / Comments
Current projects including proposed commitments			
Lake George	Diversion from Reedy Creek Mt Hope Drain	Additional volume required to meet 40 GL commitment above.	Project to investigate alternative sources of water to increase inflows to Lake George. Options under consideration: 1. Restoring a flow path from Mullins Swamps to Drain M via the Sutherlands Drain through the Iluka and Burkes Island Properties. This may not involve an engineered flow path, and may involve restoration of natural inundation and flow with en route wetland restoration benefits; 2. Creating a flow path from the Reedy Creek Mount Hope Drain to Drain M, via the Symon Main Drain. This would require upgrade of the existing Symon Main Drain channel and green fields construction of a new connecting channel; 3. Re-connecting a flow path from the Reedy Creek Division A Drain at Furner (at the head of the Reedy Creek Mount Hope Drain) to Drain M via the Reedy Creek Division A Drain.
Lake Hawdon North	Drain L	TBD	Project under Healthy Coorong Healthy Basin ("Project Coorong") investigating works to mitigate threats to key biota, providing refuge and quality habitat for migratory waterbirds. Drain L (mean annual discharge 59,100ML) passes through the wetland bed and provides the majority of surface water inflows to the wetland. Wetland also receives surface water flows from a network of smaller local drains to the north and east and the Lake Hawdon connecting drain via Lake Hawdon South. The volume of Lake Hawdon North when full is 7,920 ML. Whilst the Drain has the capacity to supply large volumes of water, it has severely compromised the hydrology of Lake Hawdon North through draining the wetland bed and causing it to dry much earlier each year than would otherwise occur (NGT 2020). Management objective: Restore a more natural hydrology to Lake Hawdon North, with inundation persisting well into summer to align more closely with the presence of migratory shorebirds in the region. Works: New regulating structure within Drain L at the exit of Lake Hawdon North (located within Drain L downstream of western margin of Lake Hawdon North), with layflat gates and fish passage Design objectives: • Pass the peak Drain L design flow with minimal impact to the existing Drain L hydraulics when all regulators are in the fully open position • Enable manipulation of water levels within Lake Hawdon North between 3.60-4.4 mAHD over the expected range of (non-flood) flows. • Permit fish passage across the full range of regulated upstream WSEL for fish size range Galaxias whitebait to adult Black Bream • Pass flows, additional to fishway flows, to meet downstream environmental water requirements whilst maintaining target upstream WSEL.

3. Stakeholder Pre-consultation

3.1 Scope

In accordance with the Project Brief issued by the LCLB, the scope of Stage 2a was to consult with industry, community, and environmental stakeholders to elicit perceptions, needs and understanding of the issue, including but not limited to:

- Future water needs and location of water need, aligning with growth opportunities for respective user groups,
- Stakeholders' perceived opportunities for additional water,
- Stakeholders' perception around additional water availability,
- Perceptions around efficiency measure opportunities in water use for their industry and others, including user groups consideration of efficiency measures as an alternate to sourcing additional water, including the perceived costs and benefit of each approach,
- Industry perception around possibility and feasibility of MAR should available water be identified within the network,
- Perception of how industry use of any additional water within the drainage networks aligns with the objectives and current and future needs of other groups (e.g., environment and community).

3.2 Approach

A multi-faceted approach was adopted to elicit feedback from as many interested stakeholders as possible. The four primary modes of consultation were:

- Face-to-face workshop-style interviews with four coordinated groups representing community, primary producers, environment, and Government. A detailed list of representatives who attended these workshops and their affiliations is provided in Table 4. For each workshop, a brief presentation was delivered to explain the context, objectives, and scope of the project, before offering a series of prompting questions to stimulate discussion and feedback on stakeholders' perceptions.
- Live radio interview on ABC South East. An interview with the host of the Rural Report was held on 18 February 2022, providing listeners with an overview of the project objectives and an invitation to submit feedback through the LCLB.
- A LCLB fact sheet (https://cdn.environment.sa.gov.au/landscape/docs/202155-LPF_Water-Security_Managed-Aquifer-Recharge-Feasibility-Study-2022.pdf) and LCLB News Release on 16 February 2022 encouraging stakeholders to make contact with IGS (https://www.landscape.sa.gov.au/lc/news/study-to-explore-aquifer-recharge-opportunities-for-primary-production). These resulted in subsequent reporting through local print media, including The Border Watch (18 February 2022).
- Phone calls and/or site visits with four individual landowners (all irrigators) and one ex-Government employee whom were alerted to the project through one or more of the above means. Their feedback is captured anonymously below under the heading of Primary Producers.

Table 4. List of stakeholder representatives who attended coordinated consultation workshops.

Stakeholders	Representative	Forum & Date
Community		
Naracoorte-Lucindale Council	Mayor Erica Vickery OAM CEO Trevor Smart	Limestone Coast Local Government Association, 11 Feb. 2022
City of Mount Gambier	Mayor Lynette Martin OAM CEO Sarah Philpot	
Wattle Range Council	Mayor Des Noll CEO Ben Gowan	
District Council of Grant	Mayor Richard Sage CEO Darryl Whicker	
District Council of Robe	Mayor Alison Nunan	
Tatiara District Council	Mayor Graham Excell CEO Anne Champness	
Kingston District Council	Mayor Kay Rasheed CEO Nat Traeger	
Primary Producers		
• **Dairy industry**	Graeme Hamilton	Primary Producers Sustainable Water Working Group, 11 Feb. 2022
• **Potato industry**	Terry Buckley	
• **Plantation forestry**	Liz McKinnon (Green Triangle Forest Industries Hub) Laurie Hein (ex-Green Triangle Forest Products) Alan Rossouw (AKD Softwoods) Jim O'Hehir (UniSA)	
• **Grape and wine industry**	Pete Balnaves (Coonawarra Vignerons)	
Environment / Government		
• **Nature Glenelg Trust**	Mark Bachmann Lachlan Farrington	Teleconference, 9 March 2022
• **Environmental Protection Agency**	Naomi Grey Andrew Solomon	Meeting at 11 Helen St. Mount Gambier, 9 March 2022
• **National Parks and Wildlife Service**	Nick McIntyre Ross Anderson	
• **Limestone Coast Landscape Board**	Sue Botting Mark de Jong Ryan Judd Alison Boomsma Phil Elson Lydia Mules Ekolina Benny Skylea McLean Emma Maxwell	

3.3 Stakeholder Responses - Community

Stakeholders expressed mixed feelings for the project with some concerned about potential environmental and economic impacts of redirecting drainage water away from the coastal creeks south of Mount Gambier and the offshore rock lobster fishery they support. Others identified major opportunities for MAR including the Bordertown town water supply and using the Blue Lake to store (and transmit) available drainage water sourced from the karst rising springs. Whilst not drainage network related, other stakeholders highlighted the need for better use of stormwater from Kalangadoo and Penola, potentially through MAR.

All council Mayors and CEOs were encouraged to take the LCLB Fact Sheet and key points from the workshop discussion back to their respective members, however no further correspondence was received.

3.4 Stakeholder Responses - Industry

The Primary Producers Sustainable Water Working Group (PPSWWG) was ultimately responsible for raising awareness and securing funding for this project. Its members have observed a long history of water allocation planning in the Limestone Coast that has always focussed on groundwater management without considering the impacts of the drainage network on net recharge and enhanced groundwater discharge. Accordingly, the widely held perception is that there is a significant quantity of drainage water available for more integrated management that should be used to benefit multiple stakeholders, including primary producers. However, respondents from both face-to-face workshops and telephone interviews were very quick to point out that the large volumes of surface water that discharge annually to the Southern Ocean should not be viewed solely as an additional resource for allocation to consumptive users. Instead, they appeal for a more holistic approach that considers the complex interactions between surface water and groundwater, recognising that many ecological values of the region now reside in the artificial drainage network.

Stakeholders viewed this project as a critical first step in thinking smarter about integrated water management in the region, particularly given the impending challenges that climate change will bring to industry and the environment. The current WAP for the LLC PWA (SENRMB, 2015) is limited to groundwater management principles and policies that apply generally at a very large management area scale (defined by hundred boundaries). Accordingly, the tools currently available in the WAP for managing water level declines around groundwater dependent ecosystems are not suitable. For example, reductions to all licensed allocations across a management area may not have a direct measurable impact to specific GDEs. Instead, localised management actions such as artificial watering, incentivised trading or environmental offsets are required. Stakeholders believe that MAR using surface water from the SEDN is one potential solution in these hotspot areas.

While all industries in the region have production and/or growth targets, it is important to realise there are numerous factors besides water availability that are likely to limit what is realistically achievable. For example, premium wine production is constrained by climate and the extent of best quality soils in areas such as Coonawarra. Plantation forestry is constrained by climate, soil type, topography and propensity for water logging; the industry is also currently confronted by soaring land values. Further details of growth opportunities provided by individual sectors are recorded below. All data and statistics reported were provided by stakeholders in attendance at the workshops unless explicitly referenced. In all cases, stakeholders do not see water use efficiency measures as offering considerable prospects.

Plantation Forestry

According to The World Bank (2016) global demand for wood fibre is expected to quadruple by 2050. Australia is currently experiencing a critical lumber shortage for housing construction. This fibre demand has been exacerbated by recent devastating bushfires in South Australia, Victoria and New South Wales, which have collectively led to a loss of 65,000 hectares of forest estate from the national inventory. The gap between supply and demand continues to grow with the Green Triangle Forest Industries Hub (GTFIH) Woodflow study showing in 2021 that demand for the region's resource exceeds supply by more than 600,000 m^3. The Green Triangle forest industry's Strategic Plan includes a direction to plant an additional 200 million trees in the region by 2030, which would equate to approximately 150,000 new hectares of forest estate (GTFIH, 2019).

Dairy

The present South Australian Dairy Industry Plan calls for milk production to increase from 500 million litres to 700 million litres per year. To reach this target the present production must be maintained, and 200 million litres of new milk produced each year. This would likely require 40 new farms producing 5 million litres each. Each farm would be 700 hectares and require nearly 1,500 ML/yr. of good quality water (ideally less than 700 mg/L as Total Dissolved Solids), amounting to a total annual water demand of approximately 60 GL. Whilst it is not essential that this growth all be generated in the South East, the region has more potential opportunities than elsewhere in the State. Currently the preferred areas for irrigated grazing herd milk production in the South East are Donovans, Mt Schank, Kongorong and Coola because of the free draining soils, access to unconfined aquifer water, proximity to services, energy supply and road infrastructure. There are other local opportunities in the region, however the profitability of existing primary production is preventing expansion of the dairy industry in these areas.

Potatoes

Current production in the South East is approximately 130,000 tonnes per annum. Each hectare of potatoes requires an average irrigation rate of 6 ML/yr. to yield approximately 50-60 tonnes per annum. Australia currently imports 120,000 tonnes of fries every year, which could be replaced by local growers in the South East if an additional 12-16 GL/yr. of water was available in areas of suitable soils and climate. There is also demand for at least one new processing factory in the region that would process an extra 200,000 tonnes per annum, which would require an additional 20-24 GL/yr.

Grape and Wine

The premium wine producing regions of Coonawarra, Wrattonbully, Padthaway, and Mount Benson are continually adapting to local and overseas market pressures, as well as many other externalities. Of these Coonawarra is the only area within the

LLCPWA that has been severely impacted by reductions to groundwater allocations under the current WAP. There is limited opportunity for expansion of the current vineyard estate in Coonawarra due to the extent of "terra rossa" soils. Instead, there is more of a focus on protecting the current industry by avoiding further reductions to groundwater allocations via the use of drainage water for strategic GDE management.

3.5 Stakeholder Responses – Environment / Government

Some stakeholders were initially cautious about the project as they assumed it was simply an attempt from primary producers to get more water allocated for their industries. Accordingly, their stance was that there is no additional water available for primary industry as ecological values associated with the SEDN were already under threat. However, this sentiment was quickly diffused through informed discussion and stakeholders were comfortable acknowledging that a more strategic, flexible and integrated water management framework is required in the region. Also, that trade-offs and offsets would be crucial (at least in some areas) to achieving meaningful wetland restoration and protection of existing ecological values whilst also enabling primary production to continue to prosper in the region, albeit not necessarily in the same locations. Levies were identified as a key instrument to enable such actions.

Stakeholders identified the highest priority sites for enhancing in-drain environmental values are those that still flow every year. The second priority should be up-catchment sites in wet years when flow is available for retention and/or MAR. They believe that rewatering of any stressed wetland will restore some ecological values, however urgency should be directed to those wetlands with known high biological values (e.g., nationally or regionally significant species). Priority sites for restoring wetland features include Mount Burr Swamp and coastal wetlands such as Hutt Bay/Middle Swamp.

IGS was directed to the following two reports to provide the necessary information on environmental values associated with the SEDN.

Slater and Farrington (2010). This report investigated opportunities for adaptive flow management to achieve improved environmental outcomes from the SEDN. A large component of the study collated in-stream ecological assets of the drains and developed a biological scoring system to prioritise the highest value drains for specific management actions. These drains are listed in Table 5 and mapped in Figure 11. The study also developed a physical and biological scoring system for prioritising wetlands associated with the SEDN. These are shown in Figure 12. The authors acknowledged at the time of writing the report in 2010 that many of the drains and wetlands prioritised in their study were already recognised under existing management and conservation frameworks. The fact that many have since received firm volume commitments from the SEDN (Table 3) indicates that additional management of these assets has been a priority.

Farrington et al. (2014). This report investigated changes in the presence and persistence of permanent pools in drains and waterways across the region and surveyed ecological values for data deficient pools. The majority of pool survey sites were consistent with the sections of high value drains identified by Slater and Farrington (2010) and are therefore not shown herein.

It was mentioned that any future retention of drainage water would need to obtain a social licence to operate. This should not be limited to managing perceptions of water availability but also include perceptions of inundation to surrounding landowners and, in the case of MAR, neighbours' perceptions of being adversely impacted (e.g., with nutrients).

Table 5. Drains with high ecological values identified by Slater and Farrington (2010).

Drain Name	Section	Biological Score
8 Mile Creek and connecting drains	Ewens Ponds to Outlet	25
Drain M	Princess Highway to Lake George (includes Sutherland Drain)	19
Deep Creek and connecting drains	Stratman's Pond to Outlet	15
Bakers Range South	Drain M intersection to Reedy Creek	15
20B and Narrowneck	Top of 20B to Lake Frome	11
Drain 44 / 88	Mayurra Weir to Lake Bonney	11
Main 31 / Drain 31	Millicent d/s to Lossie Road Weir	11
Reedy Creek Wilmot Drain	All	7
Bray Drain and Bray 45	All	7
Bevilaqua Ford Drain	All	7
Bakers Range	Katani Park Wetland (S0101999) to Country Club Road Crossing	7
Drain 41	Junction with Drain 36	7
Drain 64	Intersection with Drain 54	7
Reedy Creek Mount Hope Drain	All	7
Drain K	All	7
Drain L	All	7
Lake Frome North	All	7
Biscuit Flat	All	4
Drain A	From junction with Glencoe West Drain to junction with Trihi Lagoon Drain	4
Glencoe West	All	4
Mount Burr Heath	Section in Marshes Complex to Lake Letty	4
Hitchcox Main	All	3
Number 2 Milstead Branch 2A	Pretty Pond to Drain to junction with Number 2 Milstead	3
Mount Hope Drain	All	3
Wilmot	All	3
Drain 62	All	3
Earthquake Springs Drain	All	3

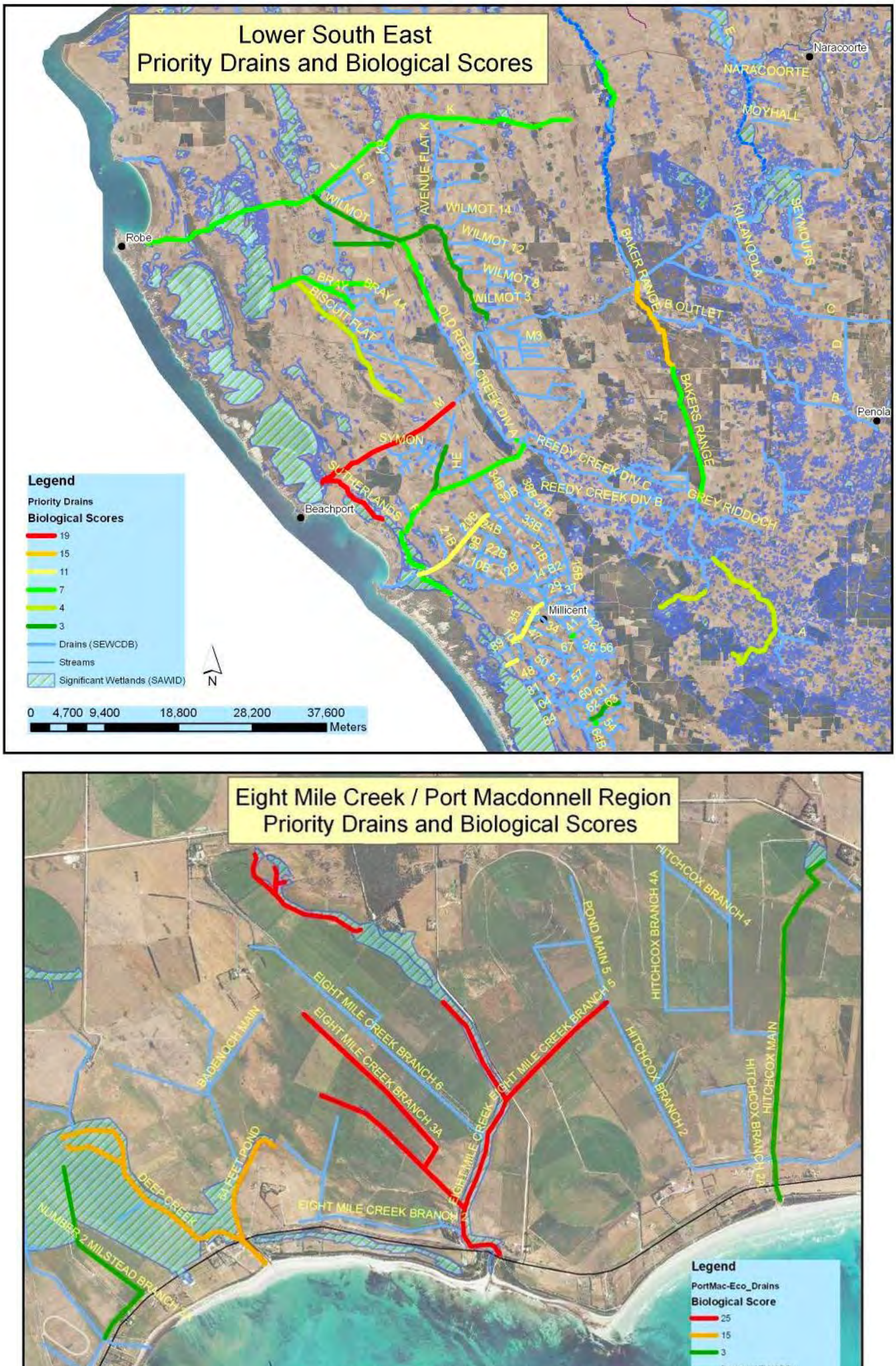


Figure 11. Priority drains with corresponding biological score (images reproduced from Slater and Farrington, 2010)

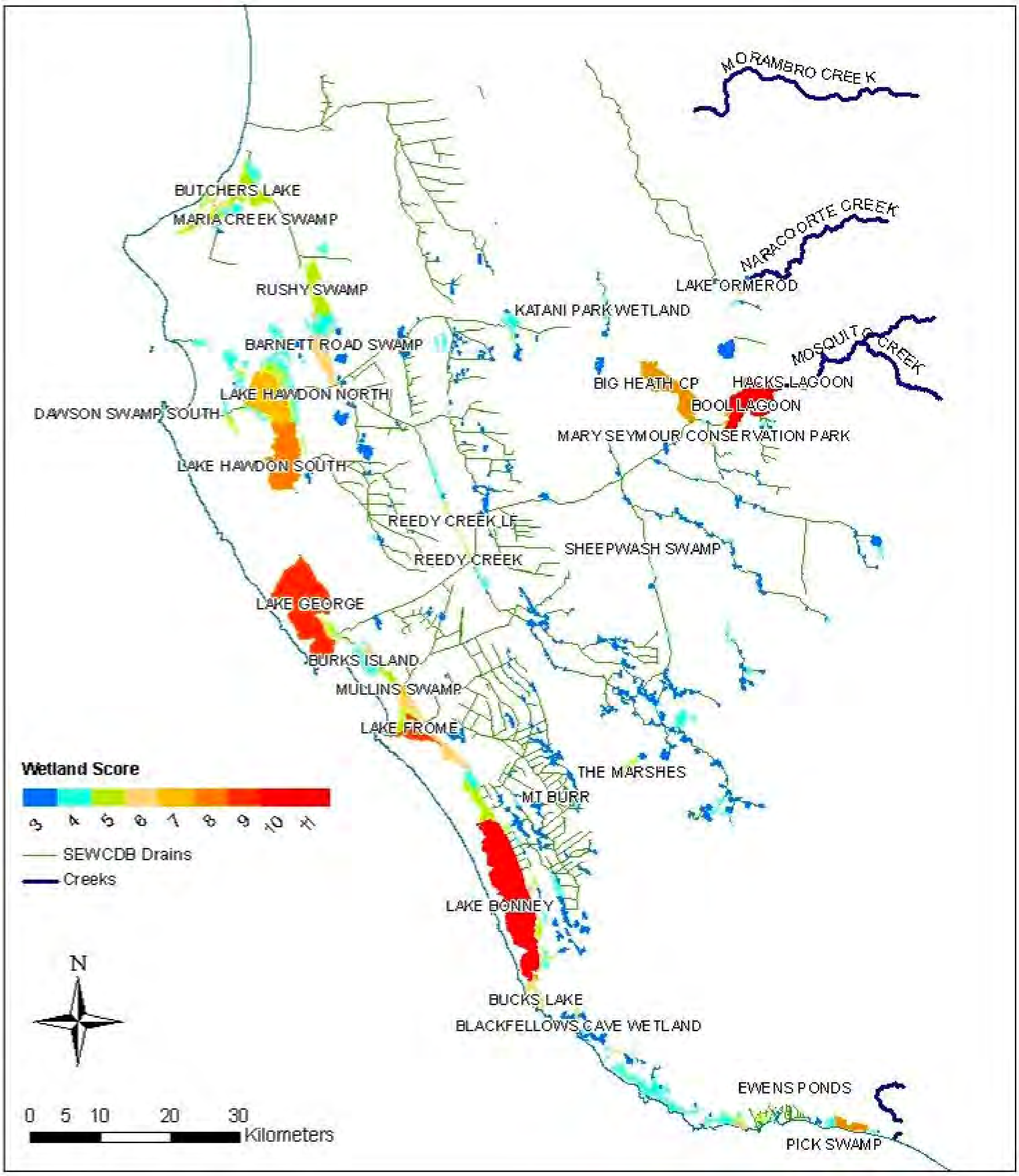


Figure 12. Priority wetlands associated with the SEDN (source: Slater and Farrington, 2010).

Stakeholders also identified specific opportunities for MAR such as around Wrattonbully and Mullingers Swamp where water is currently diverted away from runaway holes. They also suggested temporary storage of available drainage water in wetlands where MAR was not feasible, alluding to several examples where this might be possible on Crown Land. However, the topic of MAR generated lengthy discussions about water quality, specifically the potential to contaminate aquifers by injecting drainage water that contains agricultural chemicals (pesticides and herbicides) and excessive nutrient concentrations. Concerns were raised that there is currently no routine regional surface water quality monitoring (besides EC) or assessment in the South East. Regardless, the EPA Water Quality Policy provides guidance on what is allowable, which is essentially that salinity cannot change (cf. the principle of injecting “equal or better-quality water” used in some jurisdictions) and agricultural chemicals are a Class 1 pollutant and thus cannot be discharged into a water resource. Thus, seasonality of chemical usage is likely to be an important adjunct to considering seasonal availability of drainage water. The discussions closed with a comment on terminology, such that Aquifer Storage and Recovery (ASR) is used in current legislation. This is important because if there is no intention to "recover" the injected water, then the Water Quality Policy does not apply. However, the EPA is still required to exercise a General Duty of ensuring any activity does not cause environmental harm.

3. Summary of Stage 1 and 2a Outcomes

There was a consistent and overwhelming recognition by all stakeholder groups that:

- The retention of drainage water in the landscape is critically needed, however it should not be done for the sole purpose of providing additional allocation for extractive users. This is a key outcome because it has long been perceived by many non-irrigation stakeholders that primary producers simply want more water to expand their enterprises. Instead, the view held by most individuals interviewed was that any surface water that could be harvested should be used to help restore high-value environmental assets in stressed areas, thereby removing the need for blunt policy instruments (i.e., reductions to allocations at the management area scale) and protecting existing industry.
- The greatest availability of water in the drainage network is in areas near the coast, including the karst rising springs and creeks south of Mount Gambier as well as lower sections of Drain M and Drain L, which are situated a very long way from areas of high groundwater demand and/or environmental assets in need of a restored hydrologic regime.

Given the frequency with which these two points were raised and debated, there are at least three possible models for how a new integrated surface water-groundwater management scheme might look:

4. **Community or on-farm Managed Aquifer Recharge (MAR)**. This model is essentially the basis on which the current project was founded. The scheme would involve either (i) taking excess surface water at locations and times when it was available in the drainage network and injecting into the shallow water table aquifer near the offtake location for subsequent beneficial (extractive or environmental) use; or (ii) holding water up in the drains for passive MAR. The geographical divide between water availability and water demand would mean this model is likely to only be feasible at several specific locations, and almost certainly not every year. Potential locations and scale of these opportunities were assessed in Stage 2b of the current project (sections 4.3.1 and 4.3.3).
5. **Regional water transfer and Managed Aquifer Recharge (MAR)**. This model overcomes the geographical challenge through engineering solutions; specifically, by piping water from where it is most available to where it is most needed and can be stored for subsequent beneficial (extractive or environmental) use. While this option provides the greatest number of opportunities for most (if not all) stakeholders, it would require significant capital and operating expenditure, thereby necessitating funding support from Government and an ongoing user-pays arrangement. Initial, first-order estimates for a 50-kilometre-long pipeline that is capable of delivering up to 50 GL/yr. over a 50-metre elevation gain indicate a capital expenditure of

approximately $100 million and an annual operating expenditure of approximately $10 million per year. With a 20-year payback, this equates to a cost to consumers of between $200 to $400 per annual ML. Regardless, prospective locations for MAR under this model were investigated in Stage 2b of the current project (Section 4.3.2), although detailed design and economic analysis of pipeline construction options are clearly outside of scope.

6. **Regional water offsets**. This concept was proposed in two different stakeholder meetings and does not involve any water harvesting or managed aquifer recharge, and thus was not considered any further in this project. The concept requires a trade-off between degraded environmental assets in areas of high groundwater demand that can be surrendered in order to restore and enhance higher-value wetlands and waterways nearer the coast. Stakeholders expressed the strong opinion that this could not be managed by Government and would require an independent organisation or entity that is responsible for the installation and maintenance of regulators and undertaking restoration works. The latter could be funded by the existing levies and water licence fees raised from primary producers in offset areas, provided there was commitment that future reductions to licensed allocations to achieve environmental outcomes would not be required in those areas.

   At least three potential challenges need to be overcome for this concept to be viable; (i) identifying and agreeing on what degraded assets can be surrendered, (ii) a potential need to change land use from primary production to environment, and (iii) establishing a fair and equitable funding model that enables primary production in high-demand areas to continue and downstream ecosystems to prosper. All are beyond the scope of this project.

4. Desktop Assessment of MAR Feasibility: Spatial Assessment, Risk Assessment and Decision Support Models

4.1 Scope

Stage 2b of the project is the MAR feasibility study. In accordance with the Project Brief issued by the Limestone Coast Landscape Board, the scope of Stage 2b was to include the following:

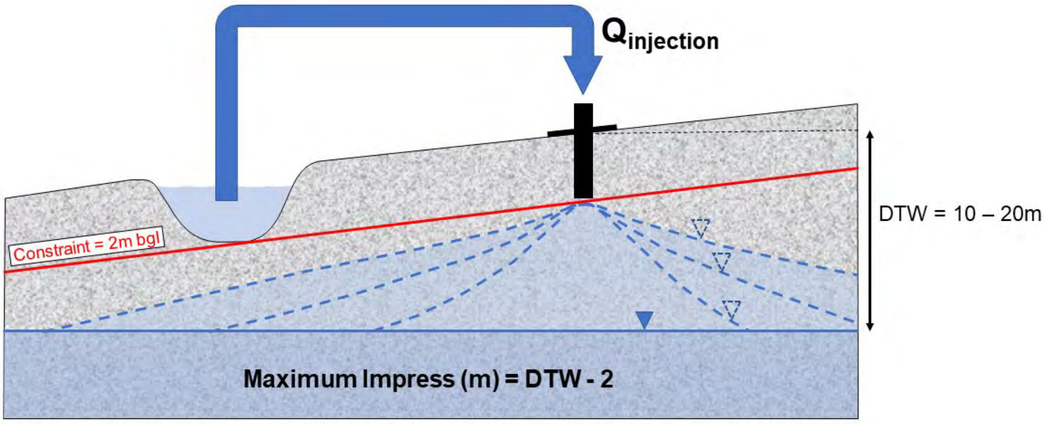
- Desktop assessment of suitable sites and methods for managed aquifer recharge, with consideration for water availability (baseline information drawn from Stage 1), water demand, environmental and cultural impacts, surface water-groundwater interactions, existing infrastructure, soil type, aquifer characteristics and water quality.
- Decision support model, identifying priority sites for potential MAR based on community, environmental or industry need, and location of opportunities to deliver desired outcomes, demonstrating the location and potential scale of MAR operations.
- Risk assessment underpinned by fit-for-purpose decision support model, developing a risk assessment framework assessing the likelihood and consequence of adverse outcomes at priority sites identified within the decision support model, and identifying mitigation strategies where possible for identified risks.
- Post investigation stakeholder consultation with industry, community and environmental stakeholders, based on identified locations where opportunity for MAR exists, including clarifying and seeking feedback on (i) perceived versus actual identified opportunities based on location of available water, and (ii) perceived limitations (physical, financial etc.) based on water availability, including quantity, quality, location and opportunity for accessing water based on identified needs and location of growth opportunity based on industry profile.

4.2 Desktop Assessment of MAR Feasibility: Initial Spatial Screening for Potential Scheme Locations

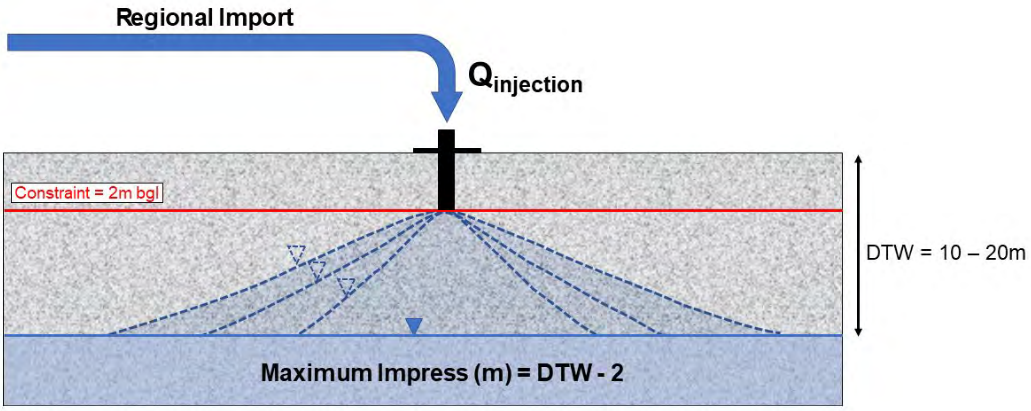
4.2.1 Approach

As a result of discussions with stakeholders during Stage 2a, three potential MAR scheme types have been identified for possible implementation in the Lower Limestone Coast region (Figure 13):

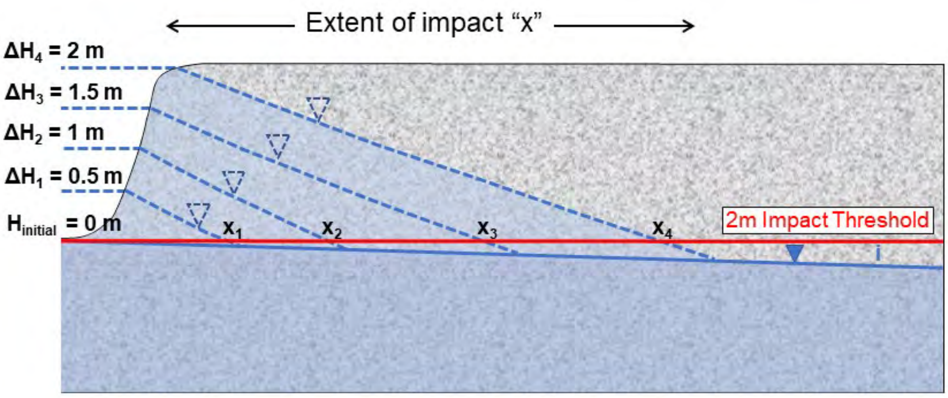
1. Community or on-farm MAR
2. Regional transfer of water and MAR
3. Use of the SEDN to hold up surface water for passive recharge to support GDEs and/or extractive uses.



(a) Scheme Type 1: Community or On-Farm MAR.



(b) Scheme Type 2: Regional Transfer of Water and MAR.



(c) Scheme Type 3: Hold water up in the SEDN.

Figure 13. Conceptual diagrams of the three potential MAR scheme types identified for the Lower Limestone Coast region. Constraints, maximum impress and impact thresholds are relevant to the decision support modelling presented in Section 4.5.

The desktop assessment to identify suitable locations for these different MAR scheme types included spatial analysis on a 1 km x 1 km grid for the following criteria (Figure 14):

- Aquifer suitability: Depth to groundwater, with different categories defined as shown in Figure 14.
- Water demand: Proximity to high levels of current groundwater abstraction or significant areas of plantation forestry land use.
- Water availability: Proximity to a drainage feature.

Whilst there is spatial data available on the locations of high value GDEs and annual surface water flow measurements, these were not used in the initial spatial screening process. GDEs represent a water demand in Figure 14, and protection or remediation of high value GDEs is considered to be one potential objective of MAR schemes in the Lower Limestone Coast. However, proximity to GDEs is not considered to be an essential criteria, as the MAR schemes considered in this project may be feasible for the purpose of simply mitigating local drawdown associated with high licenced groundwater abstraction or plantation forestry land use. Potential locations for MAR were first identified through the screening process and then reviewed qualitatively in relation to GDE proximity as described in Section 5.3. Likewise, whilst spatial data on measured flows and water quality in the SEDN network are available (Figure 2 to Figure 6), this does not provide sufficient spatial (or temporal) resolution on water availability or water quality for the purpose of identifying feasible locations for the different scheme types. Additionally, the only substantial dataset on water quality available is salinity, which is only one aspect of the water quality characteristics that are important to MAR schemes. Water availability was included where possible in the qualitative assessments in Section 4.3 and comprehensive assessments of water availability and water quality using newly collected data will be required as part of site specific feasibility assessments.

The original project Scope refers to the use of soil type in the desktop assessment of suitable sites. However, soil type was not considered to be an essential criteria for the preliminary assessment of feasibility of the scheme types shown in Figure 14 and has been omitted from this assessment.

In the spatial analysis process, locations that met an essential criteria (Figure 14) were assigned a score of 1 for that criteria. Where the criteria were not met, a score of 0 was assigned. These scores were then summed into an overall feasibility score. Therefore, in screening for Scheme Type 1, a feasibility score of 3 indicates a location that meets all of the essential criteria. For Scheme Type 2, a score of 2 indicates a location that meets all essential criteria. For Scheme Type 3, a feasibility score of 3 indicates a location that meets all essential criteria (where the depth to water criteria is different to that of Scheme Type 1).

Locations that met all of the required criteria based on the spatial analysis were then mapped and viewed relative to, for example, locations of high or very high value current or historical GDEs, data on water availability in the SEDN, whether this water already directly supports GDEs, location in the regional groundwater flow system, extent of areas of adequate depth to water, and location relative to Management Areas

Scheme Type		1. Community or On-Farm MAR	2. Regional Transfer and MAR	3. Hold water up in SEDN
Aquifer Suitability	Depth to Groundwater	Deep (> 10m)	Deep (> 10m)	Shallow - Mod (2m – 10m)
Water Demand	2021 Total Annual GW Use (Within 5km x 5km area)	> 500 ML	> 500 ML	> 500 ML
	or	or	or	or
	Land Use = Forestry	Yes	Yes	Yes
	GDE Presence (Up to 5km away) and	Yes (Likelihood Mod – VH)	Yes (Likelihood Mod – VH)	Yes (Likelihood Mod – VH)
		and	and	and
	Highest GDE Value (EVA)	High or Very High	High or Very High	High or Very High
Water Availability	Proximity to Drainage Network (Feature Within 2km)	Yes	Not Applicable	Yes

Figure 14. Matrix outlining the three different potential MAR scheme types (top row) and the criteria used in the spatial analysis for identifying potential locations (left hand column). Orange indicates an essential criteria used in the spatial screening process for potential MAR locations. Green indicates a desirable criteria assessed following the initial screening process.

assessed at the last WAP review as being Moderate to Very High Risk. This secondary assessment led to a qualitative ranking of the potential MAR locations based on feasibility and likely benefits, which is considered to be preliminary and has the objective of providing a basis for further discussion and assessment.

The following sections outline the methods for developing spatial layers used in the screening process, including specific GIS attribute fields that were generated, followed by the qualitative ranking of the identified feasible locations.

In all cases, a 1 km square grid was developed in QGIS for the study area, with the polygon centroids saved to a shapefile that provided the point locations across which the spatial assessment was carried out.

4.2.2 Aquifer Suitability

General aquifer suitability criteria for MAR may include depth to water table, water quality (e.g., salinity) and aquifer properties. Whilst there is data available for the latter two criteria for the Lower Limestone Coast region, it is too sparse to be useful for a feasibility assessment on a 1 km square grid. The focus of the initial desktop assessment of aquifer suitability was therefore depth to water table.

A state-wide shallow depth to groundwater shapefile is available on the WaterConnect website and was initially downloaded for use in this assessment. The shapefile comprises polygon zones of depth to water in the categories shown in Table 6. However, the metadata for this shapefile was not available; for example, neither the year the dataset was collected, nor the resolution of point data used in the interpolation have been documented. Therefore, a regional 2021 depth to groundwater map was sourced from Jeff Lawson (University of South Australia, 30th June 2022). This map was created using the same methodology as that used for the 2004 depth to groundwater map, which was adopted previously for WAP planning purposes around direct extraction of plantation forests. The raster underpinning what is herein referred to as the Lawson depth to water map has a 100 m x 100 m grid and includes corrections for topography. Whilst the full details of the method used for development of the 2021 (and 2004) map remain unpublished, the Lawson map was considered to be more reliable than the coarser state-wide map for this assessment.

Table 6. Depth to water categories used in this assessment (based on the categories used in the state-wide shallow depth to water map)

Depth to Water	Depth to Water Category
0 – 2m	1
2 – 5m	2
5 – 10m	3
10 – 20 m	4
>20 m	5

The Point Sampling Tool in QGIS was used to obtain a depth to water value from the Lawson depth to water map for each 1 km grid centroid (2021 SWL_Raster field). Points were then assigned a depth to water category value of 1 to 5 (SWL_Group) based on the categories shown in Table 6. As the Lawson depth to water map did not extend outside the Lower Limestone Coast Prescribed Wells Area, the state-wide map was used to extend the dataset to the north of this area. The state-wide shapefile was converted to a raster on a 1 km grid and the Point Sampling Tool in QGIS was again used to obtain a depth to water category value (as per Table 6) for each 1 km grid centroid (SWL_Raster field). The two sets of depth to water categories were then merged into a Combined SWL (Comb_SWL) field where the SWL_Raster value was taken if there was no value in SWL_Group. The resulting combined depth to water table map is shown in Figure 15.

Figure 14 shows the depth to water criteria adopted for each of the three potential MAR scheme types. Scheme types 1 and 2 involve recharge to the aquifer via injection bore(s), which require adequate depth to water to prevent waterlogging (Figure 13a and b). Whilst the minimum depth to water can realistically only be determined via site specific modelling, a threshold value of 10 m was selected as the screening criteria based upon expert knowledge of the unconfined aquifer properties. For Scheme Type 3, regulators would be used to hold water up in the SEDN, allowing for maintenance of surface water at critical locations in the SEDN and/or passive recharge to the aquifer at a local scale (Figure 13c). For this scheme type, shallower depths to water may be feasible due to the passive nature of the recharge and could be preferable if the primary objective is to benefit GDEs. Again, site specific modelling will always be required to determine the appropriate depth to water at any particular site. However, depths of 2 m to 10 m have been adopted for the initial desktop assessment.

Two water level score fields were assigned a value of either 0 or 1 based upon the depth to water criteria in Figure 14:

- SWLScore1 = 1 if Comb_SWL = 4 or 5 (SWL > 10 m; Table 6), indicating that the depth to water criteria for Scheme Types 1 and 2 are satisfied. SWLScore1 = 0 if this is not true.
- SWLScore2 = 1 if Comb_SWL = 2 to 3 (SWL = 2 – 10 m; Table 6). SWLScore2 = 1 indicates that the depth to water criteria for Scheme Type 3 is satisfied. SWLScore2 = 0 if this is not true.

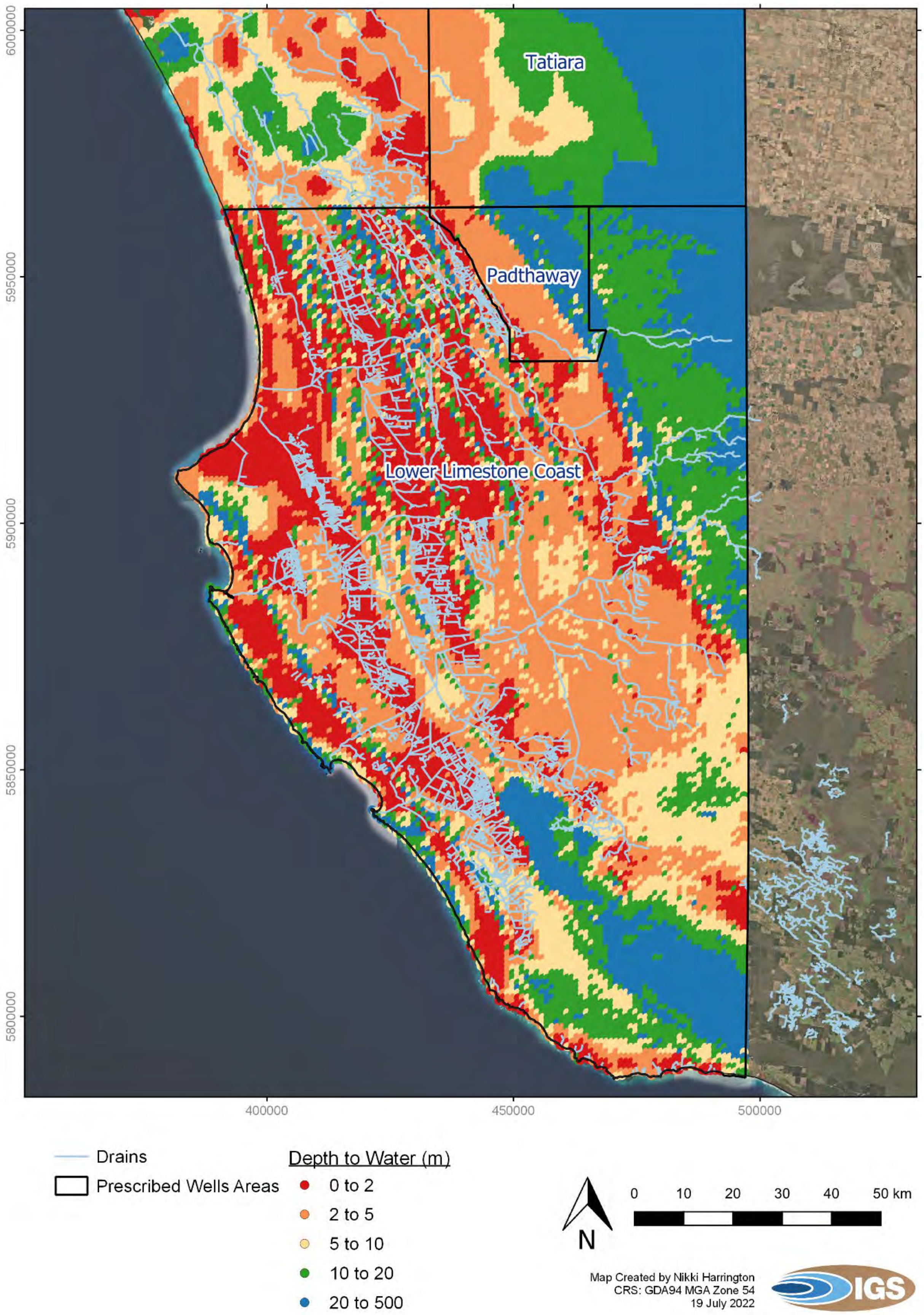


Figure 15. Depth to groundwater categories for each point on a 1 km grid.

4.2.3 Water Demand

In the Lower Limestone Coast region, MAR schemes are likely to be most beneficial in areas where high (ground)water demand has resulted in excess drawdown. This would be particularly important where drawdown impacts on either currently intact or historical GDEs of high ecological value can be mitigated or reversed. For the purpose of the screening assessment, groundwater demand is considered to arise from licenced groundwater abstraction and significant areas of plantation forestry land use. Groundwater demand from the latter will be higher in areas of shallower water tables, where plantations directly access groundwater, but is also significant in areas of deeper water tables via recharge interception.

Licenced Groundwater Abstraction

Three years of groundwater use data (2019, 2020, 2021) were provided by the Department of Environment and Water (DEW) via the LCLB (pers. comm., S. Botting, LCLB, 12 January 2022). The datasets were reviewed and found to have approximately 1,000 records with missing well coordinates for each of the three years of data, despite the fact that many of these coordinates are available on the Obswell database. In some cases, however, the coordinates were actually recorded in the SOURCEDESC field. A number of other issues were also identified; for example, there were obvious typos in the unit number or there was no unit number listed to reference in the Obswell database. Missing well coordinates were obtained from the Obswell database where possible and those present in the SOURCEDESC column were copied across. Finally, for those records where co-ordinates were still unavailable due to a lack of unit number, some additional coordinates were obtained by cross-referencing between the three annual datasets via the meter ID number or Source ID number, as it was found that coordinates were available for some years but not others. Following this process, the number of records and volumes of abstraction that were not able to be georeferenced for use in this project were:

- 2019: 47 records, 1.79 GL (0.7% of total use)
- 2020: 45 records, 2.21 GL (0.1% of total use)
- 2021: 34 records, 1.51 GL (0.7% of total use)

The 2021 Groundwater Use dataset, being the most recent, was used as the basis for identifying areas of high groundwater demand from licenced groundwater abstraction. The spatial distribution of the 2021 groundwater use data is shown on Figure 16. To assist with the spatial analysis process (i.e., identifying areas of high groundwater use), total groundwater use was obtained for 5 km x 5 km grid cells across the study area. To do this, a 5 km square grid was generated in QGIS, and the Join Attributes by Location (summary) tool was used with ‘sum’ as the summary value (un-joinable attributes were kept as some grid cells have zero use). Groundwater use totals for each grid cell were then categorized in a new attribute field as shown in Table 7.

Table 7. Categories of 2021 groundwater use as calculated for 5 km x 5 km grid cells.

Total Annual Use (ML)	Use Category
0	1
0 to 50	2
50 to 200	3
200 to 500	4
500 to 1,000	5
1,000 to 5,000	6

The dataset was then filtered to select only categories 5 and 6; that is, only grid cells with 2021 Groundwater Use greater than 500 ML within a 5 km x 5 km area. These cells were assigned a value of 1 in a new field.

The limitation of using this method in screening locations for proximity to high groundwater use is that some points of high groundwater use may occur near the margins of the 5 km x 5 km grid cells. This means that a location in the adjacent grid cell would be assessed as not having proximity to high groundwater demand despite being very close to a high groundwater use location. The objective of the MAR feasibility screening tool is to identify all potential locations, which can then be further assessed, and it is therefore important that potential locations are not eliminated at this point. For this reason, a 2 km buffer was applied around each high groundwater use grid cell (Figure 16). Whilst this means that some locations up to 7 km from an area of intensive groundwater use may be selected as having high groundwater demand, this can be assessed on a site-by-site basis following the initial screening phase. The 5 km square grid with 2 km buffer, which is considered to capture locations with proximity to areas of intensive groundwater use are shown in Figure 15. The Join Attributes by Location tool was used in QGIS with the 1 km grid points to assign a value of 1 to the Use_Code field for all points that fall within the buffer zone for Groundwater Use (5 km grid) greater than 500 ML (Category 5 or 6; Table 7).

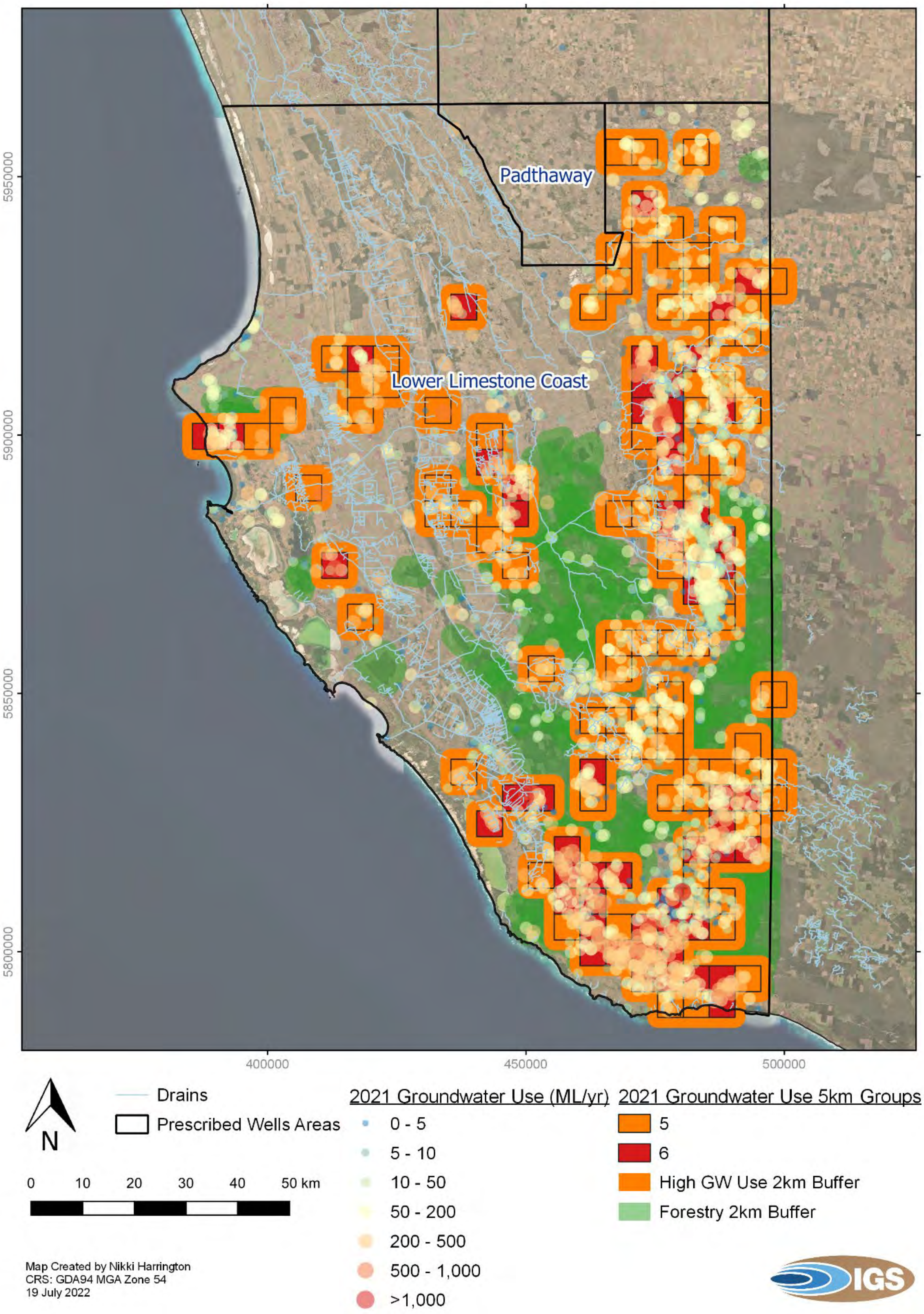


Figure 16. 2021 High groundwater use areas with forestry land use areas and 2 km buffer applied.

Plantation Forestry Land Use

The spatial dataset for areas of significant plantation forestry land use was developed from the ACLUMP (Australian Collaborative Land Use and Management Program) Land Use dataset (Land Use (ACLUMP) - Dataset - data.sa.gov.au, accessed 25th October 2021). The dataset depicts land use across South Australia according to the Australian Land Use and Management (ALUM) Classification Version 8 aggregated from surveys in 2008, 2014 and 2016.

The ACLUMP Land Use dataset was filtered in QGIS for a selection of Forest Land Use codes and then for shape size that was based on visual assessment of the dataset to ensure that only plantations of sufficient size to have an impact on groundwater levels and local water balances were included in the assessment. As for the licenced Groundwater Abstraction, a 2 km buffer was applied around plantation forestry land use areas (Figure 16). This buffer distance was selected subjectively to both target plantation forestry areas, providing the highest potential to offset water level impacts, and to allow flexibility in placement of MAR schemes. Again, this was done to ensure that the screening process did not exclude potential sites, whereby the details of particular identified sites could be reviewed later.

Information from the plantation forestry land use dataset was attributed to the 1 km square grid of points using the Join Attributes by Location tool in QGIS and all points located within a plantation forestry land use buffer zone were assigned a value of 1 in the ForestCode field.

Finally, locations with proximity to either high levels of licenced groundwater abstraction or significant areas of plantation forestry land use were identified in the UseScore2 field so that either a value of 1 under ForestCode OR a value of 1 under Use_Code resulted in a value of 1 under UseScore2. Any points not located within buffer zones for high licenced groundwater use or plantation forestry land use had a value of 0 in the UseScore2 field.

Groundwater Dependent Ecosystems of High Ecological Value

As described above, proximity to a GDE was not used as an essential criterion in the initial spatial screening process. However, potential sites identified during the initial screening process were reviewed in the context of proximity to GDEs in Section 4.3.

A shapefile named Wetlands_EVA_GDE_June2020.shp was provided by the LCLB (pers. comm., S. Botting, LCLB, 20th July 2022) for the purpose of the assessment. This dataset is reported to include a 2020 update to the South Australian Wetlands Inventory Database (SAWID; S. Botting, LCLB, pers. comm., 20th July 2022). The dataset includes the following information:

- GDE_Likeli (GDE_Likelihood_1990-2005): based on SKM 1990-2005 baseline as identified in the current LLC WAP. All wetlands that are VH,H,M GDE Likelihood were considered GDEs (of the unconfined aquifer).
- GDE_Like_1 (GDE_Likelihood_2010-2015): most current GDE likelihood assessment as per Cranswick and Herpich (2018). All wetlands that are VH,H,M GDE Likelihood were considered GDEs (of the unconfined aquifer).
- Ecological Value Assessment (EVA) (Low, Moderate, High and Very High).

Two datasets were created from this shapefile (Figure 17). The first represents those current Moderate to Very High likelihood GDEs (at 2010-2015) with High or Very High EVA, while the second represents previous Moderate to Very High likelihood GDEs (1990-2005) with High or Very High EVA. The latter GDEs were included as they may have only been down-graded in 2020 (post-Millennium Drought) due to an increase in depth to water table. These have potential to be restored via the MAR schemes proposed.

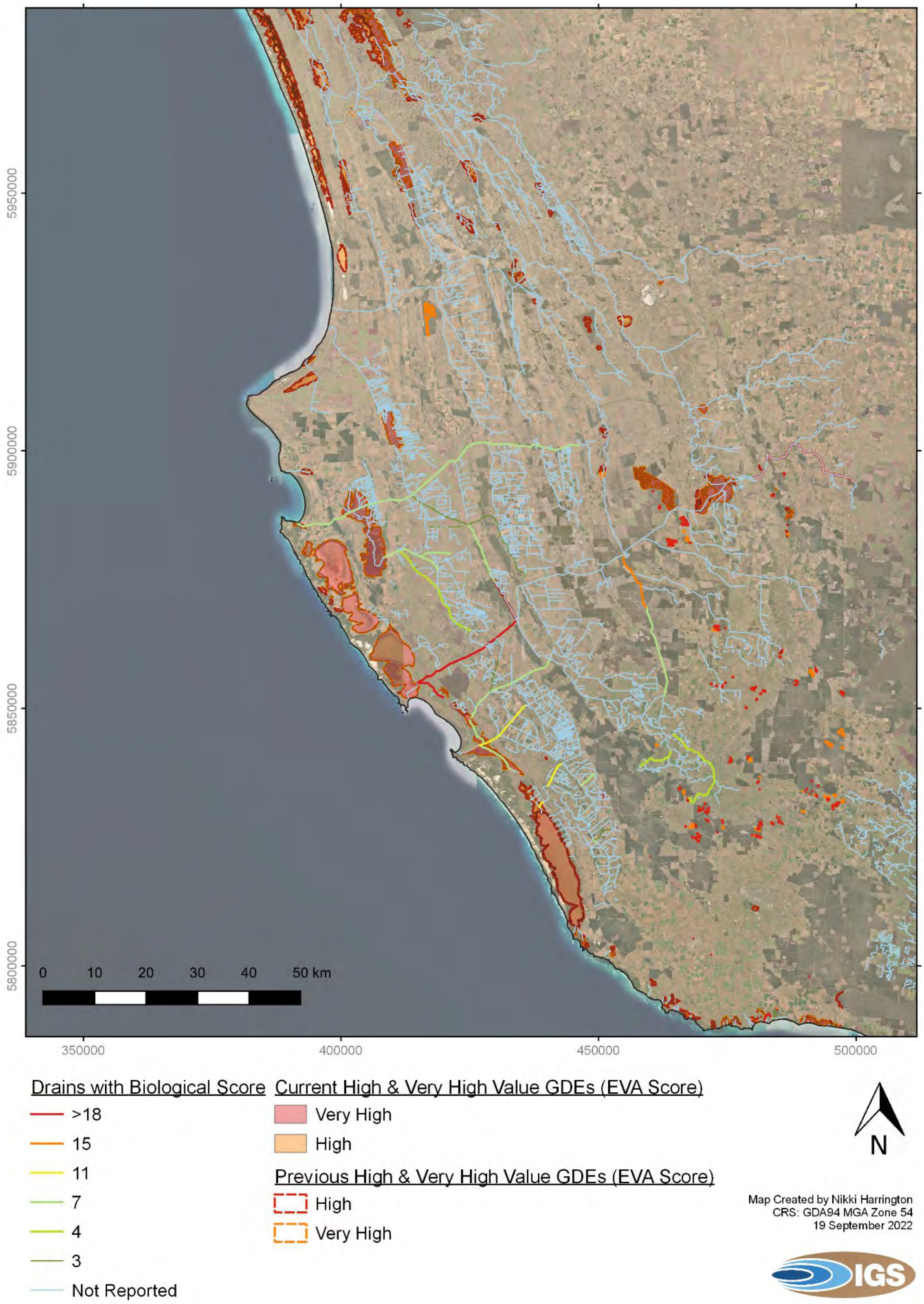


Figure 17. Current (2020) and previous high and very high value GDEs (moderate to high likelihood of groundwater dependence). Locations of drains are also shown for reference with biological scores assigned by Slater and Farrington (2010).

4.2.4 Water Availability and Proximity to Drainage Infrastructure

As described in Section 4.2.1, there is insufficient spatial resolution in the data for water availability (annual flows) in the SEDN for screening of potential MAR sites at the 1 km scale. Therefore, initial screening for water availability focused on proximity to surface drainage features only. Feasible locations for Scheme Type 1 were considered to be located within 2 km of a surface drainage feature (constructed drain or natural feature). In some instances, two kilometres may be considered an excessive distance to pipe water for a local-scale MAR schemes. However, the premise for the initial screening process is to identify all potential locations for further detailed assessment and therefore to be inclusive rather than exclusive.

A SE_Drainage shapefile was provided for the purpose of this assessment by DEW via the LCLB (pers. comm., S. Botting, LCLB, 25th January 2022). This shapefile includes both natural drainage features and constructed drains in both the Upper and Lower South East drainage networks. A 2 km buffer was applied around all drainage features as shown in Figure 18 and the Join Attributes by Location tool in QGIS was used to join the ‘Enabled’ attribute field (which by default contained values of 1 for all drainage features) to the 1 km grid points, thereby forming a new field (DrainScor4). This process assigns a value of 1 to the DrainScor4 attribute for all points located within the 2 km buffer zones around drainage features.

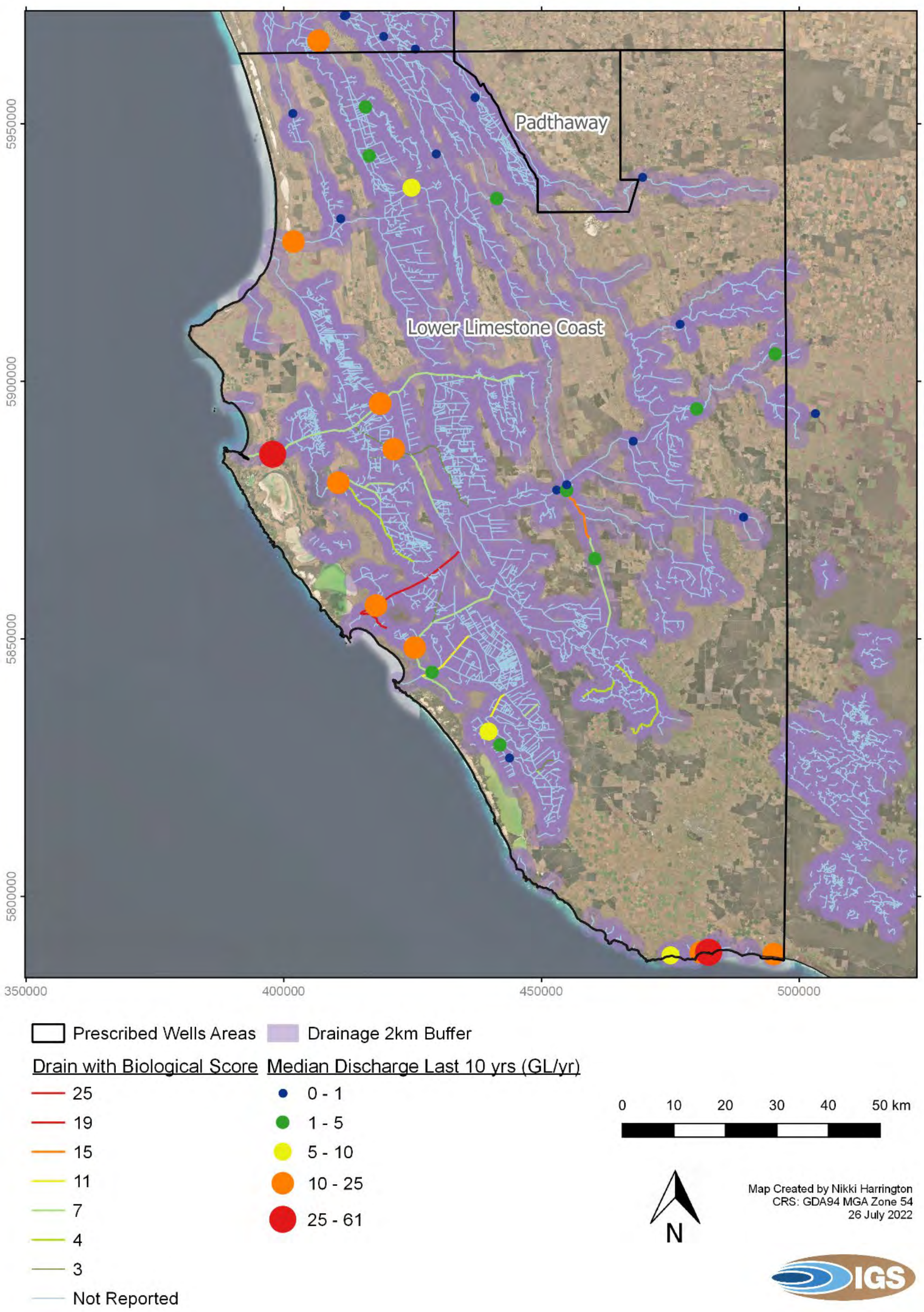


Figure 18. Locations of drainage features with a 2 km buffer and available discharge data (median discharge for the last 10 years). Drain biological scores are provided where these have been assigned by Slater and Farrington (2010).

4.2.5 MAR Feasibility Calculations

To identify potential locations for the three MAR scheme types, several MAR Feasibility Scores were calculated in QGIS based on the essential criteria shown in Figure 14. Recall that where a criterion is satisfied for a point on the 1km x 1km grid, the relevant field is assigned a value of 1. Where the criterion is not satisfied, the field is assigned a value of 0. Several Feasibility Scores were trialled, including some that consider location within a 5 km buffer zone around GDEs (GDEScore field). As described above, GDE criteria were not used in the initial screening process and proximity to GDEs was assessed qualitatively during the next stage of assessment. Scores for relevant fields (either 0 or 1) were summed for each Feasibility Score. Locations that satisfy all criteria for a particular scheme type have the maximum possible score.

The Feasibility Scores calculated were as follows:

Feas1 = SWLScore1 + UseScore2 + GDEScore
Feas2 = SWLScore1 + UseScore2 + GDEScore + DrainScor4
Feas3 = SWLScore1 + UseScore2
Feas4 = SWLScore1 + UseScore2 + DrainScor4
Feas5 = SWLScore2 + UseScore2 + GDEScore + DrainScor4
Feas6 = SWLScore2 + UseScore2 + DrainScor4

These Feasibility Scores apply to the three MAR scheme types as follows:

1. Community On-Farm MAR: Feas2 and **Feas4**
2. Regional Transfer and MAR: Feas1 and **Feas3**
3. Use SEDN to Support Ecosystems: Feas5 and **Feas6**

Following the decision to remove GDEs from the initial spatial screening, the Feasibility Scores listed in **bold** were used as the final Feasibility Scores. The outcomes of this screening process are presented in the next section.

4.3 Summary of Spatial Analysis Results and Preliminary Ranking of Potential Locations

This section provides an overview of the potential scheme locations identified through the initial spatial screening process, which considered the depth to groundwater, groundwater demand (licenced abstraction and plantation forests), and water availability (proximity to surface drainage features) criteria shown in Figure 14. Also presented are outcomes of preliminary ranking of the identified potential areas, which subjectively considered factors such as proximity to previous and current (2020) GDEs, potential water availability (where this information is available) and included a closer review of the depth to water (DTW) map and proximity to groundwater demand. It also loosely considered whether the sites are located within Unconfined Management Areas that were assessed as having a high risk to the groundwater resource at the previous review of the LLC WAP. This initial ranking is intended to provide a starting point for discussions about site selection and feasibility as it was subjective, based on the regional-scale data available and IGS' broad general knowledge of the LLC region. It is expected to alter with further stakeholder and technical input.

4.3.1 Type 1: Community or On-Farm MAR

The spatial distribution of Feasibility Scores for Scheme Type 1 (Community or On-Farm MAR Schemes) is shown in Figure 19. Locations with the maximum possible Feasibility Score of 3, indicated by red zones in Figure 19, satisfy all of the essential criteria outlined in Figure 14. Each of these red zones in Figure 19 were subsequently selected, outlined, and numbered for identification purposes (Figure 20). Relevant details for each zone are summarised in tabular form in Appendix C (Table C1). The latter also includes a subjective ranking as discussed above, which is designated by colour shading and also corresponds to the colour ranking shown in Figure 20. Those zones identified as having highest and high ranking are summarised in Table 8.

Potential areas for Scheme Type 1 are scattered throughout the Lower Limestone Coast Prescribed Wells Area and vary in size. In some cases, the areas of adequate depth to water (DTW) are quite small and may be represented by only one or two points on the 1 km x 1 km grid. Local scale studies would be required to confirm these depths to water and determine the effects of seasonal fluctuations. In some cases, much larger areas have been identified. All areas shown in Figure 20 should be considered as potential locations for Scheme Type 1 regardless of colour (ranking) until more detailed local scale assessments have been carried out in the context of scheme objectives. The details listed in Table C1 and the ranking of schemes presented here is intended to highlight the considerations for each of the identified areas.

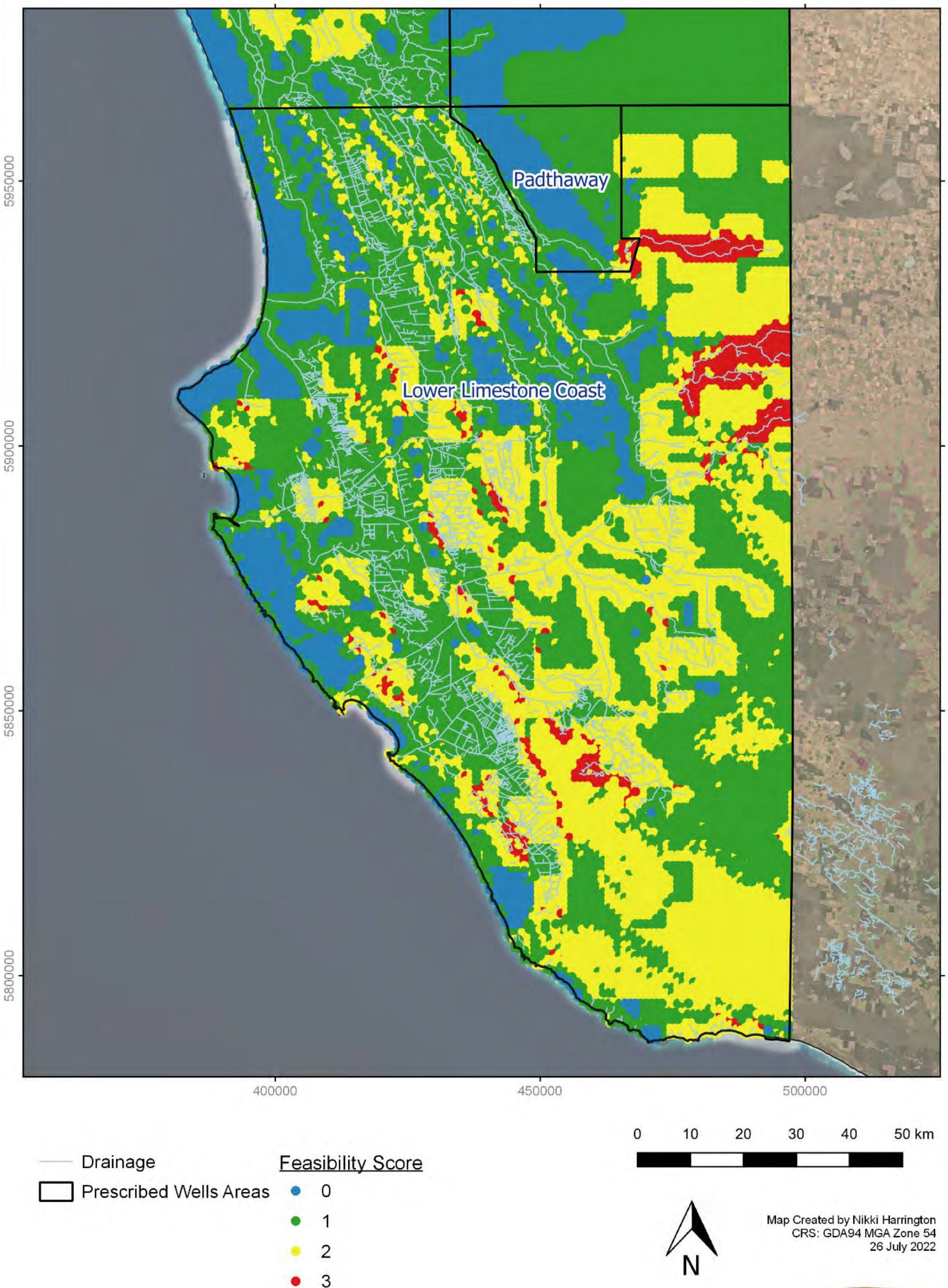


Figure 19. Scheme Type 1 MAR feasibility score based on (1) Depth to groundwater > 10m, (2) Groundwater demand defined as nearby use > 500 ML/yr or plantation forest land use nearby, and (3) Proximity to drainage feature. Areas coloured in red satisfy all essential criteria for Scheme Type 1 as outlined in Figure 14.

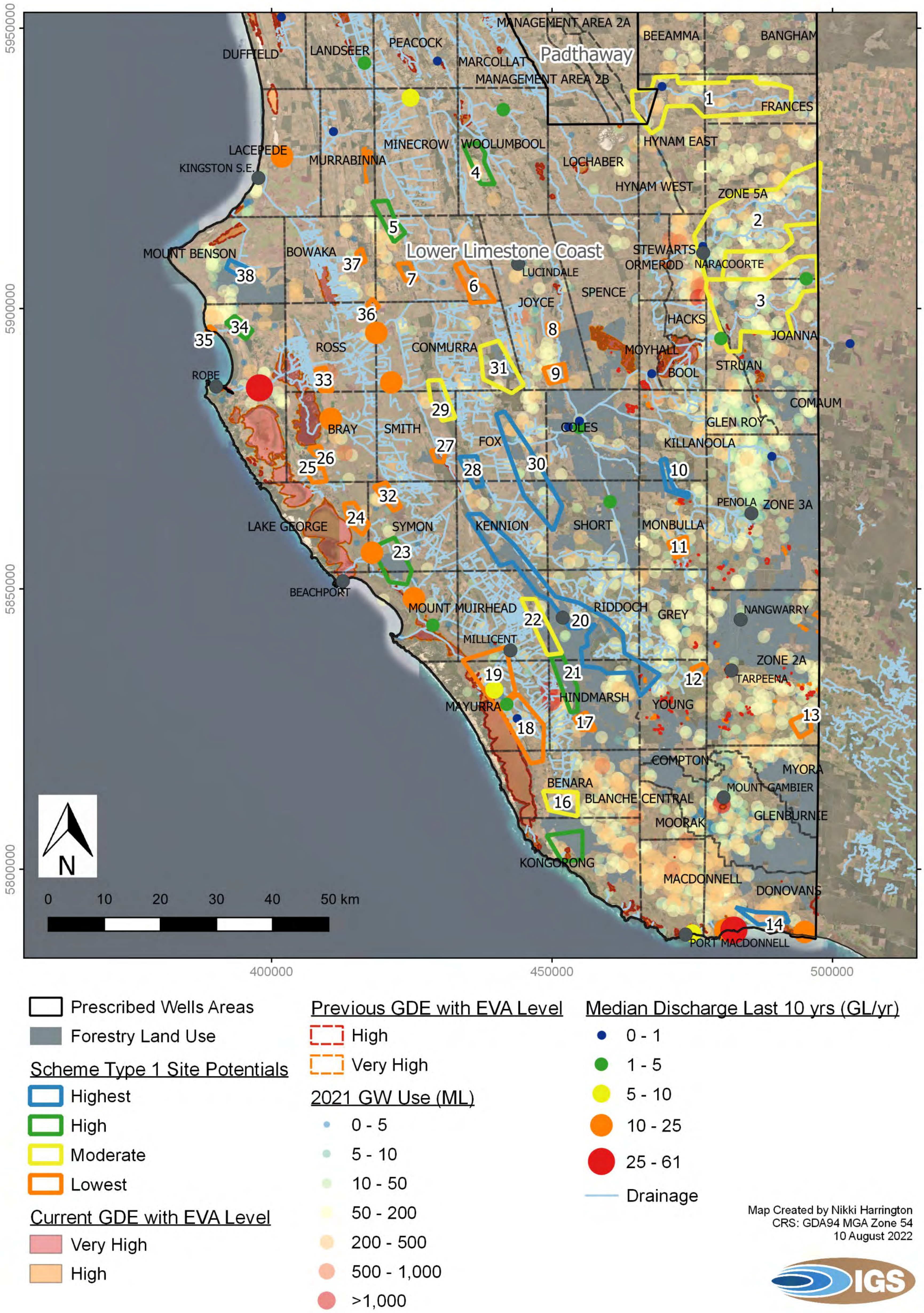


Figure 20. Scheme Type 1 (Community or On-Farm MAR) potential areas with qualitative ranking from Lowest to Highest potential based on information provided in Table C1 (Appendix C).

Table 8. Summary of areas identified as having the highest and high potential for Scheme Type 1 (Community or On-Farm MAR) based on the desktop assessment of available information and further qualitative assessment as provided in Table C1. Refer to Figure 20 for locations of each area referenced by the ID number.

ID	Description	Comment
Highest Potential (Blue)		
10	East of Coles-Short forested area.	Potential to offset plantation forestry impacts and support previously assessed GDEs to south but may be limited by depth to water. Depth to water at GDE is 4.8 m, although nearby it is 8.3 m and 10.6 m at feasible point. Hydraulics of providing benefit to GDEs to south and south east are unclear. Localised areas of adequate DTW within forest zone. The previous GDEs have forest to the west of them and Coonawarra irrigation upgradient.
14	Southern Coastal Creeks	Possible to intercept water at high flows from coastal outflows to alleviate drawdown associated with abstraction, incl. around Bones Pond and Dead Pond.
20	North eastern edge of Mt Burr Forest	Possible to support previously assessed GDEs although water source may be uncertain. Stakeholders identified Mt Burr Swamp as a priority wetland.
28	East of Reedy Creek Wilmot Drain	Possible. Small area of adequate DTW, no large use near site besides plantation forestry.
30	Various sites around forested areas just west of Coles-Short	Possible to offset impacts of groundwater use but no GDE benefit.
38	Mount Benson	Could offset plantation forestry impacts
High Potential (Green)		
4	Around Tatiara Swamp	Possible. Located near GDEs and proximal to Reflows and associated minor drains.
5	Western side of Blackford Drain	Possible. No local existing GDE benefit, although previous GDE, Mount Scott Floodplain to north. Prev. High GDE Likelihood, now Low. Potential site based on DTW and proximity to Blackford Drain.
15	Blackfellows Caves	Possible to intercept water at high flows from coastal outflows to alleviate any drawdown associated with regional abstraction and local forestry plantations.
21	Western edge of Mt Burr forest – within forest.	May not be practical as deeper water tables are within forest. Drains flow into Lake Bonney. Possible benefit to Snuggery Drain Spring.
23	South east of Lake George	Drains already flow into Lake George, but possible benefits to Burks Island, which is adjacent a forest area, and the NW end of Mullins Swamp.
34	North of Robe	Possible – protection for wetland if needed.

Scheme Type 1 relies on availability of water in the SEDN in close proximity to the proposed MAR scheme. The available data suggests that larger and more reliable flows occur in the west of the LLC region and in the southern coastal creeks, meaning that Type 1 schemes are more viable in these areas. Figure 19 shows that some potential locations have been identified in this area through the spatial screening process. Specific comments about these are provided in Table 8. Stakeholders identified that priority sites for restoring wetland features include some of the coastal wetlands such as Hutt Bay/Middle Point Swamp.

Limited flow data in the east and north of the study area indicates that significant flows may be available in these areas but are less consistent / less reliable (Section 2.3). Stakeholders identified that priority should be given to up-catchment sites in wet years when flow is available for retention and/or MAR. They indicated the belief that rewatering of any stressed wetland will restore some ecological values, however urgency should be directed to those wetlands with known high biological values (e.g., nationally or regionally significant species). The spatial screening process has identified some potential locations for Scheme Type 1 on the creeks that flow out of the Naracoorte Ranges (Figure 19).

Stakeholders also identified specific opportunities for MAR such as around Wrattonbully and Mullingers Swamp where water is currently diverted away from runaway holes. They also suggested temporary storage of available drainage water in wetlands where MAR was not feasible, alluding to several examples where this might be possible on Crown Land. This should be considered when further assessing the information provided in Figure 19, Figure 20 and Table 8.

4.3.2 Type 2: Regional Transfer and MAR

The spatial distribution of Feasibility Scores for Scheme Type 2 (Regional Transfer and MAR) is shown in Figure 21. Locations with the maximum possible Feasibility Score of 2, indicated by red zones in Figure 21, satisfy all of the essential criteria outlined in Figure 14. Each red zone from Figure 21 was subsequently selected, outlined, and numbered for identification purposes (Figure 22). Relevant details for each zone are summarised in tabular form in Appendix C (Table C2). The latter also includes a subjective ranking as discussed above, which is designated by colour shading and also corresponds to the colour ranking shown in Figure 22. Those zones identified as having highest and high ranking are summarised in Table 9.

Many potential areas identified for Scheme Type 2 are expanded versions of those identified for Scheme Type 1 due to removal of the requirement to be proximal to a surface drainage feature. In some cases, areas for Scheme Type 1 have been merged due to identification of areas in between. Hence, the ID numbers used for potential Scheme Type 2 areas are partially (but not always) consistent with those for Scheme Type 1.

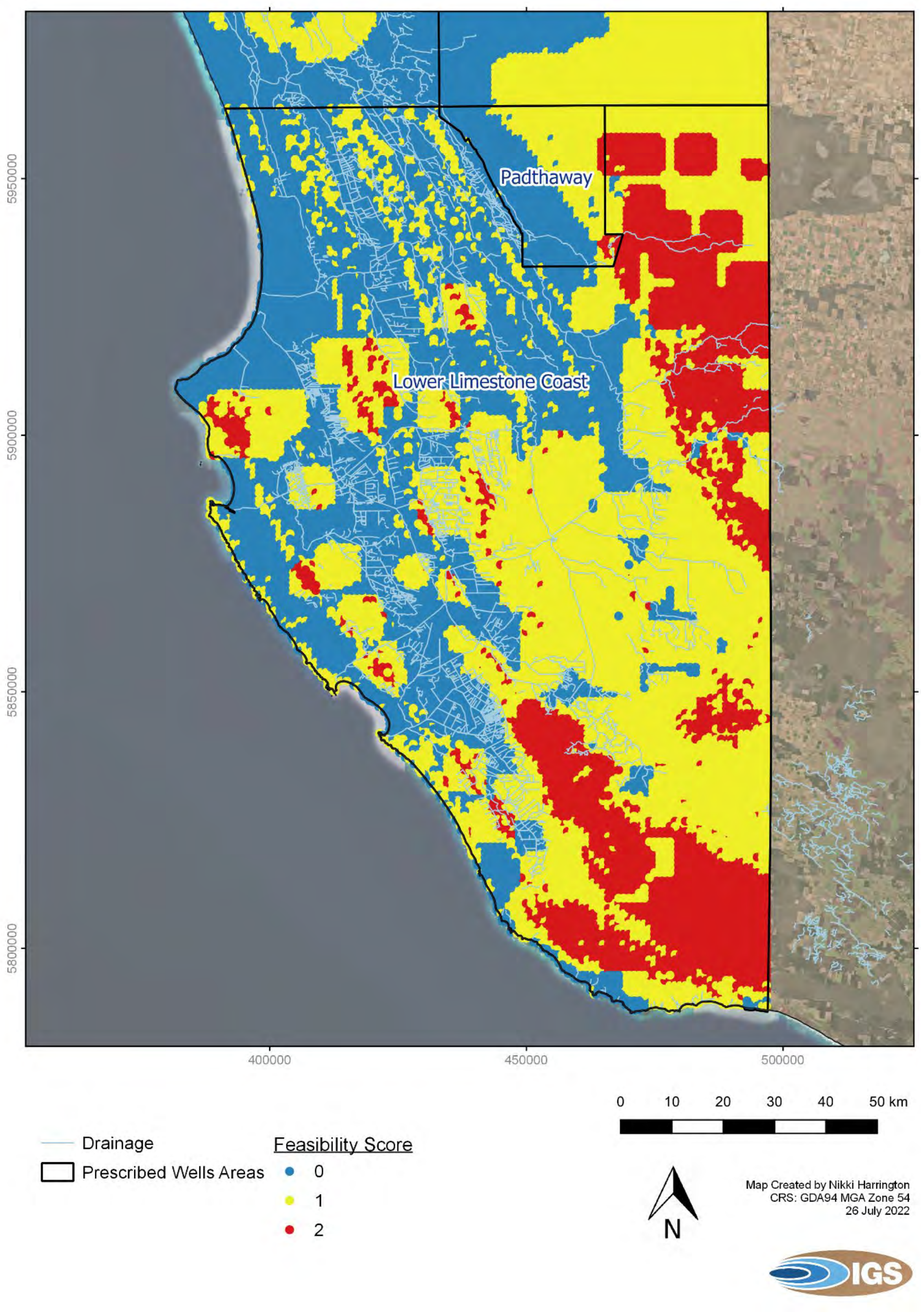


Figure 21. Scheme Type 2 MAR feasibility score based on (1) Depth to groundwater > 10m, and (2) Groundwater demand defined as nearby use > 500 ML/yr or plantation forest land use nearby.

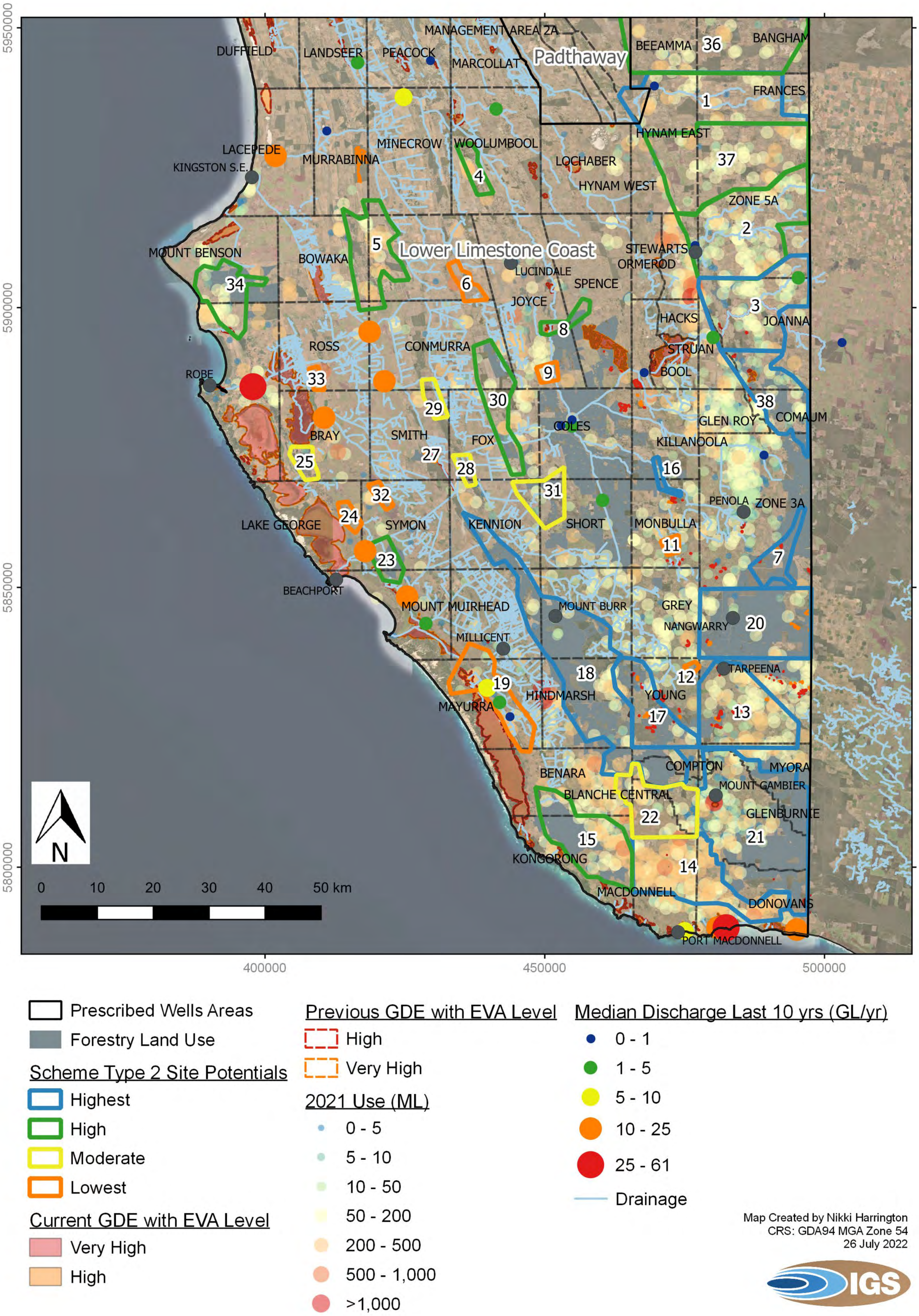


Figure 22. Scheme Type 2 (Regional Transfer and MAR) potential areas with qualitative ranking from Lowest to Highest potential based on information provided in Table C2 (Appendix C).

Table 9. Summary of areas identified as having the highest potential for Scheme Type 2 (Regional Transfer and MAR) based on the desktop assessment of available information and further qualitative assessment as provided in Table C2. Refer to Figure 22 for locations of each area referenced by the ID number.

ID	Description	Comment
Highest Potential (Blue)		
1	Northern Hynam East and Frances	Possible to mitigate impacts from abstraction.
3	Around Mosquito Creek and Yelloch Creek. Northern part of Joanna	Possible to alleviate drawdown and protect down-gradient GDE. This area ('around Wrattonbully') identified as potential for MAR by stakeholders.
7	South-eastern Zone 3A	Possible benefit to offset plantation forestry impacts and restore previous GDEs in SW corner of Zone 3A.
13	Southern Zone 2A and northern margin of Myora	Possible benefit at Dismal Swamp to offset impacts of both plantation forestry and abstraction.
14	Donovans and Macdonnell Irrigation areas - Southern Coastal Creeks	Possible to intercept water at high flows from coastal outflows to alleviate drawdown associated with abstraction, incl. around Bones Pond and Dead Pond.
16	Forest area across Killanoola / Monbulla border (eastern edge of Coles-Short forest estate)	Possible to offset forestry impacts and restore previous GDEs but potentially limited by depth to water. Depth to water at GDE is 4.8 m, although nearby it is 8.3 m and 10.6 m at feasible point.
17	In southern part of Mt Burr Forest zone. Areas around previous GDEs in Young	Possible to restore previous GDEs.
18	Mount Burr Forest	Can alleviate drawdown – mainly forest area. Possible benefit to Snuggery Drain Spring and previous GDE. Stakeholders identified Mt Burr Swamp as a priority wetland.
20	Nangwarry forest in Zone 2A	Possible to restore previous GDEs and alleviate plantation forestry / abstraction impacts.
21	Mount Gambier area and forests to the east / south.	Possible to offset impacts from plantation forests and abstraction (particularly in Myora). Blue Lake is the only GDE.
38	Southern Joanna and Comaum	Could offset plantation forestry impacts to current and previous GDEs.
High Potential (Green)		
2	Southern Zone 5A	Possible to alleviate drawdown and protect down-gradient GDE. Mullingers Swamp is in eastern portion. Not identified as a GDE in spatial analysis but identified by stakeholders as potential MAR location.
4	Around Tatiara Swamp	Possible. Located near GDEs.
5	Western side of Blackford Drain	Possible. No local existing GDE benefit, although previous GDE, Mount Scott Floodplain to north. Prev. High GDE Likelihood, now Low. Potential site based on DTW.
8	Northern edge of Coles-Short forested area	Possible to offset plantation forestry impacts but very small area of adequate DTW.
15	Inland of Blackfellows Caves and southern edge of Lake Bonney	Possible to intercept water at high flows from coastal outflows to alleviate drawdown associated with regional abstraction and local plantation forestry.

23	South east of Lake George	Drains already flow into Lake George. Possible benefits to Burks Island, which is adjacent to forest area, and NW end of Mullins Swamp.
30	Various sites around forested areas just west of Coles-Short	Possible. May alleviate drawdown associated with forest plantation.
34	North of Robe, Mount Benson forestry area	Possible – protection for wetland if needed, offset for plantation forestry impacts – may have limited benefit so close to coast.
36	Beeamma / Bangham	Possible to offset plantation forestry impacts.
37	Hynam East / Northern Zone 5A	Possible to mitigate impacts from abstraction.

All areas shown in Figure 22 should be considered as potential locations for Scheme Type 2 regardless of colour (ranking) until more detailed local scale assessments have been carried out in the context of scheme objectives. The information provided in Table C2 and subsequent ranking of schemes presented here is intended to highlight considerations for each of the identified areas.

It has previously been identified that the greatest availability of water in the drainage network is in areas near the coast, including the karst rising springs and creeks south of Mount Gambier as well as lower sections of Drain M and Drain L (Section 2.3). These are generally a very long way from areas of high groundwater demand and/or environmental assets in need of a restored hydrologic regime. High potential for MAR has been identified via the spatial screening process in the Donovans and Macdonnell Management Areas, which are proximal to the water availability from the karst rising springs (Figure 21 and Figure 22). However, the other highest potential areas identified for MAR are in Glenburnie (around Mount Gambier), through the Mount Burr forest area and along the Victorian border strip, which are quite distant from where significant and reliable flows are available in the SEDN. This means that significant regional transfer infrastructure would be required to connect water availability in the SEDN with these potential MAR locations.

4.3.3 Type 3: Hold water up in the SEDN

Areas identified as having potential for Scheme Type 3 (Hold water up in the SEDN) are shown in blue in Figure 23. These areas had a Feasibility Score of 3 and hence satisfied all of the criteria outlined in Figure 14; that is, a depth to groundwater of between 2 m and 10 m, are close to groundwater abstraction or plantation forests, and are within 2 km of a surface drainage feature.

The concept behind this scheme type is that surface water flows would be held up in the SEDN during times of peak flow, with the water allowed to passively recharge the surrounding aquifer either to offset drawdown associated with groundwater abstraction or plantation forestry impacts, or to support GDEs located very close to the flow regulation point. The high feasibility locations shown on Figure 23 are focused around surface drainage features as expected. However, it is also notable that the blue ‘feasible’ zones often extend some distance from the surface drainage features. The spatial screening process has selected any locations that satisfy the depth to groundwater and groundwater use criteria within 2 km of a surface drainage feature. For Scheme Type 3, feasible locations should be considered to be those that lie on surface drainage features.

The greatest limitation on the feasibility of a Type 3 scheme will be water availability and the details around this. Figure 23 shows that very few gauging locations exist within the areas identified as being feasible for this scheme type. This means there is insufficient spatial resolution in flow records to warrant any further ranking of the identified locations. However, the following comments can be made:

- Locations around the Southern Coastal Creeks, which have high median annual discharge have been identified as being feasible.
- Locations identified in the Zone 3A Management Area may offset drawdown associated with intensive groundwater abstraction and impacts from plantation forestry located in the east of this Management Area. However, availability of sufficient surface flows is uncertain.
- Several current or previously identified GDEs are located adjacent to or on drainage features in the feasible locations; for example, in the southern portion of the Moyhall Management Area, in Killanoola, Coles, Spence, Joyce, and Mount Benson Management Areas.
- In several cases, GDEs exist at the headwaters of a drainage feature identified as a feasible location. However, in these cases, the surface drainage feature forms the outflow from the GDE, and surface water flow is probably initiated once the GDE is filled. Examples of this are locations within Kongorong, Zone 3A, Waterhouse and Young Management Areas.
- Several of the drainage features identified as being feasible locations have high biological values according to Slater and Farrington (2010) (Figure 23). As described in Section 3.5, stakeholders identified the highest priority sites for enhancing in-drain environmental values are those that still flow every year.

Existing infrastructure available for regulation of surface flows is shown on Figure 10. It is worth recalling that each of these regulating structures has an agreed set of operating procedures to achieve target summer levels and/or late autumn-winter levels; and these are tabulated in SEWCDB (2017).

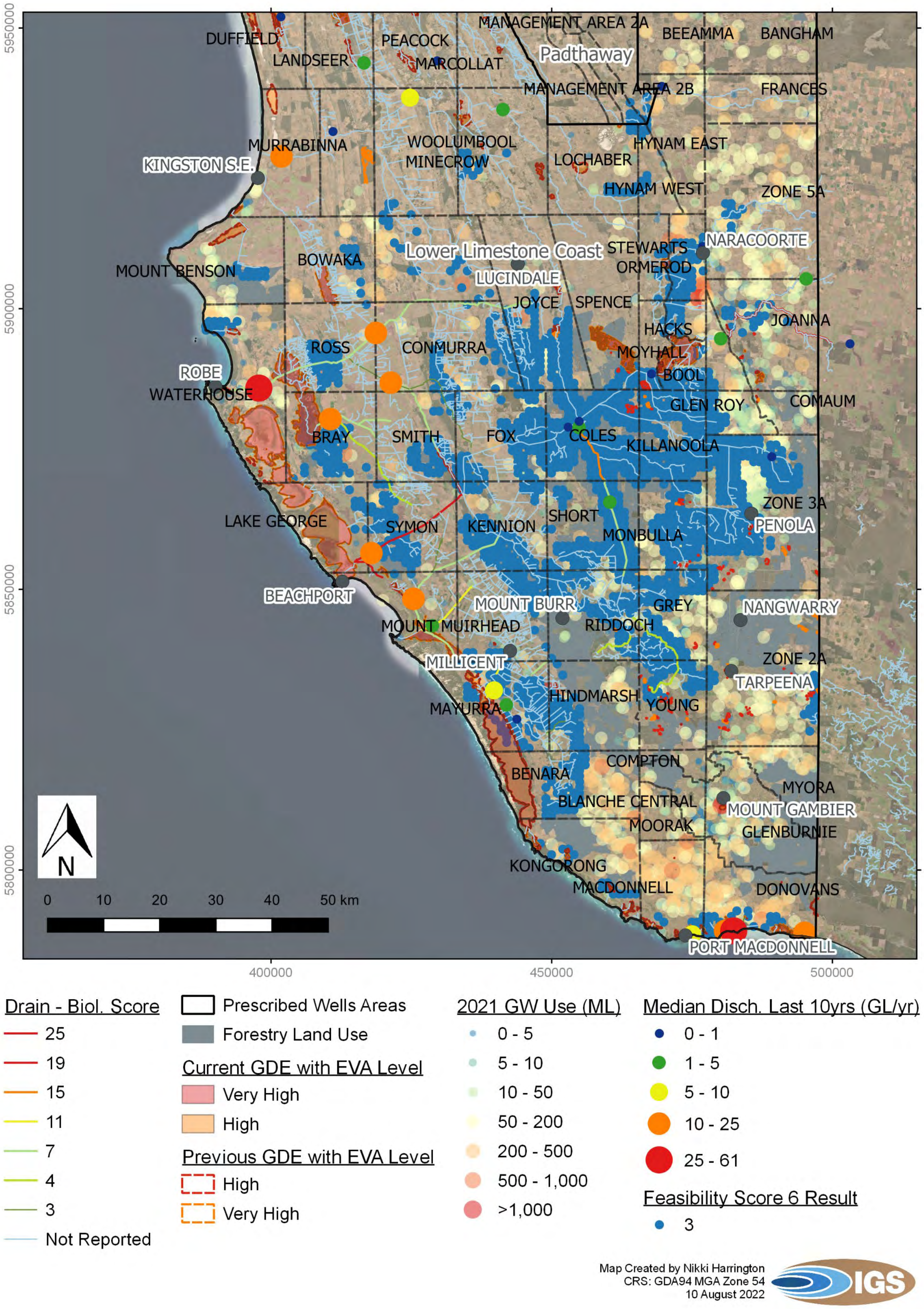


Figure 23. Locations identified as being suitable for Scheme Type 3 (Hold water up in the SEDN), i.e. Feasibility Score 6 = 3, satisfying the following criteria (1) Depth to groundwater = 2m to 10m, (2) Groundwater demand defined as nearby use > 500 ML/yr or near plantation forest land use, and (3) Proximity to drainage feature. Feasible sites within 2 km of a surface drainage feature are identified in blue, however feasible sites for Scheme Type 3 should be considered to be those located on a surface drainage feature.

4.4 Risk Assessment

4.4.1 Context

Any scheme that aims to modify the water balance of a landscape requires evaluation of the risks and the development of methodologies for mitigating these risks. A preliminary risk assessment has been designed and carried out for the broad scheme types identified in Figure 13 and Figure 14. The objective of the Risk Assessment is to provide a first pass assessment of the physical risks of the actions associated with developing a scheme at any one of the locations identified in Section 4.3. The assessment is based upon the regional-scale information presented in this report and IGS' expert knowledge of the resource and constraints at a broad scale. The Risk Assessment does not assess the risks to project proponents associated with the regulatory environment; for example, SEWCDB, LC Landscape Board, EPA approvals etc. Potential risks were identified through the stakeholder consultation for this project. However, stakeholders were not involved in the development or execution of the Risk Assessment as this is outside the scope of the current project. Rather, the Risk Assessment presented here is intended to be preliminary and may be either used as the basis for more detailed site specific risk assessments or refined with stakeholder input as needed. The Risk Assessment is revisited in Section 4.5.4 to explore the potential impact of applying Decision Support Models to mitigate some of the identified risks.

The Risk Assessment follows the principles and methods outlined in the Risk Management Framework for Water Planning and Management (DEWNR, 2012a) and Risk Management Policy and Guidelines for Water Allocation Plans (DEWNR, 2012b). The Risk Assessment criteria and evaluation methodology are loosely based upon some of those used in the 2019 Risk Assessment for the Lower Limestone Coast Water Allocation Plan (SENRMB, 2019).

The Risk Assessment assesses risks over the timeframe of the next 10 years. It does not assess the effects of potential changes or events that may occur over longer timeframes, including potential climate change impacts.

4.4.2 Risk Identification

Risks associated with retaining water in the landscape were identified through stakeholder consultation and can be summarised as follows:

1. Localised water logging associated with water table mounding around MAR injection wells.
2. More frequent and/or longer-term inundation of localised areas upstream of regulators due to higher water levels in the SEDN, thus inhibiting optimal performance of any private drainage network. The same risk would apply to dryland farmers in low-lying areas who don't have an existing private drainage network.
3. Reduced frequency of moderate (and potentially high) flows at downstream regulators, environmental receptors, and ocean outlets; and

4. Increased frequency of low flows due to higher groundwater levels and thus more prolonged baseflow in drains. It is thought that this altered hydrological regime could lead to new ecological diversity, most notably for aquatic flora and fauna, e.g., through the movement of invasive species.
5. Contamination of the shallow receiving aquifer with nutrients and agricultural chemicals (herbicides and pesticides) in surface runoff.
6. Higher salinity regimes in the northern wetlands and outfall at Salt Creek due to reduced frequency and/or magnitude of freshening inflows from the SEDN to the south. However, this risk could easy be mitigated through alternative management of the Upper South East elements of the network.

The above identified risks have been used to formulate risk statements that are recorded in the Risk Register (Table 10).

Table 10. Risk register.

ID	Source of Risk	Event	Consequence	Risk Statement
1	Managed Aquifer Recharge	Localised water logging associated with water table mounding	Land becomes unsuitable for current land use.	There is potential for Managed Aquifer Recharge to cause localised water logging associated with water table mounding which in turn could lead to land becoming unsuitable for current land use.
2	Managed Aquifer Recharge	Localised water logging associated with water table mounding	Reduced benefit from investment in private drainage networks.	There is potential for Managed Aquifer Recharge to cause localised water logging which in turn could lead to reduced benefit from investment in private drainage networks.
3	Holding water up in the SEDN at targeted locations	More frequent and/or longer-term inundation of localised areas upstream of regulators.	Land becomes unsuitable for current land use.	There is potential for the practice of holding water up in the SEDN at targeted locations to cause more frequent and/or longer-term inundation of localised areas upstream of regulators which in turn could lead to land becoming unsuitable for current land use.
4	Holding water up in the SEDN at targeted locations	More frequent and/or longer-term inundation of localised areas upstream of regulators.	Reduced benefit from investment in private drainage networks.	There is potential for the practice of holding water up in the SEDN at targeted locations to cause more frequent and/or longer-term inundation of localised areas upstream of regulators which in turn could lead to a reduced benefit from investment in private drainage networks.
5	Diversion of or holding up water in the SEDN for use in MAR or passive recharge.	Reduced frequency of moderate (and potentially high) flows at downstream regulators, environmental receptors and ocean outlets	Degradation of downstream terrestrial and coastal ecosystems via reduced periods of adequate water volume and reduced freshwater inputs.	There is potential for diversion of or holding up water in the SEDN for use in MAR or passive recharge to cause reduced frequency of moderate (and potentially high) flows at downstream regulators, environmental receptors and ocean outlets which in turn could lead to degradation of

				downstream terrestrial and coastal ecosystems.
6	Managed Aquifer Recharge	Higher groundwater levels leading to more prolonged baseflow in drains and thus increased frequency of low flows.	Altered hydrological regime that could lead to a new ecological diversity, most notably for aquatic flora and fauna, e.g., movement of invasive species	There is potential for Managed Aquifer Recharge to cause higher groundwater levels leading to more prolonged baseflow in drains and thus increased frequency of low flows which in turn could lead to a new ecological diversity, most notably for aquatic flora and fauna, e.g., movement of invasive species.
7	Recharge of surface runoff to the shallow aquifer via MAR or enhanced recharge around the SEDN.	Introduction of contaminants (nutrients and agricultural chemicals) from surface runoff into the shallow aquifer.	Groundwater from shallow aquifer becomes unsuitable for uses such as domestic or stock watering	There is potential for the recharge of surface runoff to the shallow aquifer via MAR or enhanced recharge around the SEDN to introduce contaminants (nutrients and agricultural chemicals) to the shallow aquifer which in turn could lead to groundwater becoming unsuitable for uses such as domestic or stock watering.
8	Diversion of surface water flows in the SEDN for recharge to the shallow aquifer.	Reduced frequency and/or magnitude of freshening inflows from the SEDN to the south.	Higher salinity regimes in the northern wetlands and outfall at Salt Creek.	There is potential for diversion of surface water flows in the SEDN for recharge to the shallow aquifer to cause reduced frequency and/or magnitude of freshening inflows from the SEDN to the south which in turn could lead to higher salinity regimes in the northern wetlands and outfall at Salt Creek.

4.4.3 Likelihood Criteria

The Likelihood Criteria used in the present Risk Assessment are based on those used for the Lower Limestone Coast Water Allocation Plan 2019 Risk Assessment (SENRMB, 2019) and are shown in Table 11.

Table 11. Likelihood criteria. Modified from 2019 LLC WAP Risk Assessment.

Rating	Description	Probability
Very likely	Expected in all circumstances	90% to 100%
Likely	Greater than even chance but not certain	60% to 80%
Possible	Less than even chance but not unusual	30% to 50%
Unlikely	Unusual but not exceptional	10% to 20%
Very unlikely	Only occurs in exceptional circumstances	0%

4.4.4 Consequence Criteria

Based upon the risk statements listed in Table 10, the potential consequences to be assessed are as follows:

- Land not suitable for existing land use.
- Economic impact of reduced benefit of private drainage networks.
- Ecosystems detrimentally impacted.
- Groundwater quality not suitable for human or stock use.

Land Suitability for Existing Land Use

The severity of consequences affecting land suitability is related to:

- The area of land affected and the frequency / duration of impact.
- The percentage of land with that land use affected for a single landholder.
- The number of landholders affected.
- Whether private drainage networks are in place and can alleviate impact.

For the purpose of this preliminary risk assessment, the potential area of land affected (based on radial extent of waterlogging) and the frequency / duration of impact are considered. More detailed risk assessments carried out for site specific studies may wish to consider impacts on individual landholders, numbers of landholders impacted, and whether private drains are present and/or impacted.

Table 12. Consequence criteria for change in land use suitability. Note that for the purpose of the current risk assessment potential for waterlogging is considered to occur where depth to water < 2 m.

Rating	Consequence Criteria
Catastrophic	o Radial extent of waterlogging extends for more than 500 m for more than a month at least one in five years, or o Radial extent of waterlogging extends between 100 m and 500 m for more than a month at least every second year.
Major	o Radial extent of waterlogging extends between 100 m and 500 m for more than a month at least one in five years, or o Radial extent of waterlogging extends between 50 m and 100 m for more than a month at least every second year.
Moderate	o Radial extent of waterlogging extends between 50 m and 100 m for more than a month at least one in five years, or o Radial extent of waterlogging extends between 10 m and 50 m for more than a month at least every second year.
Low	o Radial extent of waterlogging extends between 10 m and 50 m for more than a month at least one in five years, or o Radial extent of waterlogging extends < 10 m for more than a month at least every second year.
Insignificant	o No waterlogging

Economic Impact on Private Drainage Systems

This consequence is related to the potential reduction in return on investment from private drainage networks where their efficiency or benefits are reduced. This may be caused by a severity of flooding that reduces the efficiency of the drainage system or changed spatial distribution of flooding so that the existing drainage scheme is not able to mitigate it.

The severity of consequences affecting private drainage networks is related to:

- The area of land affected and the frequency / duration of impact.
- The value of private drains near the area of impact.
- The degree to which the efficiency or benefit of the drains is reduced.

Determination of even preliminary consequence criteria for economic impact on private drainage networks requires consultation with stakeholders on, for example, the economic value of private drainage networks and the potential impact of changed flooding patterns on the operation of these drainage networks. Such consultation was beyond the scope of this project. An example of potential consequence criteria is provided in Table 13 and these should be reviewed and revised with stakeholders. This consequence table also includes the same spatial and temporal waterlogging criteria as those in Table 12 to allow for direct comparison between these criteria and for consistency.

Table 13. Consequence criteria for economic impact of reduced benefit from private drainage networks. Note that for the purpose of the current risk assessment, waterlogging is defined as depth to water < 2 m.

Rating	Consequence Criteria
Catastrophic	o Radial extent of waterlogging extends for more than 500 m for more than a month at least one in five years, or o Radial extent of waterlogging extends between 100 m and 500 m for more than a month at least every second year. AND o The function or benefits of more than 5 km of private drains are reduced by at least 50%, or o The function or benefits of more than 2 km of private drains are reduced by at least 80%.
Major	o Radial extent of waterlogging extends between 100 m and 500 m for more than a month at least one in five years, or o Radial extent of waterlogging extends between 50 m and 100 m for more than a month at least every second year. AND o The function or benefits of more than 2 km of private drains are reduced by at least 50%, or o The function or benefits of more than 1 km of private drains are reduced by at least 80%.
Moderate	o Radial extent of waterlogging extends between 50 m and 100 m for more than a month at least one in five years, or o Radial extent of waterlogging extends between 10 m and 50 m for more than a month at least every second year. AND o The function or benefits of more than 1 km of private drains are reduced by at least 50%, or o The function or benefits of more than 500 m of private drains are reduced by at least 80%.
Low	o Radial extent of waterlogging extends between 10 m and 50 m for more than a month at least one in five years, or o Radial extent of waterlogging extends < 10 m for more than a month at least every second year. AND o The function or benefits of more than 200 m of private drains are reduced by at least 50%, or
Insignificant	o No waterlogging. o No reduction in function or benefit of private drains.

Ecosystems

The severity of consequences affecting ecosystems is related to (Table 14):

- The value of the ecosystem (endangered species, regional significance, international obligations (Ramsar), etc.).
- The reduction in area of the ecosystem.
- The degree of change in ecological function of the ecosystem.
- The extent to which consequences are temporary or permanent in nature.

Table 14. Consequence criteria for impacts to downstream ecosystems.

Rating	Consequence Criteria
Catastrophic	o Significant loss of ecosystem values having international, national or state importance. Recovery of ecosystem values not feasible over medium term (less than a decade).
Major	o Some loss of ecosystem values having international, national or state importance. Recovery of ecosystem is not feasible over medium term. o Significant loss of ecosystem values having regional or local importance. Recovery of ecosystem values not feasible over medium term (less than a decade), or
Moderate	o Some loss of ecosystem values having international, national or state importance. Recovery of ecosystem is feasible over medium term. o Significant loss of ecosystem values having regional or local importance. Recovery of ecosystem values feasible over medium term (less than a decade),
Minor	o Some loss of ecosystem values having regional or local importance. Recovery of ecosystem values is feasible over medium term.
Insignificant	o Any loss of ecosystem values is minimal.

Groundwater Quality

The severity of consequences associated with groundwater quality for human or stock consumption is related to (Table 15):

- The number of bores affected by adverse water quality;
- The availability of alternative supplies; and
- The extent to which the consequences are permanent or temporary in nature.

Table 15. Consequence criteria for changes to groundwater quality.

Rating	Consequence Criteria
Catastrophic	o Change to adverse water quality for more than 10 bores and no alternative supply for the majority of users affected is readily available.
Major	o Change to adverse groundwater quality for: o More than 10 bores but alternative supply readily available, OR o 5 to 10 bores and alternative supplies are not readily available.
Moderate	o Change to adverse groundwater quality for: o 5 to 10 bores and alternative supplies are readily available, OR o < 5 bores and alternative supplies are not readily available.
Low	o Change to adverse groundwater quality for: o < 5 bores and alternative supplies are readily available.
Insignificant	o No change in groundwater quality.

4.4.5 Risk Analysis and Evaluation

4.4.5.1 Methodology

The risk analysis for each risk statement listed in Table 10 is carried out using the template shown in Table 16 (SENRMB, 2019). The percentage likelihood values selected are guided by the likelihood levels shown in Table 11. Each of the five consequence levels must be given a percentage score value and the sum of the five percentage scores assigned must equal 100%. Consequence ratings assessed for each risk statement are guided by the consequence criteria contained in Table 12 to Table 15. The specific consequence table used will depend on the consequence the risk is being assessed against.

Table 16. Individual risk analysis record template

Risk Source:	<source of risk>			Consequence:			<a consequence>			
Consequence Criteria:			<consequence criteria>							
Risk Factors:										
Consequence	Percentage likelihood.									
Catastrophic	0	10	20	30	40	50	60	70	80	90
Major	0	10	20	30	40	50	60	70	80	90
Moderate	0	10	20	30	40	50	60	70	80	90
Low	0	10	20	30	40	50	60	70	80	90
Insignificant	0	10	20	30	40	50	60	70	80	90

The risk evaluation process for each risk involves taking the probability percentage score for each level of consequence and using the likelihood criteria (Table 11) to assign likelihood ratings in a Risk Matrix as shown in Table 17. Based on the precautionary principle, the highest level of risk recorded in the Risk Matrix forms the final risk level and is then used as the basis for determining the level of risk treatment required. In the hypothetical example shown in Table 17, two levels of consequence have a low level of risk and three have a medium level of risk, so the highest level of risk recorded is medium.

Table 17: Risk Matrix showing example of risk ratings. Green = low risk rating, yellow = medium risk rating, red = high risk rating.

		Consequence				
Likelihood		Insignificant	Low	Moderate	Major	Catastrophic
	Very Likely					
	Likely		X			
	Possible	X		X		
	Unlikely				X	
	Very Unlikely					X

The final part of the risk evaluation process is to evaluate confidence in the risk assessment. The framework for this is set out in Table 18.

Table 18. Confidence categories and ratings (modified from SENRMB (2019)).

Category	Low Confidence (Score = 1)	Moderate Confidence (Score = 2)	High Confidence (Score = 3)
Data/ Information	Anecdotal evidence only and/or historical or scientific evidence but not relevant at the spatial scale	Relevant validated historical or scientific evidence at the relevant spatial scale	Relevant validated historical or scientific evidence at the spatial scale targeted by the risk assessment
Knowledge	No relevant scale specific knowledge	Scale specific knowledge and knowledge of relevant disciplines or knowledge of risk assessment process	Scale specific knowledge and knowledge of relevant disciplines and knowledge of risk assessment process
Score	Rating		
2 to 3	Low confidence		
4 to 5	Moderate confidence		
6	High confidence		

The confidence rating of each risk statement determines whether further action is required to properly assess the risk and the level of action required according to the Confidence Rating and Action Matrix (Table 19).

Table 19. Confidence Rating & Action Matrix. Green = no action, yellow = monitor risk, orange = monitor risk and re-evaluate based on monitoring, red = undertake new evidence and knowledge acquisition and reassess risk.

	Low Confidence	Moderate Confidence	High Confidence
High level Risk	Undertake targeted new evidence collection or acquire greater knowledge and reassess risk	Monitor risk and treatment and re-evaluate risk based on monitoring	Monitor risk and treatment
Medium Level Risk	Monitor risk and re-evaluate risk based on monitoring	Monitor risk	Monitor risk
Low Level Risk	Monitor risk	Monitor risk	No action

4.4.4.2 Results

The risk analysis and risk evaluation tables developed according to the above methodology for each risk statement are provided in Appendix D and the final risk levels are summarised in Table 20.

This preliminary risk assessment is based upon broad regional knowledge rather than site specific assessments. Therefore, using Table 18 as a guide, confidence in data / information is low (i.e., limited relevant data at the appropriate spatial scale), whilst confidence in knowledge of the relevant processes is moderate. The overall confidence in this preliminary risk assessment is therefore considered to be low. Based on Table 19, the appropriate action in this setting for an overall risk level of Low may be to monitor risk. For an overall risk level of Medium, the appropriate action may be to monitor the risk and re-evaluate based on monitoring outcomes. In the case of this risk assessment, it is proposed that the higher level of action be taken for Medium level risks; i.e., collect additional site specific information before reassessing the risk.

Table 20. Final risk levels for each risk statement. Risk Level 1 was determined prior to development of the Decision Support Tools presented in Section 5.5 and relates to the risk analysis described above and presented in Appendix D. Risk Level 2 was determined following development of the Decision Support Tools (see Section 4.5.4).

ID	Risk Statement	Risk Level 1	Risk Level 2
1	There is potential for Managed Aquifer Recharge to cause localised water logging associated with water table mounding which in turn could lead to land becoming unsuitable for current land use.	Medium	Low
2	There is potential for Managed Aquifer Recharge to cause localised water logging which in turn could lead to reduced benefit from investment in private drainage networks.	Medium	Low
3	There is potential for the practice of holding water up in the SEDN at targeted locations to cause more frequent and/or longer-term inundation of localised areas upstream of regulators which in turn could lead to land becoming unsuitable for current land use.	Medium	High
4	There is potential for the practice of holding water up in the SEDN at targeted locations to cause more frequent and/or longer-term inundation of localised areas upstream of regulators which in turn could lead to a reduced benefit from investment in private drainage networks.	Medium	High
5	There is potential for diversion of or holding up water in the SEDN for use in MAR or passive recharge to cause reduced frequency of moderate (and potentially high) flows at downstream regulators, environmental receptors and ocean outlets which in turn could lead to degradation of downstream terrestrial and coastal ecosystems.	Medium	Medium
6	There is potential for Managed Aquifer Recharge to cause higher groundwater levels leading to more prolonged baseflow in drains and thus increased frequency of low flows which in turn could lead to a new ecological diversity, most notably for aquatic flora and fauna, e.g. movement of invasive species.	Low	Low
7	There is potential for the recharge of surface runoff to the shallow aquifer via MAR or enhanced recharge around the SEDN to introduce contaminants (nutrients and agricultural chemicals) to the shallow aquifer which in turn could lead to groundwater becoming unsuitable for uses such as domestic or stock watering.	Low	Low
8	There is potential for diversion of surface water flows in the SEDN for recharge to the shallow aquifer to cause reduced frequency and/or magnitude of freshening inflows from the SEDN to the south which in turn could lead to higher salinity regimes in the northern wetlands and outfall at Salt Creek.	Low	Low

4.5 Decision Support Tools for Assessing Potential for Waterlogging

4.5.1 Overview and Approach

A range of potential risks associated with Scheme Types 1, 2 and 3 have been identified in the previous section. Those risks associated with waterlogging (i.e., risk IDs 1 to 4; Table 10) should be assessed in future as part of any site feasibility study for a potential scheme. Likewise, the potential volumes of water that could be injected to an aquifer or held up in the SEDN with minimal risk of waterlogging should also be assessed.

However, in order to provide general guidance for a range of plausible conditions in the LLC, a combination of numerical and analytical modelling has been performed in this project as simple decision support tools to inform the following:

1. the magnitude and duration of injection rates that may be applied in MAR without the risk of waterlogging (Schemes 1 and 2); and
2. the extent of potential waterlogging impacts from Scheme Type 3 (holding water up in the SEDN).

Numerous combinations of aquifer hydraulic properties specific to the region were used to develop the tools, thereby ensuring applicability across the Lower Limestone Coast.

The conceptual models for each of the three scheme types are shown in Figure 13 (Section 4.2.1). For the purpose of this assessment, a risk of waterlogging is conservatively assumed to occur when the water table is within 2 m of ground surface, allowing for capillary rise in a range of soil types. For MAR (Scheme Types 1 and 2), this depth to water table constraint is used to identify optimum injection rates (and durations) for specific combinations of initial depth to water and aquifer properties (Figure 13a and b). For Scheme Type 3 (Holding water up in the SEDN), the constraint is used to define the extent of impact, whereby the extent of impact is deemed to be the area in which the resulting water table is within 2 m of the ground surface (Figure 13c). Further details of each decision support tool are provided below.

4.5.2 Scheme Types 1 and 2: Managed Aquifer Recharge

Whilst the conceptual models for Scheme Types 1 and 2 are slightly different, the drivers and processes leading to waterlogging are the same. In Scheme Type 1, water is pumped from a surface drainage feature and injected into the unconfined aquifer at a nearby location (the desktop MAR feasibility assessment assumed within 2 km) (Figure 13a). In Scheme Type 2, water is pumped from a surface drainage feature and transferred over much larger distances before injection into the unconfined aquifer (Figure 13b). The difference between the two schemes is the proximity of the water source (surface drainage feature) to the MAR injection site. However, in both cases the largest risk of waterlogging will occur at the injection bore (Figure 13a). Therefore, despite slightly different conceptual models, potential waterlogging impacts from Scheme Types 1 and 2 may be simulated in the same way.

Methodology

The Theis analytical solution was used to estimate the maximum constant injection rate that is tolerable over a specified timeframe to ensure the water table within 1.0 m of the injection well (where impress will be greatest) does not rise above 2 m below ground level. The solution typically features drawdown (*s* in Equation 1) as the dependent variable for a known pumping rate but was rearranged here (Equation 2) to provide the injection rate from a known impress. The well function *W(u)* features in the equation incorporating radial distance, aquifer storage and transmissivity, and time (Equation 3).

$$s = {}^{Q}\!/_{4\pi T}\, W(u) \tag{1}$$

$$Q = {}^{4s\pi T}\!/_{W(u)} \tag{2}$$

$$u = {}^{r^2 S}\!/_{4Tt} \tag{3}$$

Where s = impress (m)
- Q = MAR injection rate (m^3/d)
- T = aquifer transmissivity (m^2/d)
- t = time (days)
- S = aquifer storativity
- r = radius (m)

The assessment was limited to a maximum duration of 28 days on the basis that this was considered the maximum likely timeframe over which high surface flows could be diverted for MAR. It included a range of transmissivity (1 m^2/d to 1,000 m^2/d), specific yield (0.05 to 0.2), and starting depth to water (10 mbgl to 20 mbgl). A Python script was developed to solve and plot the results for different combinations aquifer properties, with the resulting curves forming the decision support tools that may be used to assess potential volumes (rates and durations) that may be injected whilst minimising the risk of waterlogging.

Decision Support Tool

The decision support tool for assessing the risk of waterlogging for a particular MAR scheme, or potential volumes that can be injected with minimal risk of waterlogging, takes the form of sets of curves developed using the above methodology and these are provided in Appendix E. Each set of curves represents a different aquifer transmissivity and one example set of curves, for a transmissivity of 10 m^2/d is shown in Figure 24. The vertical axes represent injection rate in m^3/d (left) and L/s (right) while the horizontal axis represents duration of injection in days. Each line represents a specific combination of initial depth to water (DTW) and aquifer storage (Sy).

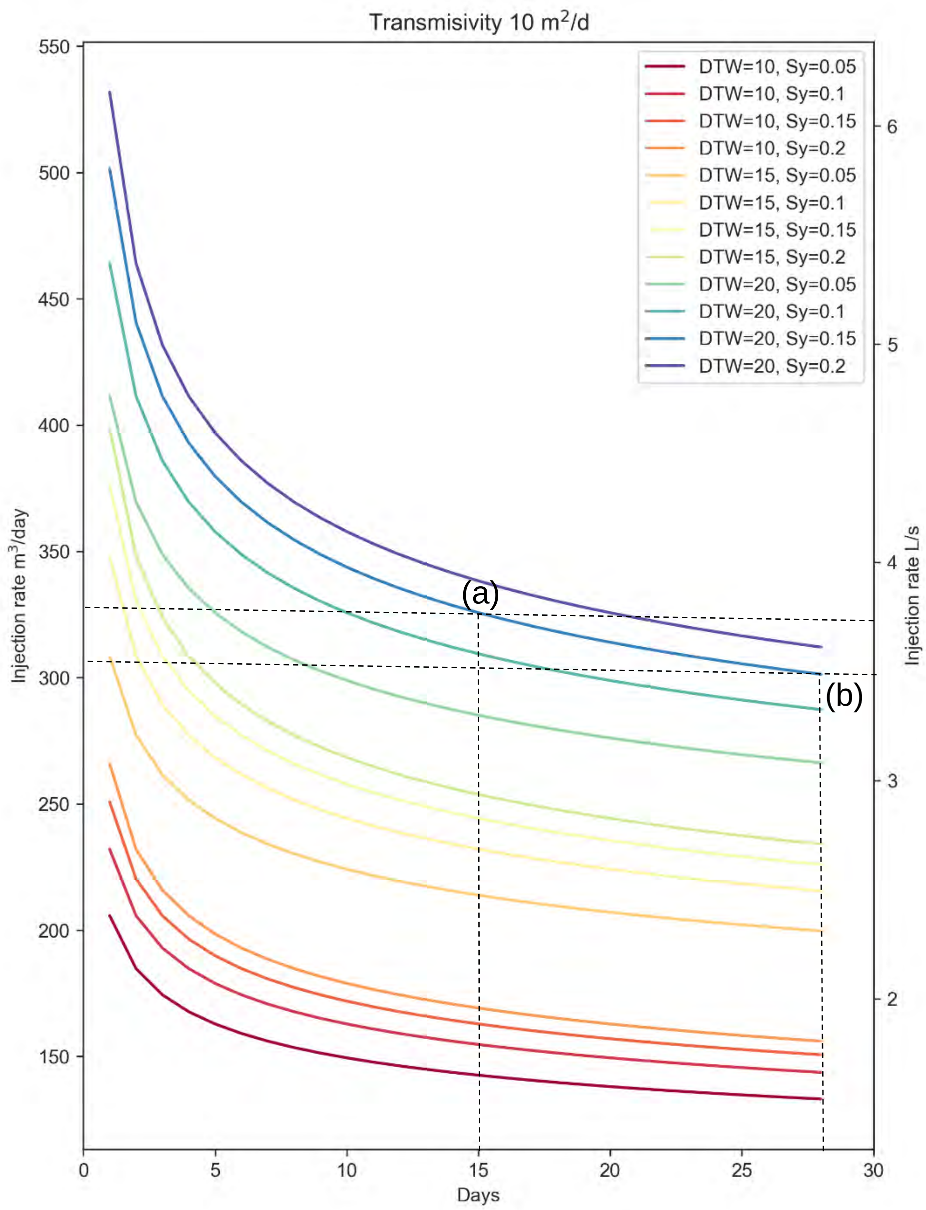


Figure 24. Injection rates and duration that result in a minimum depth to water of 2 m (within 1 m of the injection bore) for combinations of initial DTW and storage at T = 10 m²/d.

The graphs can be used to guide selection of an appropriate fixed rate of injection for a prescribed number of days for a specific set of aquifer characteristics with some assurance that potential for water logging is kept to a minimum. In the example provided in Figure 24, for a transmissivity of 10 m^2/d, initial depth to water of 20 m at the injection well, and Sy of 0.15, the blue curve indicates that an injection rate of either (a) approximately 325 m^3/day (3.75 L/s) could be injected over 15 days, or (b) just over 300 m^3/day (3.5 L/s) could be injected over 28 days. For longer periods of injection, it is advised that users consider adopting conservative injection rates and durations due to the limitations of the Theis solution. This is primarily due to site specific characteristics that have not been account for in this assessment, such as rainfall recharge and proximity to flow barriers or discharge features.

The above interpretation for the blue curve provides an indicative volume for injection of around 5 ML per well over a 15 day period, or 8 ML per well over a 28 day period in an aquifer with initial depth to water of 20 m, transmissivity of 10 m^2/d and Sy of 0.15. Using other results presented in Appendix D, injection volumes for an aquifer with similar initial depth to water and aquifer specific yield, but a higher aquifer transmissivity of 100 m^2/day, may be of the order of 38 ML per well over a 15 day period or 70 ML per day over a 28 day period. Obviously, if a MAR scheme involves multiple injection wells operating simultaneously, then well impress interference would need to be considered to optimise wellfield design.

4.5.3 Scheme Type 3: Hold water up in the SEDN

For Scheme Type 3, the water level in a surface drainage feature, or stage as it is commonly termed, is deliberately raised to enhance passive recharge to the adjacent unconfined aquifer (Figure 13c). The greatest potential for waterlogging from this scheme type, which is a risk to pastoral land but potentially beneficial to GDEs, will occur when the drain is connected to the water table. This is because disconnected drains will have greater available storage in the underlying unsaturated zone. As the stage in the drain is raised to a given height and maintained at this height for a given number of days, a water table mound spreads away from the drain recharging the aquifer.

Methodology

A MODFLOW6 (Langevin et al., 2017) numerical model was developed using FloPy (Bakker et al., 2016) to determine the range of possible lateral extents of water table mounding, and therefore the potential for waterlogging defined herein as groundwater levels within two metres of ground surface. The drain depth was assumed to be two metres for reasons that will become clear below. At the scale of this problem, the ground surface was assumed to be flat, which is considered to be a valid assumption in the South East.

Simulations were performed for a range of specified drain stage rises, timeframes over which the higher stage is maintained, initial groundwater hydraulic gradients away from the drain (i.e., losing conditions) and aquifer properties of hydraulic conductivity (K) and specific yield (Sy). Analytical equations were considered for this modelling but would have precluded an assessment of sloping water tables. Only losing initial conditions were simulated because gaining conditions (i.e., groundwater hydraulic gradients into the drain) would prevent significant ingress of drain water to the aquifer and therefore provide limited recharge benefit.

The processes simulated by the numerical model are summarised in Figure 25, along with the resulting metric used to produce the decision support tool. The model was a 2D cross section, 1,000 m in length and 20 m in depth with uniform cell size of 0.1 m square. The right side of the model comprised a general head boundary (GHB) condition used to set the gradient of the water table for the initial condition. The left side of the model featured a constant head boundary (CHB) to represent the water in the drain and a GHB below that was implemented to ensure numerical convergence of the steady state starting condition.

The initial water table was in contact with the base of the drain with a hydraulic gradient towards the right. These simulations assume that the drain is always connected to the water table. Whilst this is not always the case across the SEDN, in reality, water tables fluctuate on a seasonal basis and the assumption can be considered conservative because a disconnected water table will promote vertical infiltration, thereby reducing the horizontal migration of the water table rise.

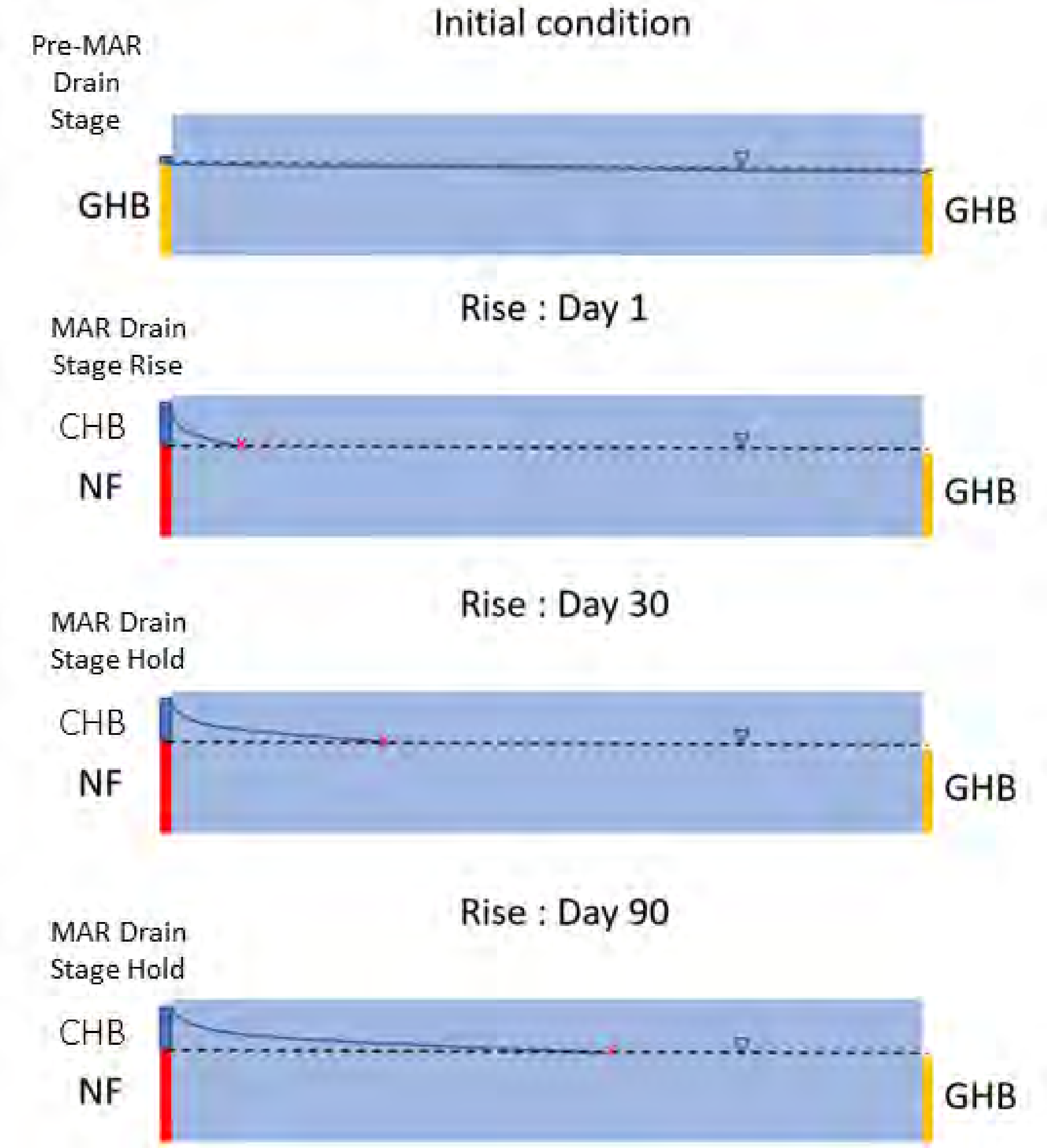


Figure 25. Conceptual schematic of the numerical model used to assess the potential extent of waterlogging from MAR Scheme Type 3. CHB = constant head boundary, GHB = general head boundary, NF = no flow.

Simulating a stage rise in the drain was accomplished by increasing the hydraulic head in previously assigned CHB cells in addition to activating new CHB conditions in those cells whose bottom elevation was below the new drain stage. A no-flow (NF) condition was simultaneously enforced below the channel to prevent gradient reversal and establish a flow divide. This also ensured that flow into the aquifer would be limited to the region immediately adjacent the channel and not the full thickness of the aquifer. The elevated water level remained constant for the duration of the transient simulation over 100 days with daily time steps. The model's output files were post-processed to record the point of intersection of the water table with the 2 mbgl constraint each day (indicated by the x in Figure 25). Model build, execution and post-processing were scripted to facilitate rapid assessment of a range of water level rise, aquifer properties and water table slopes.

Water table gradients considered in this assessment included 0.0, 0.1, 0.01, 0.001. Hydraulic conductivity values were 0.5, 5, 50, and 200 m/d while specific yield values were 0.05, 0.1, 0.15. The entire ensemble of different combinations was repeated for different drain stage rises from 0.5 m to 2.0 m.

Decision Support Tool

The decision support tool for assessing the potential extent of waterlogging for a given stage rise in the drain takes the form of sets of curves developed using the above methodology and these are provided in Appendix F. Each set of curves represents a different combination of stage rise above the base of the drain and initial (losing) hydraulic gradient. One example set of curves, for a water level rise of 1.0 m and an initial hydraulic gradient of 0.001 is shown in Figure 26. The vertical axis represents the extent (distance from channel) of the predicted impact, i.e., where the water table is predicted to be within 2 m of ground surface. The horizontal axis represents the duration of holding the raised stage in the drain. Each curve represents a specific combination of aquifer hydraulic properties, colour coded according to hydraulic conductivity (Kx) and dashed according to specific yield (Sy). A plateau indicates attainment of a new steady state condition. These occur rapidly with higher hydraulic conductivity and are also delayed by increasing storage.

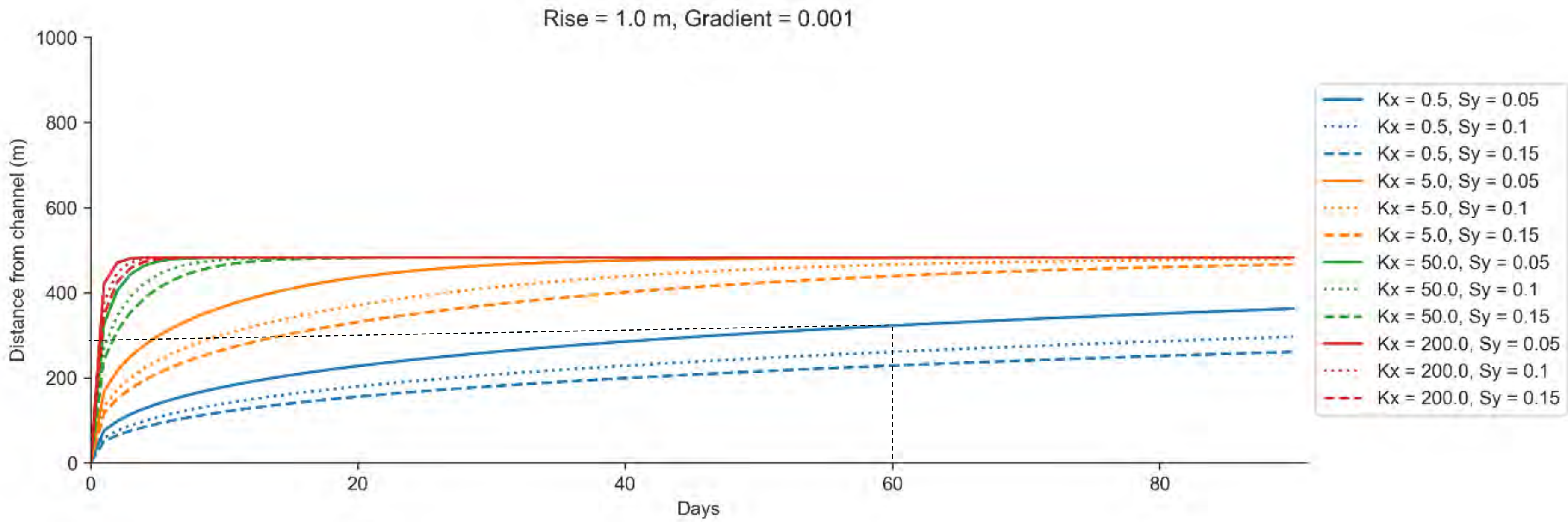


Figure 26. Predicted extent of potential waterlogging impact (water table less than 2 mbgl) for a 1.0 m stage rise above the base of the drain and a hydraulic gradient of 0.001. Kx is in m/d.

The graphs can be used to estimate the potential extent of waterlogging (as distance from the channel) for a given stage rise above the base of the drain and initial hydraulic gradient. The example in Figure 26 shows a potential extent of waterlogging of approximately 280 m for an imposed drain stage rise of 1 m for 60 days under an initial hydraulic gradient of 0.001, hydraulic conductivity of 0.5 m/d and Sy of 0.05.

The graphs in Appendix F indicate that the predicted extent of impact is highly dependent on the initial hydraulic gradient away from the drain. With this in mind, the following summarises the likely extents of impact from Scheme Type 3:

- For a flat water table, the extent of impact may exceed 1 km, with the exception of aquifers with lower hydraulic conductivities (i.e., 0.5 m/d). For Kx = 5 m/d, the impact may reach 1 km within about 20 days depending on Sy.
- For an initial water table gradient of 0.001 (1 m in 1 km), the extent of impact may be up to 300 m for a stage rise of 0.5 m, 500 m for a stage rise of 1 m, 600 m for a stage rise of 1.5 m, and 650 m for a stage rise of 2 m.
- For an initial water table gradient of 0.01 (10 m in 1 km), the extent of impact is less than 200 m.
- For an initial water table gradient of 0.1 (100 m in 1 km), the predicted extent of impact is negligible. However, this hydraulic gradient is unrealistically high for any part of the South East.

These results indicate that the potential for waterlogging is likely to be a significant limitation on the implementation of this scheme type and the site specific risks would require careful assessment and mitigation on a case by case basis.

4.5.4 Effects of the Decision Support Tools on the Risk Assessment

The objective of the Decision Support Tools was to assist with mitigation of the risks of waterlogging (Risk IDs 1 to 4; Table 10) from the three scheme types shown in Figure 13, as well as to assist with understanding the potential scales of proposed schemes. The Risk Assessment (Section 4.4) was re-run for Risk IDs 1 to 4 following development of the Decision Support Tools. The updated Risk Analysis for these four risk statements is provided in Appendix G and the outcomes are summarised in Table 20 (Section 4.4.5).

The use of the Decision Support Tool for Scheme Types 1 and 2 is expected to reduce the risk of waterlogging from these schemes by enabling an understanding of optimum injection rates and durations to minimise the risk of waterlogging during pre-feasibility assessments. As a result, the Risk Levels for Risk IDs 1 and 2 reduce from Medium to Low (Table 20).

Conversely, development of the Decision Support Tool for Scheme Type 3, which provides an understanding of the potential for waterlogging associated with this scheme type under typical conditions encountered in the Lower Limestone Coast, led to an increase in the Risk Level for Risk IDs 3 and 4 from Medium to High. This is due to the information provided in Section 4.5.3 above, which suggested that potential waterlogging impacts may extend beyond 1 km where the water table is flat and between 300 m and 650 m for a gradient of 1 m in 1 km. The relevant Action for a Risk Level of High with a Low Confidence is *Undertake targeted new evidence collection or acquire greater knowledge and reassess risk.* This highlights the need to develop a good understanding of the site specific hydraulics associated with Scheme Type 3 as well as the potential consequences of waterlogging prior to revisiting the Risk Assessment for an individual site. It should be noted that the consequence criteria for waterlogging used in the preliminary Risk Assessment are relatively arbitrary and require stakeholder input before the Risk Assessment can be used in any capacity.

4.6 Final Stakeholder Consultation

The key findings of Stage 2b were presented to the Limestone Coast Landscape Board on Friday 28th October 2022 and attracted significant interest. Particular attention and questions focussed on the most feasible sites identified for each scheme type, as well as the potential costs involved, particularly for Scheme Type 2 (regional transfer). There was general agreement amongst Board members and observers that the paucity of flow gauging data for large parts of the region may delay further investigations into Scheme Type 3 (holding water up in the drains).

This final report will be distributed to all other stakeholders consulted in Stage 2a of the project (Table 4, Section 3) with face-to-face briefings to follow.

5 Conclusions

The following points summarise the major conclusions from this project:

- There is widespread stakeholder demand for more strategic and integrated surface water / groundwater / environmental management in the LLC. The retention of drainage water in the landscape is a critical aspect of this, and all stakeholders shared the vision of ensuring water security for current entitlements rather than enabling additional primary production.
- Most stakeholders believe that any surface water that can be harvested should be used to help restore high-value environmental assets in stressed areas, thereby removing the need for blunt policy instruments (i.e., reductions to allocations at the management area scale) and protecting existing industry.
- The greatest physical constraint on the application of Managed Aquifer Recharge (MAR) is geography, with highest water availability in the west but the greatest demand and potential benefit generally in the east.
- Numerous feasible areas have been identified for community or on-farm MAR to support high water demand by licensed extraction, plantation forestry and high-value GDEs.
- In addition to community and on-farm MAR, opportunities for regional transfer of water for MAR have also been identified, but there are significant costs involved in this option.
- The simplest and lowest cost option is holding water up in drains for localised recharge to support existing primary production and benefit adjacent GDEs. Potential locations for this have been identified, however the current resolution of flow data insufficient for confirming water availability and for decision making around this option.
- Stakeholder consultation identified potential risks around the concept of using available water in the SEDN for MAR. These include localised waterlogging, reduced frequency of moderate and high flows at downstream environmental receptors, impacts to ecological diversity and migration of invasive species caused by more prolonged baseflow to drains, contamination of receiving aquifers with agricultural chemicals, and higher salinity regimes in the northern wetlands due to reduced freshening flows from the south.
- A preliminary Risk Assessment framework, assessing the above risks, was developed and executed, finding that the Risk Level for most risks is Low to Medium.
- However, numerical modelling showed that holding water up in the SEDN presents a high risk of more frequent and/or longer-term inundation of localised areas leading to land becoming unsuitable for the current land use or a reduced benefit from existing private drainage networks. However, this risk level was based upon preliminary Consequence Criteria, which could be explored further with stakeholders in the future.
- Risks of waterlogging caused by any scheme type can be mitigated and reduced during site-specific feasibility assessments using an ensemble of simple decision support models developed during this project.
- Next steps should include site specific studies to support MAR trials.

6 Limitations and Recommendations for Further Work

It is important to acknowledge the following limitations when interpreting the outcomes of this project:

- This report presents results for MAR feasibility that are limited to the LLC PWA, whereas the SEDN assessment extended further north to encompass all available flow data.
- The desktop assessment of MAR feasibility relies on regional-scale datasets, in particular depth to groundwater. Other feasible locations that have not been captured in this assessment may occur in localised areas of high depth to groundwater. Likewise, some of the locations identified as being feasible may be found to be infeasible during local-scale investigations.
- The available flow data in the SEDN is not sufficient to enable a high-resolution assessment of the distribution of water availability across the network. There are 24 currently active SEDN flow monitoring sites across the study area. However, 36 additional historical discharge sites existed predominantly until around 2014. As well as there being a limited number of current monitoring sites, the low number of complete years (i.e., years with less than a total of one month missing data) of record was a significant limitation on statistical analysis of the flow data. Whilst the current resolution of monitoring data may be sufficient for the present operational objectives of the SEDN, any effort towards more holistic management of surface water and groundwater will require a review of surface water monitoring requirements. Surface water modelling may be useful to some degree in filling data gaps. However, adequate measured data is required for validation of such models, particularly considering the complex nature of the surface water – groundwater interactions in the South East.
- There is currently no routine regional surface water quality monitoring (besides EC) or assessment in the South East. As a result, there was insufficient water quality data to enable assessment of the risks to water quality from MAR schemes.
- Assessment of water availability is based on current and historical measurements. Potential impacts of climate change have not been assessed.
- The buffer distances used around plantation forestry land use, areas of high groundwater abstraction, and surface drainage features in the desktop spatial screening process were developed subjectively in the absence of anything that can provide formal guidance. They were designed to be generous yet sensible with the main principle being that the spatial screening process should aim to be more inclusive rather than exclusive.
- Higher- and lower-cost options are discussed. However an assessment of economic feasibility was outside the scope of this project.
- The Risk Assessment presented here is preliminary and broad scale (i.e., not site specific) and reflects limited stakeholder input. It is intended to provide a framework and starting point for future regional or site-specific risk assessments as the concept of holding water up in the landscape is further

developed at both scales. It is expected that refinement of the risk register and consequence criteria will occur over time and with further stakeholder input as this was beyond the scope of the current project.

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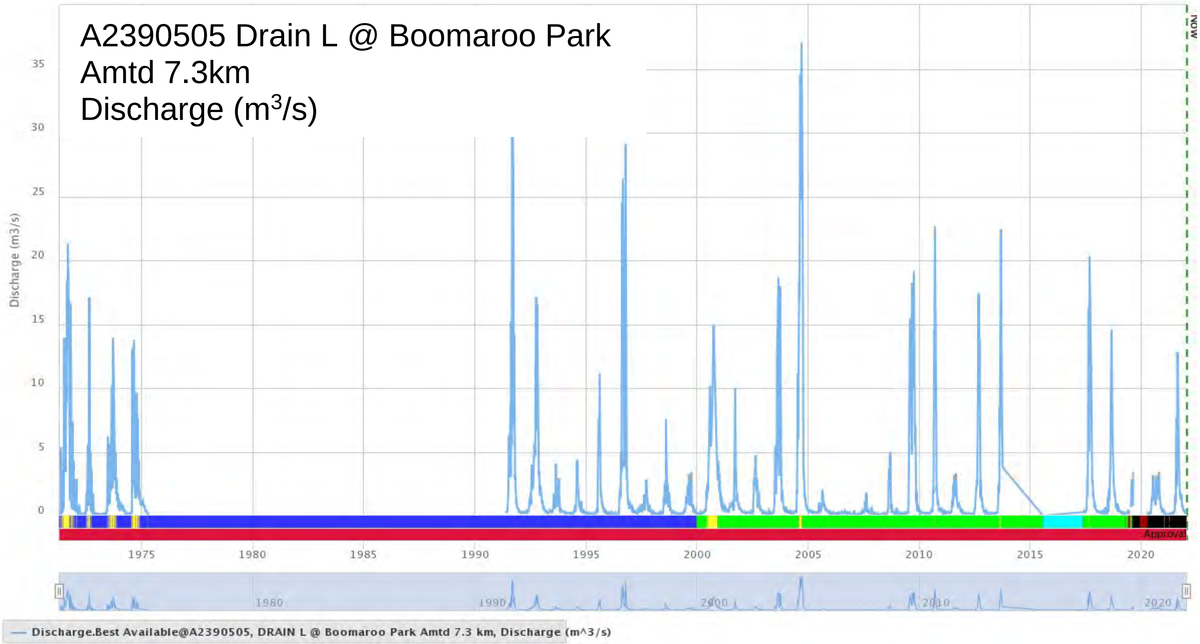
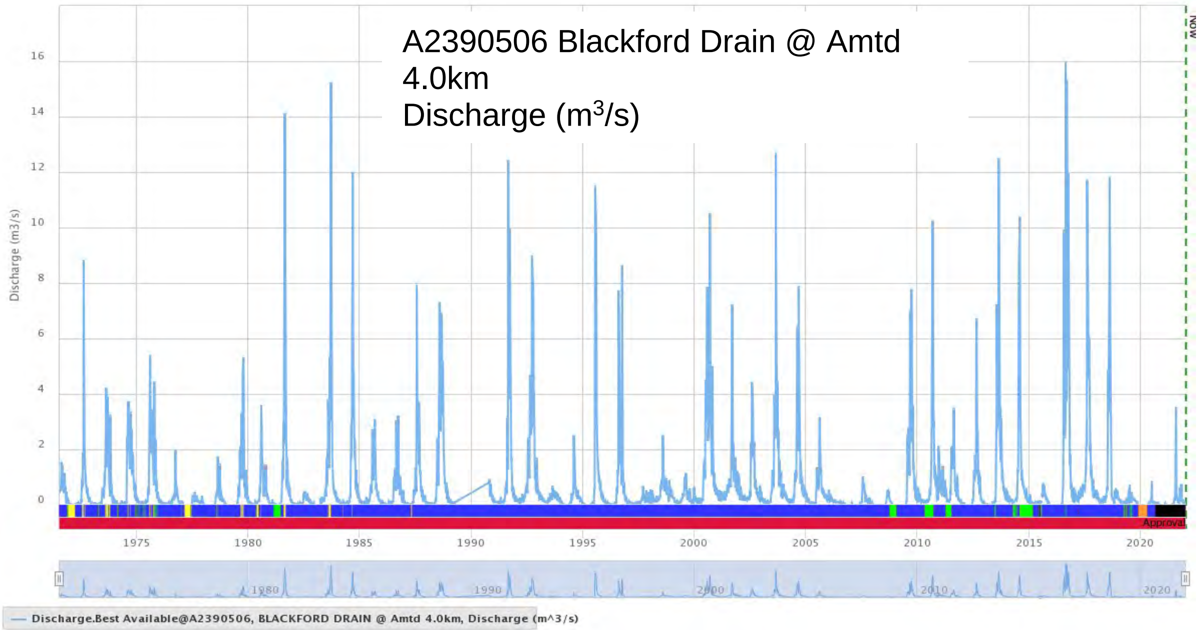
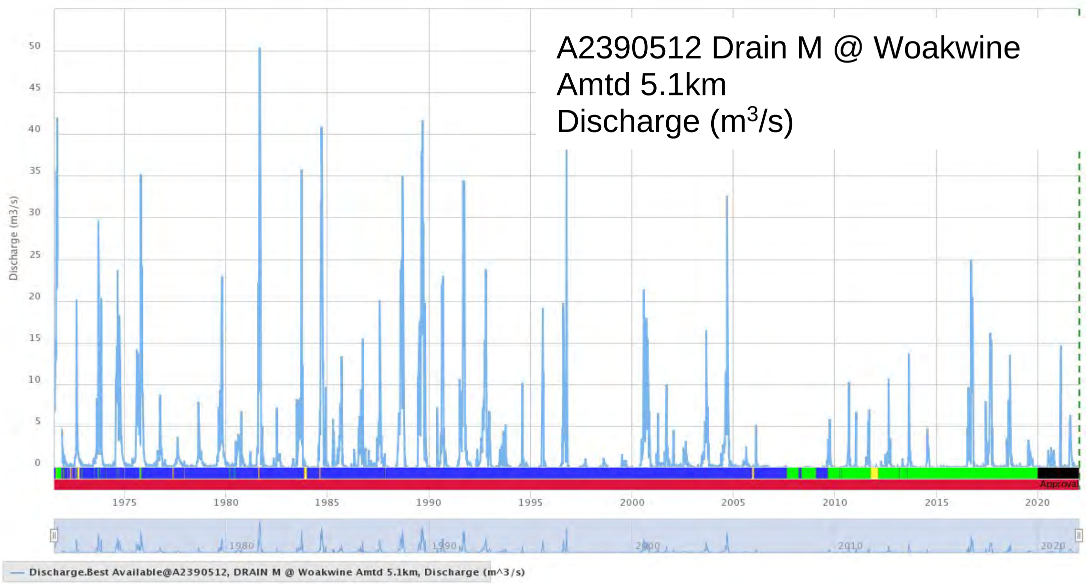
Appendix A – Hydrographs (discharge in m^3/s) and Flow Duration Curves for SEDN Gauging Stations, Coastal Creeks and Historical Gauging Sites

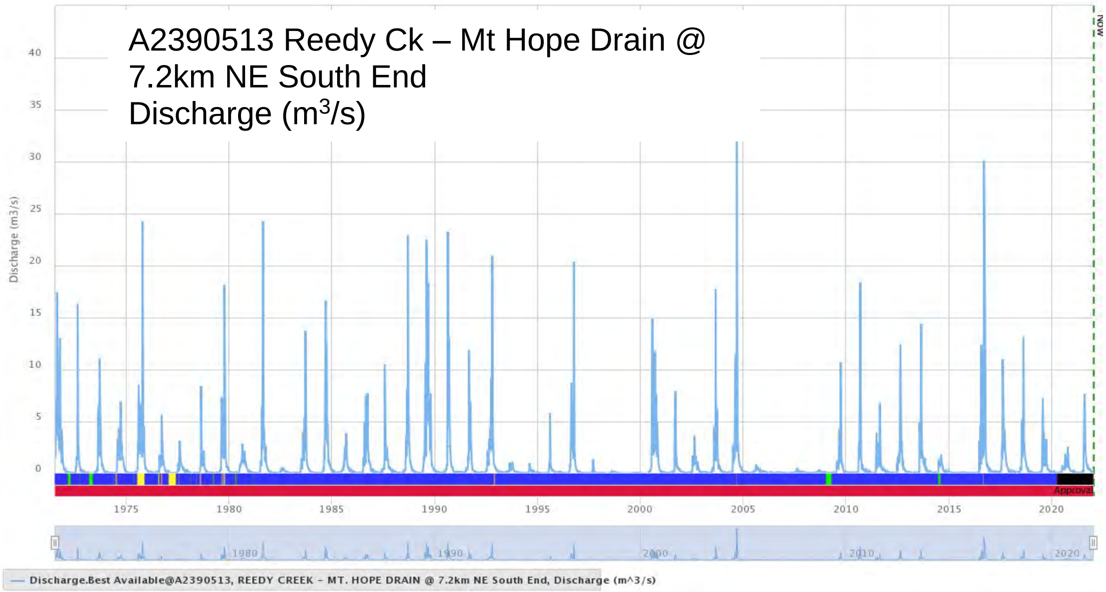
Key for data grade and approval level (shown in coloured bars at the base of each graph).

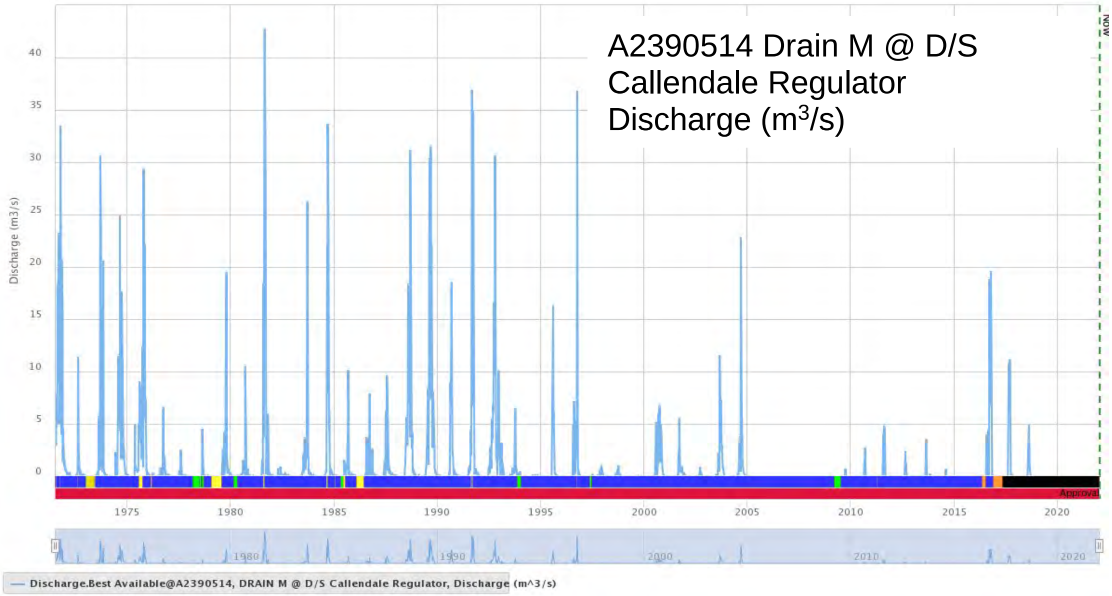
Hydrographs – SEDN

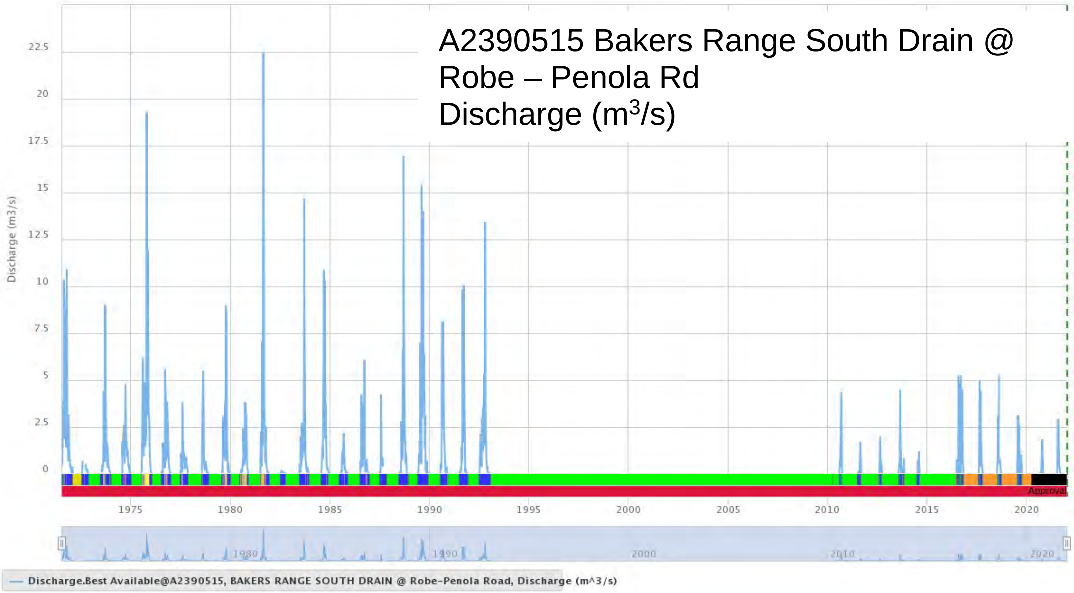


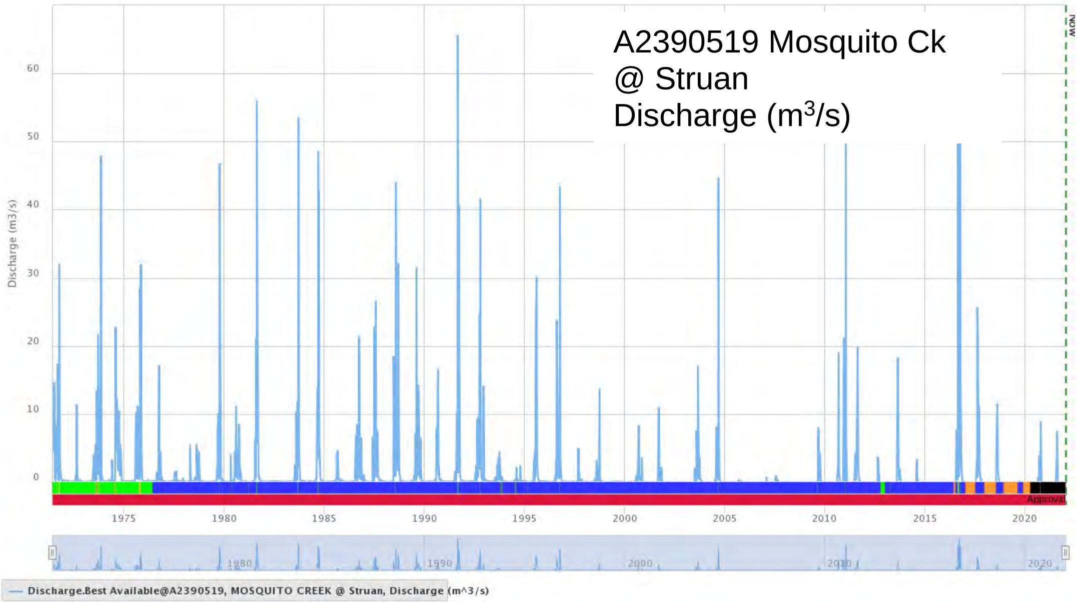


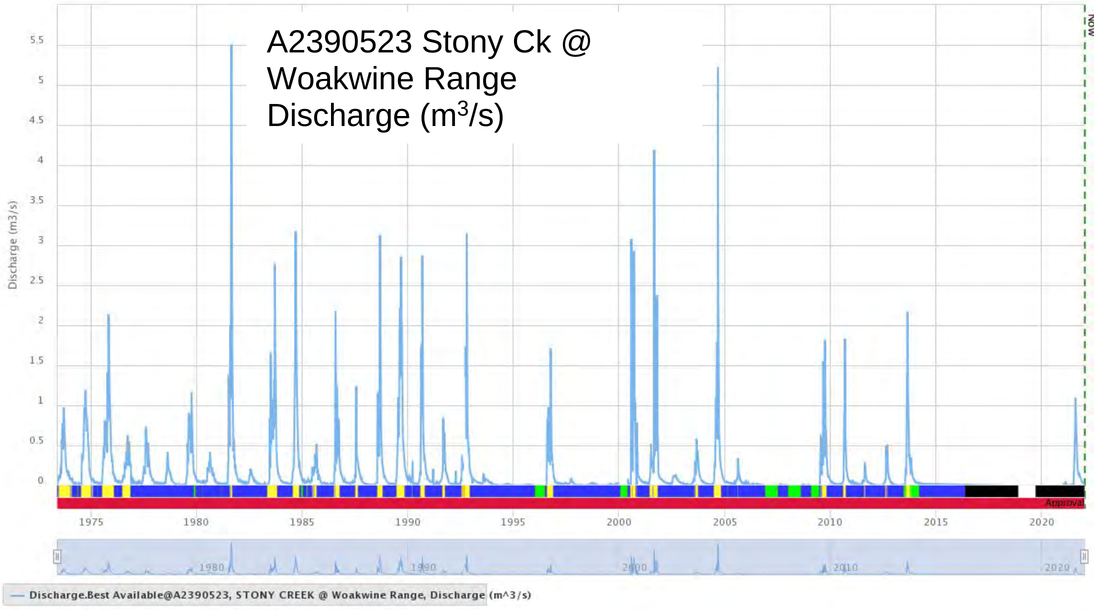

A2390512 Drain M @ Woakwine
Amtd 5.1km
Discharge (m3/s)
Discharge (m3/s)
0
5
10
15
20
25
30
35
40
45
50
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020
Approval
Discharge.Best Available@A2390512, DRAIN M @ Woakwine Amtd 5.1km, Discharge (m^3/s)

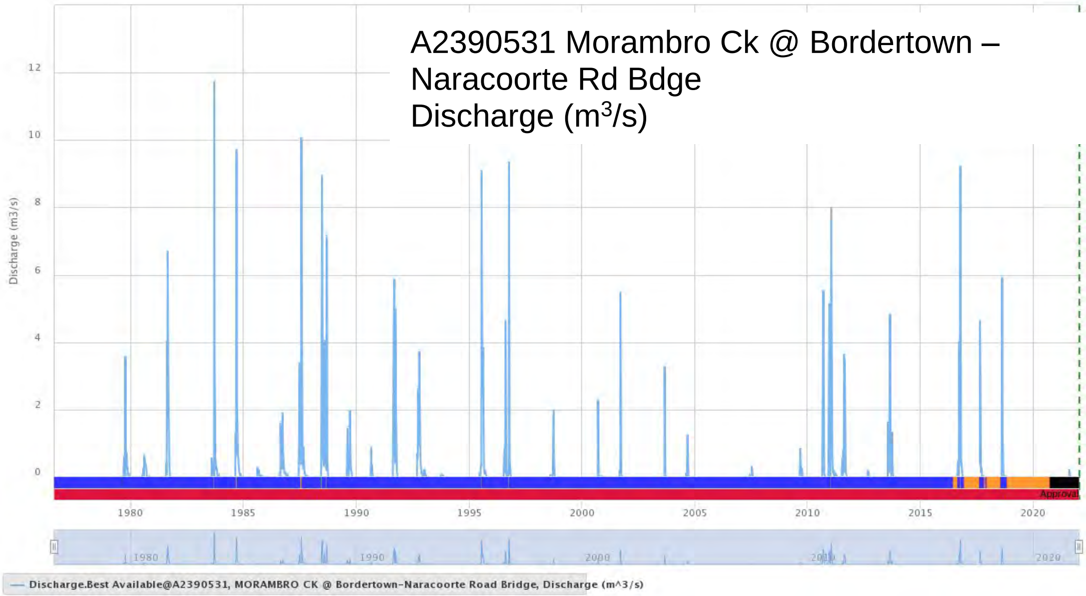

A2390513 Reedy Ck – Mt Hope Drain @
7.2km NE South End
Discharge (m3/s)
Discharge (m3/s)
0
5
10
15
20
25
30
35
40
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020
Approval
NOW
Discharge.Best Available@A2390513, REEDY CREEK - MT. HOPE DRAIN @ 7.2km NE South End, Discharge (m^3/s)

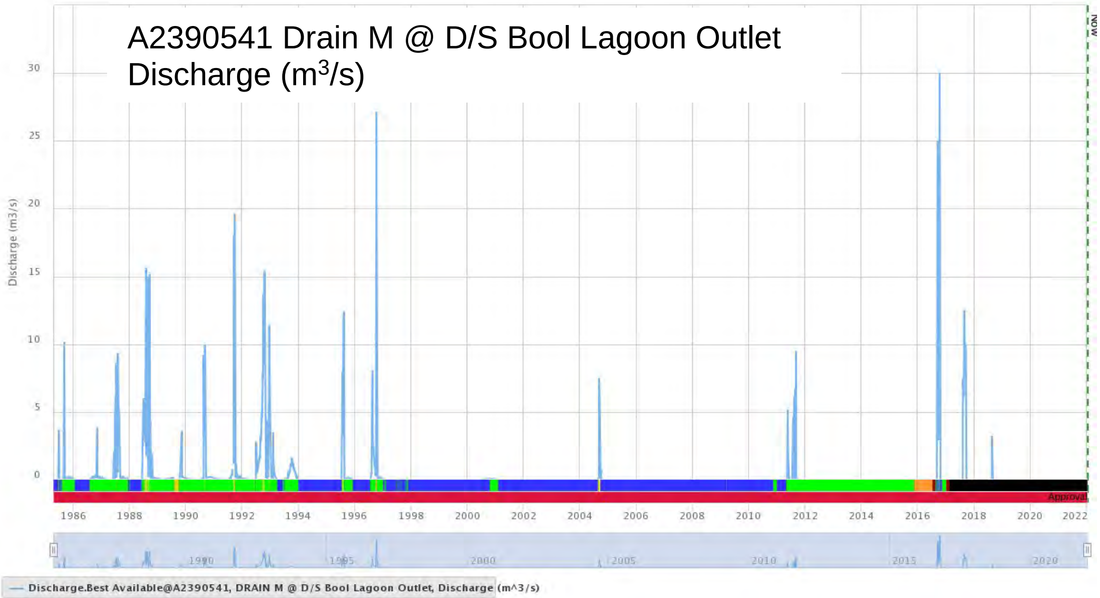

A2390514 Drain M @ D/S Callendale Regulator Discharge (m3/s)
Discharge (m3/s)
40
35
30
25
20
15
10
5
0
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020
Approval
NOW
Discharge.Best Available@A2390514, DRAIN M @ D/S Callendale Regulator, Discharge (m^3/s)

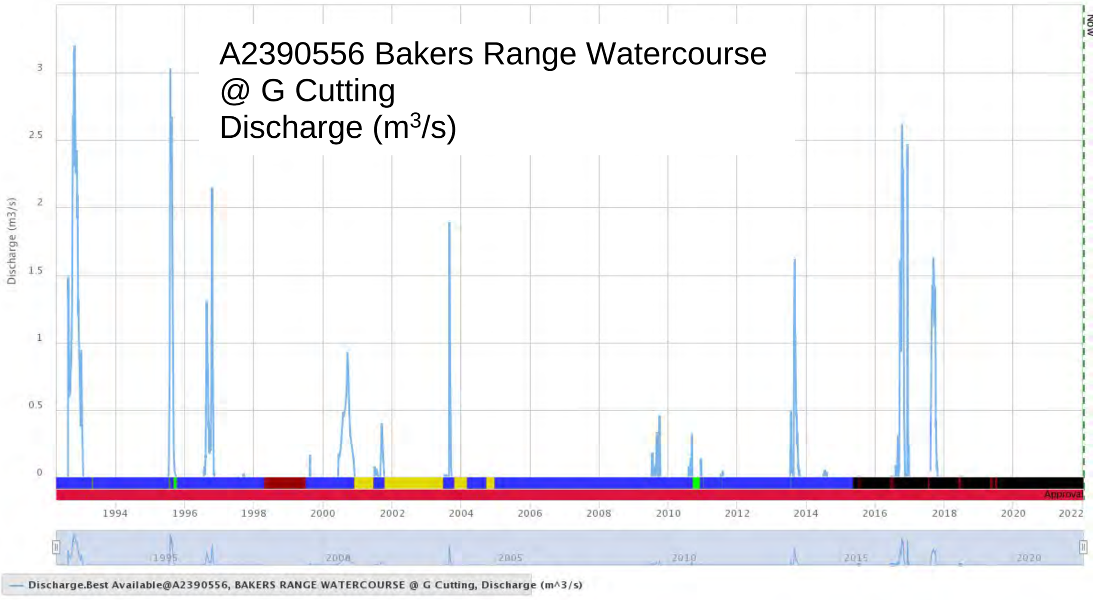

A2390515 Bakers Range South Drain @ Robe – Penola Rd
Discharge (m3/s)
Discharge (m3/s)
22.5
20
17.5
15
12.5
10
7.5
5
2.5
0
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020
Approval
Discharge.Best Available@A2390515, BAKERS RANGE SOUTH DRAIN @ Robe-Penola Road, Discharge (m^3/s)

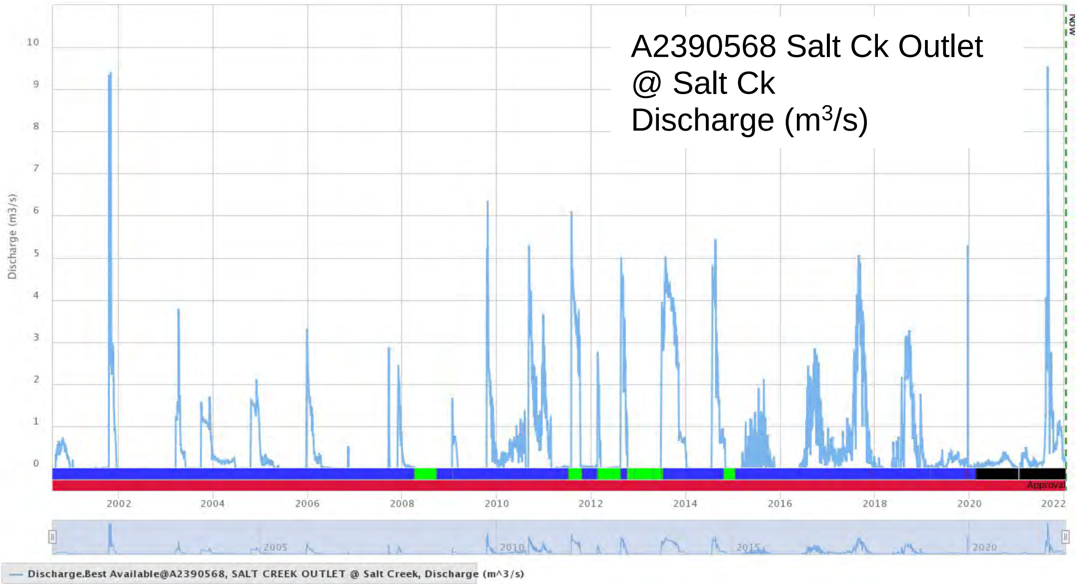

A2390519 Mosquito Ck @ Struan
Discharge (m3/s)
Discharge (m3/s)
60
50
40
30
20
10
0
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020
Approval
NOW
Discharge.Best Available@A2390519, MOSQUITO CREEK @ Struan, Discharge (m^3/s)

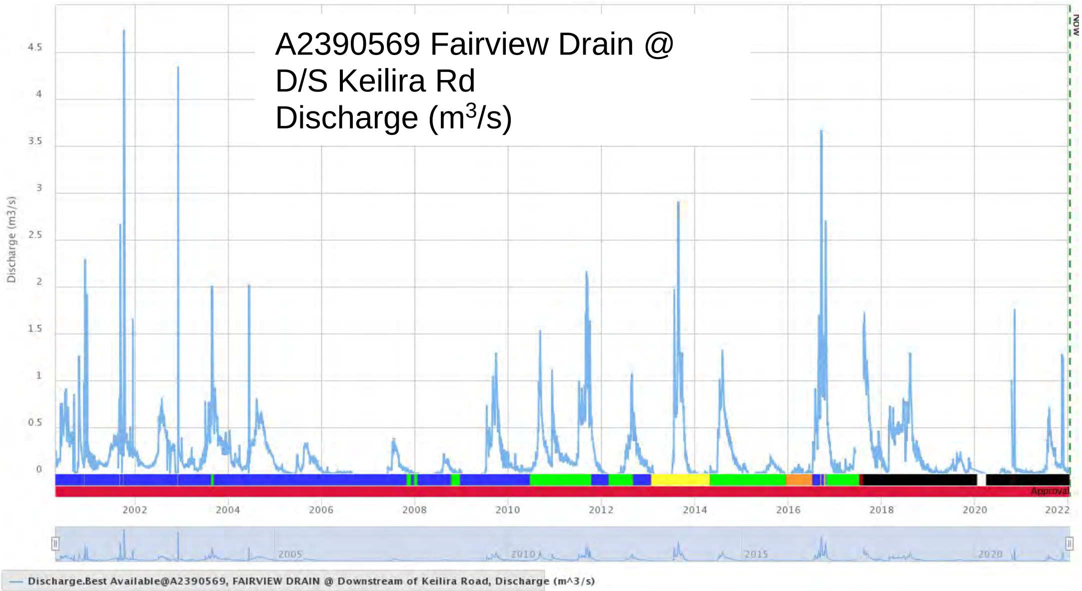

A2390523 Stony Ck @
Woakwine Range
Discharge (m3/s)
Discharge (m3/s)
5.5
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020
NOW
Approval
Discharge.Best Available@A2390523, STONY CREEK @ Woakwine Range, Discharge (m^3/s)

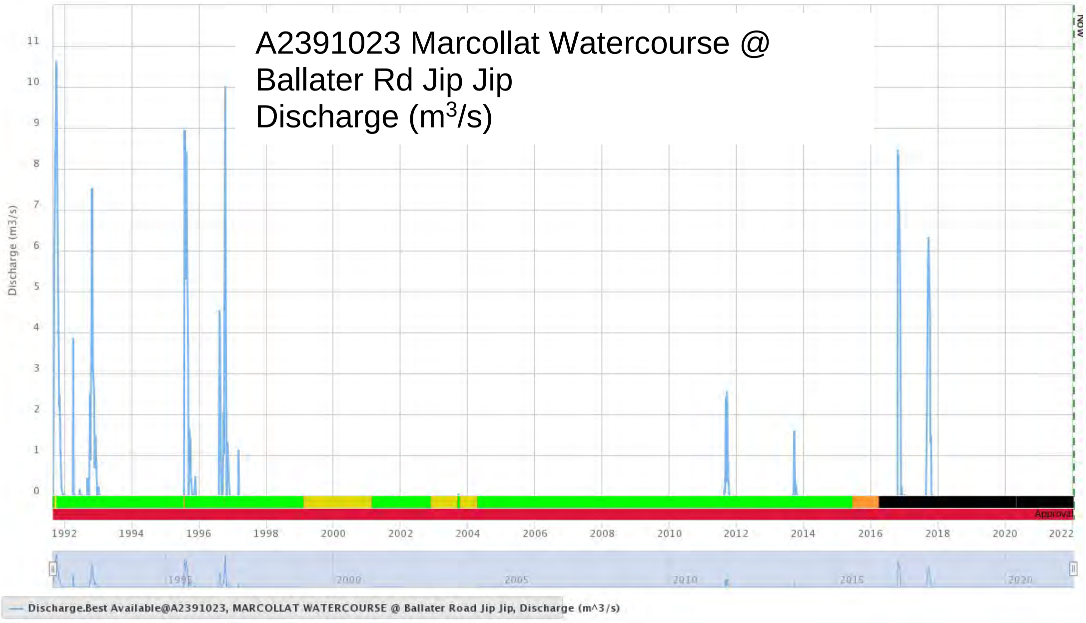

A2390531 Morambro Ck @ Bordertown – Naracoorte Rd Bdge
Discharge (m3/s)
Discharge (m3/s)
Discharge.Best Available@A2390531, MORAMBRO CK @ Bordertown-Naracoorte Road Bridge, Discharge (m^3/s)

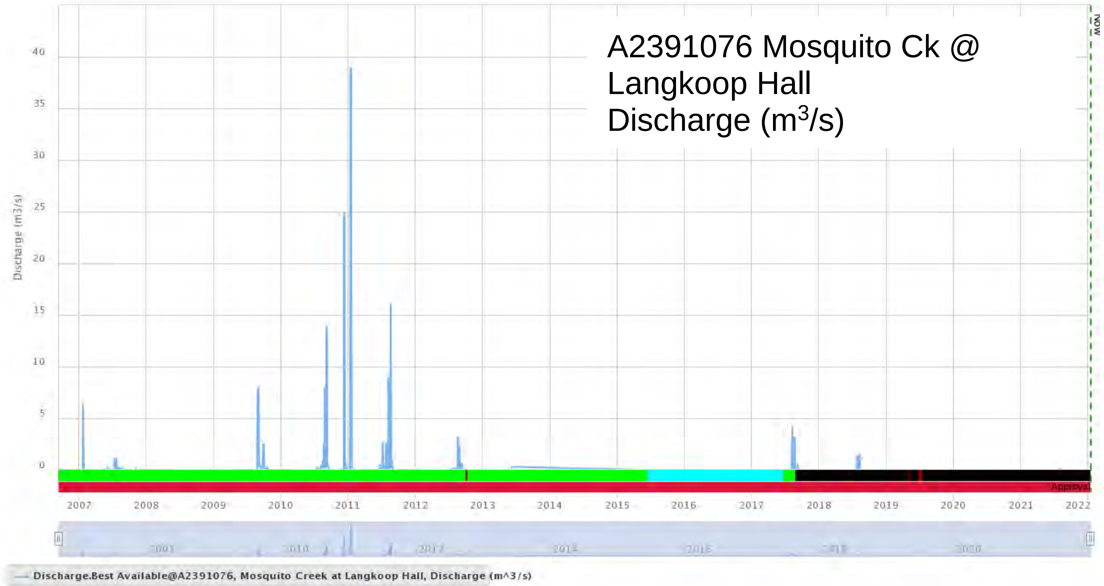

A2390541 Drain M @ D/S Bool Lagoon Outlet
Discharge (m3/s)
Discharge (m3/s)
Discharge.Best Available@A2390541, DRAIN M @ D/S Bool Lagoon Outlet, Discharge (m^3/s)

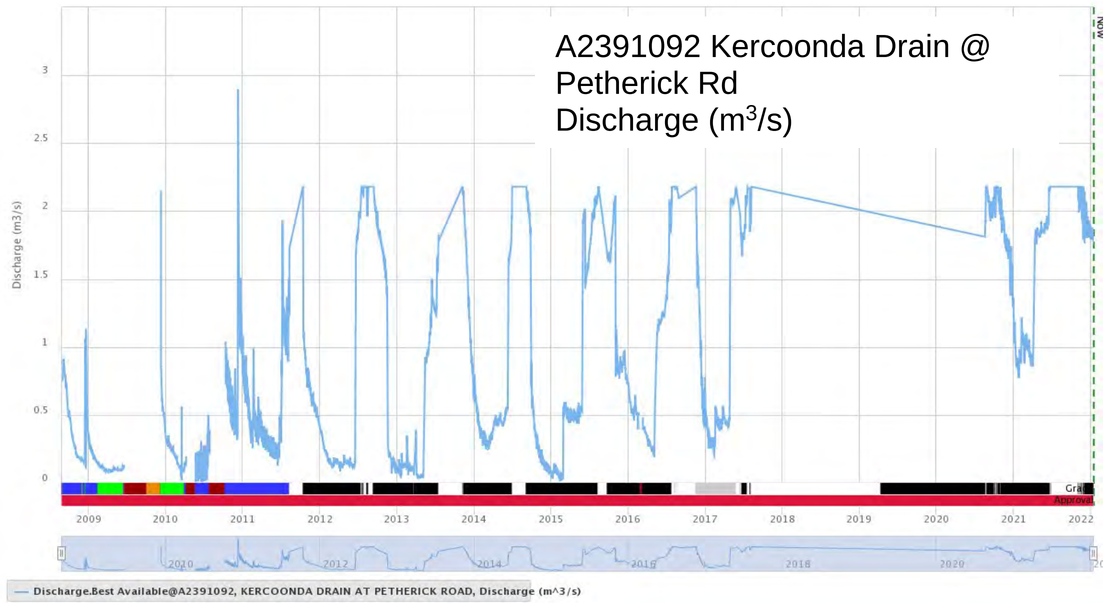

A2390556 Bakers Range Watercourse
@ G Cutting
Discharge (m3/s)
Discharge (m3/s)
3
2.5
2
1.5
1
0.5
0
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Approval
NOW
Discharge.Best Available@A2390556, BAKERS RANGE WATERCOURSE @ G Cutting, Discharge (m^3/s)

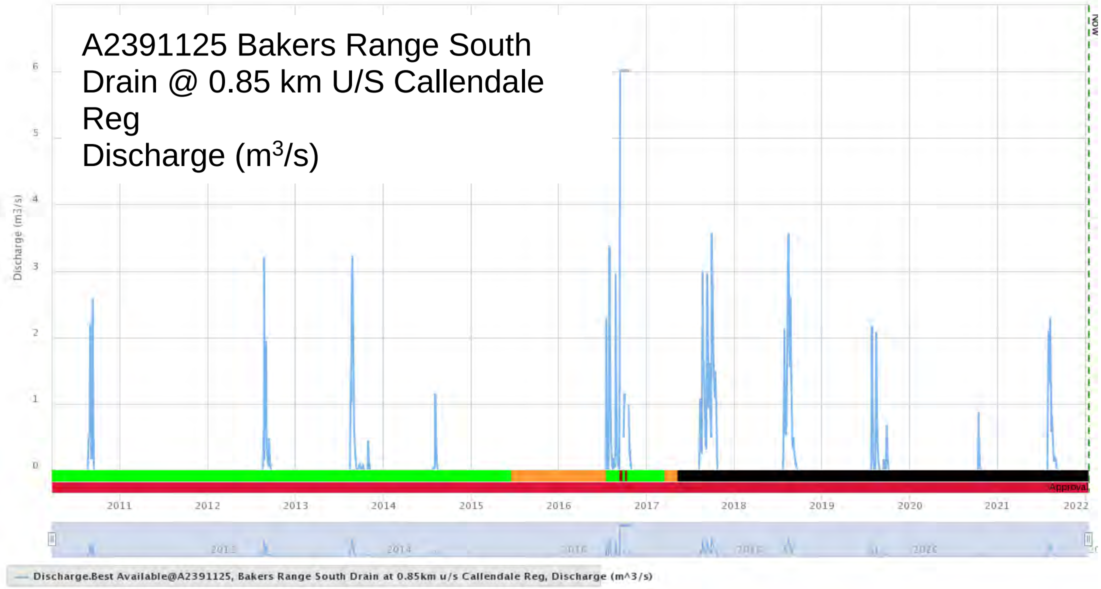

A2390568 Salt Ck Outlet @ Salt Ck Discharge (m3/s)
Discharge (m3/s)
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Approval
NOW
Discharge.Best Available@A2390568, SALT CREEK OUTLET @ Salt Creek, Discharge (m^3/s)

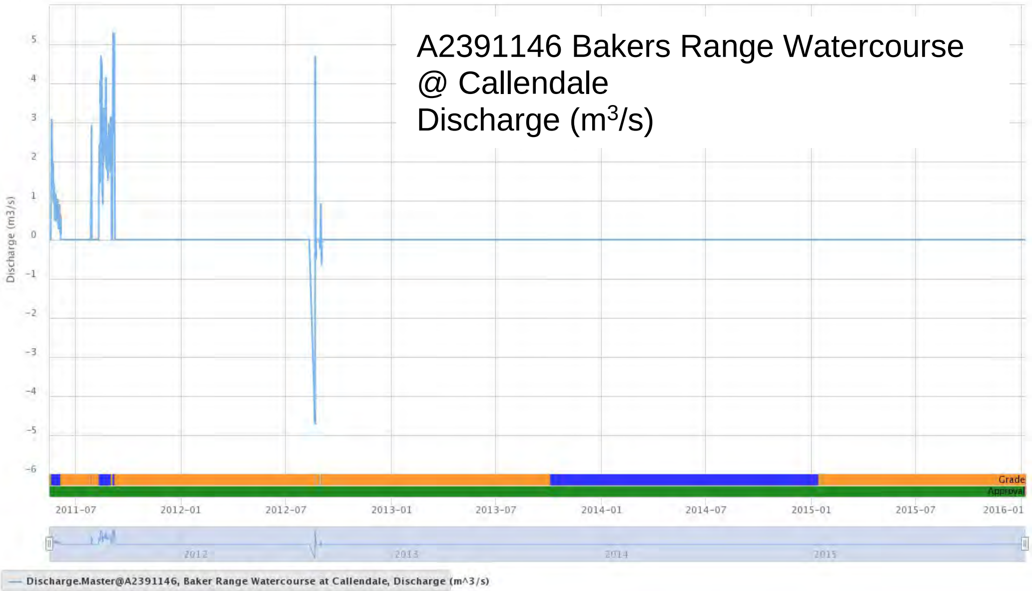

A2390569 Fairview Drain @ D/S Keilira Rd Discharge (m3/s)
Discharge (m3/s)
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Approval
NOW
Discharge.Best Available@A2390569, FAIRVIEW DRAIN @ Downstream of Keilira Road, Discharge (m^3/s)

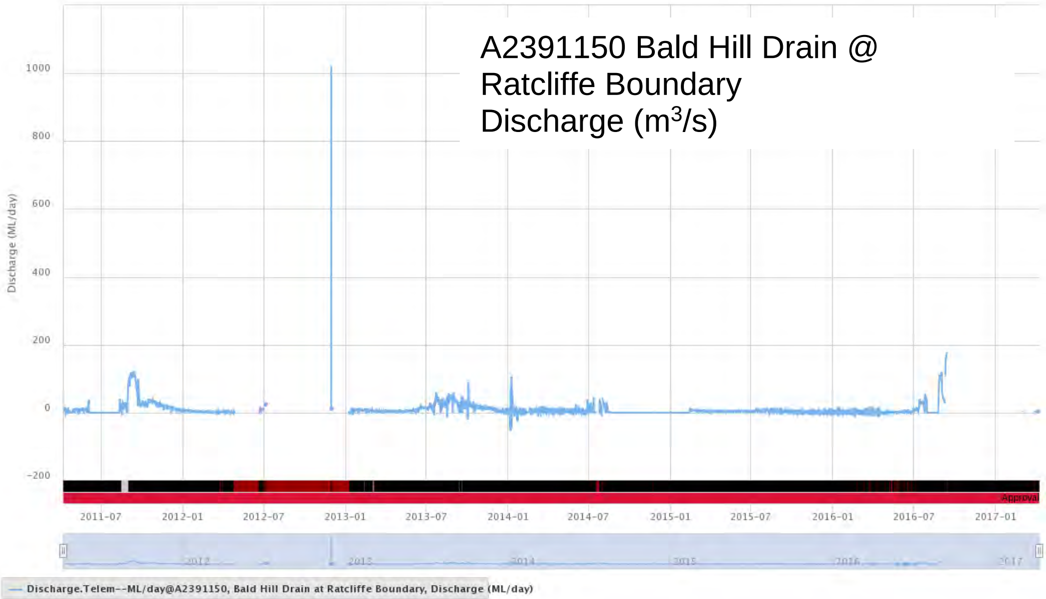

A2391023 Marcollat Watercourse @
Ballater Rd Jip Jip
Discharge (m3/s)
Discharge (m3/s)
0
1
2
3
4
5
6
7
8
9
10
11
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Approval
NOW
Discharge.Best Available@A2391023, MARCOLLAT WATERCOURSE @ Ballater Road Jip Jip, Discharge (m^3/s)

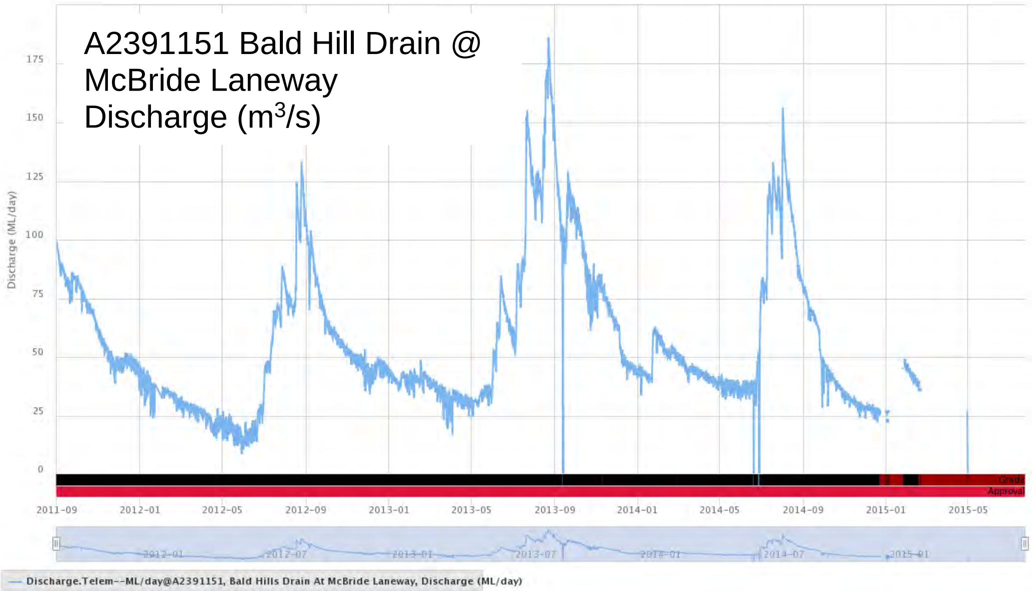

A2391076 Mosquito Ck @
Langkoop Hall
Discharge (m3/s)
Discharge (m3/s)
40
35
30
25
20
15
10
5
0
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
Approval
Discharge.Best Available@A2391076, Mosquito Creek at Langkoop Hall, Discharge (m^3/s)

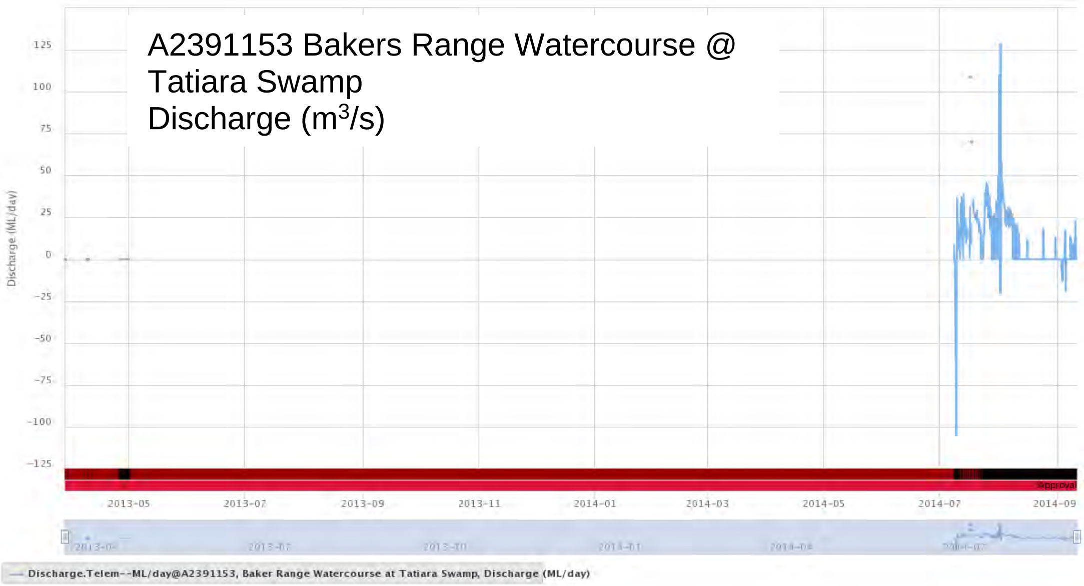

A2391092 Kercoonda Drain @
Petherick Rd
Discharge (m3/s)
Discharge (m3/s)
3
2.5
2
1.5
1
0.5
0
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
Approval
Discharge.Best Available@A2391092, KERCOONDA DRAIN AT PETHERICK ROAD, Discharge (m^3/s)

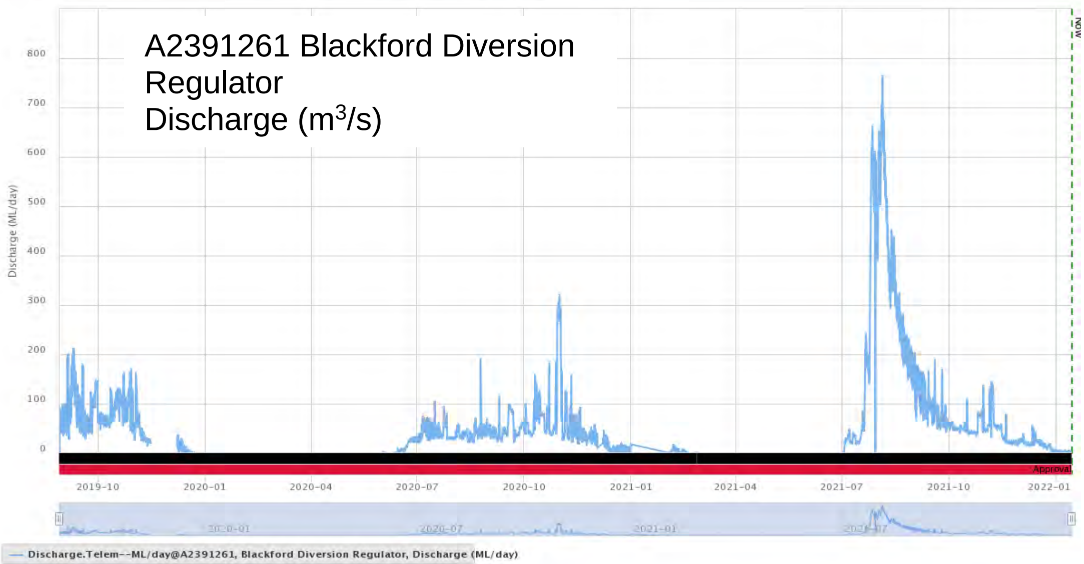

A2391125 Bakers Range South Drain @ 0.85 km U/S Callendale Reg
Discharge (m3/s)
Discharge (m3/s)
0
1
2
3
4
5
6
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
Discharge.Best Available@A2391125, Bakers Range South Drain at 0.85km u/s Callendale Reg, Discharge (m^3/s)

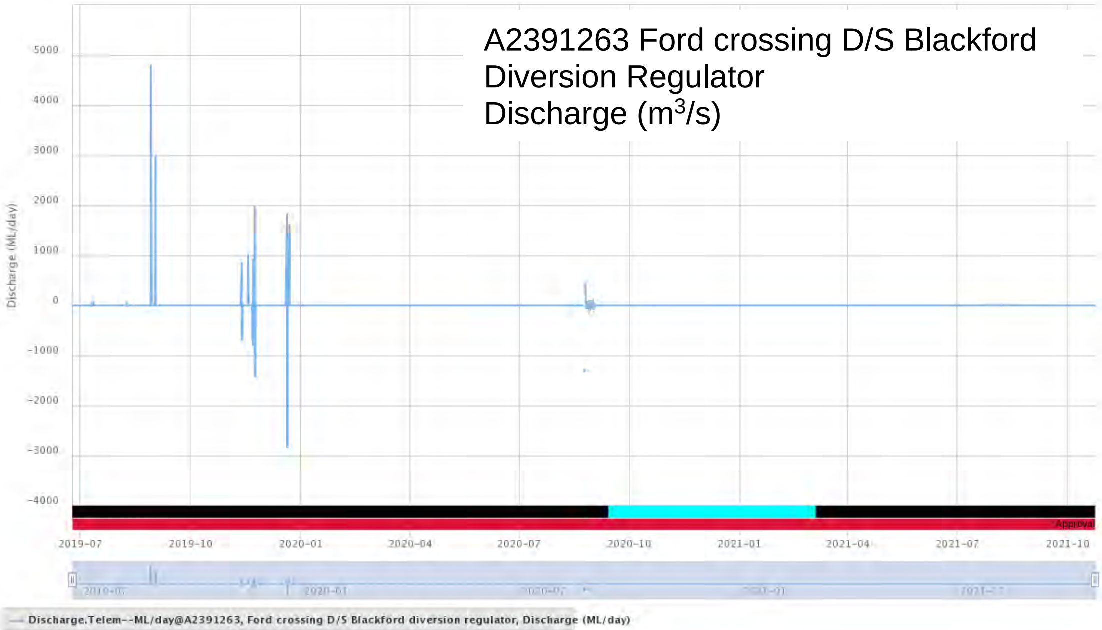

A2391146 Bakers Range Watercourse
@ Callendale
Discharge (m3/s)
Discharge (m3/s)
5
4
3
2
1
0
-1
-2
-3
-4
-5
-6
Grade
Approval
2011-07
2012-01
2012-07
2013-01
2013-07
2014-01
2014-07
2015-01
2015-07
2016-01
2012
2013
2014
2015
Discharge.Master@A2391146, Baker Range Watercourse at Callendale, Discharge (m^3/s)

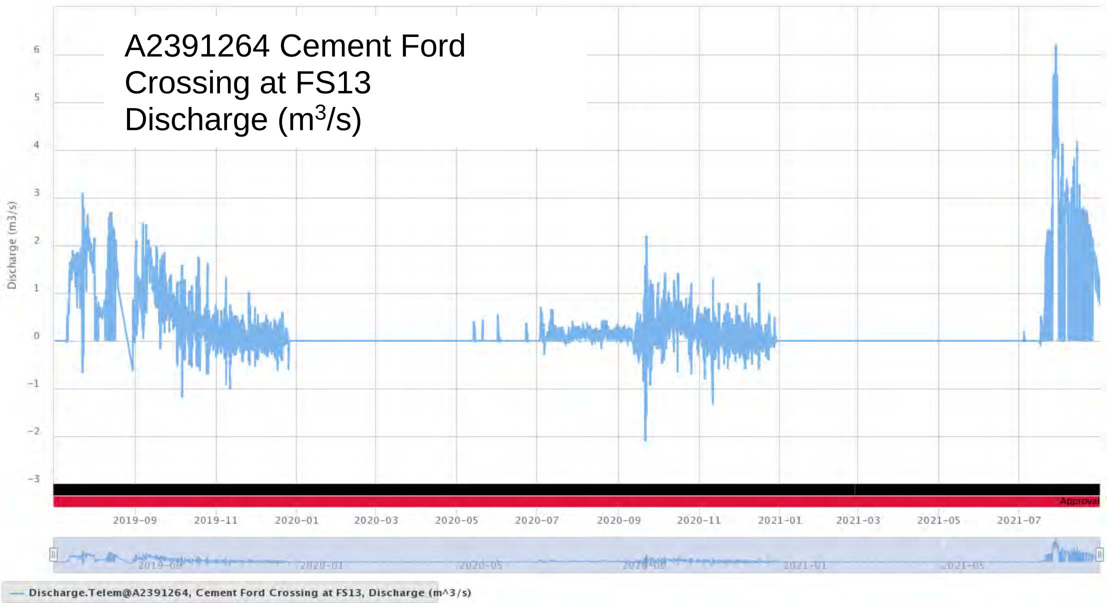

A2391150 Bald Hill Drain @
Ratcliffe Boundary
Discharge (m3/s)
Discharge (ML/day)
1000
800
600
400
200
0
-200
Approval
2011-07
2012-01
2012-07
2013-01
2013-07
2014-01
2014-07
2015-01
2015-07
2016-01
2016-07
2017-01
Discharge.Telem--ML/day@A2391150, Bald Hill Drain at Ratcliffe Boundary, Discharge (ML/day)


A2391151 Bald Hill Drain @
McBride Laneway
Discharge (m3/s)
Discharge (ML/day)
175
150
125
100
75
50
25
0
2011-09
2012-01
2012-05
2012-09
2013-01
2013-05
2013-09
2014-01
2014-05
2014-09
2015-01
2015-05
Approval
Discharge.Telem--ML/day@A2391151, Bald Hills Drain At McBride Laneway, Discharge (ML/day)

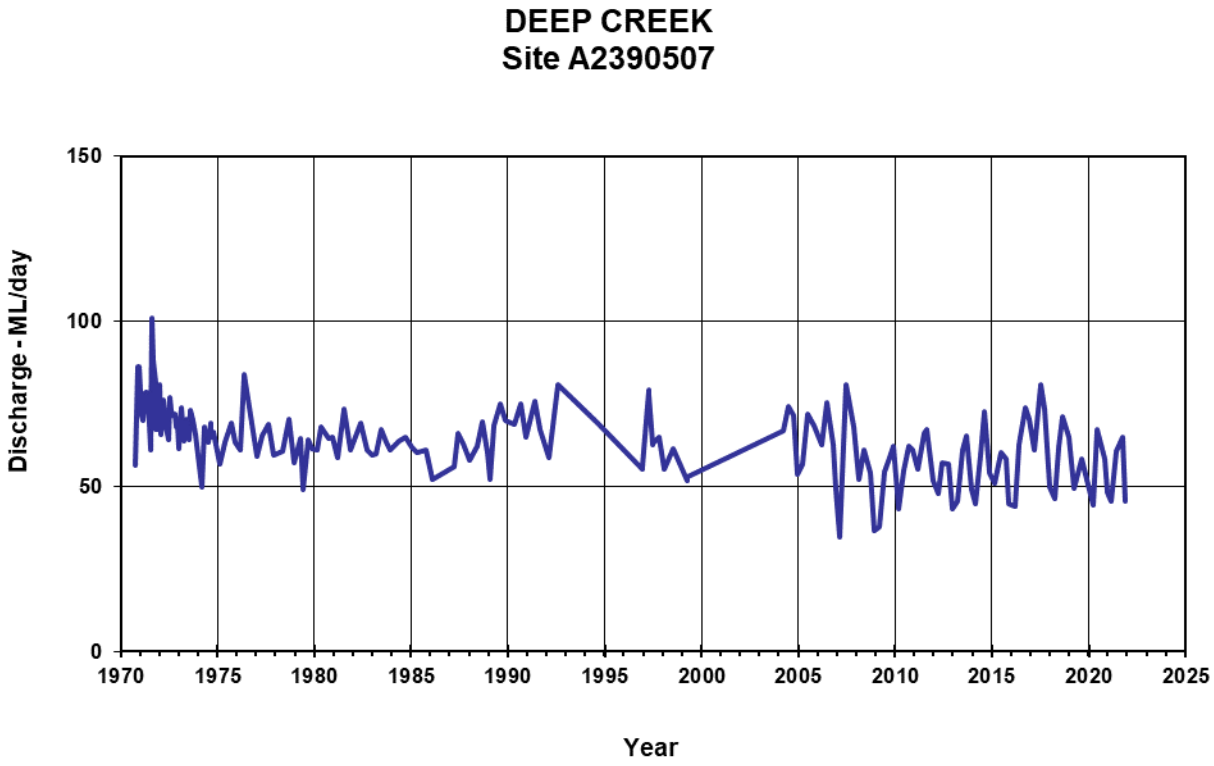

A2391153 Bakers Range Watercourse @
Tatiara Swamp
Discharge (m3/s)
Discharge (ML/day)
125
100
75
50
25
0
-25
-50
-75
-100
-125
2013-05
2013-07
2013-09
2013-11
2014-01
2014-03
2014-05
2014-07
2014-09
Approval
Discharge.Telem--ML/day@A2391153, Baker Range Watercourse at Tatiara Swamp, Discharge (ML/day)

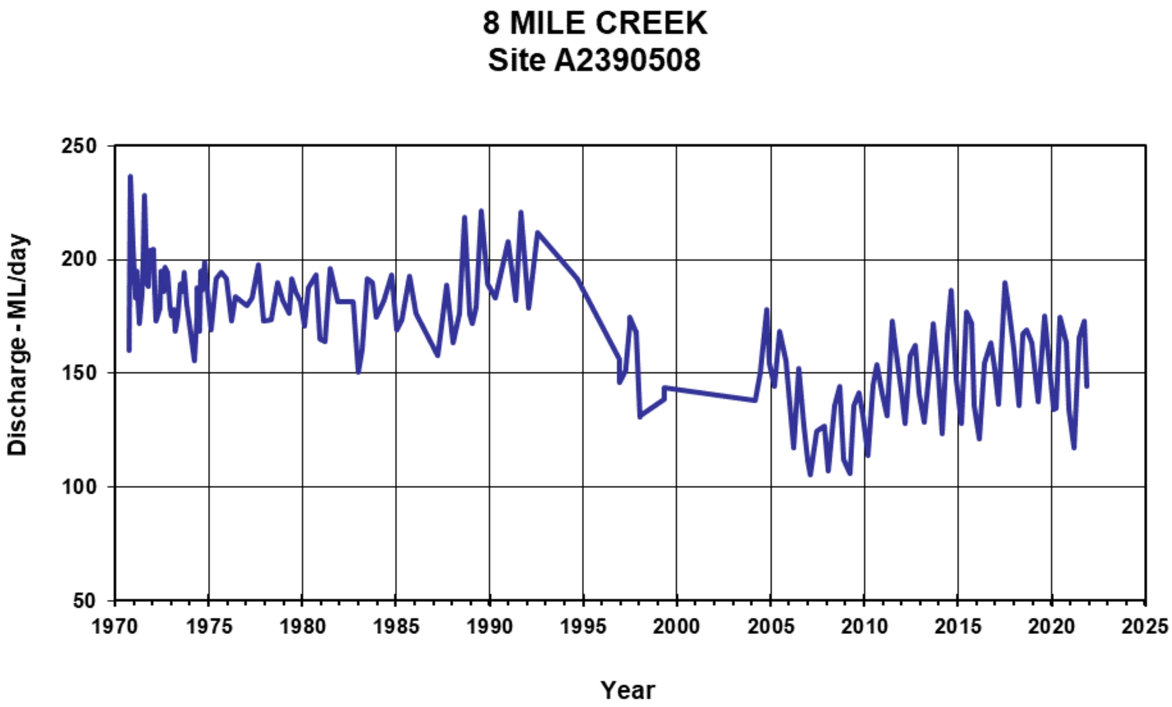

A2391261 Blackford Diversion
Regulator
Discharge (m3/s)
Discharge (ML/day)
800
700
600
500
400
300
200
100
0
2019-10
2020-01
2020-04
2020-07
2020-10
2021-01
2021-04
2021-07
2021-10
2022-01
Approval
NOW
Discharge.Telem--ML/day@A2391261, Blackford Diversion Regulator, Discharge (ML/day)


A2391263 Ford crossing D/S Blackford Diversion Regulator Discharge (m3/s)
Discharge (ML/day)
5000
4000
3000
2000
1000
0
-1000
-2000
-3000
-4000
Approval
2019-07
2019-10
2020-01
2020-04
2020-07
2020-10
2021-01
2021-04
2021-07
2021-10
Discharge.Telem--ML/day@A2391263, Ford crossing D/S Blackford diversion regulator, Discharge (ML/day)

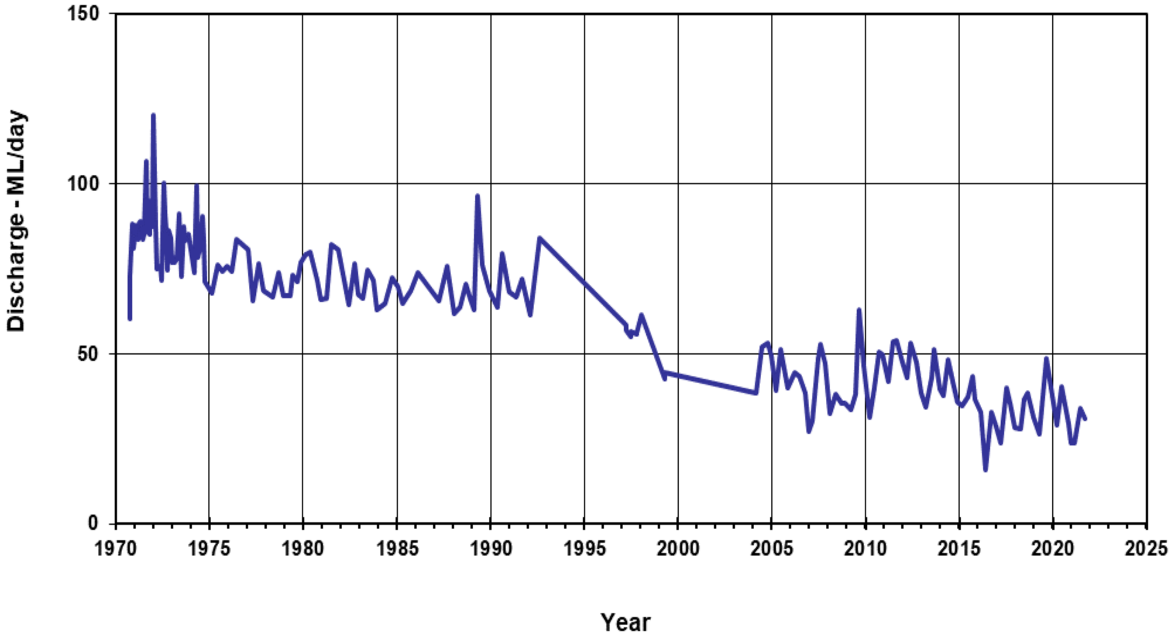

A2391264 Cement Ford Crossing at FS13 Discharge (m3/s)
Discharge (m3/s)
6
5
4
3
2
1
0
-1
-2
-3
Approval
2019-09
2019-11
2020-01
2020-03
2020-05
2020-07
2020-09
2020-11
2021-01
2021-03
2021-05
2021-07
Discharge.Telem@A2391264, Cement Ford Crossing at FS13, Discharge (m^3/s)

Hydrographs – Coastal Creeks

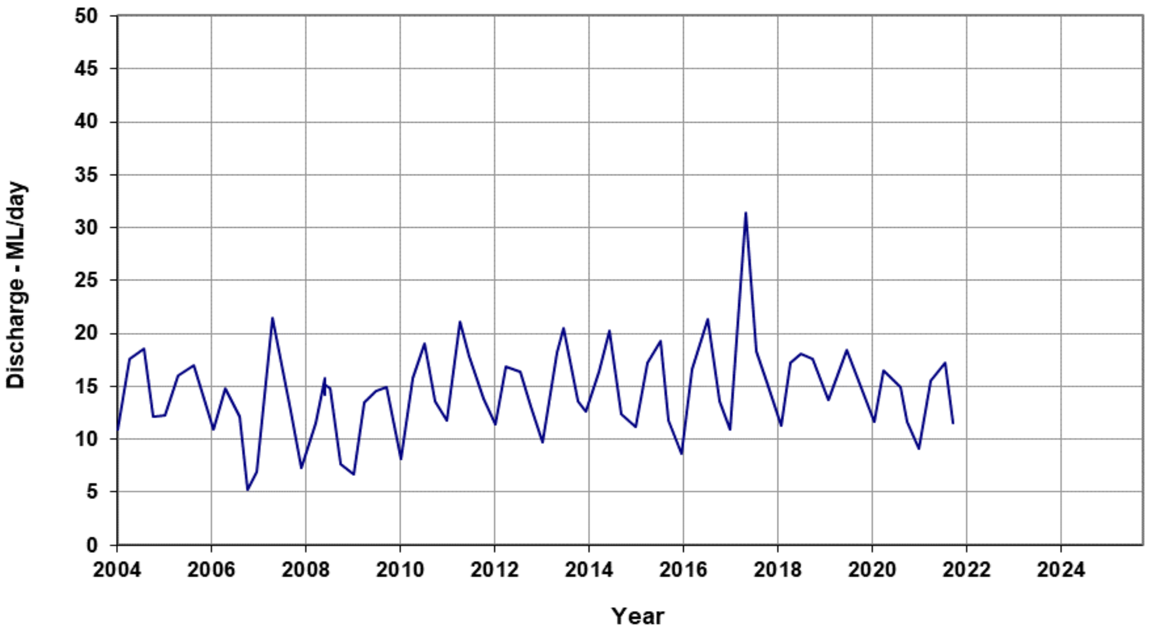




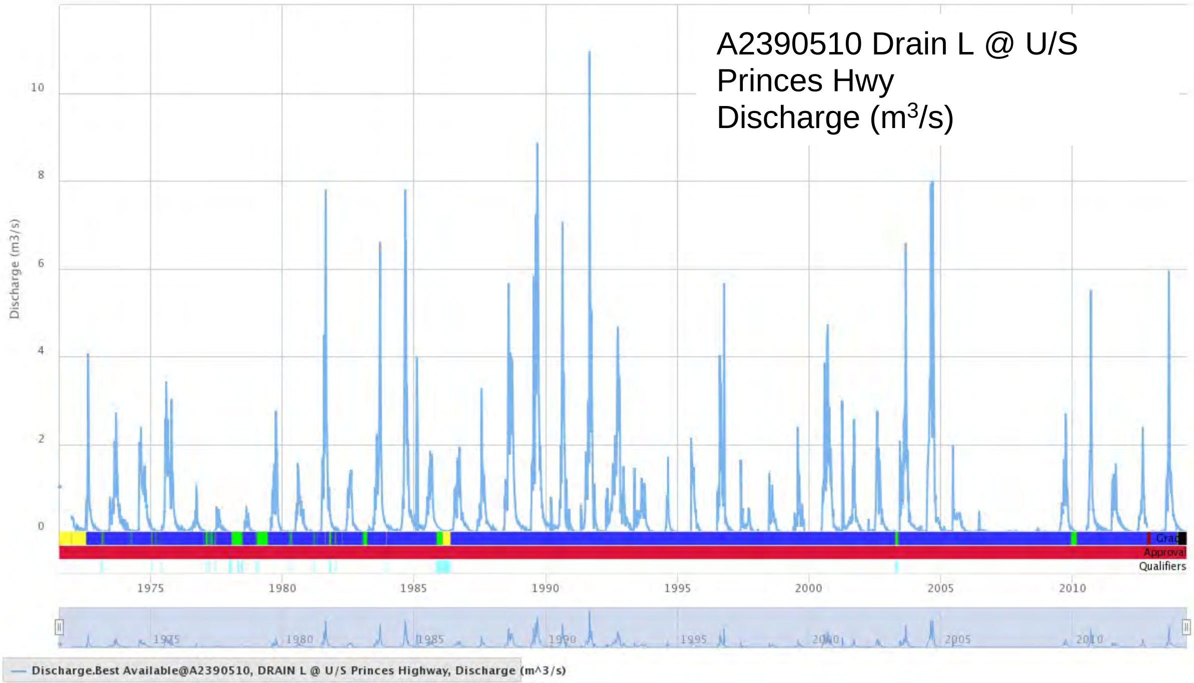
PICCANINNIE PONDS
Site A2390509

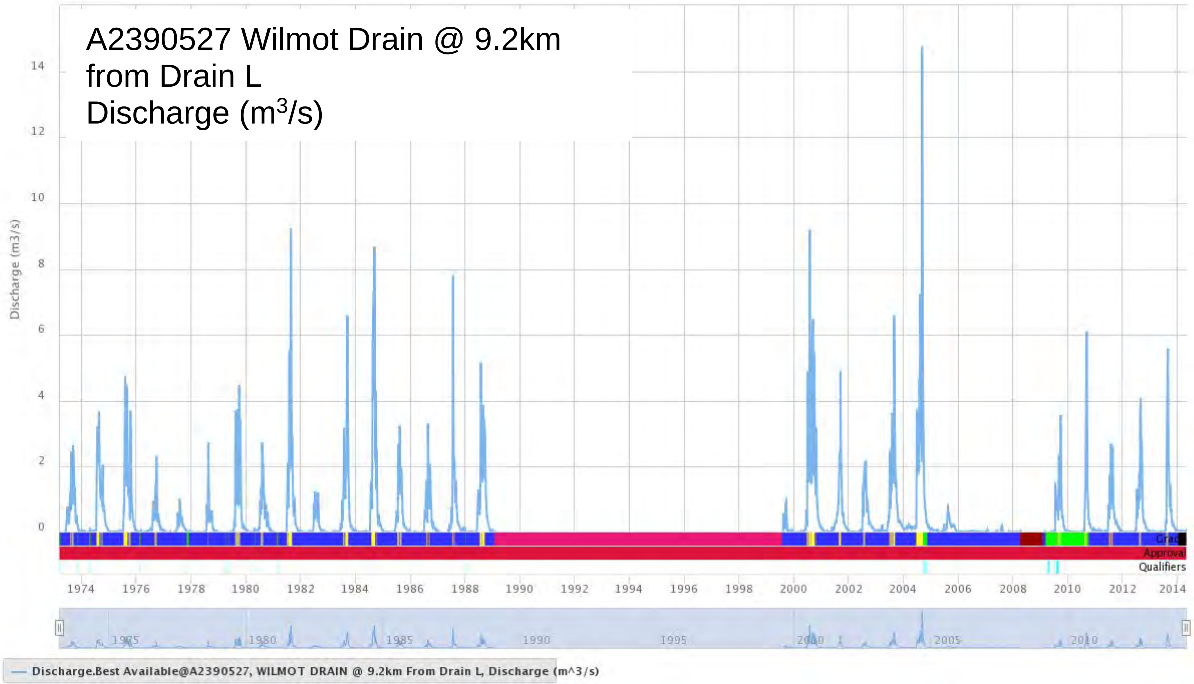


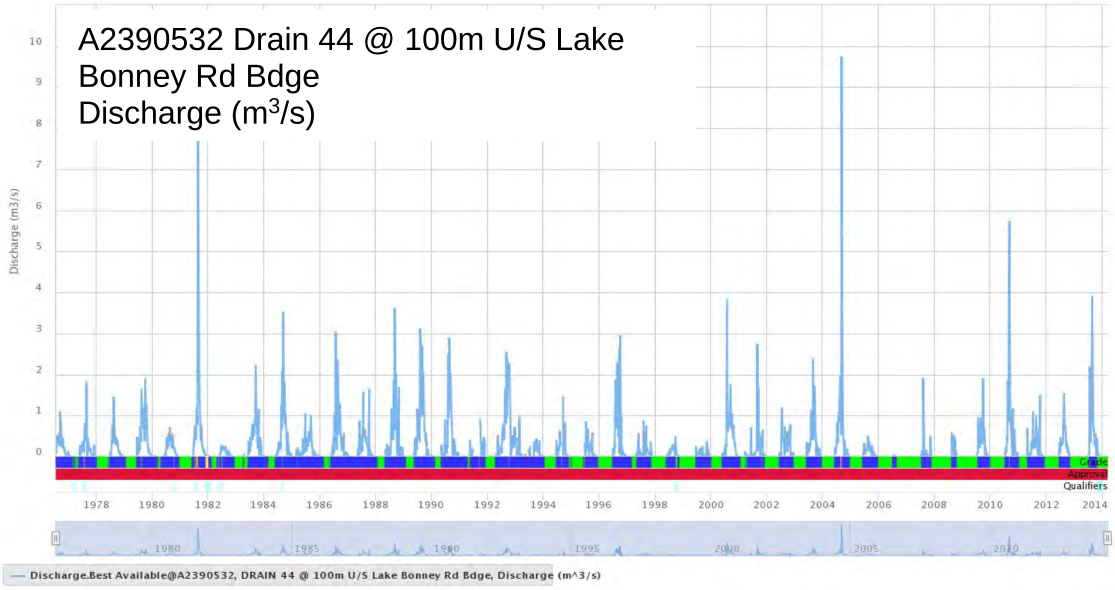
CRESS CREEK Discharge ML/day
Site A2390570

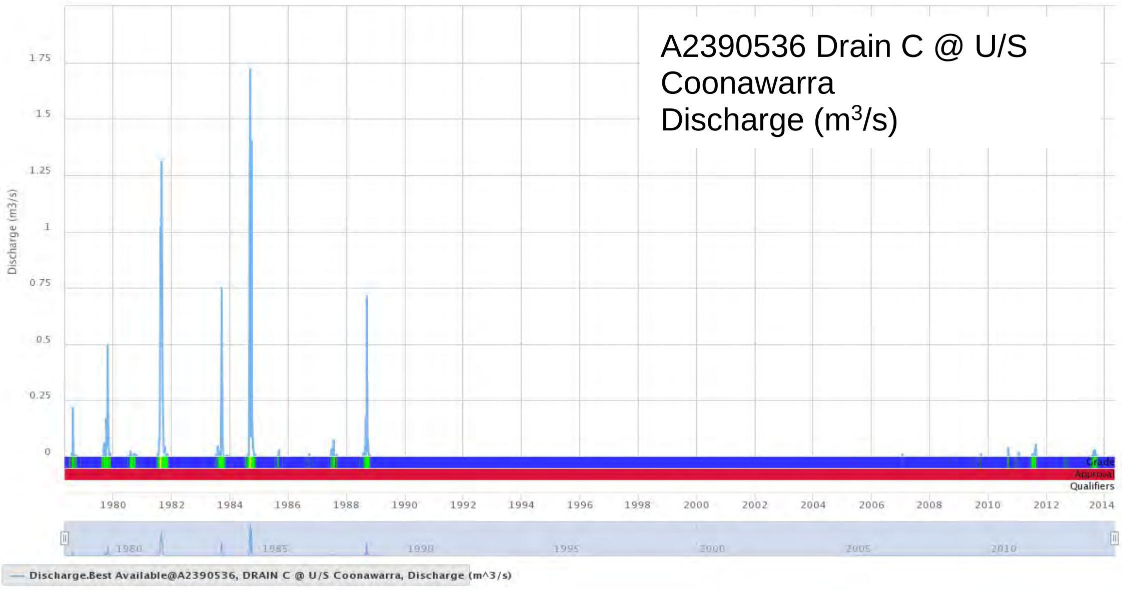


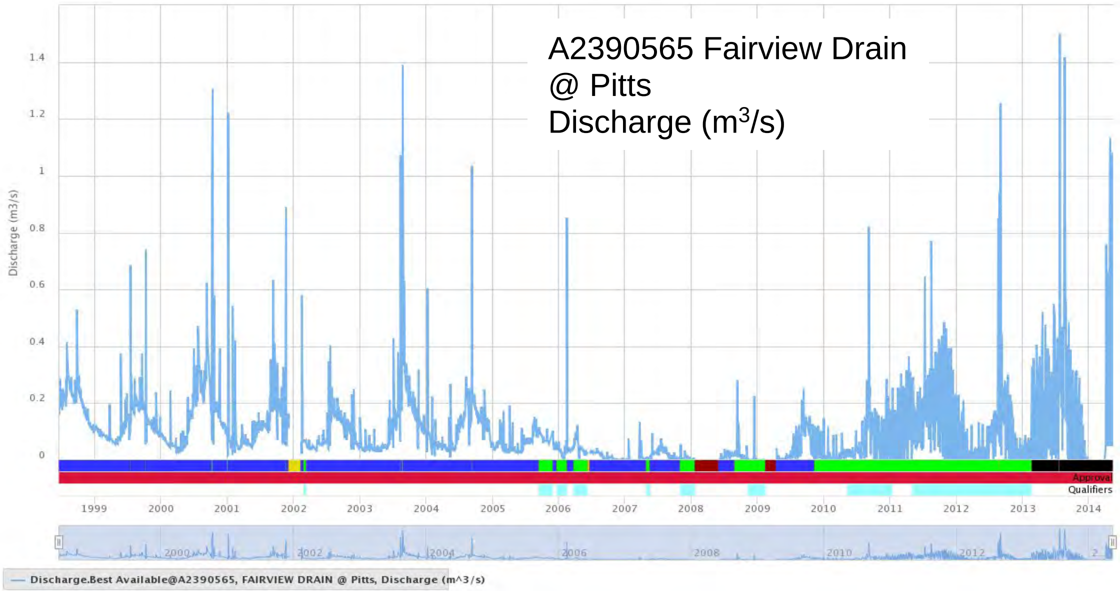
Hydrographs – Historical

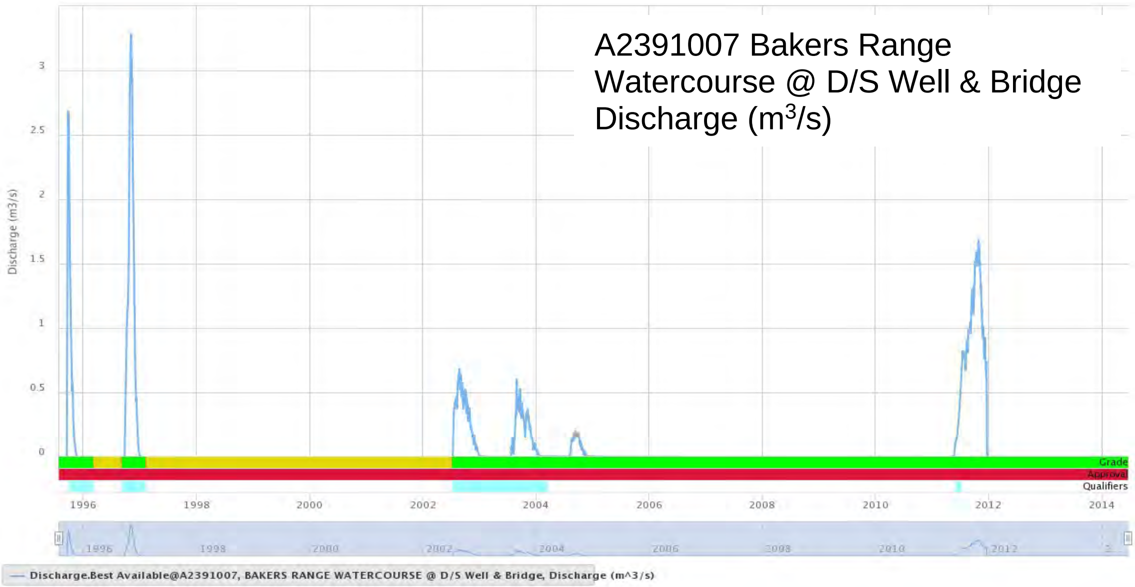


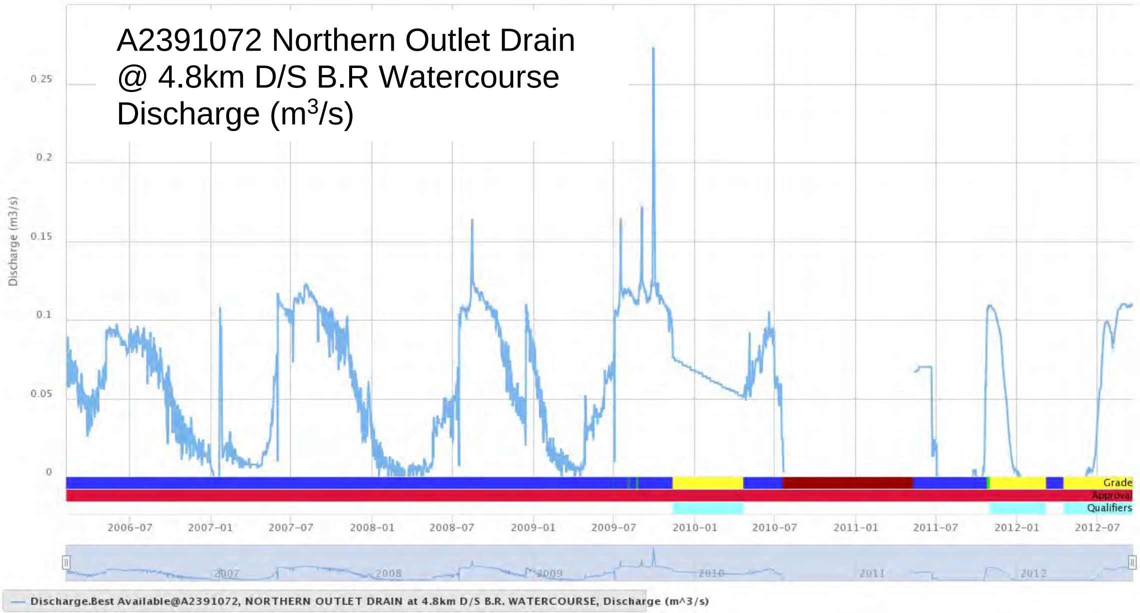


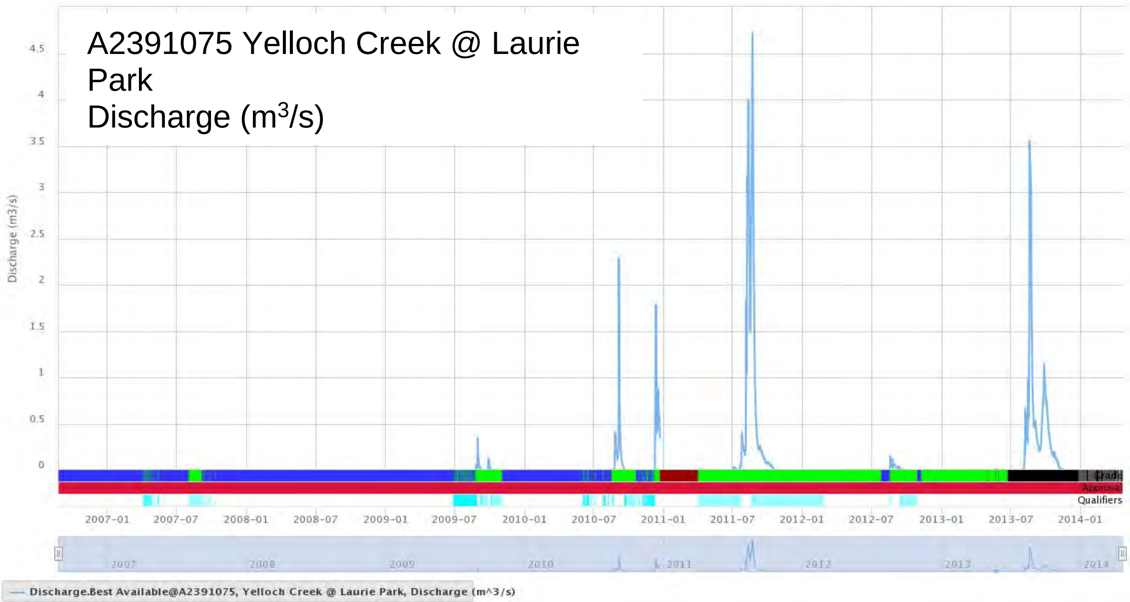

A2390532 Drain 44 @ 100m U/S Lake Bonney Rd Bdge
Discharge (m3/s)
Discharge (m3/s)
Grade
Approval
Qualifiers
1978 1980 1982 1984 1986 1988 1990 1992 1994 1996 1998 2000 2002 2004 2006 2008 2010 2012 2014
Discharge.Best Available@A2390532, DRAIN 44 @ 100m U/S Lake Bonney Rd Bdge, Discharge (m^3/s)

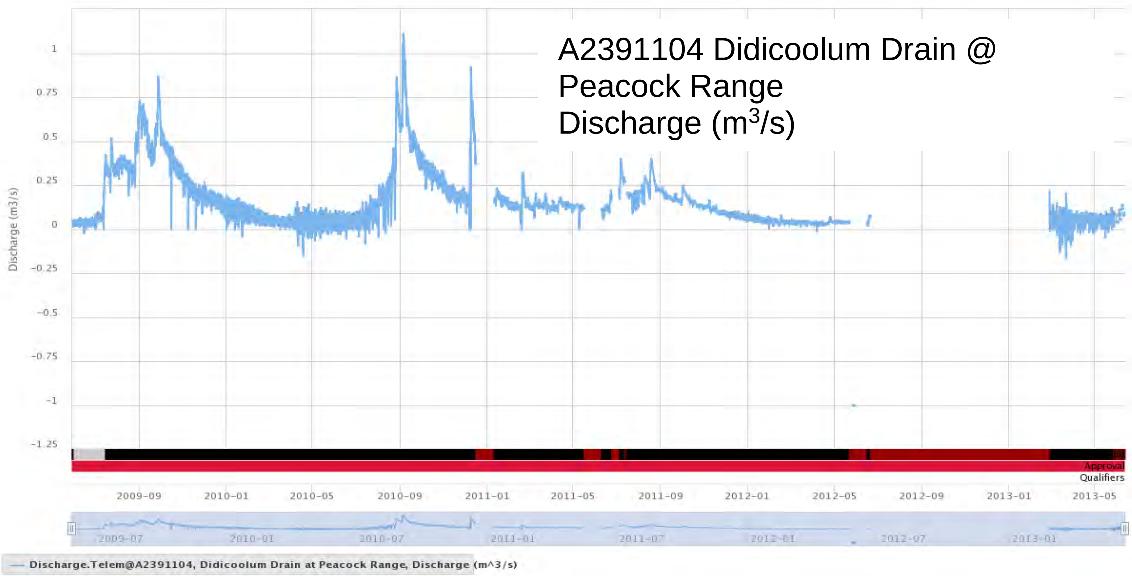

A2390536 Drain C @ U/S Coonawarra
Discharge (m3/s)
Discharge (m3/s)
Grade
Approval
Qualifiers
1980 1982 1984 1986 1988 1990 1992 1994 1996 1998 2000 2002 2004 2006 2008 2010 2012 2014
Discharge.Best Available@A2390536, DRAIN C @ U/S Coonawarra, Discharge (m^3/s)

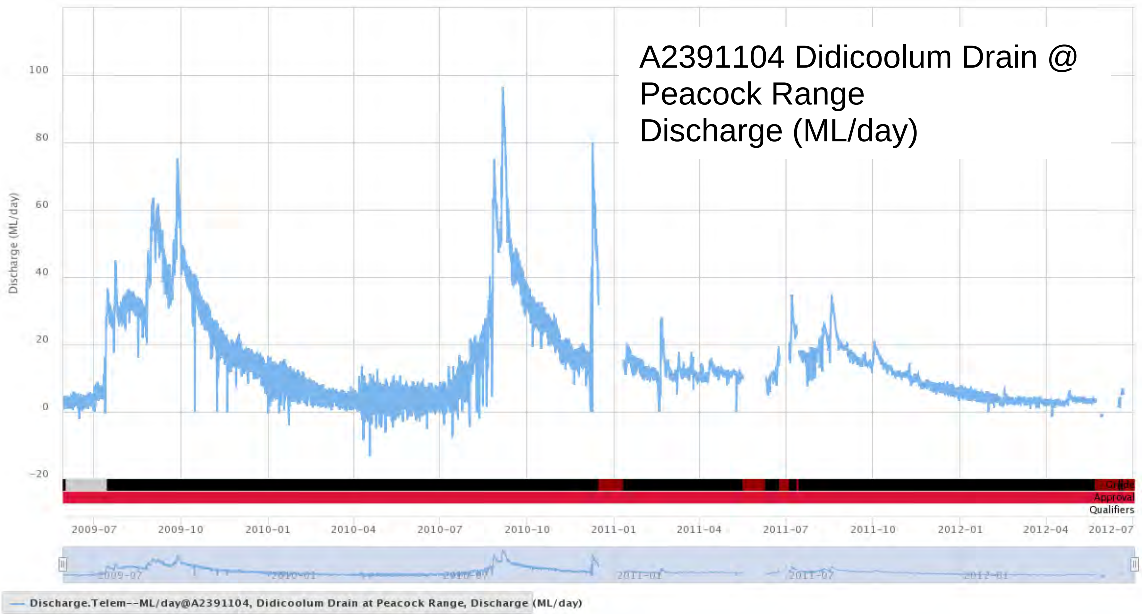

A2390565 Fairview Drain
@ Pitts
Discharge (m3/s)
Discharge (m3/s)
1.4
1.2
1
0.8
0.6
0.4
0.2
0
Approval
Qualifiers
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
Discharge.Best Available@A2390565, FAIRVIEW DRAIN @ Pitts, Discharge (m^3/s)

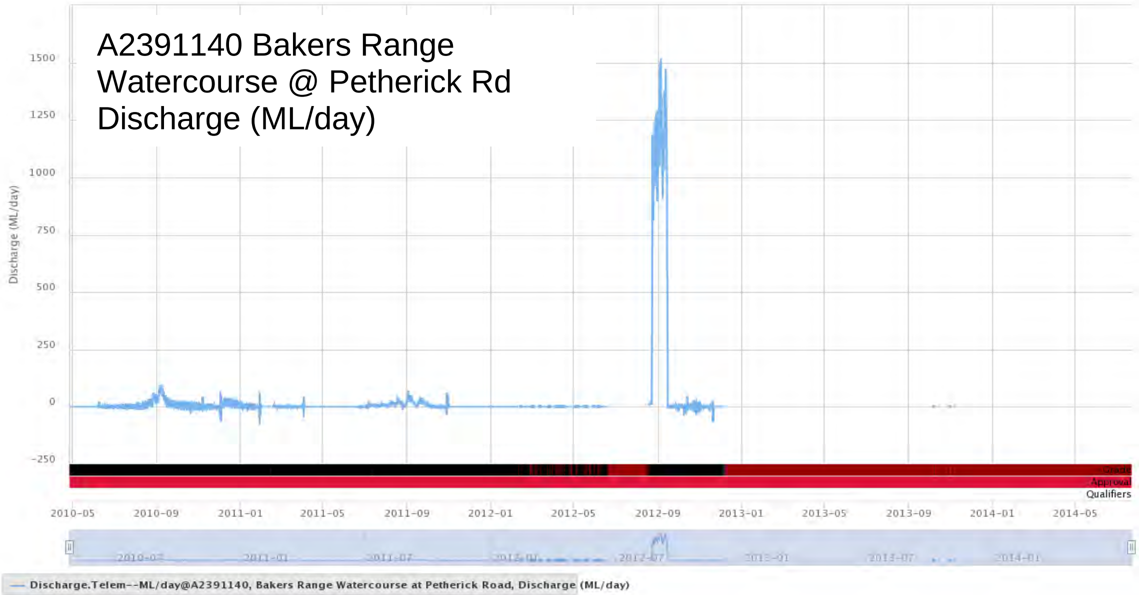

A2391007 Bakers Range
Watercourse @ D/S Well & Bridge
Discharge (m3/s)
Discharge (m3/s)
3
2.5
2
1.5
1
0.5
0
Grade
Approval
Qualifiers
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
Discharge.Best Available@A2391007, BAKERS RANGE WATERCOURSE @ D/S Well & Bridge, Discharge (m^3/s)

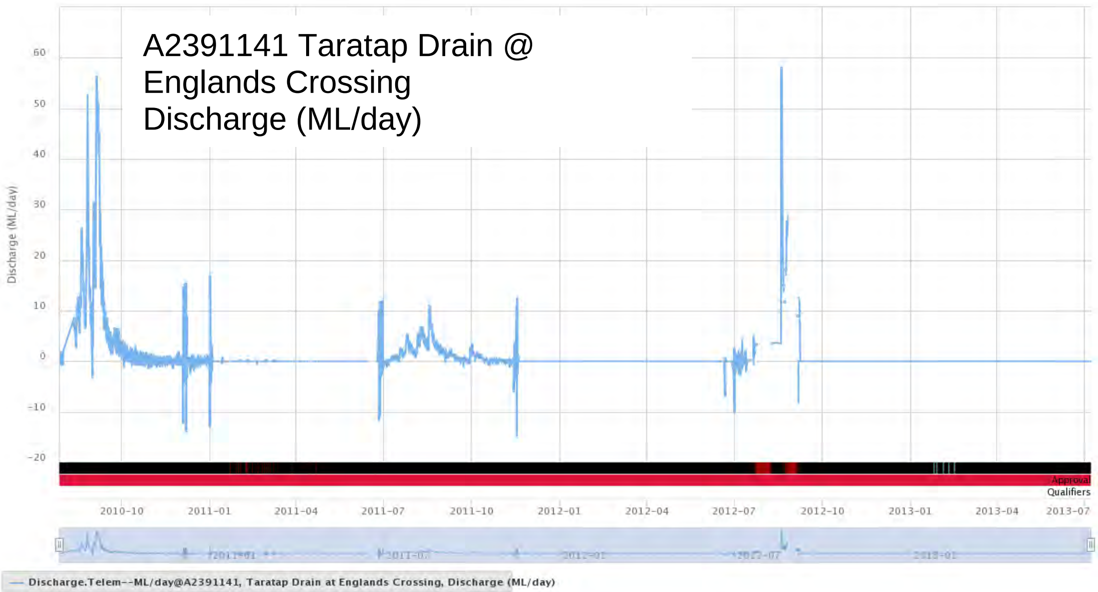

A2391072 Northern Outlet Drain
@ 4.8km D/S B.R Watercourse
Discharge (m3/s)
Discharge (m3/s)
0.25
0.2
0.15
0.1
0.05
0
Grade
Approval
Qualifiers
2006-07
2007-01
2007-07
2008-01
2008-07
2009-01
2009-07
2010-01
2010-07
2011-01
2011-07
2012-01
2012-07
Discharge.Best Available@A2391072, NORTHERN OUTLET DRAIN at 4.8km D/S B.R. WATERCOURSE, Discharge (m^3/s)

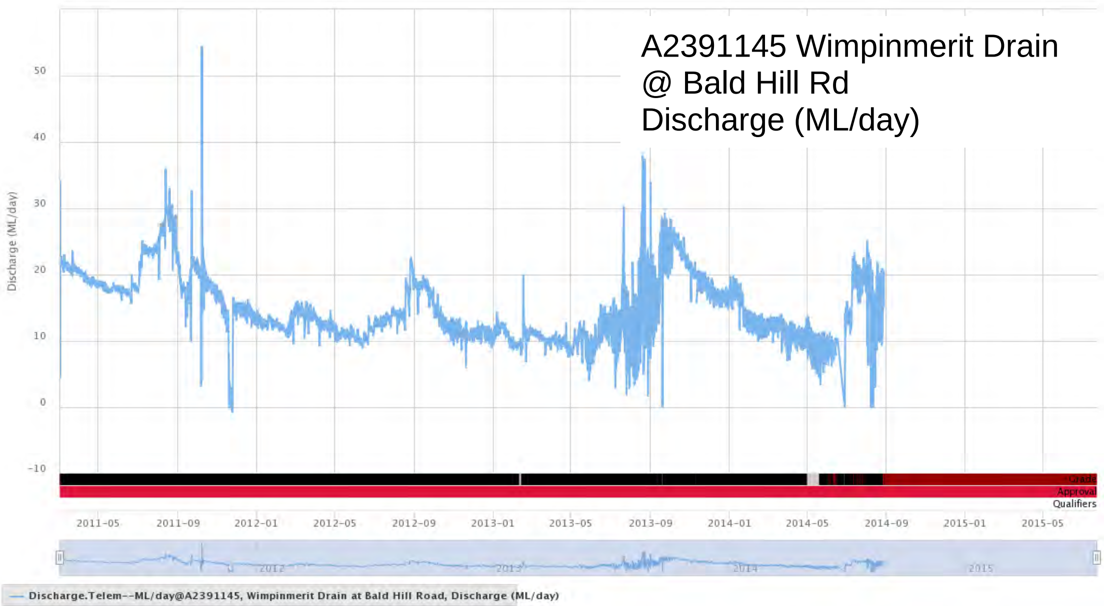

A2391075 Yelloch Creek @ Laurie
Park
Discharge (m3/s)
Discharge (m3/s)
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
Grade
Approval
Qualifiers
2007-01
2007-07
2008-01
2008-07
2009-01
2009-07
2010-01
2010-07
2011-01
2011-07
2012-01
2012-07
2013-01
2013-07
2014-01
Discharge.Best Available@A2391075, Yelloch Creek @ Laurie Park, Discharge (m^3/s)

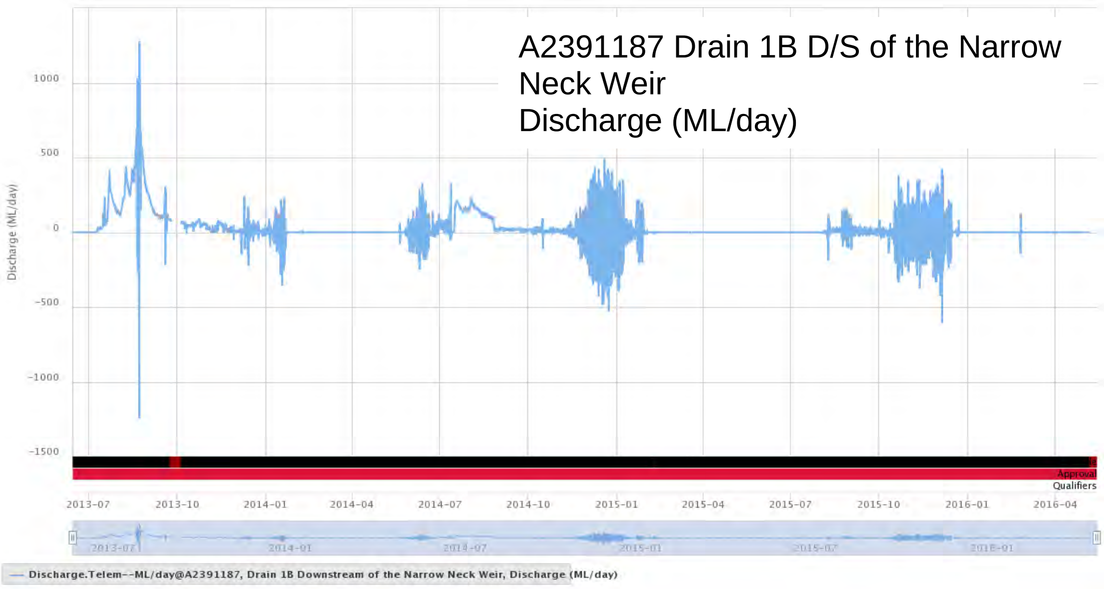

A2391104 Didicoolum Drain @
Peacock Range
Discharge (m3/s)
Discharge (m3/s)
Approval
Qualifiers
2009-09
2010-01
2010-05
2010-09
2011-01
2011-05
2011-09
2012-01
2012-05
2012-09
2013-01
2013-05
Discharge.Telem@A2391104, Didicoolum Drain at Peacock Range, Discharge (m^3/s)

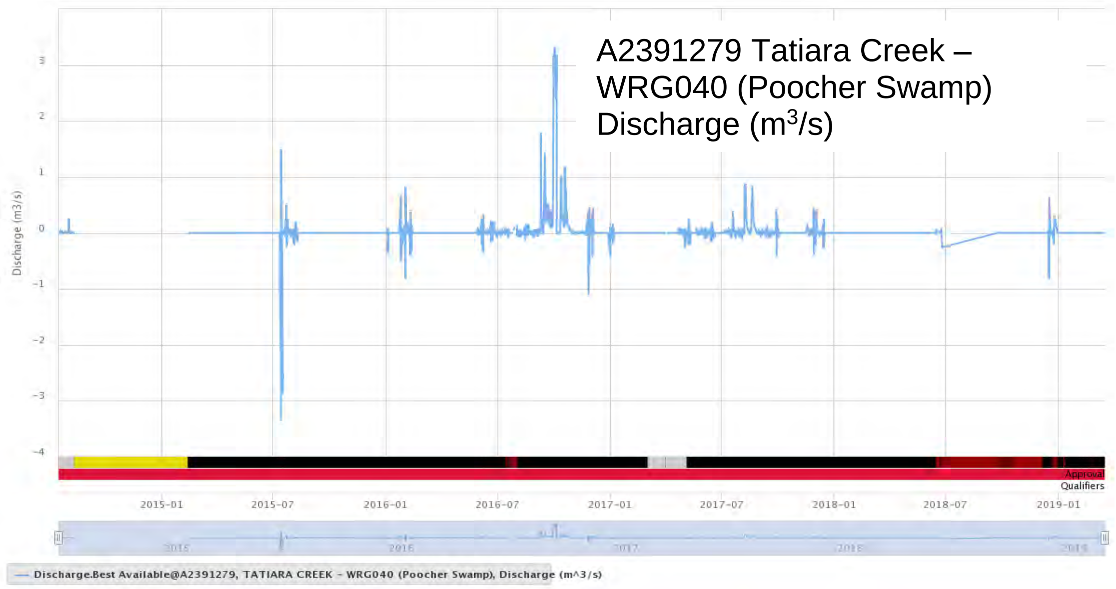

A2391104 Didicoolum Drain @
Peacock Range
Discharge (ML/day)
Discharge (ML/day)
Approval
Qualifiers
2009-07
2009-10
2010-01
2010-04
2010-07
2010-10
2011-01
2011-04
2011-07
2011-10
2012-01
2012-04
2012-07
Discharge.Telem--ML/day@A2391104, Didicoolum Drain at Peacock Range, Discharge (ML/day)

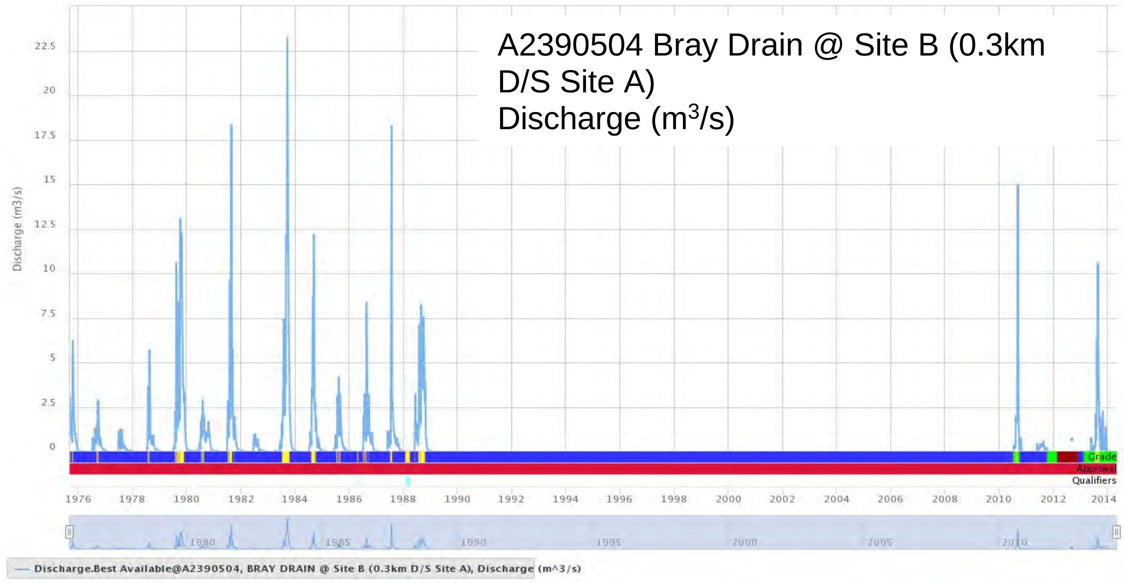

A2391140 Bakers Range
Watercourse @ Petherick Rd
Discharge (ML/day)
Discharge (ML/day)
1500
1250
1000
750
500
250
0
-250
Qualifiers
2010-05
2010-09
2011-01
2011-05
2011-09
2012-01
2012-05
2012-09
2013-01
2013-05
2013-09
2014-01
2014-05
Discharge.Telem--ML/day@A2391140, Bakers Range Watercourse at Petherick Road, Discharge (ML/day)

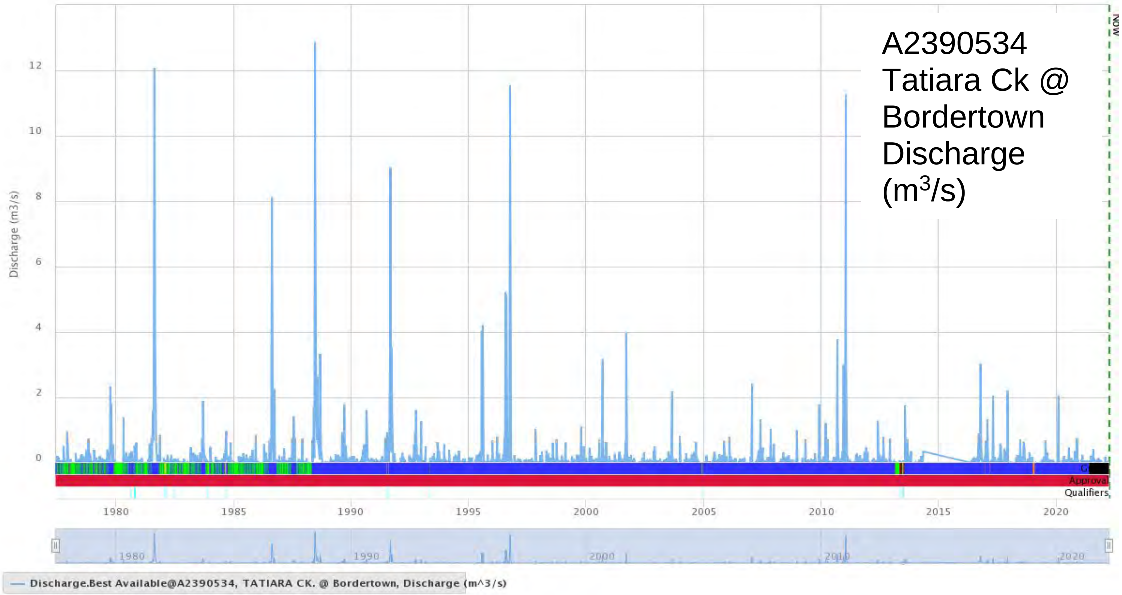

A2391141 Taratap Drain @
Englands Crossing
Discharge (ML/day)
Discharge (ML/day)
60
50
40
30
20
10
0
-10
-20
Approval
Qualifiers
2010-10
2011-01
2011-04
2011-07
2011-10
2012-01
2012-04
2012-07
2012-10
2013-01
2013-04
2013-07
Discharge.Telem--ML/day@A2391141, Taratap Drain at Englands Crossing, Discharge (ML/day)

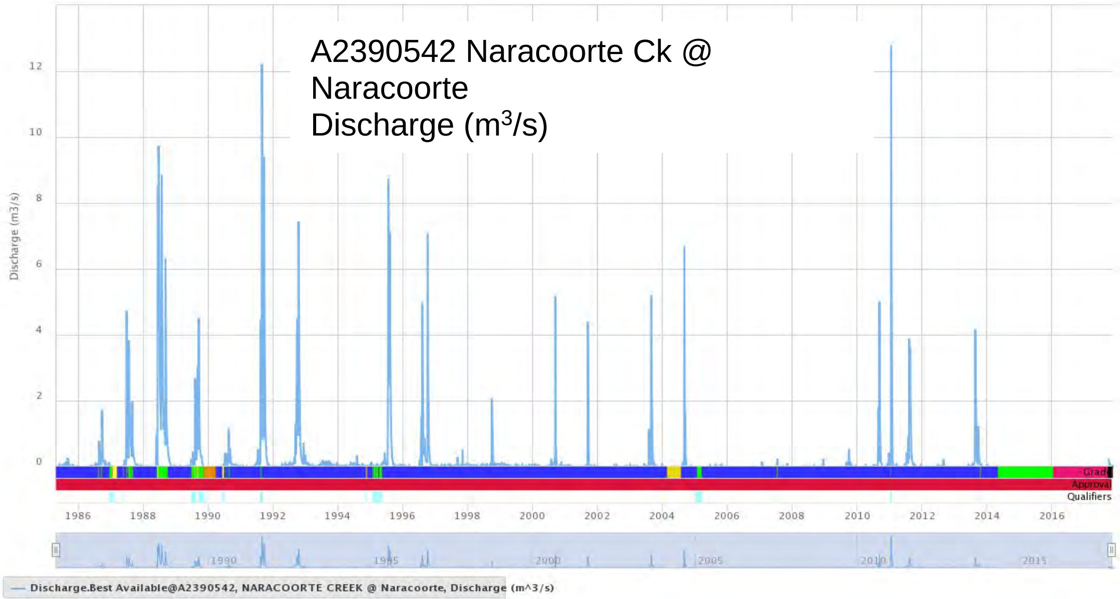

A2391145 Wimpinmerit Drain
@ Bald Hill Rd
Discharge (ML/day)
Discharge (ML/day)
50
40
30
20
10
0
-10
Approval
Qualifiers
2011-05
2011-09
2012-01
2012-05
2012-09
2013-01
2013-05
2013-09
2014-01
2014-05
2014-09
2015-01
2015-05
Discharge.Telem--ML/day@A2391145, Wimpinmerit Drain at Bald Hill Road, Discharge (ML/day)


A2391187 Drain 1B D/S of the Narrow
Neck Weir
Discharge (ML/day)
Discharge (ML/day)
1000
500
0
-500
-1000
-1500
Approval
Qualifiers
2013-07
2013-10
2014-01
2014-04
2014-07
2014-10
2015-01
2015-04
2015-07
2015-10
2016-01
2016-04
Discharge.Telem--ML/day@A2391187, Drain 1B Downstream of the Narrow Neck Weir, Discharge (ML/day)

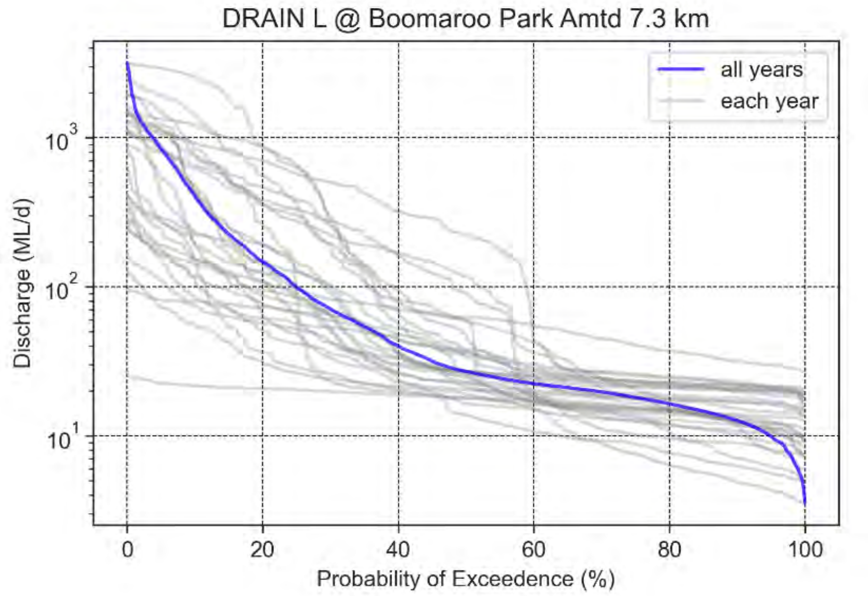

A2391279 Tatiara Creek – WRG040 (Poocher Swamp) Discharge (m3/s)
Discharge (m3/s)
2015-01
2015-07
2016-01
2016-07
2017-01
2017-07
2018-01
2018-07
2019-01
Approval
Qualifiers
Discharge.Best Available@A2391279, TATIARA CREEK - WRG040 (Poocher Swamp), Discharge (m^3/s)

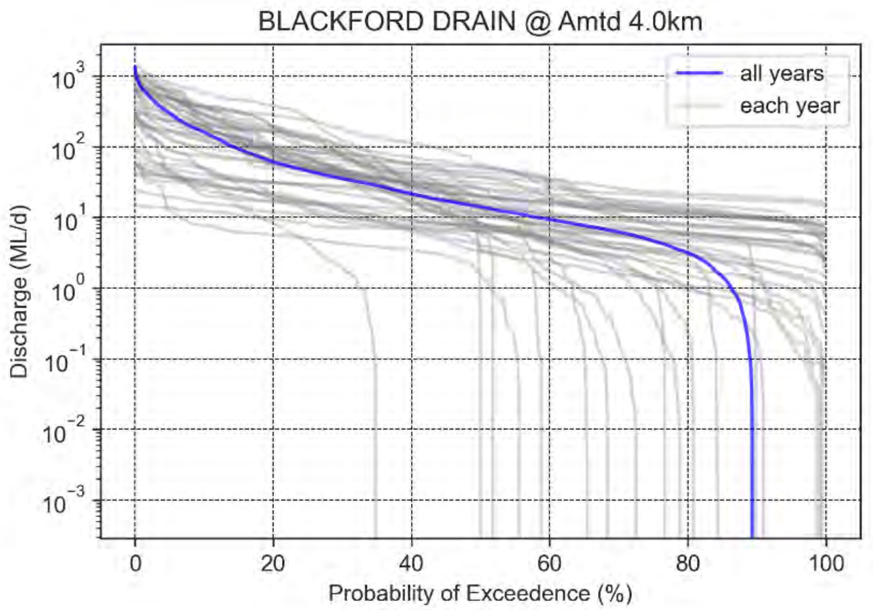

A2390504 Bray Drain @ Site B (0.3km D/S Site A) Discharge (m3/s)
Discharge (m3/s)
22.5
20
17.5
15
12.5
10
7.5
5
2.5
0
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
Grade
Approval
Qualifiers
Discharge.Best Available@A2390504, BRAY DRAIN @ Site B (0.3km D/S Site A), Discharge (m^3/s)

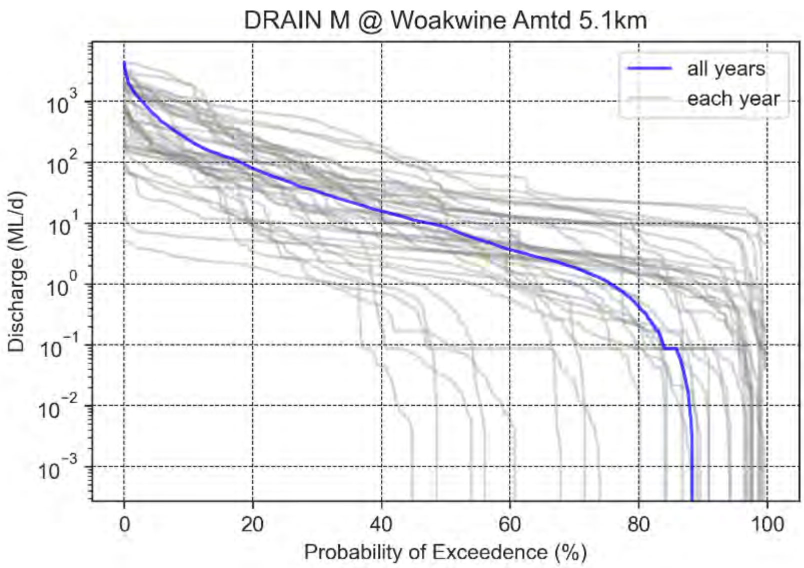

A2390534
Tatiara Ck @
Bordertown
Discharge
(m3/s)
Discharge (m3/s)
1980
1985
1990
1995
2000
2005
2010
2015
2020
Approval
Qualifiers
Discharge.Best Available@A2390534, TATIARA CK. @ Bordertown, Discharge (m^3/s)

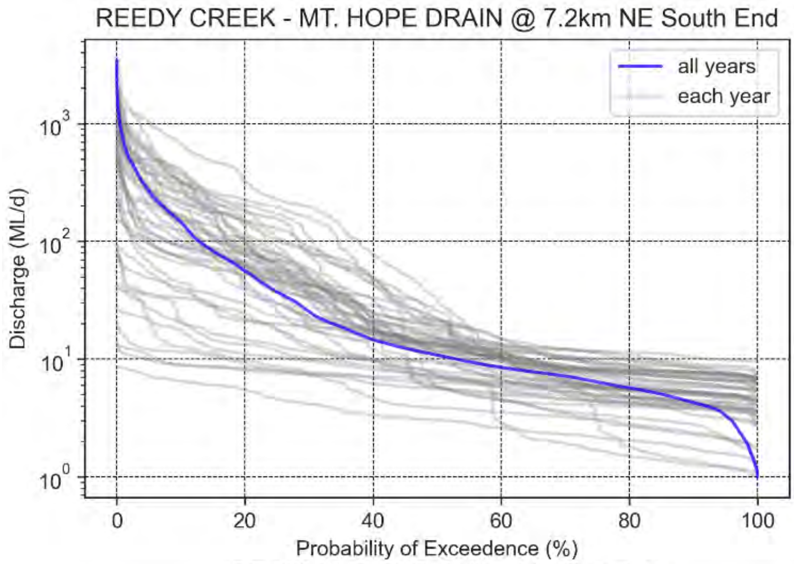

A2390542 Naracoorte Ck @
Naracoorte
Discharge (m3/s)
Discharge (m3/s)
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
Approval
Qualifiers
Discharge.Best Available@A2390542, NARACOORTE CREEK @ Naracoorte, Discharge (m^3/s)

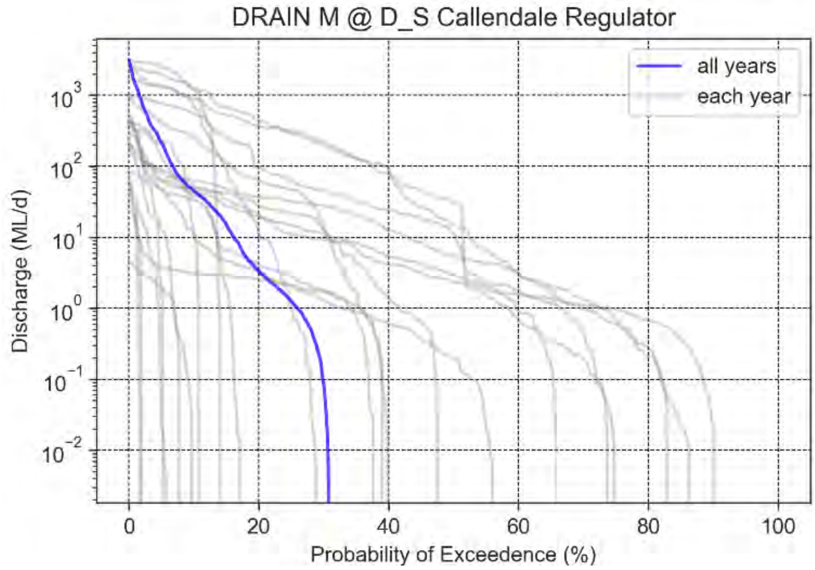
Flow Duration Curves – SEDN

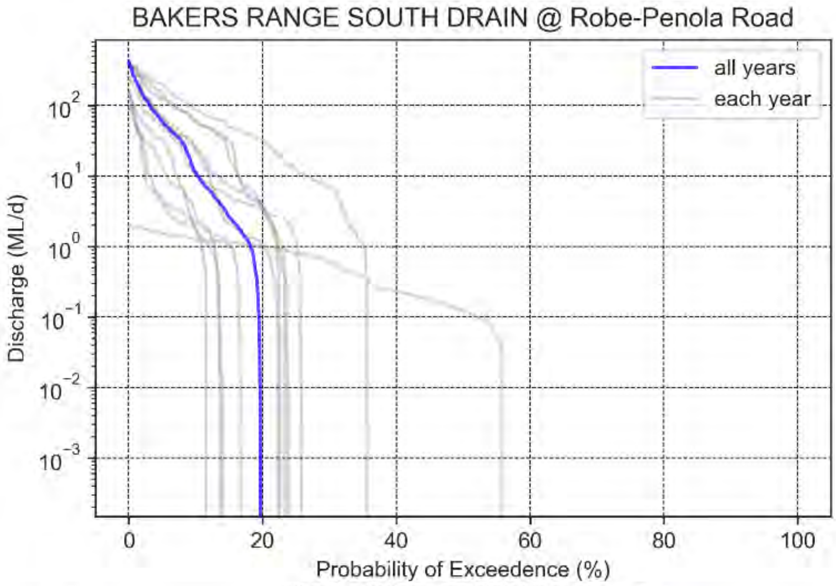


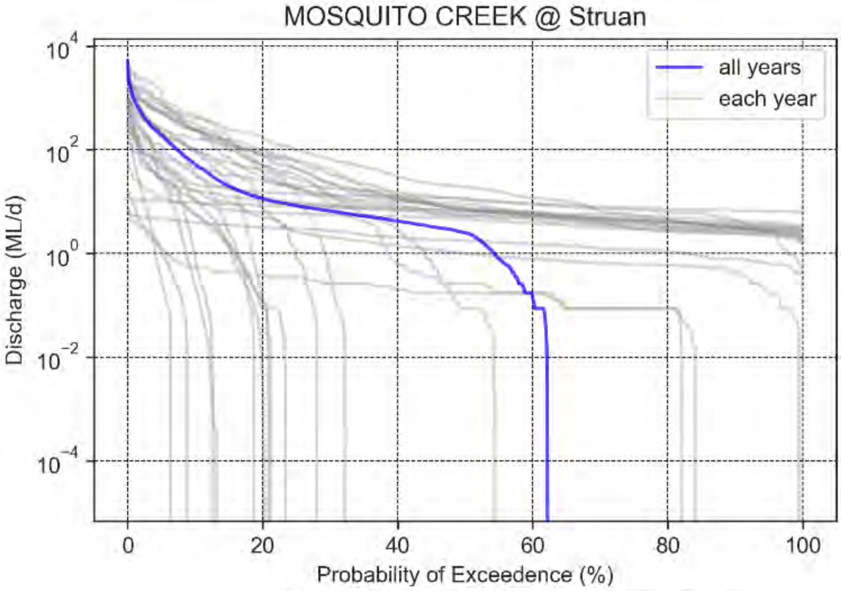


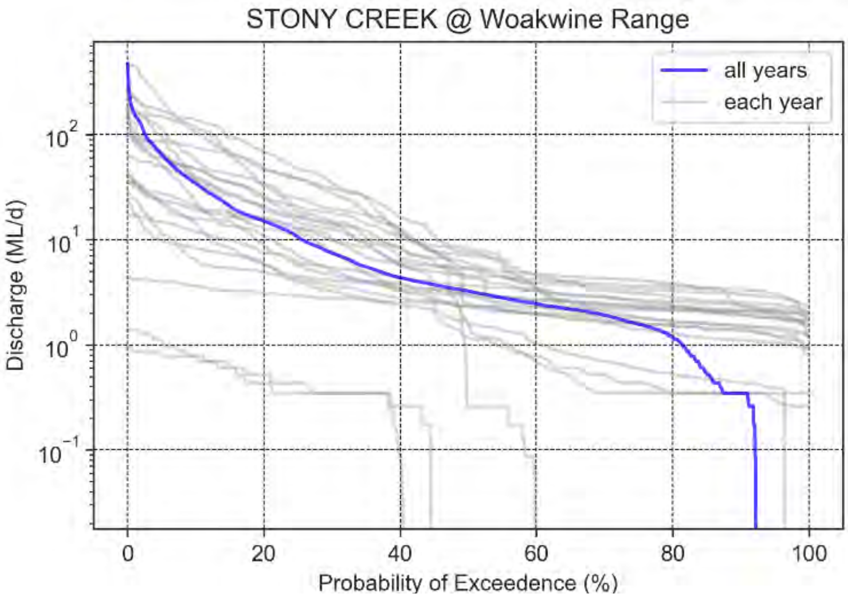

DRAIN M @ Woakwine Amtd 5.1km
all years
each year
Discharge (ML/d)
Probability of Exceedence (%)

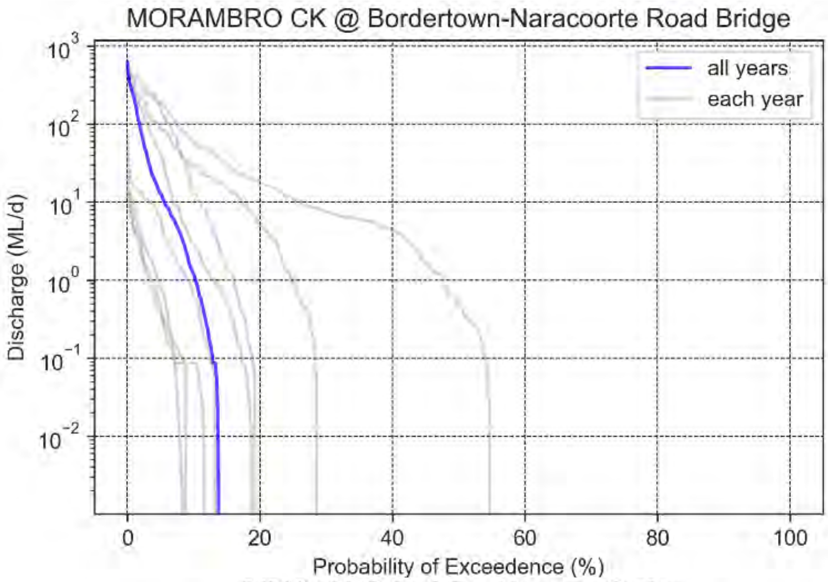

REEDY CREEK - MT. HOPE DRAIN @ 7.2km NE South End
all years
each year
Discharge (ML/d)
Probability of Exceedence (%)

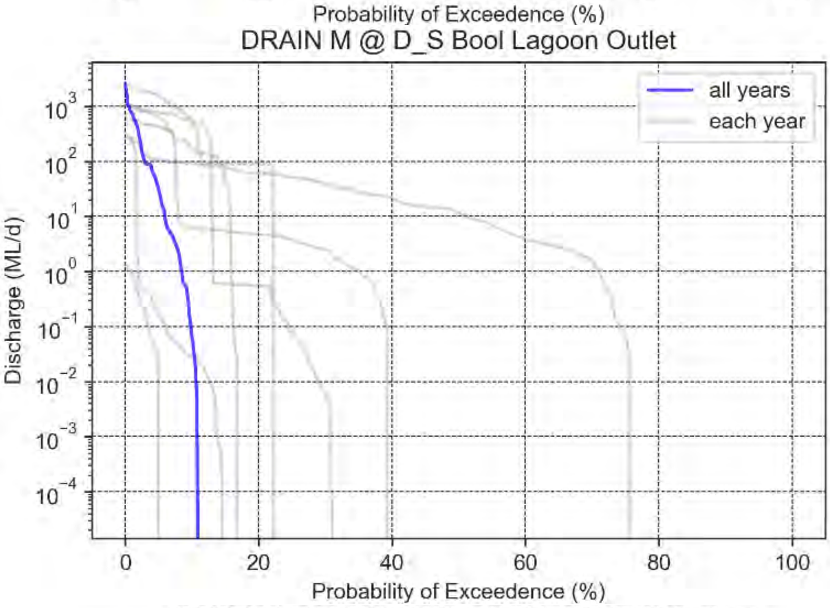

DRAIN M @ D_S Callendale Regulator
all years
each year
Discharge (ML/d)
Probability of Exceedence (%)

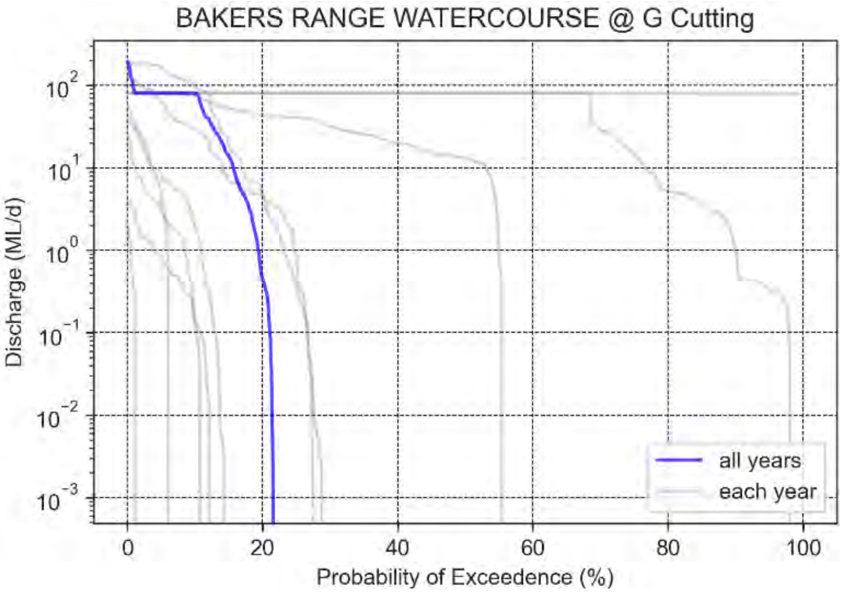

BAKERS RANGE SOUTH DRAIN @ Robe-Penola Road
all years
each year
Discharge (ML/d)
Probability of Exceedence (%)

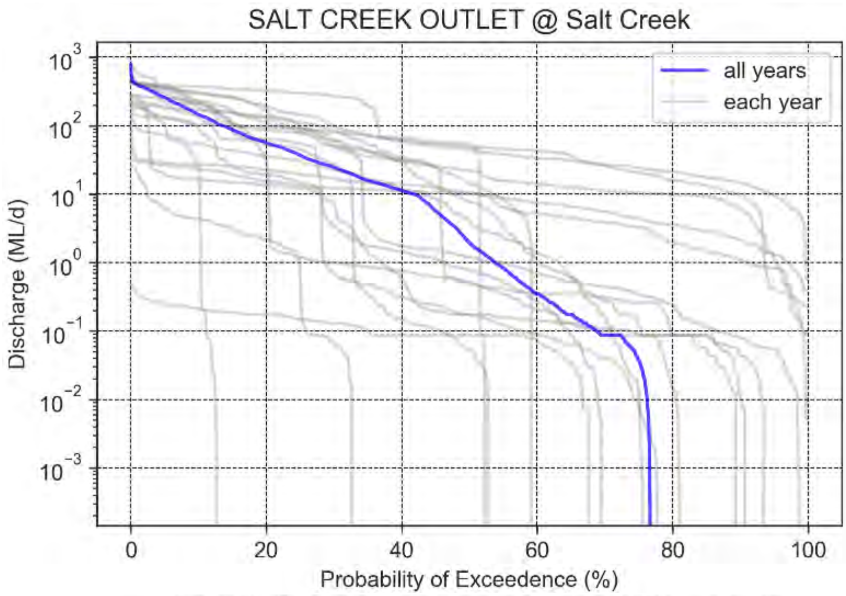

MOSQUITO CREEK @ Struan
all years
each year
Discharge (ML/d)
Probability of Exceedence (%)

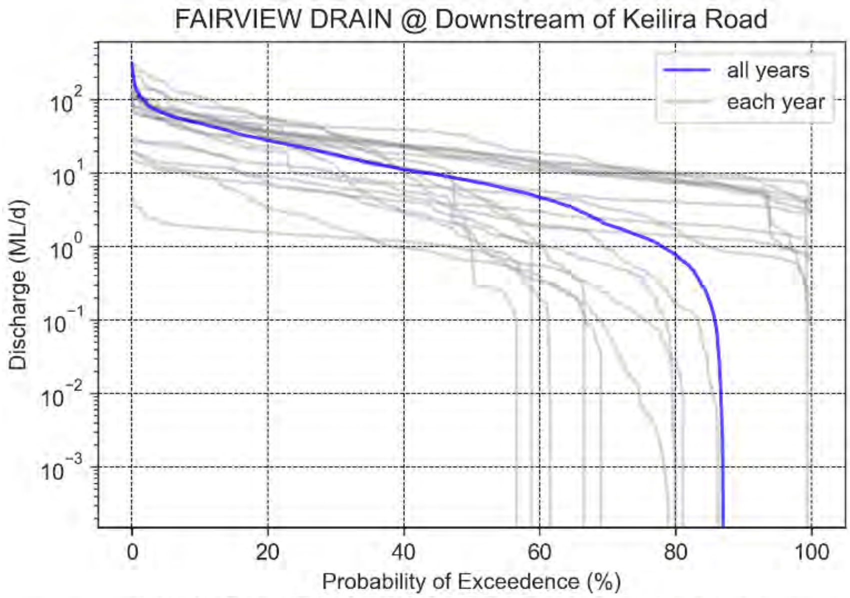

STONY CREEK @ Woakwine Range
all years
each year
Discharge (ML/d)
Probability of Exceedence (%)

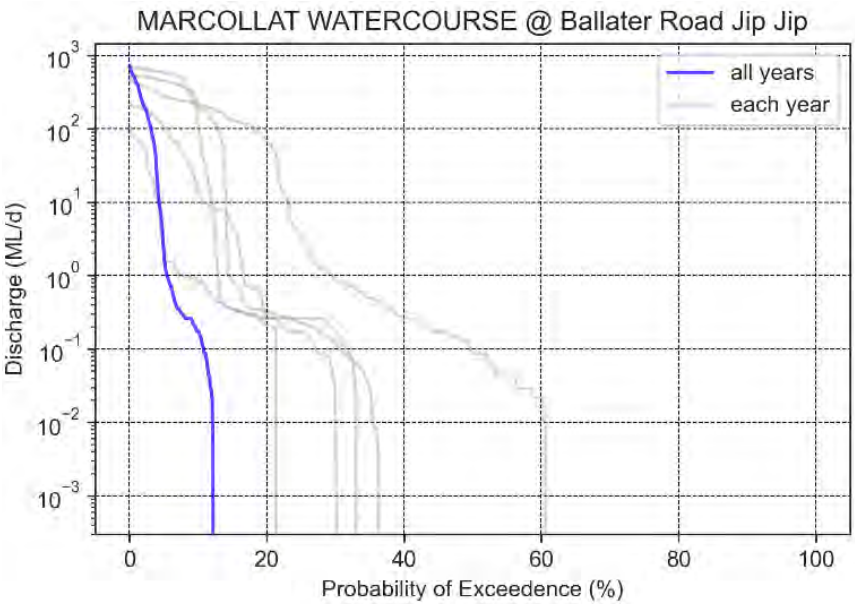

MORAMBRO CK @ Bordertown-Naracoorte Road Bridge
all years
each year
Discharge (ML/d)
Probability of Exceedence (%)

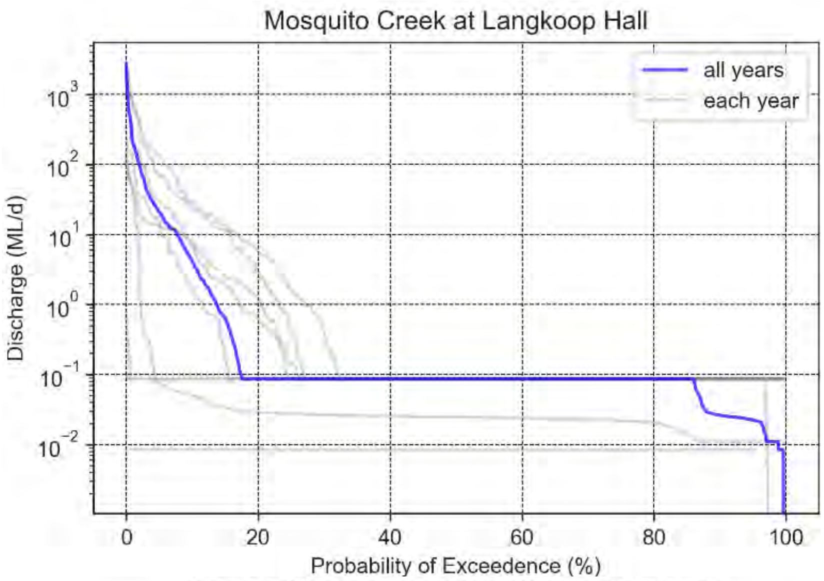

DRAIN M @ D_S Bool Lagoon Outlet
all years
each year
Discharge (ML/d)
Probability of Exceedence (%)

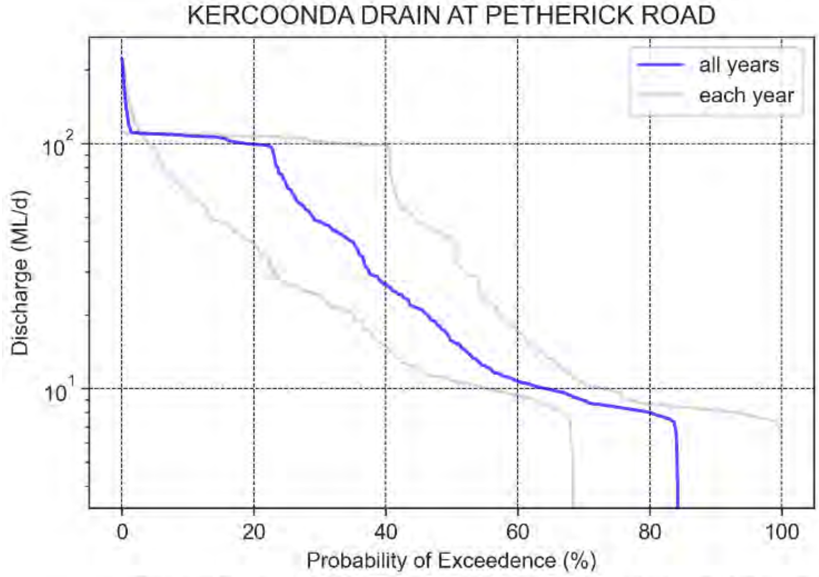

BAKERS RANGE WATERCOURSE @ G Cutting
all years
each year
Discharge (ML/d)
Probability of Exceedence (%)

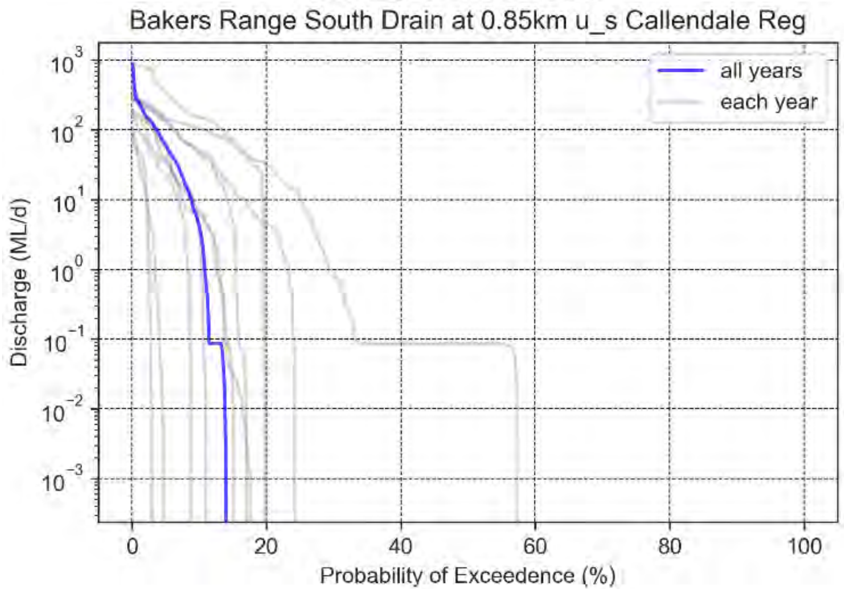

SALT CREEK OUTLET @ Salt Creek
all years
each year
Discharge (ML/d)
Probability of Exceedence (%)

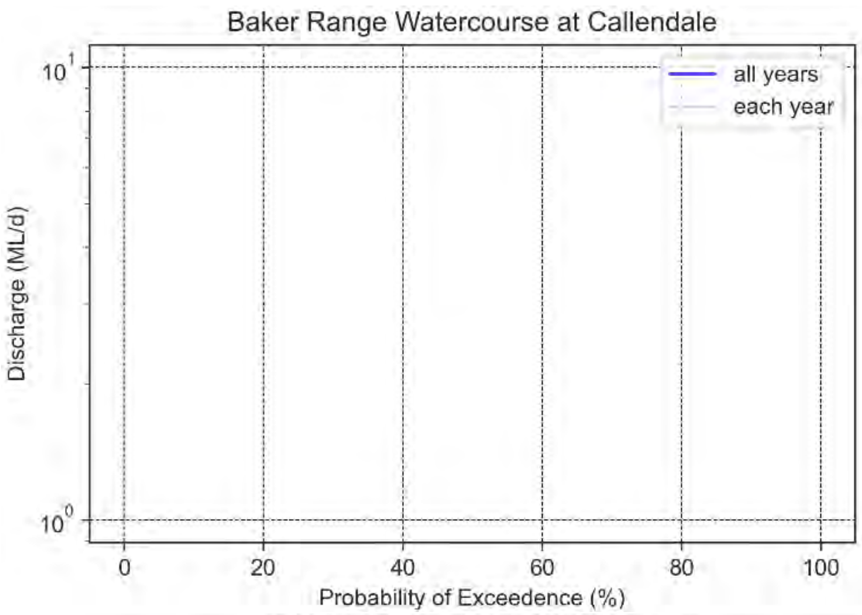

FAIRVIEW DRAIN @ Downstream of Keilira Road
all years
each year
Discharge (ML/d)
Probability of Exceedence (%)

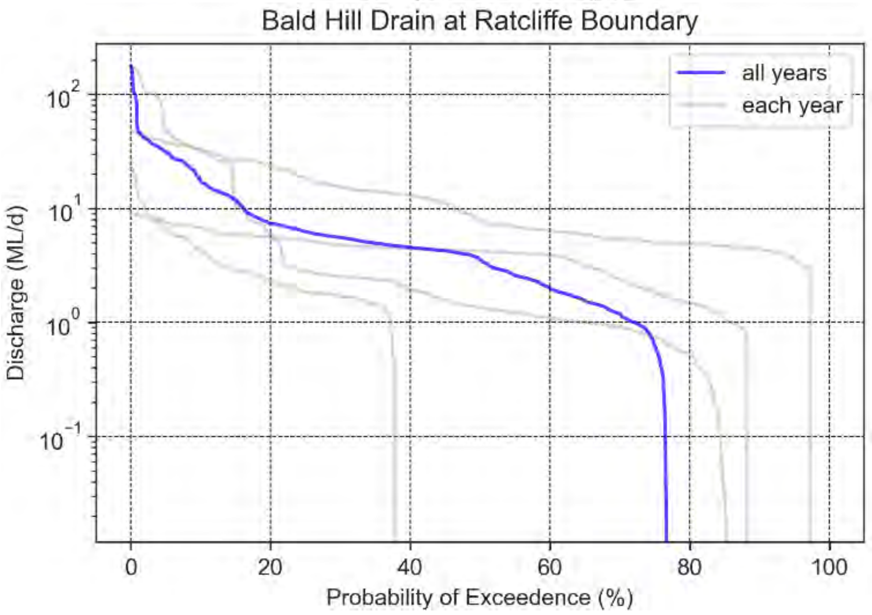

MARCOLLAT WATERCOURSE @ Ballater Road Jip Jip
all years
each year
Discharge (ML/d)
Probability of Exceedence (%)

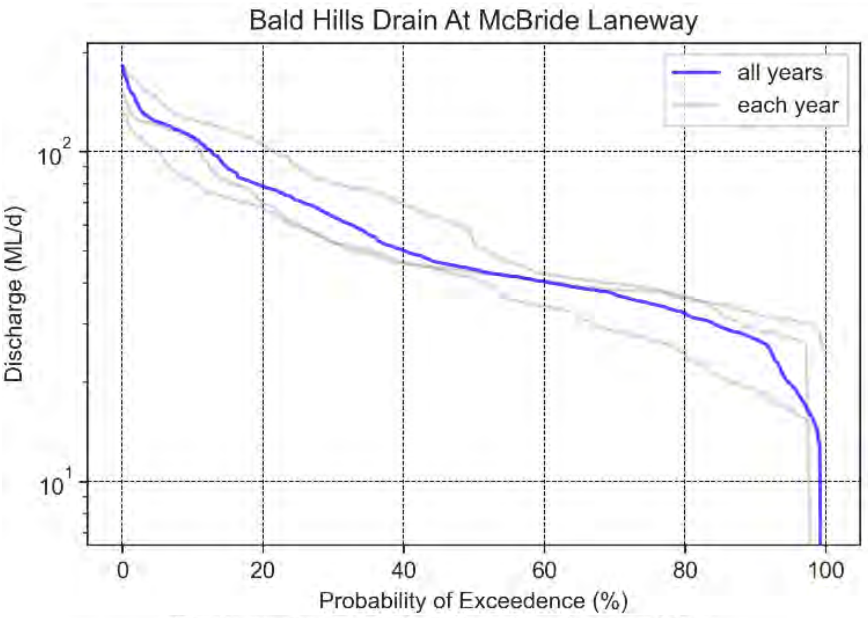

Mosquito Creek at Langkoop Hall
all years
each year
Discharge (ML/d)
Probability of Exceedence (%)

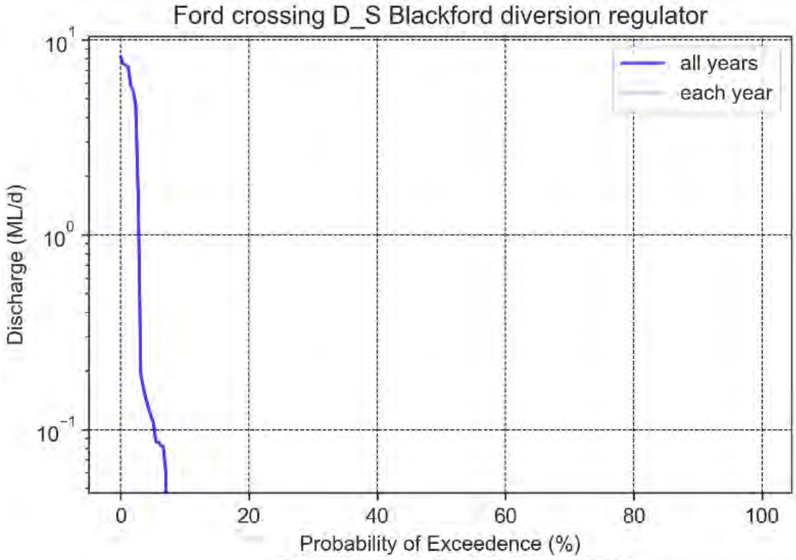

KERCOONDA DRAIN AT PETHERICK ROAD
all years
each year
Discharge (ML/d)
Probability of Exceedence (%)

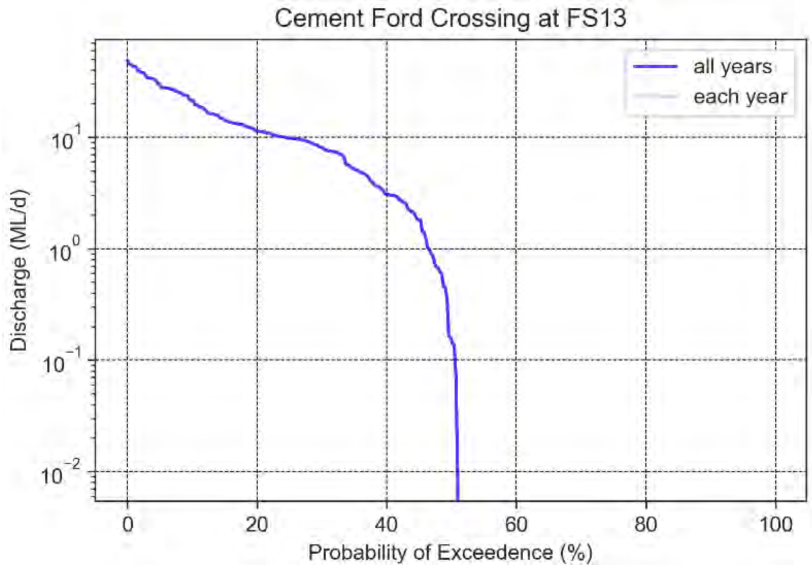

Bakers Range South Drain at 0.85km u_s Callendale Reg
all years
each year
Discharge (ML/d)
Probability of Exceedence (%)


Baker Range Watercourse at Callendale
all years
each year
Discharge (ML/d)
10^1
10^0
0
20
40
60
80
100
Probability of Exceedence (%)

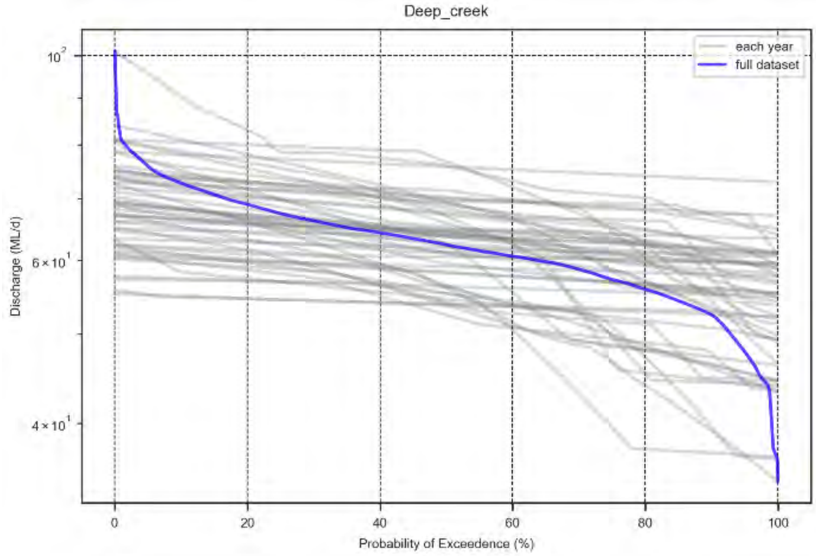

Bald Hill Drain at Ratcliffe Boundary
all years
each year
Discharge (ML/d)
10^2
10^1
10^0
10^{-1}
0
20
40
60
80
100
Probability of Exceedence (%)

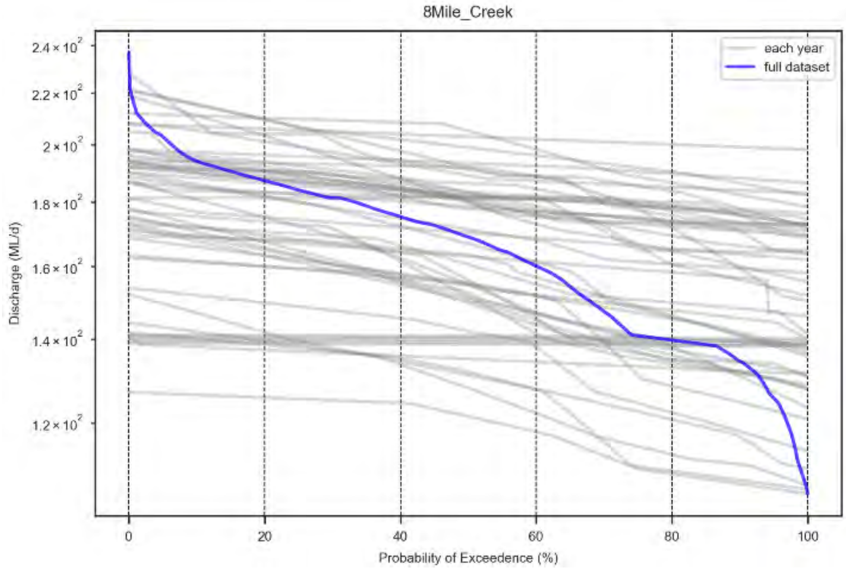

Bald Hills Drain At McBride Laneway
all years
each year
Discharge (ML/d)
10^2
10^1
0
20
40
60
80
100
Probability of Exceedence (%)

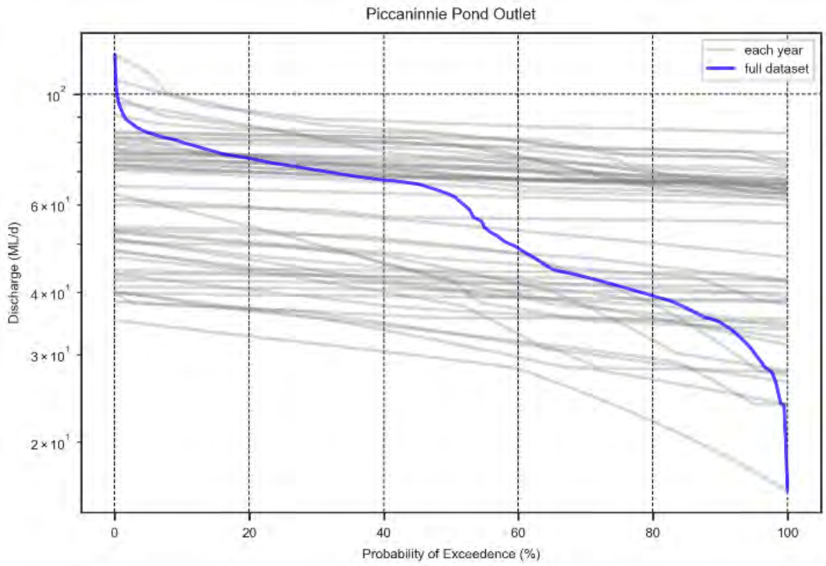

Ford crossing D_S Blackford diversion regulator
all years
each year
Discharge (ML/d)
10^1
10^0
10^{-1}
0
20
40
60
80
100
Probability of Exceedence (%)

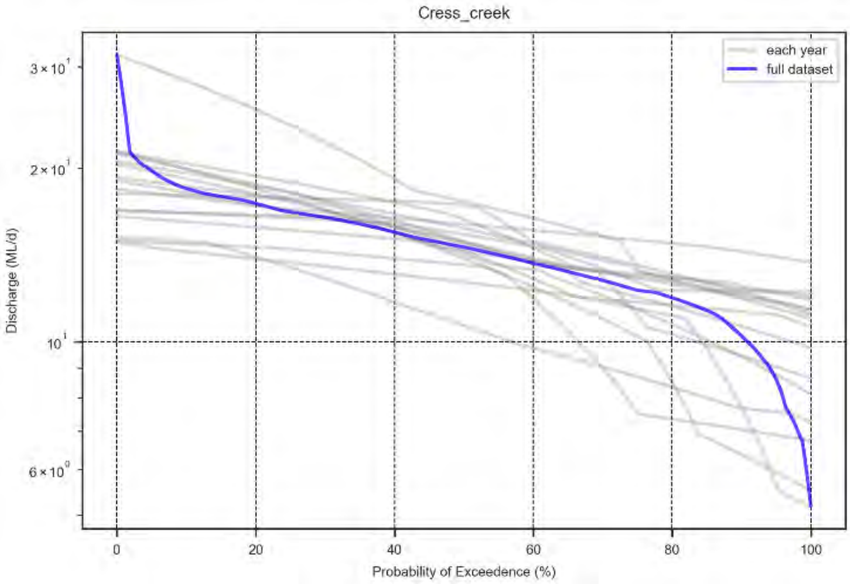

Cement Ford Crossing at FS13
all years
each year
Discharge (ML/d)
10^1
10^0
10^{-1}
10^{-2}
0
20
40
60
80
100
Probability of Exceedence (%)

Flow Duration Curves – Coastal Creeks

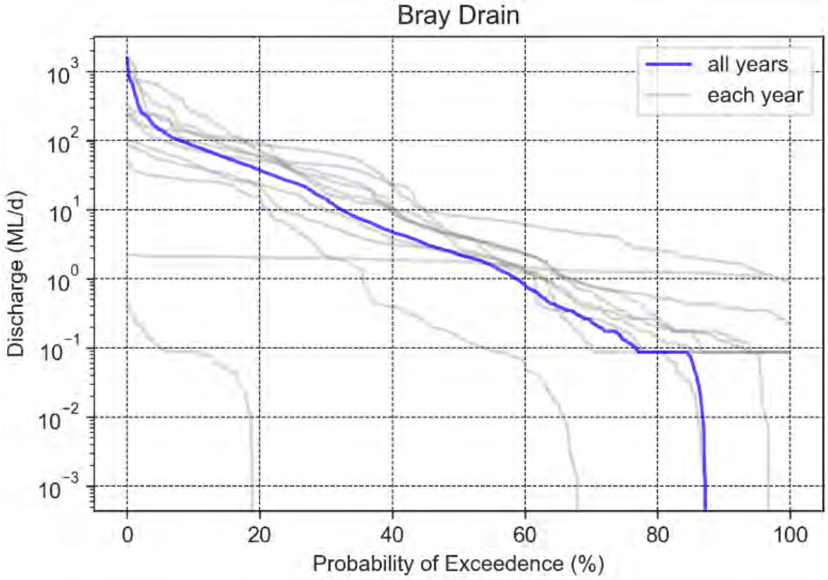


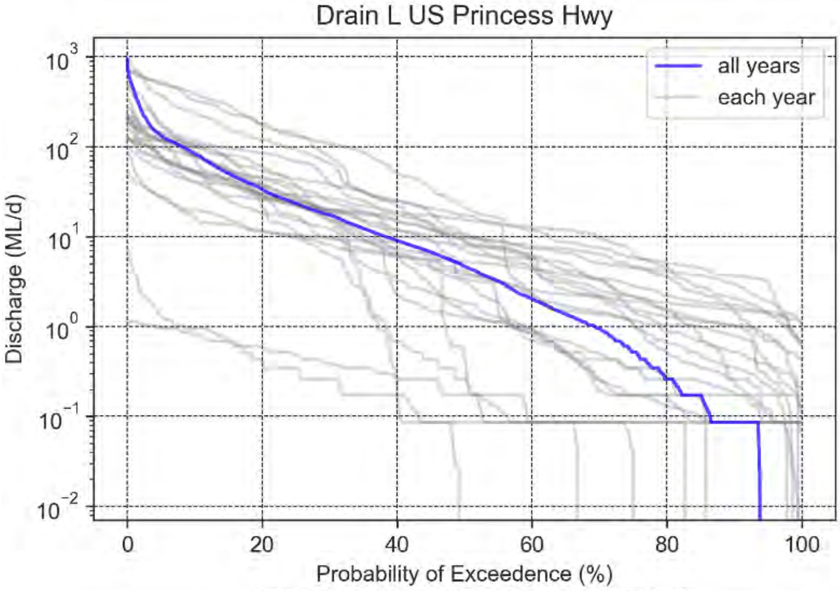


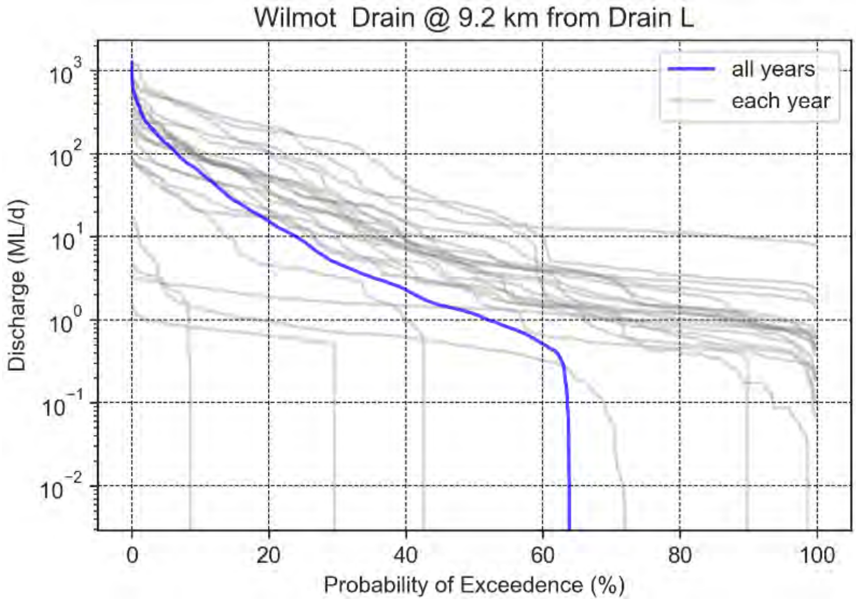

Piccaninnie Pond Outlet
each year
full dataset
Discharge (ML/d)
10^2
6×10^1
4×10^1
3×10^1
2×10^1
0
20
40
60
80
100
Probability of Exceedence (%)

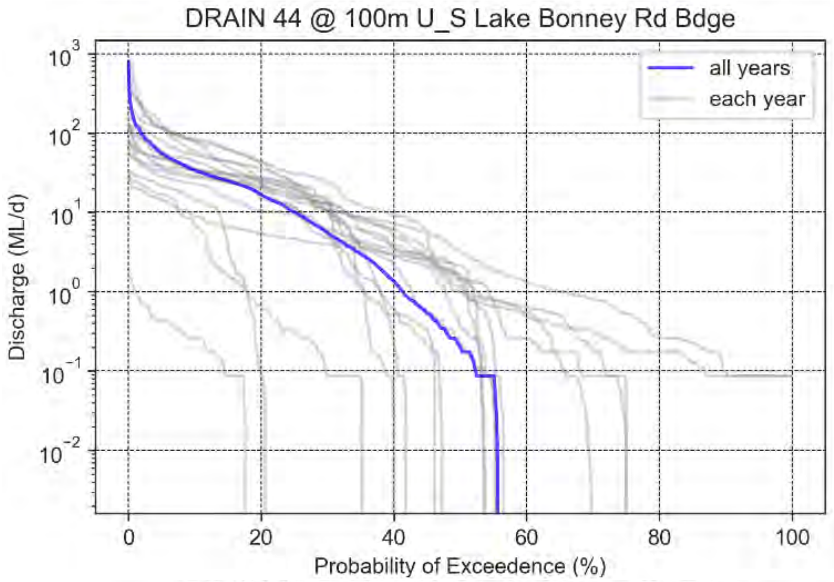

Cress_creek
each year
full dataset
Discharge (ML/d)
3×10^1
2×10^1
10^1
6×10^0
0
20
40
60
80
100
Probability of Exceedence (%)

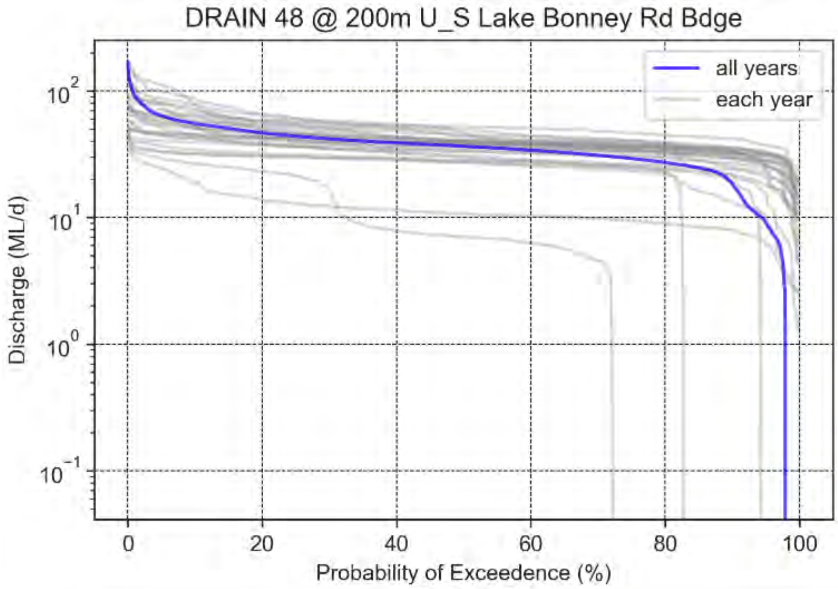
Flow Duration Curves – Historical Sites

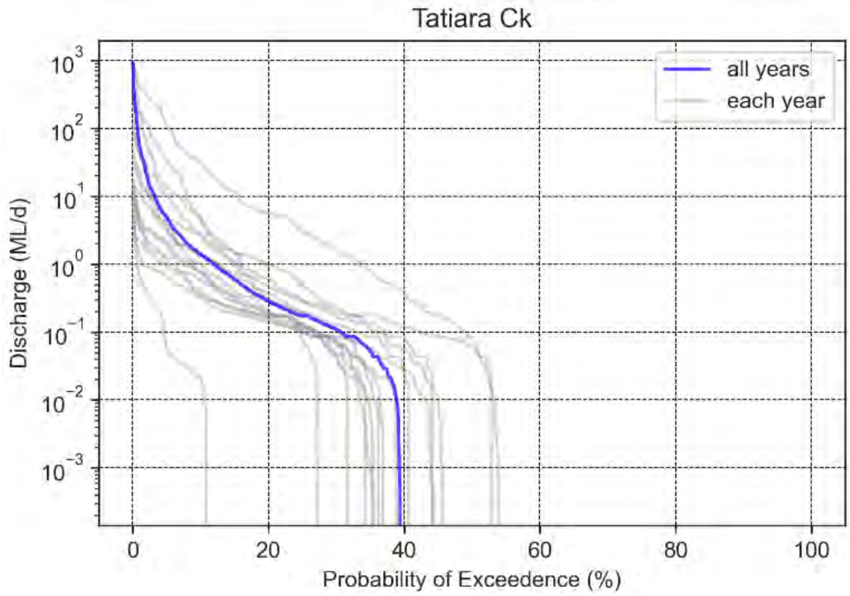


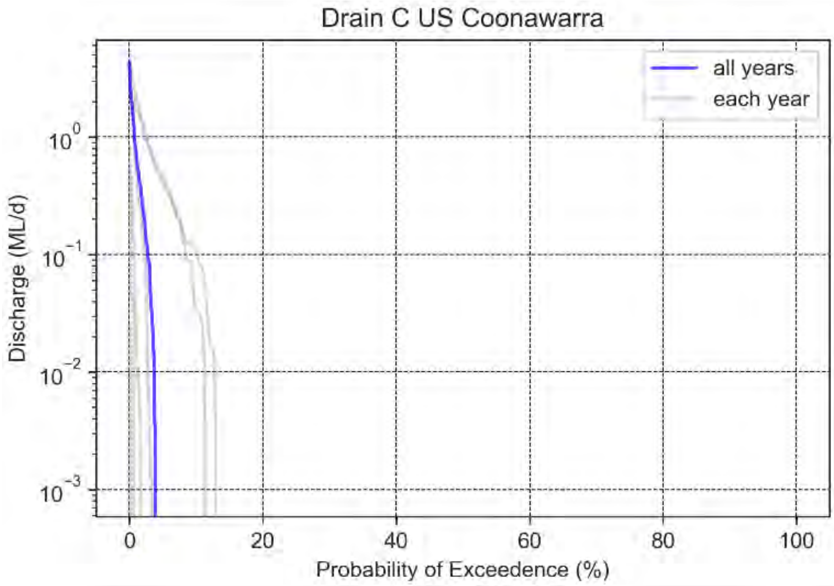


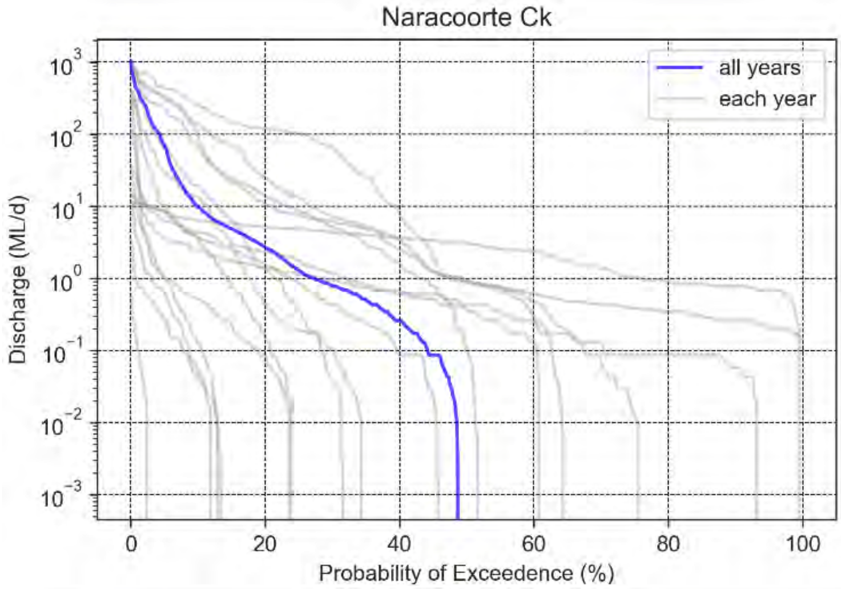


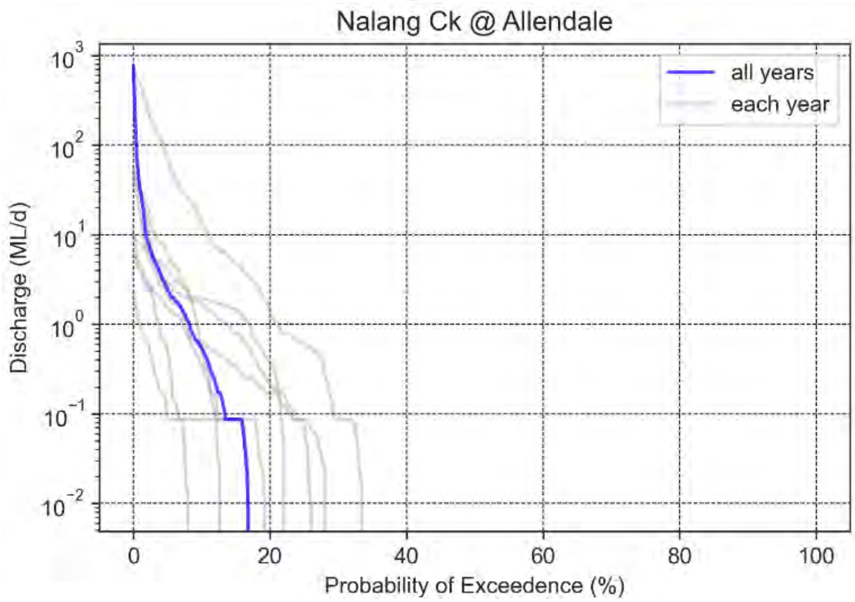

DRAIN 44 @ 100m U_S Lake Bonney Rd Bdge
all years
each year
Discharge (ML/d)
Probability of Exceedence (%)

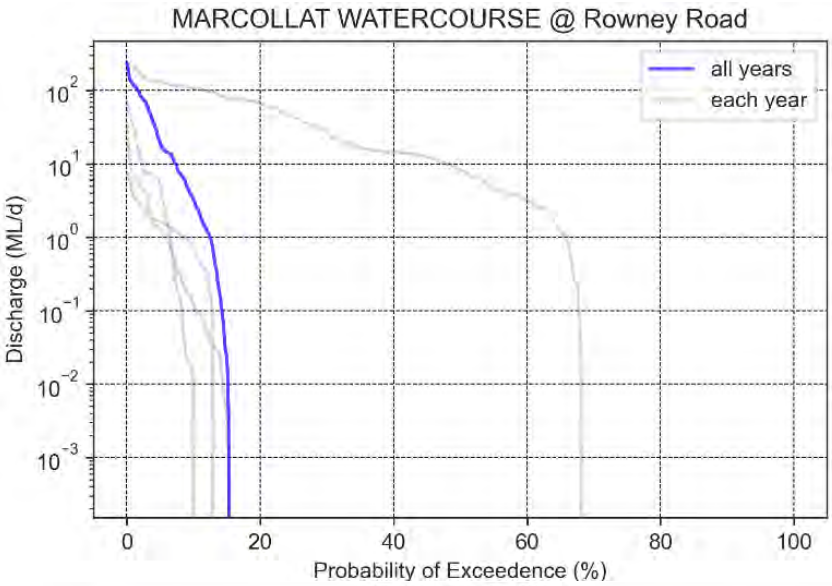

DRAIN 48 @ 200m U_S Lake Bonney Rd Bdge
all years
each year
Discharge (ML/d)
Probability of Exceedence (%)

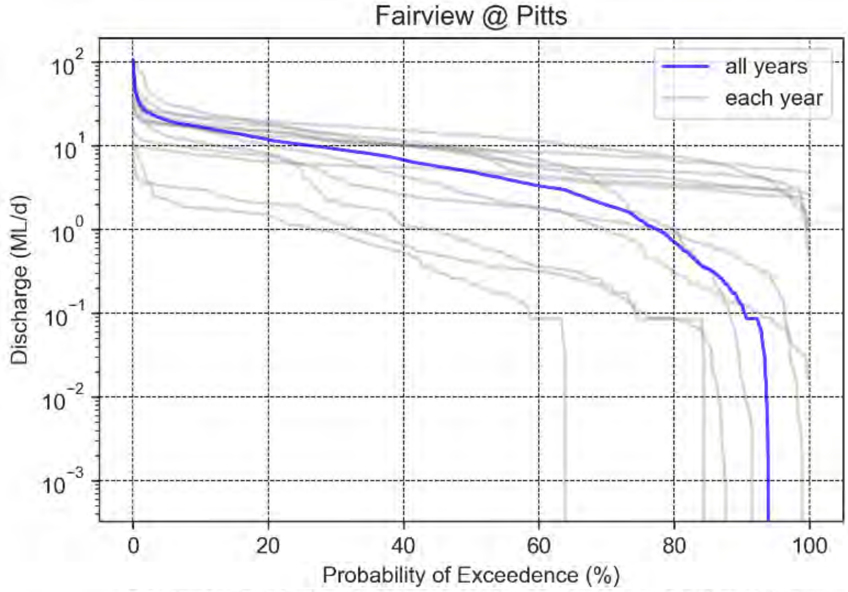

Tatiara Ck
all years
each year
Discharge (ML/d)
Probability of Exceedence (%)

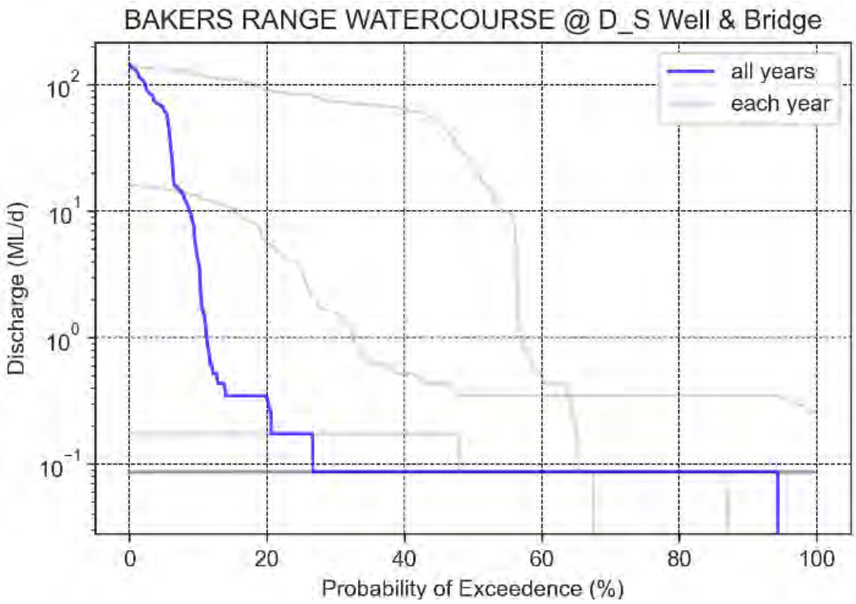

Drain C US Coonawarra
all years
each year
Discharge (ML/d)
10^0
10^-1
10^-2
10^-3
0
20
40
60
80
100
Probability of Exceedence (%)

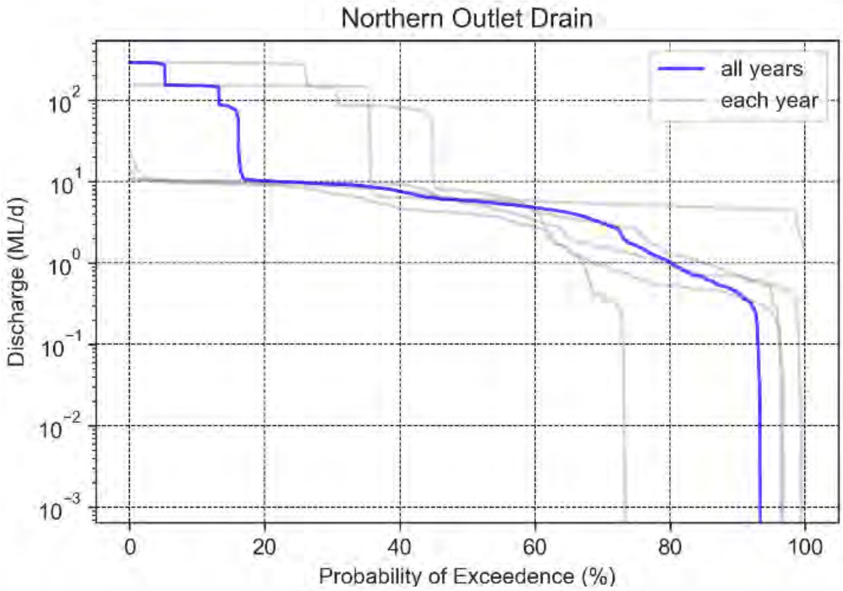

Naracoorte Ck
all years
each year
Discharge (ML/d)
10^3
10^2
10^1
10^0
10^-1
10^-2
10^-3
0
20
40
60
80
100
Probability of Exceedence (%)

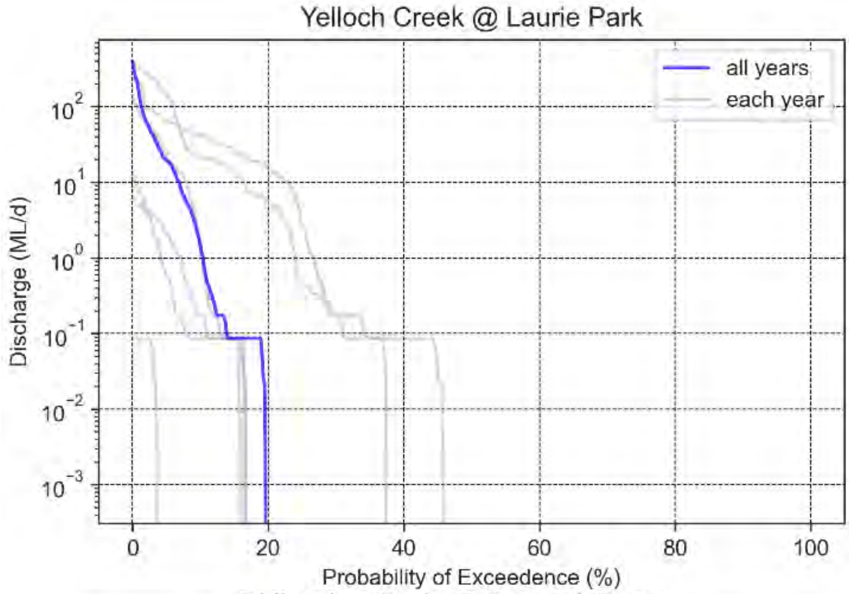

Nalang Ck @ Allendale
all years
each year
Discharge (ML/d)
10^3
10^2
10^1
10^0
10^-1
10^-2
0
20
40
60
80
100
Probability of Exceedence (%)

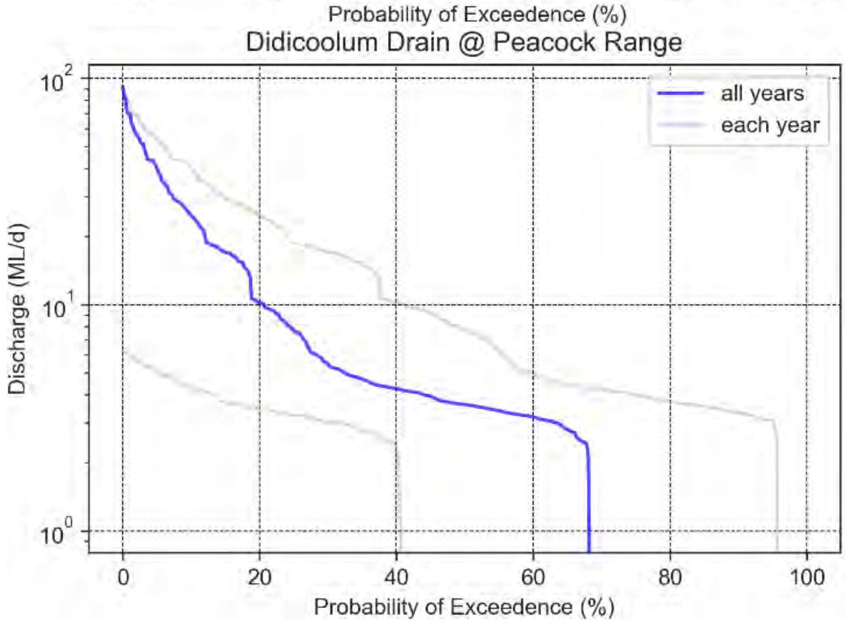

MARCOLLAT WATERCOURSE @ Rowney Road
all years
each year
Discharge (ML/d)
10^2
10^1
10^0
10^{-1}
10^{-2}
10^{-3}
0
20
40
60
80
100
Probability of Exceedence (%)

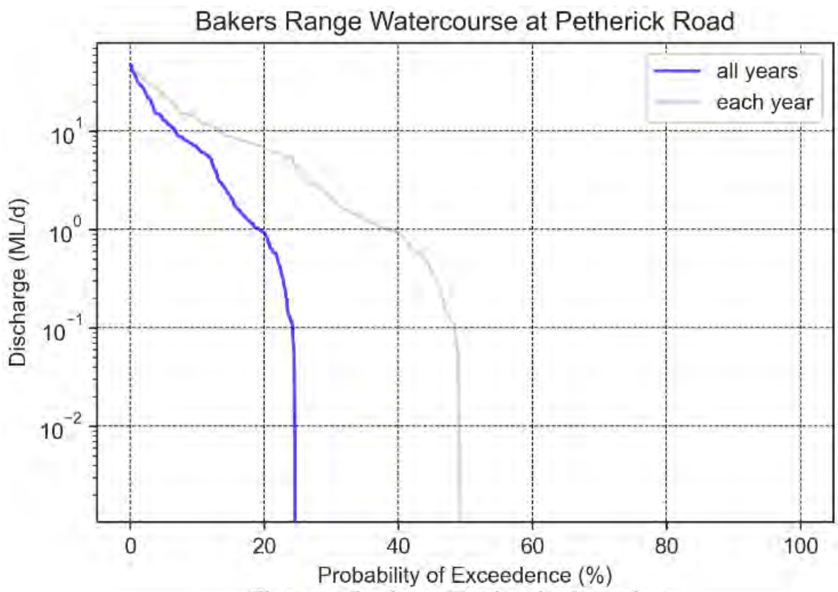

Fairview @ Pitts
all years
each year
Discharge (ML/d)
10^2
10^1
10^0
10^{-1}
10^{-2}
10^{-3}
0
20
40
60
80
100
Probability of Exceedence (%)

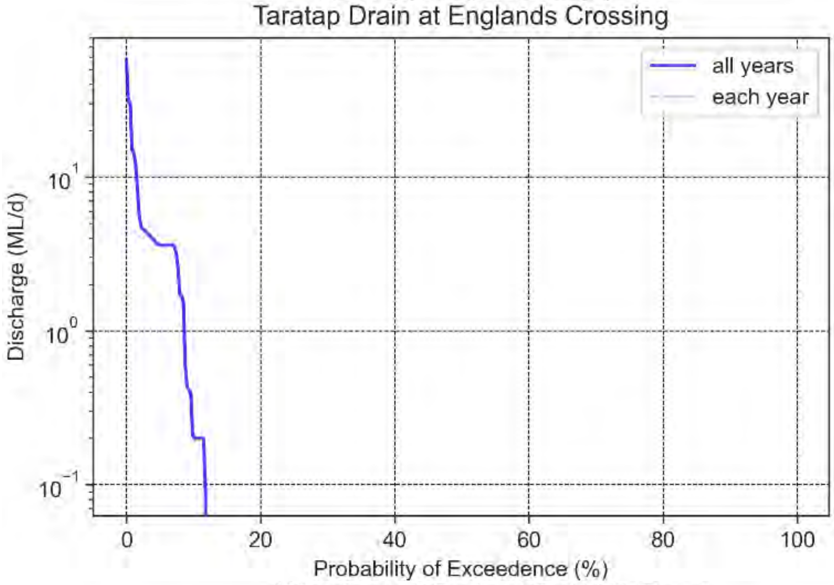

BAKERS RANGE WATERCOURSE @ D_S Well & Bridge
all years
each year
Discharge (ML/d)
10^2
10^1
10^0
10^{-1}
0
20
40
60
80
100
Probability of Exceedence (%)

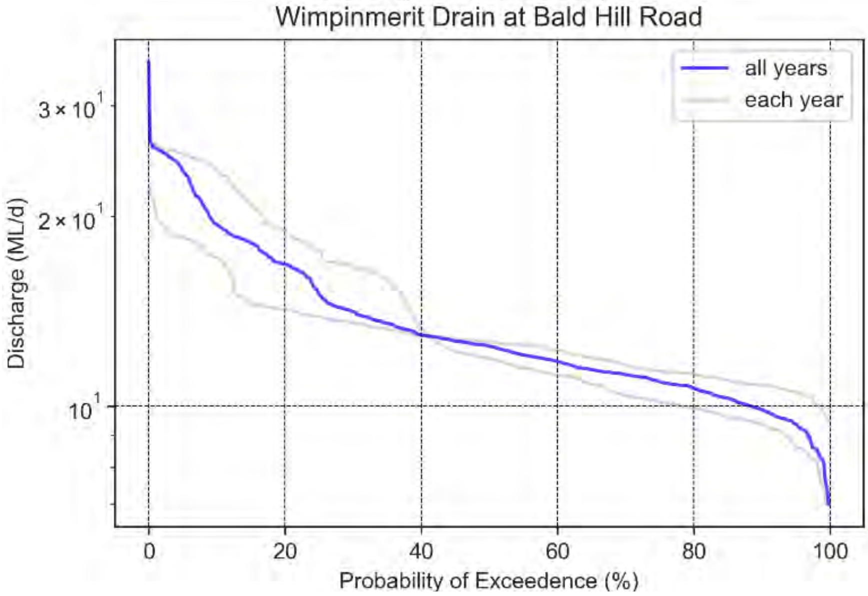

Northern Outlet Drain
all years
each year
Discharge (ML/d)
Probability of Exceedence (%)
0
20
40
60
80
100

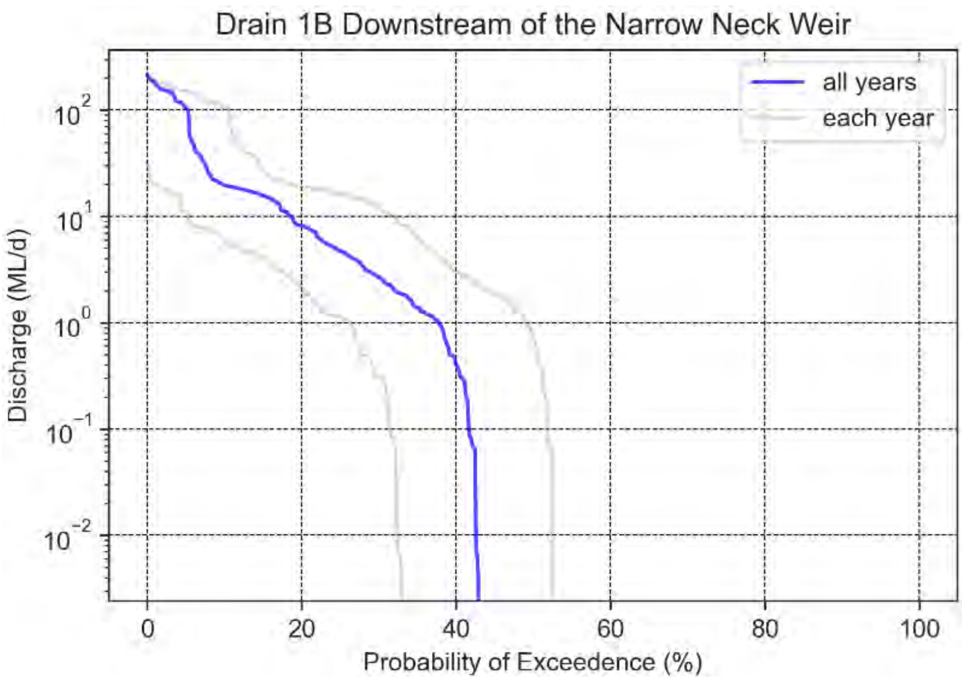

Yelloch Creek @ Laurie Park
all years
each year
Discharge (ML/d)
Probability of Exceedence (%)
0
20
40
60
80
100


Didicoolum Drain @ Peacock Range
all years
each year
Discharge (ML/d)
Probability of Exceedence (%)
0
20
40
60
80
100


Bakers Range Watercourse at Petherick Road
all years
each year
Discharge (ML/d)
10^1
10^0
10^{-1}
10^{-2}
0
20
40
60
80
100
Probability of Exceedence (%)


Taratap Drain at Englands Crossing
all years
each year
Discharge (ML/d)
10^1
10^0
10^{-1}
0
20
40
60
80
100
Probability of Exceedence (%)


Wimpinmerit Drain at Bald Hill Road
all years
each year
Discharge (ML/d)
3×10^1
2×10^1
10^1
0
20
40
60
80
100
Probability of Exceedence (%)

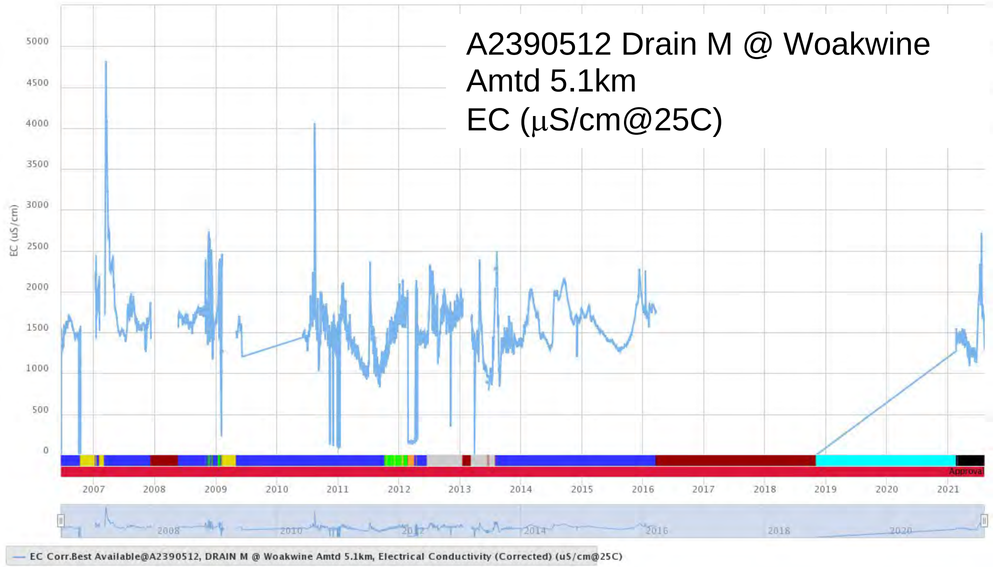


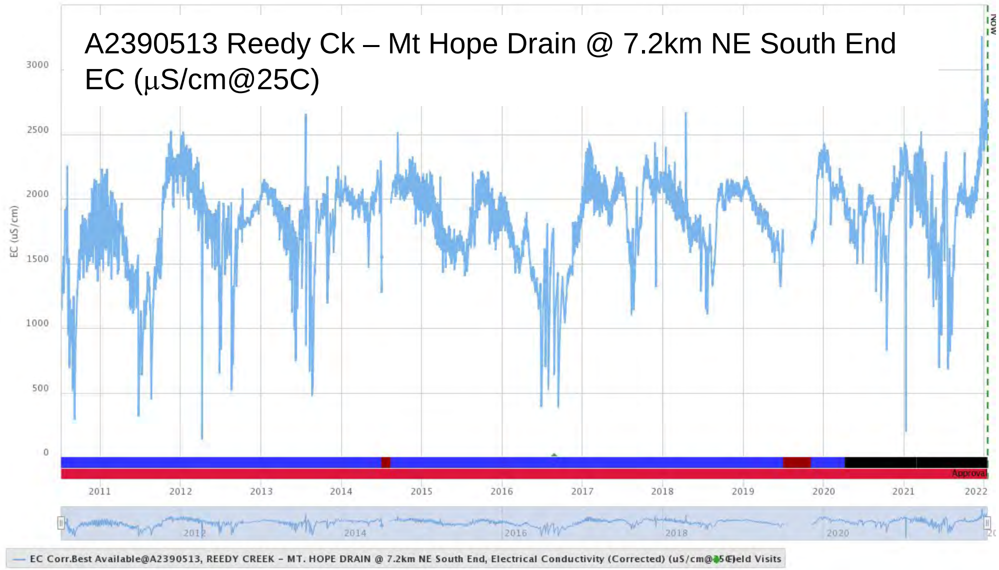
Drain 1B Downstream of the Narrow Neck Weir
all years
each year
Discharge (ML/d)
10^2
10^1
10^0
10^-1
10^-2
0
20
40
60
80
100
Probability of Exceedence (%)

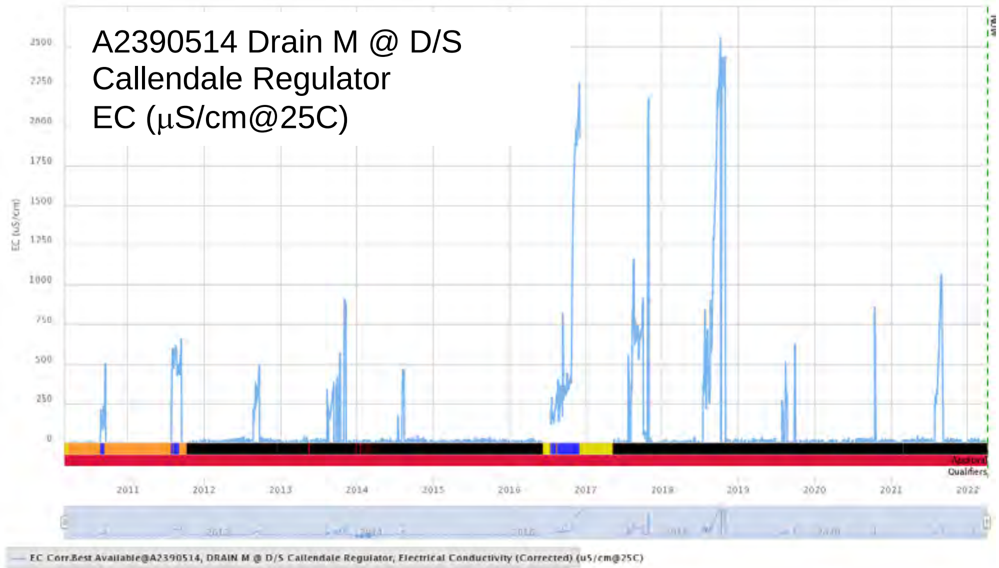
Appendix B – All Available Electrical Conductivity Graphs for SEDN and Historical Gauging Stations

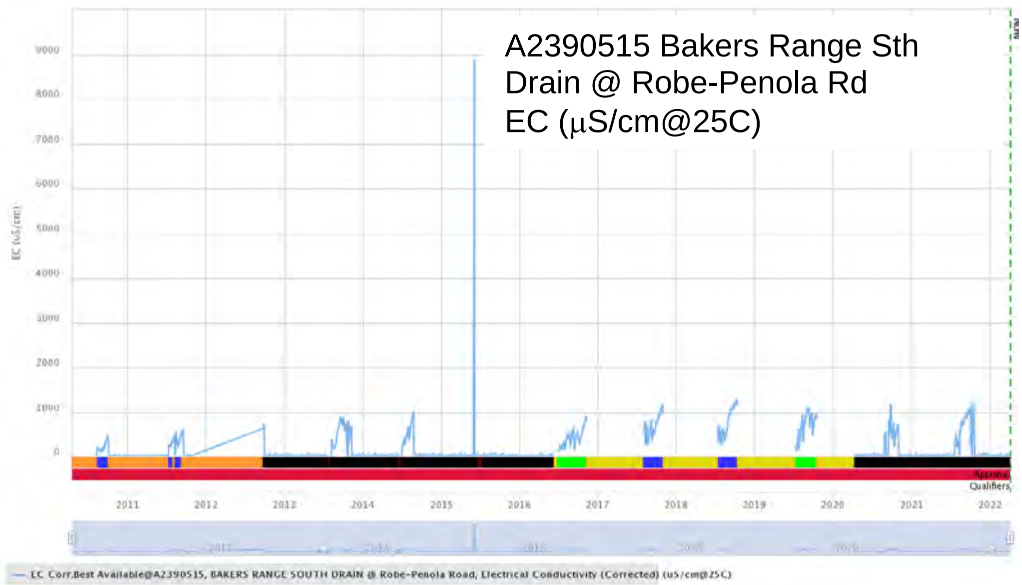
Key for data grade and approval level (shown in coloured bars at the base of each graph).

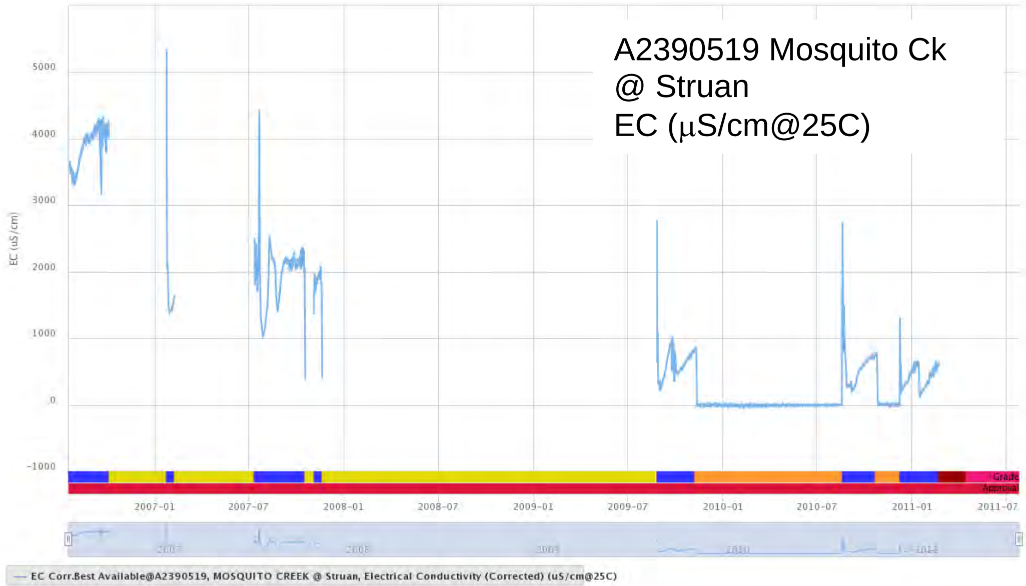
EC Graphs – SEDN Gauging Stations

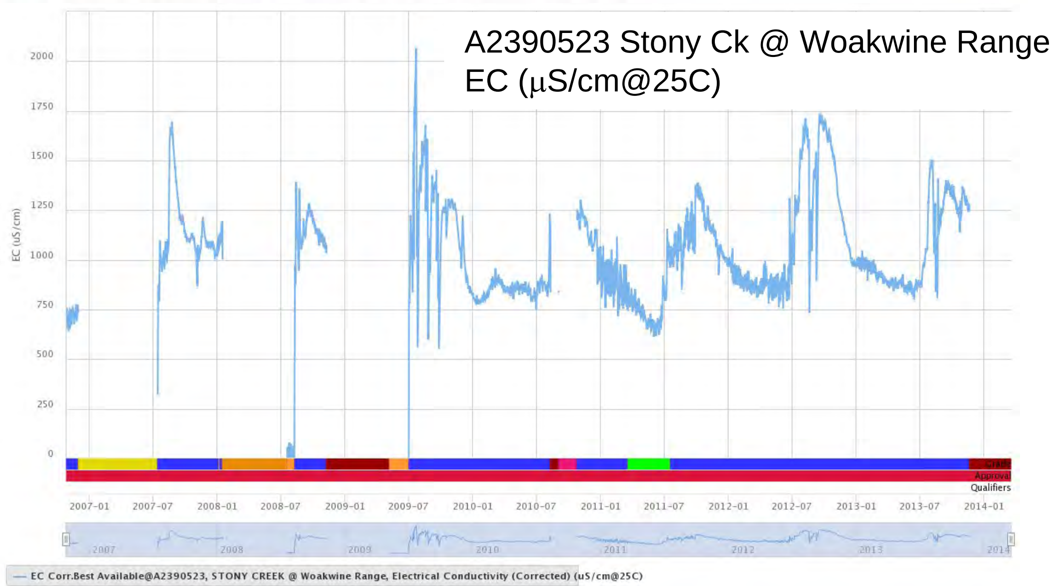


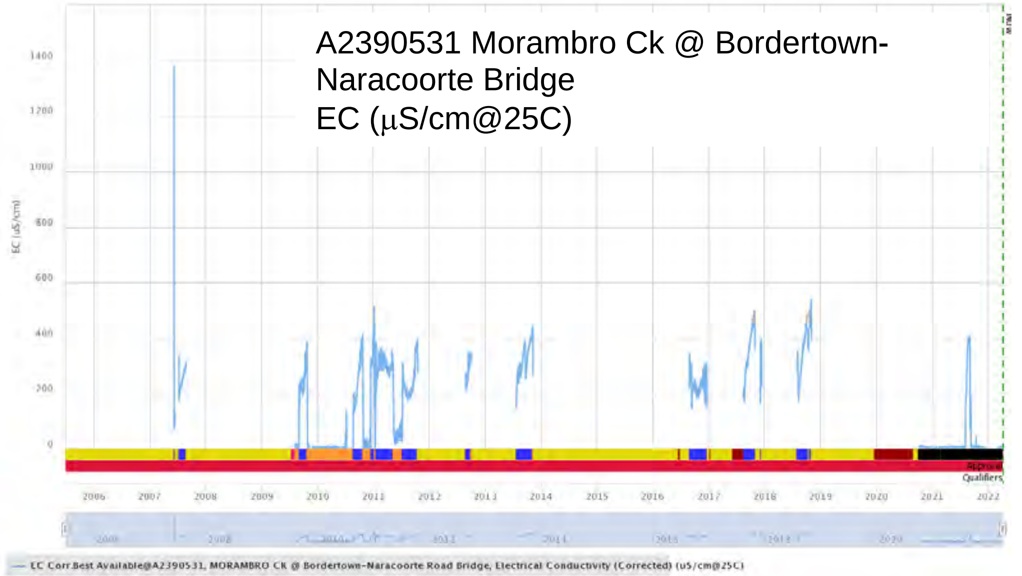


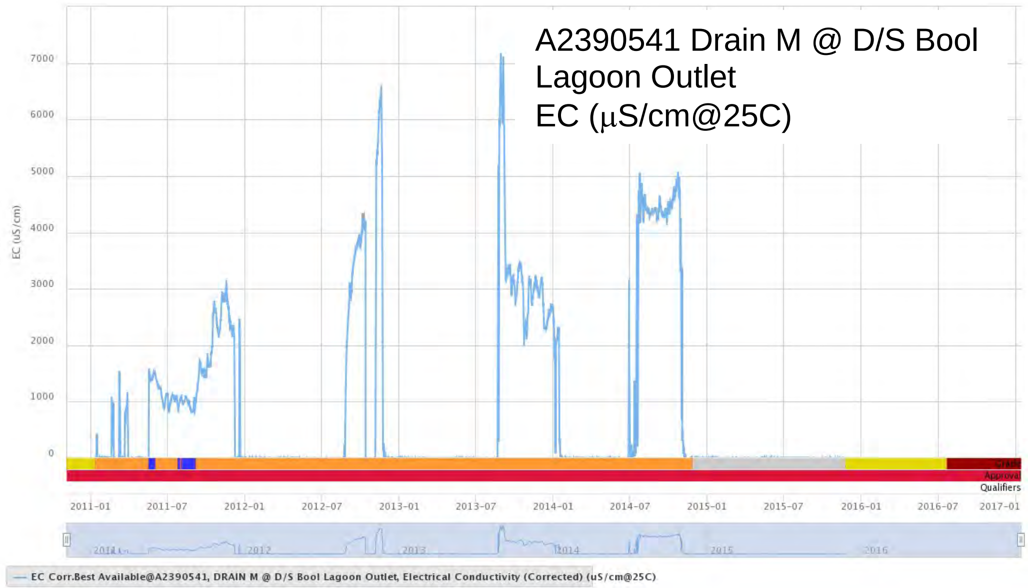


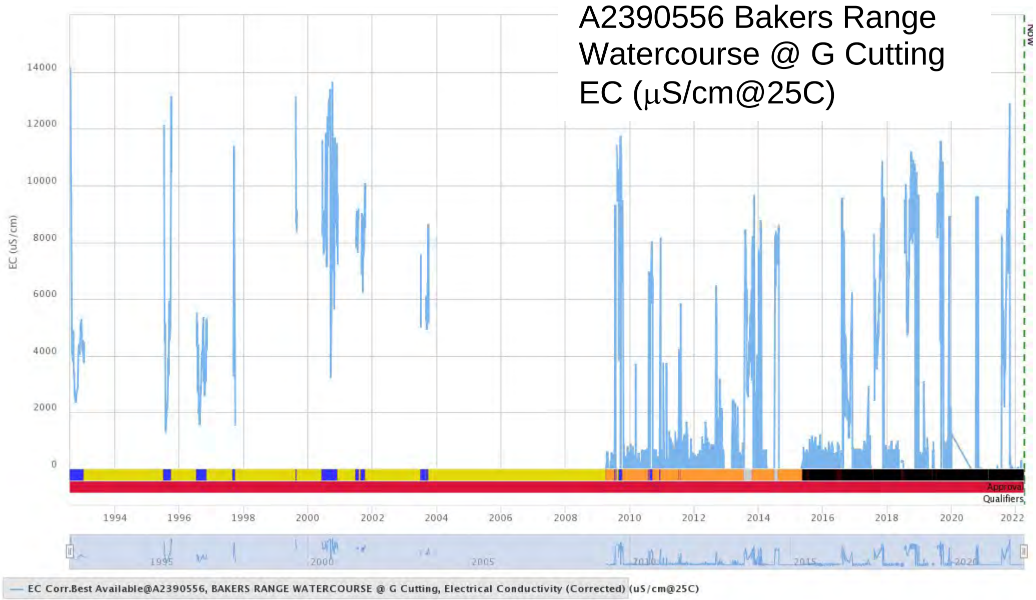

A2390515 Bakers Range Sth
Drain @ Robe-Penola Rd
EC (µS/cm@25C)
EC Corr.Best Available@A2390515, BAKERS RANGE SOUTH DRAIN @ Robe-Penola Road, Electrical Conductivity (Corrected) (uS/cm@25C)

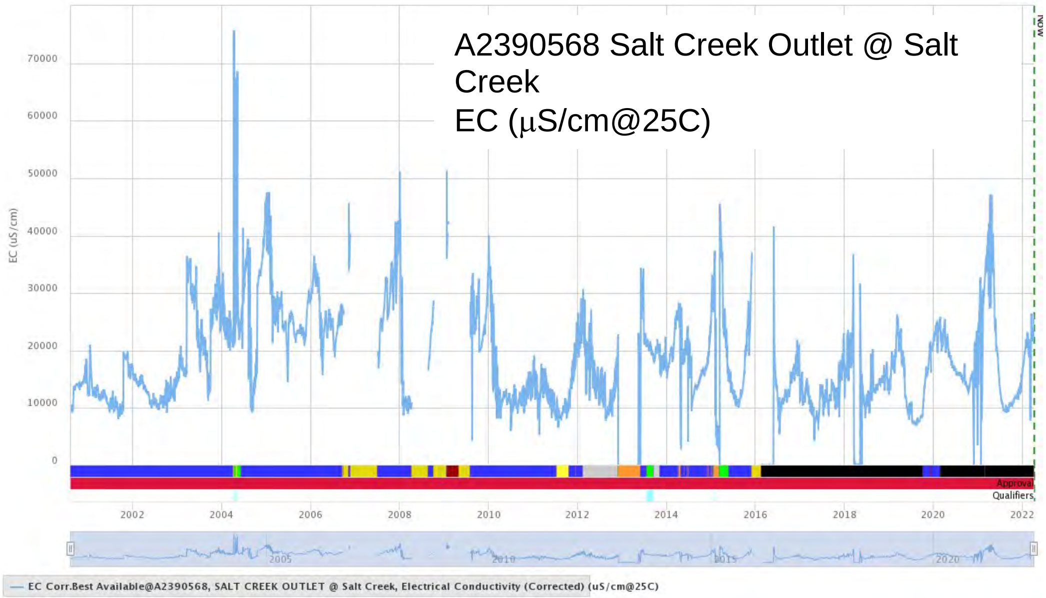

A2390519 Mosquito Ck
@ Struan
EC (µS/cm@25C)
EC Corr.Best Available@A2390519, MOSQUITO CREEK @ Struan, Electrical Conductivity (Corrected) (uS/cm@25C)

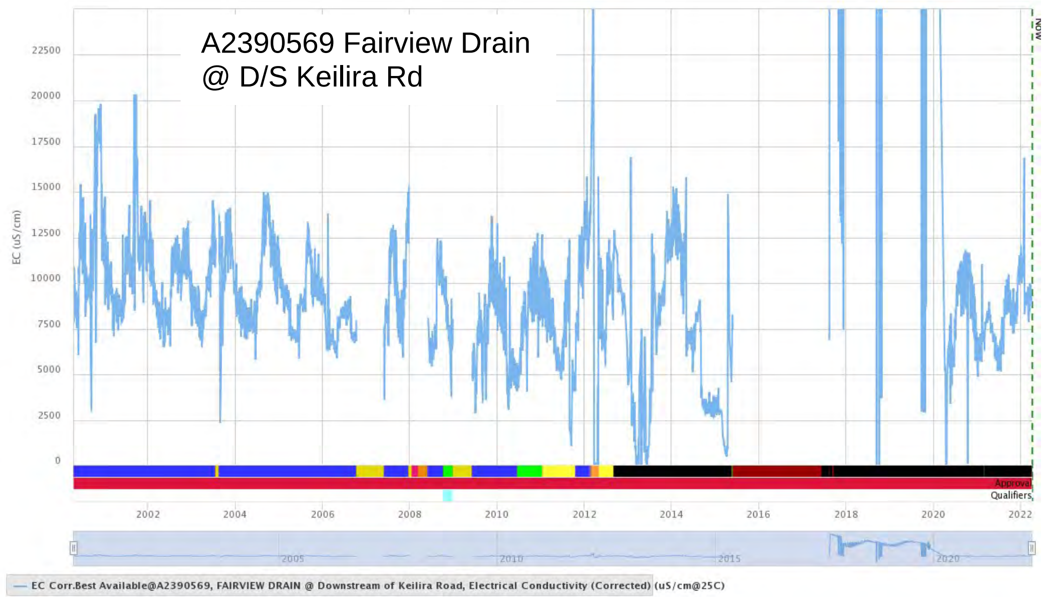

A2390523 Stony Ck @ Woakwine Range
EC (µS/cm@25C)
EC Corr.Best Available@A2390523, STONY CREEK @ Woakwine Range, Electrical Conductivity (Corrected) (uS/cm@25C)

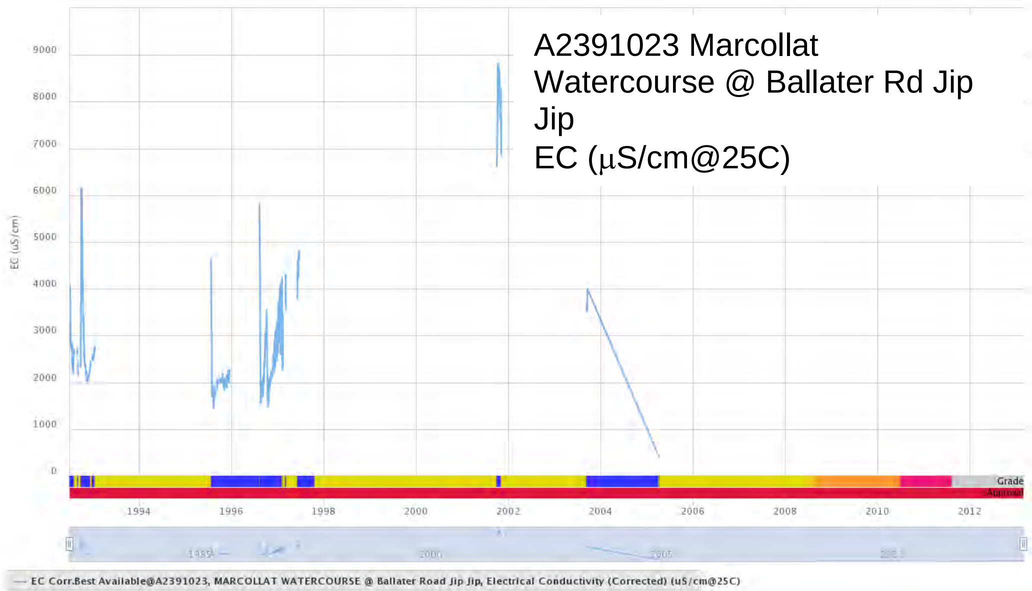

A2390531 Morambro Ck @ Bordertown-Naracoorte Bridge
EC (µS/cm@25C)
EC (uS/cm)
0
200
400
600
800
1000
1200
1400
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
Approval
Qualifiers
EC Corr.Best Available@A2390531, MORAMBRO CK @ Bordertown-Naracoorte Road Bridge, Electrical Conductivity (Corrected) (uS/cm@25C)

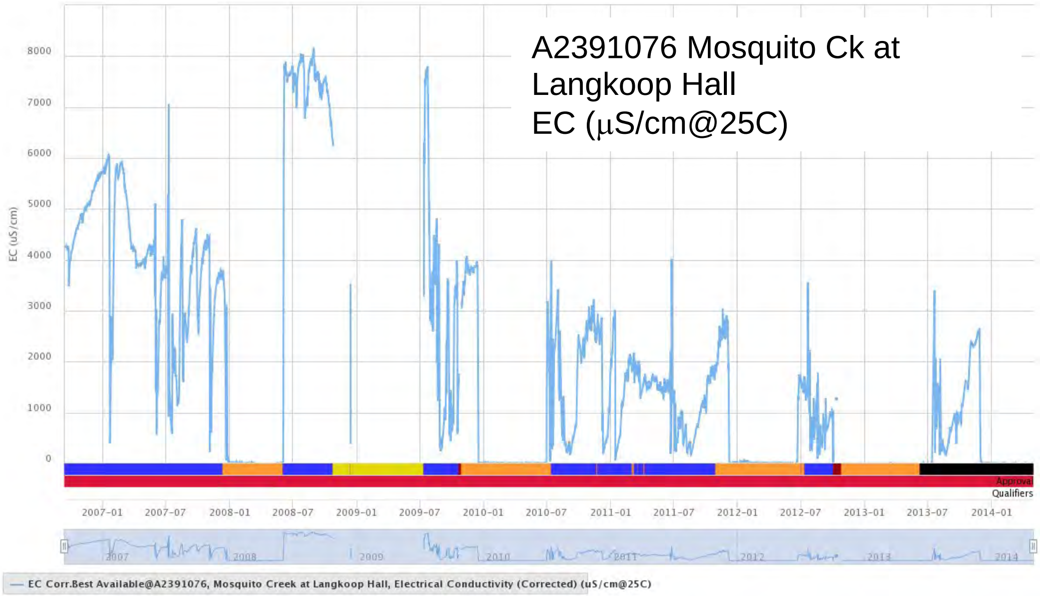

A2390541 Drain M @ D/S Bool Lagoon Outlet
EC (µS/cm@25C)
EC (uS/cm)
0
1000
2000
3000
4000
5000
6000
7000
2011-01
2011-07
2012-01
2012-07
2013-01
2013-07
2014-01
2014-07
2015-01
2015-07
2016-01
2016-07
2017-01
Grade
Approval
Qualifiers
EC Corr.Best Available@A2390541, DRAIN M @ D/S Bool Lagoon Outlet, Electrical Conductivity (Corrected) (uS/cm@25C)

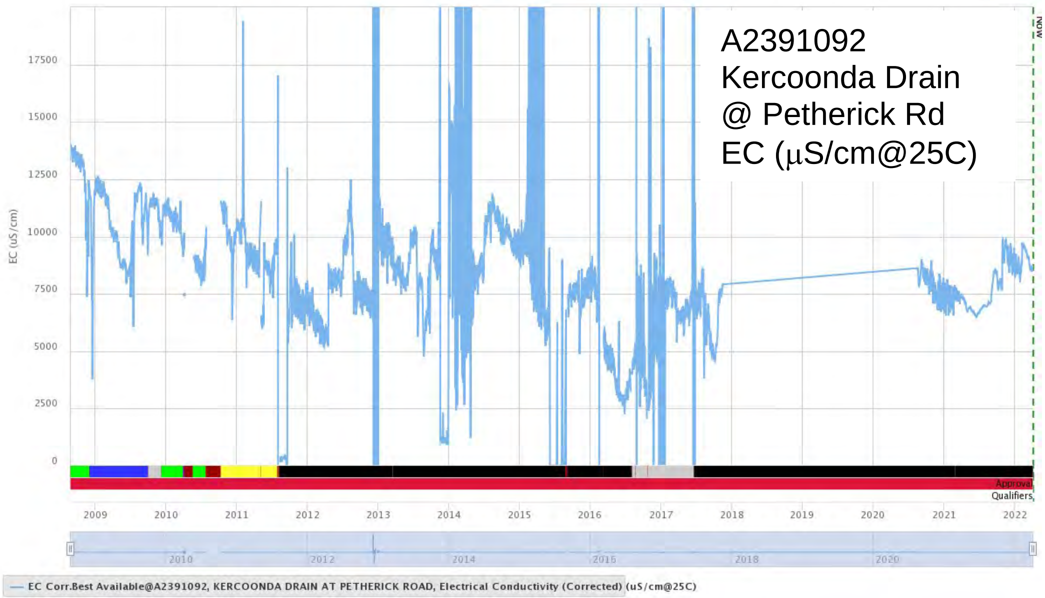

A2390556 Bakers Range Watercourse @ G Cutting
EC (µS/cm@25C)
EC (uS/cm)
14000
12000
10000
8000
6000
4000
2000
0
Approval
Qualifiers
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
NOW
EC Corr.Best Available@A2390556, BAKERS RANGE WATERCOURSE @ G Cutting, Electrical Conductivity (Corrected) (uS/cm@25C)

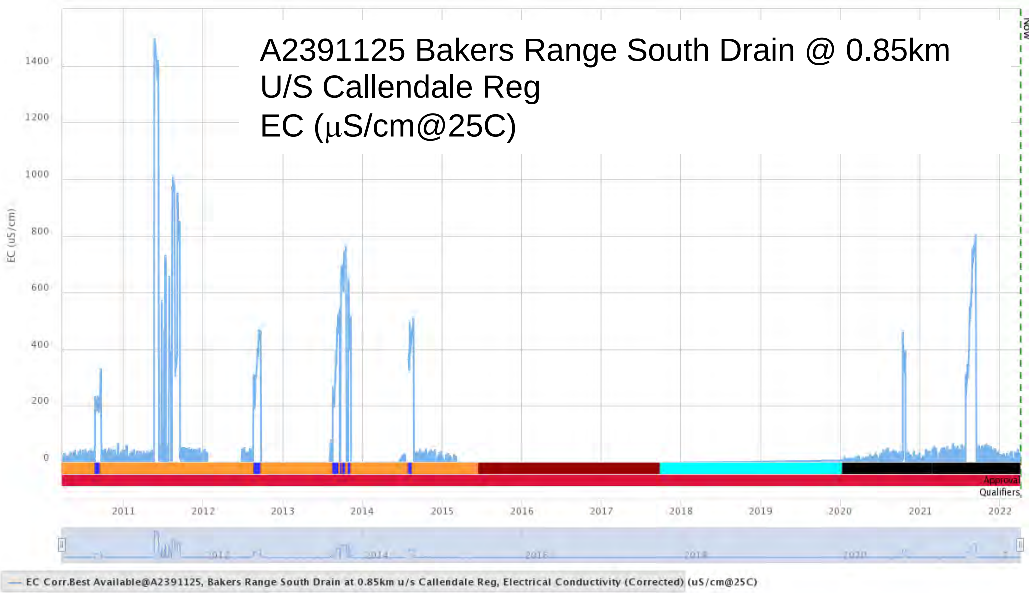

A2390568 Salt Creek Outlet @ Salt Creek
EC (µS/cm@25C)
EC (uS/cm)
70000
60000
50000
40000
30000
20000
10000
0
Approval
Qualifiers
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
NOW
EC Corr.Best Available@A2390568, SALT CREEK OUTLET @ Salt Creek, Electrical Conductivity (Corrected) (uS/cm@25C)

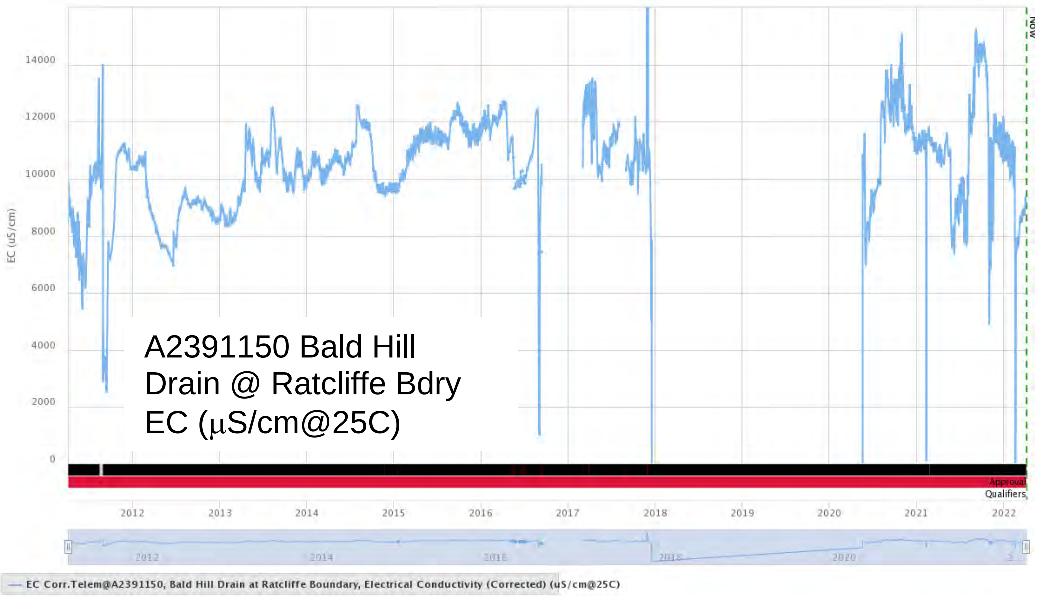

A2390569 Fairview Drain
@ D/S Keilira Rd
EC (uS/cm)
22500
20000
17500
15000
12500
10000
7500
5000
2500
0
Approval
Qualifiers
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
EC Corr.Best Available@A2390569, FAIRVIEW DRAIN @ Downstream of Keilira Road, Electrical Conductivity (Corrected) (uS/cm@25C)

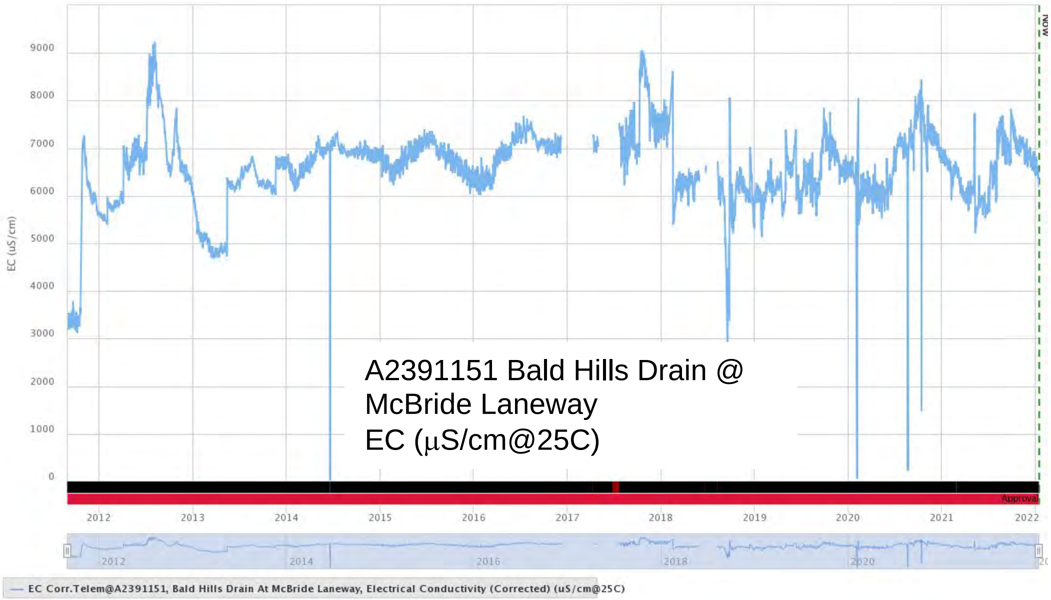

A2391023 Marcollat
Watercourse @ Ballater Rd Jip
Jip
EC (μS/cm@25C)
EC (uS/cm)
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
Grade
Approval
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
EC Corr.Best Available@A2391023, MARCOLLAT WATERCOURSE @ Ballater Road Jip Jip, Electrical Conductivity (Corrected) (uS/cm@25C)

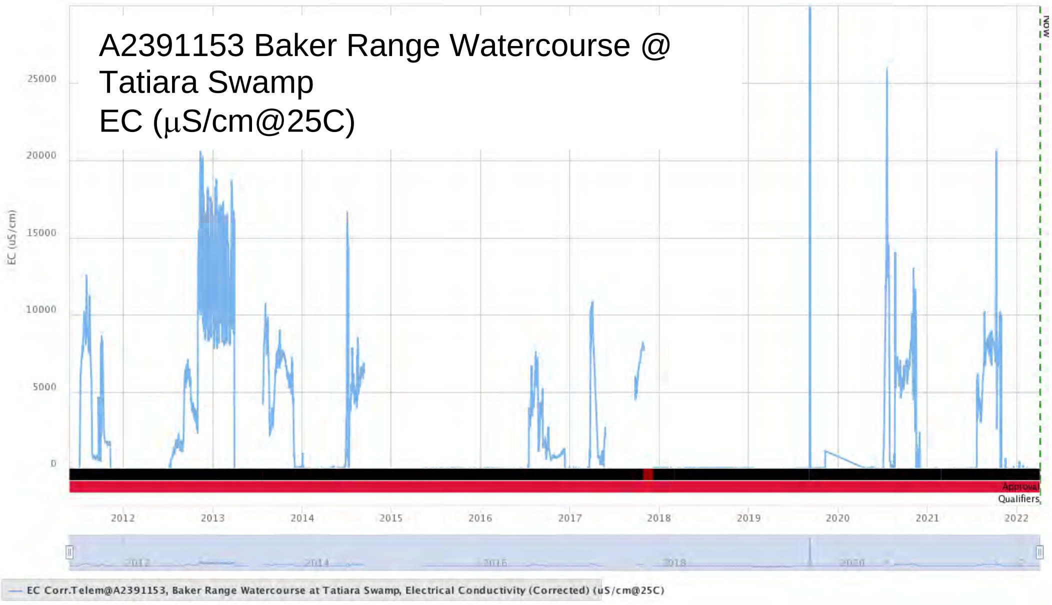

A2391076 Mosquito Ck at
Langkoop Hall
EC (µS/cm@25C)
8000
7000
6000
5000
4000
3000
2000
1000
0
EC (uS/cm)
Approval
Qualifiers
2007-01
2007-07
2008-01
2008-07
2009-01
2009-07
2010-01
2010-07
2011-01
2011-07
2012-01
2012-07
2013-01
2013-07
2014-01
EC Corr.Best Available@A2391076, Mosquito Creek at Langkoop Hall, Electrical Conductivity (Corrected) (uS/cm@25C)

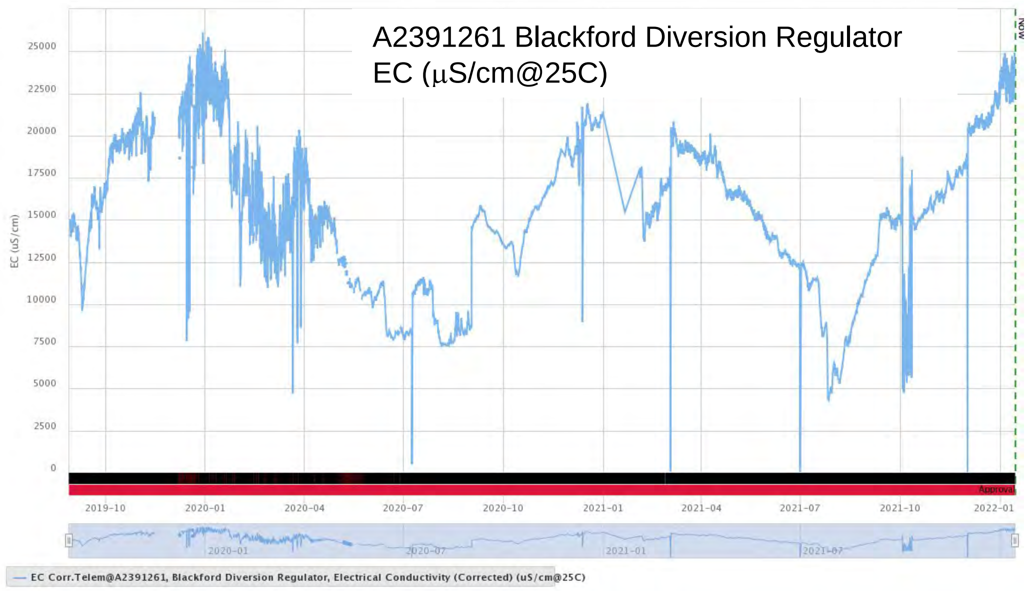

A2391092
Kercoonda Drain
@ Petherick Rd
EC (µS/cm@25C)
17500
15000
12500
10000
7500
5000
2500
0
EC (uS/cm)
NOW
Approval
Qualifiers
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
EC Corr.Best Available@A2391092, KERCOONDA DRAIN AT PETHERICK ROAD, Electrical Conductivity (Corrected) (uS/cm@25C)

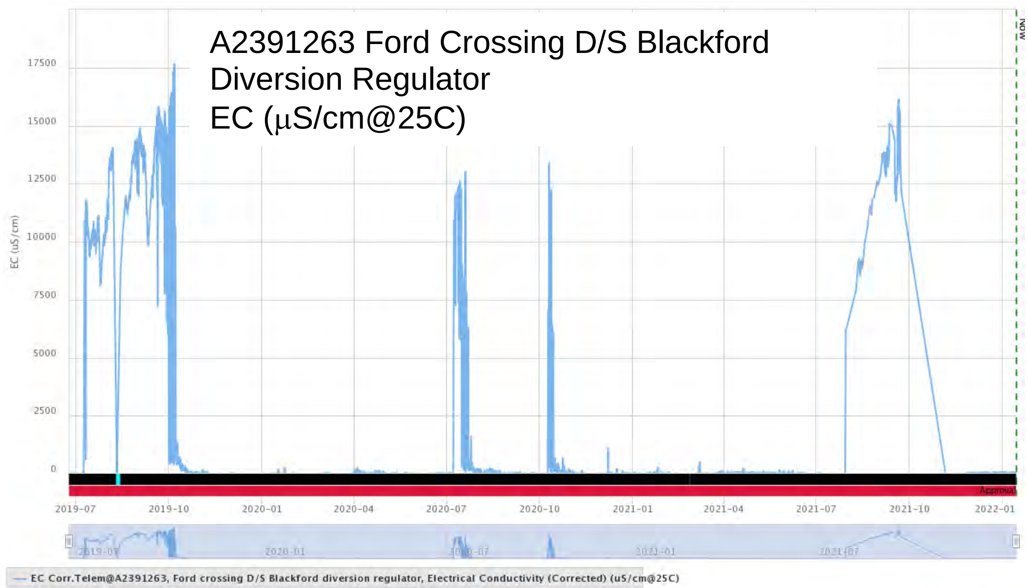

A2391125 Bakers Range South Drain @ 0.85km
U/S Callendale Reg
EC (µS/cm@25C)
EC (uS/cm)
1400
1200
1000
800
600
400
200
0
Approval
Qualifiers
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
EC Corr.Best Available@A2391125, Bakers Range South Drain at 0.85km u/s Callendale Reg, Electrical Conductivity (Corrected) (uS/cm@25C)

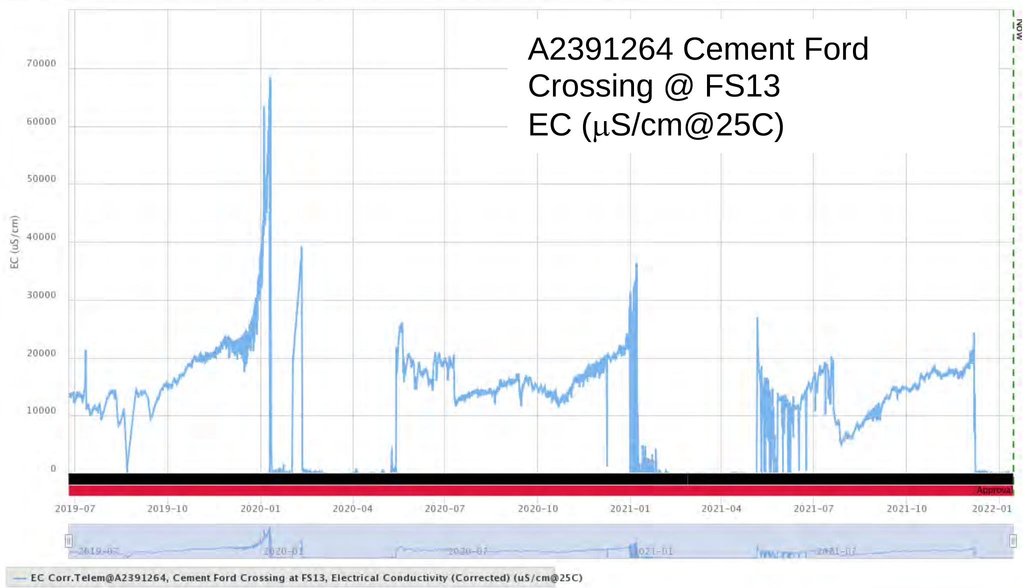

A2391150 Bald Hill
Drain @ Ratcliffe Bdry
EC (µS/cm@25C)
EC (uS/cm)
14000
12000
10000
8000
6000
4000
2000
0
Approval
Qualifiers
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
EC Corr.Telem@A2391150, Bald Hill Drain at Ratcliffe Boundary, Electrical Conductivity (Corrected) (uS/cm@25C)


A2391151 Bald Hills Drain @
McBride Laneway
EC (µS/cm@25C)
EC (uS/cm)
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
NOW
Approval
EC Corr.Telem@A2391151, Bald Hills Drain At McBride Laneway, Electrical Conductivity (Corrected) (uS/cm@25C)

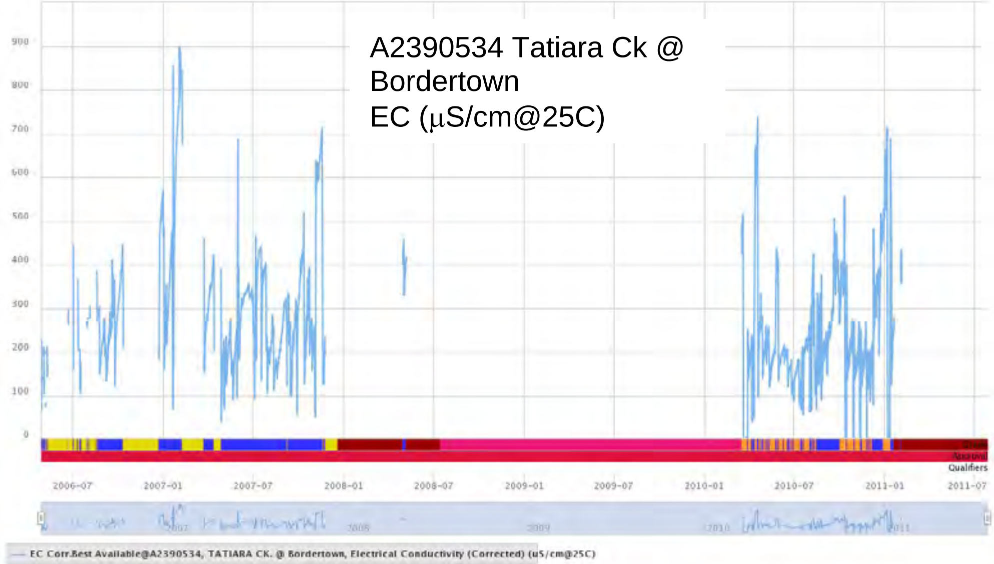

A2391153 Baker Range Watercourse @
Tatiara Swamp
EC (µS/cm@25C)
EC (uS/cm)
25000
20000
15000
10000
5000
0
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
NOW
Approval
Qualifiers
EC Corr.Telem@A2391153, Baker Range Watercourse at Tatiara Swamp, Electrical Conductivity (Corrected) (uS/cm@25C)

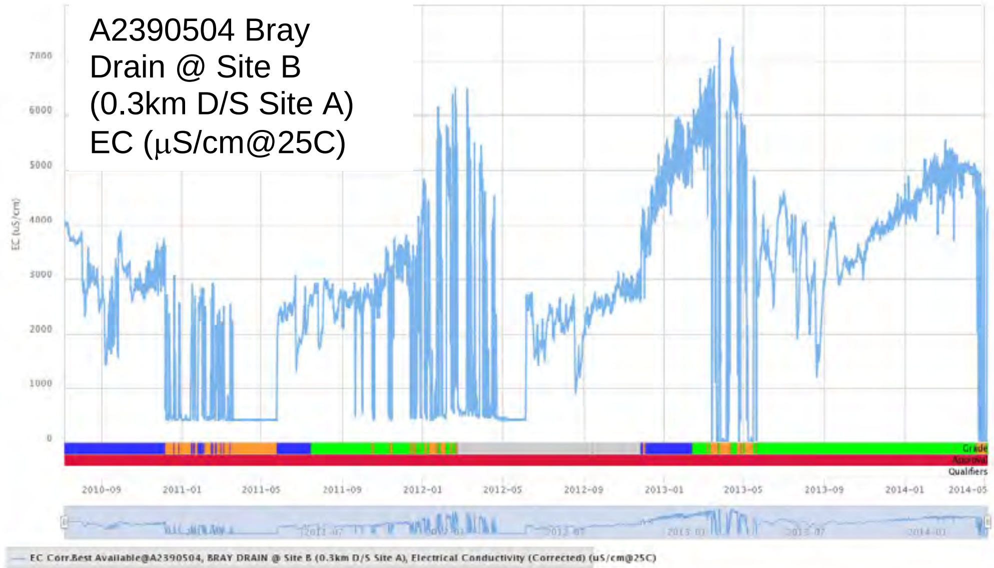

A2391261 Blackford Diversion Regulator
EC (µS/cm@25C)
EC (uS/cm)
25000
22500
20000
17500
15000
12500
10000
7500
5000
2500
0
2019-10
2020-01
2020-04
2020-07
2020-10
2021-01
2021-04
2021-07
2021-10
2022-01
EC Corr.Telem@A2391261, Blackford Diversion Regulator, Electrical Conductivity (Corrected) (uS/cm@25C)

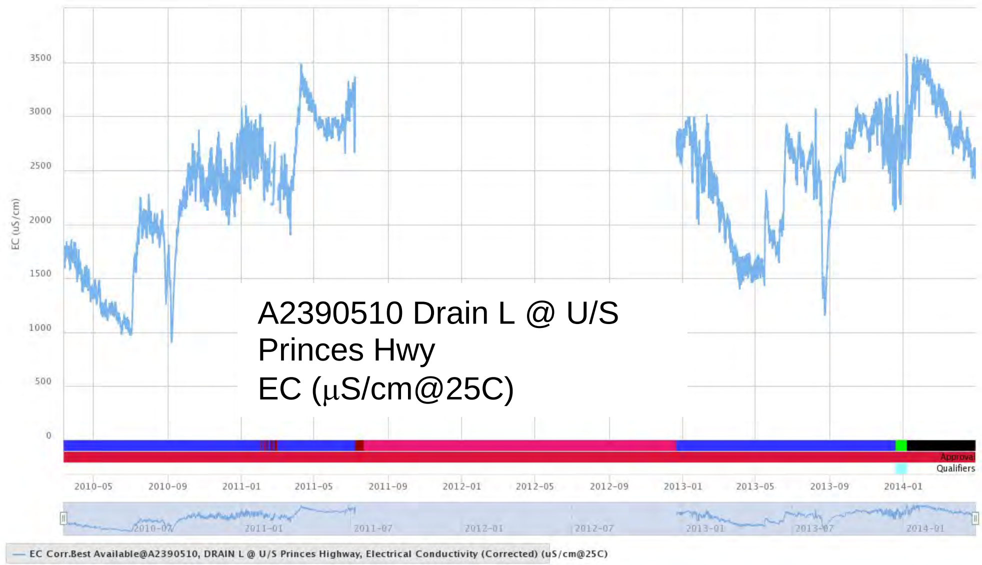

A2391263 Ford Crossing D/S Blackford
Diversion Regulator
EC (µS/cm@25C)
EC (uS/cm)
17500
15000
12500
10000
7500
5000
2500
0
2019-07
2019-10
2020-01
2020-04
2020-07
2020-10
2021-01
2021-04
2021-07
2021-10
2022-01
EC Corr.Telem@A2391263, Ford crossing D/S Blackford diversion regulator, Electrical Conductivity (Corrected) (uS/cm@25C)

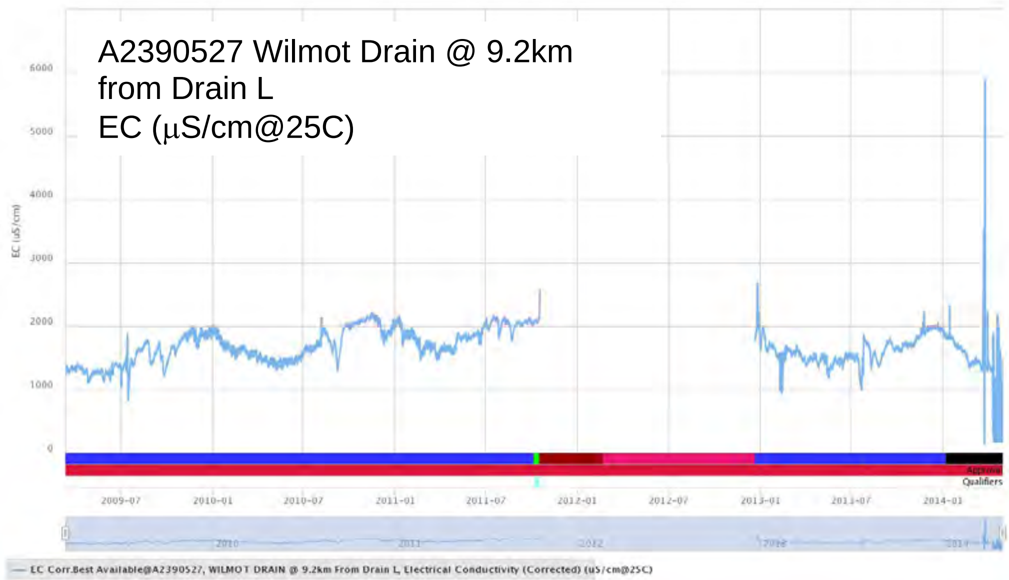

A2391264 Cement Ford
Crossing @ FS13
EC (µS/cm@25C)
EC (uS/cm)
70000
60000
50000
40000
30000
20000
10000
0
2019-07
2019-10
2020-01
2020-04
2020-07
2020-10
2021-01
2021-04
2021-07
2021-10
2022-01
EC Corr.Telem@A2391264, Cement Ford Crossing at FS13, Electrical Conductivity (Corrected) (uS/cm@25C)

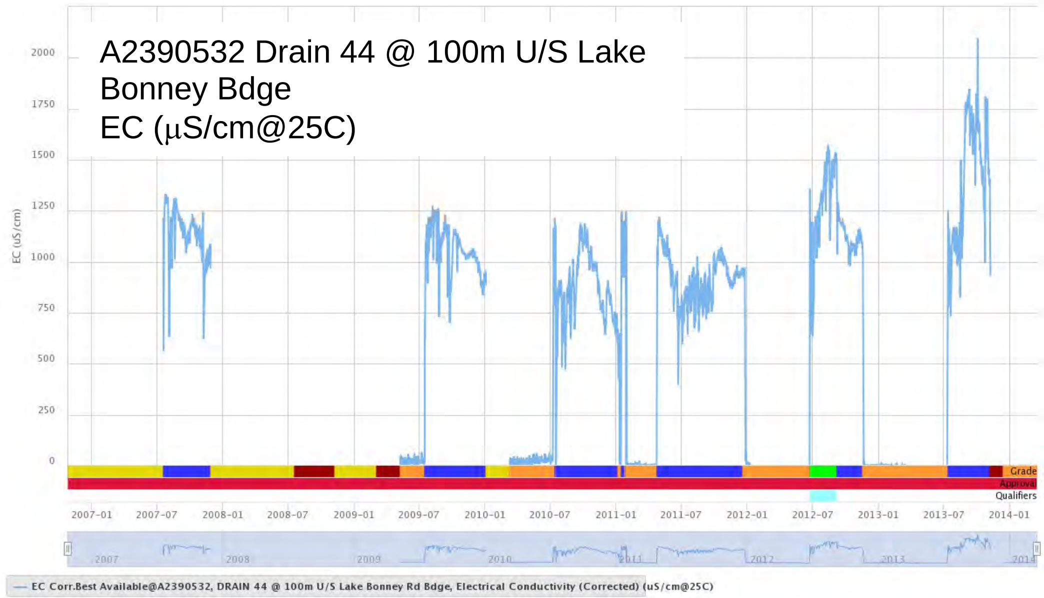
EC Graphs – Historical Sites








A2390527 Wilmot Drain @ 9.2km
from Drain L
EC (µS/cm@25C)
EC (uS/cm)
0
1000
2000
3000
4000
5000
6000
Approval
Qualifiers
2009-07
2010-01
2010-07
2011-01
2011-07
2012-01
2012-07
2013-01
2013-07
2014-01
EC Corr.Best Available@A2390527, WILMOT DRAIN @ 9.2km From Drain L, Electrical Conductivity (Corrected) (uS/cm@25C)


A2390532 Drain 44 @ 100m U/S Lake
Bonney Bdge
EC (µS/cm@25C)
EC (uS/cm)
0
250
500
750
1000
1250
1500
1750
2000
Grade
Approval
Qualifiers
2007-01
2007-07
2008-01
2008-07
2009-01
2009-07
2010-01
2010-07
2011-01
2011-07
2012-01
2012-07
2013-01
2013-07
2014-01
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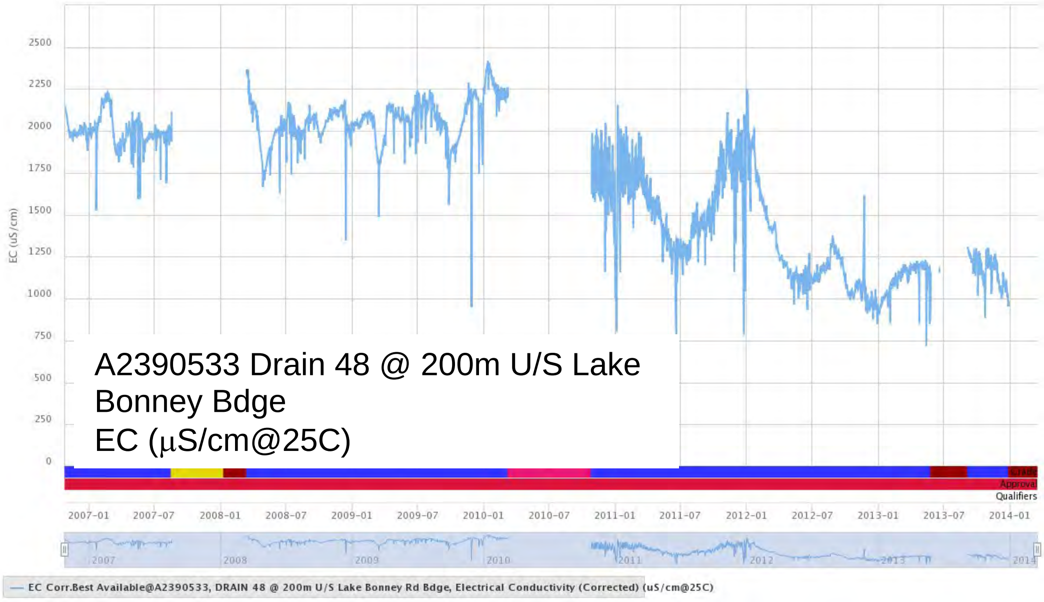
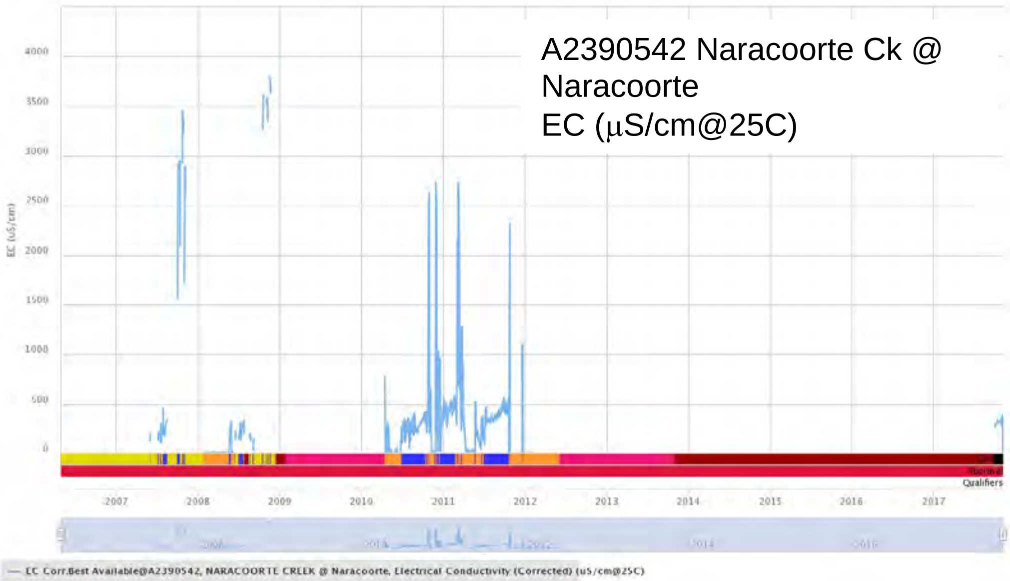
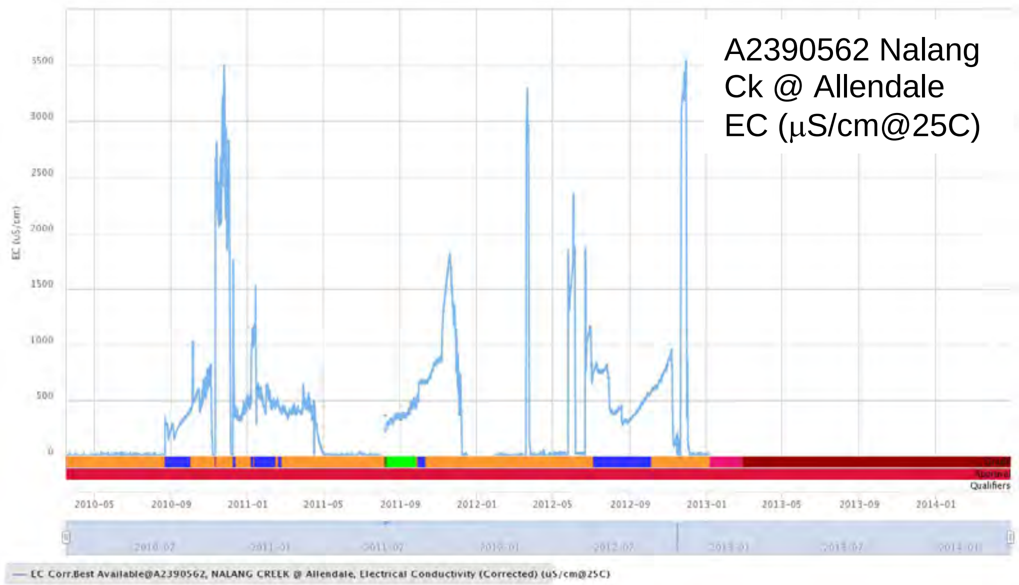

A2390533 Drain 48 @ 200m U/S Lake Bonney Bdge
EC (µS/cm@25C)
EC (uS/cm)
2500
2250
2000
1750
1500
1250
1000
750
500
250
0
Approval
Qualifiers
2007-01
2007-07
2008-01
2008-07
2009-01
2009-07
2010-01
2010-07
2011-01
2011-07
2012-01
2012-07
2013-01
2013-07
2014-01
EC Corr.Best Available@A2390533, DRAIN 48 @ 200m U/S Lake Bonney Rd Bdge, Electrical Conductivity (Corrected) (uS/cm@25C)


A2390542 Naracoorte Ck @ Naracoorte
EC (µS/cm@25C)
EC (uS/cm)
4000
3500
3000
2500
2000
1500
1000
500
0
Qualifiers
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
EC Corr.Best Available@A2390542, NARACOORTE CREEK @ Naracoorte, Electrical Conductivity (Corrected) (uS/cm@25C)


A2390562 Nalang
Ck @ Allendale
EC (µS/cm@25C)
3500
3000
2500
2000
1500
1000
500
0
EC (uS/cm)
Qualifiers
2010-05
2010-09
2011-01
2011-05
2011-09
2012-01
2012-05
2012-09
2013-01
2013-05
2013-09
2014-01
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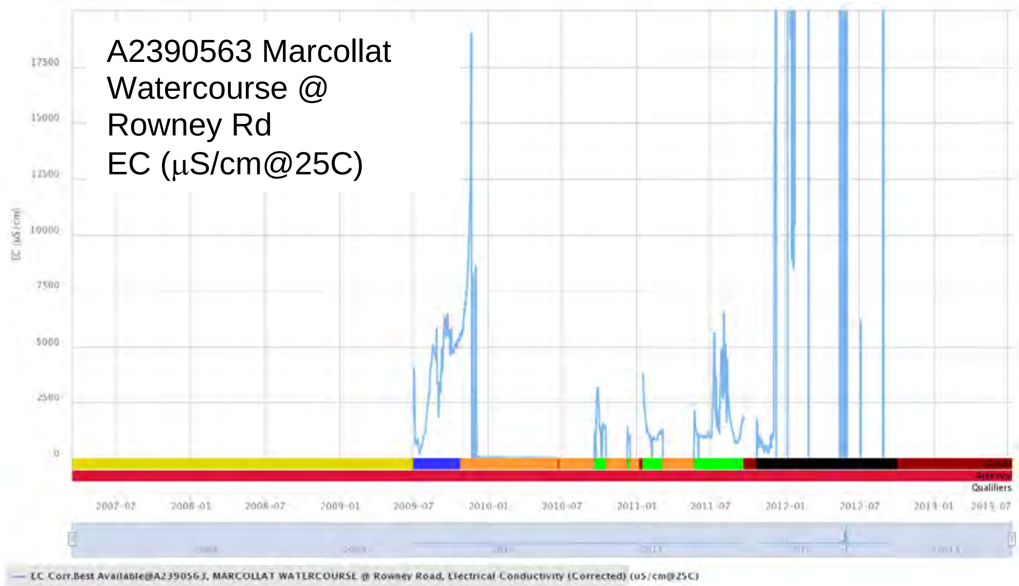
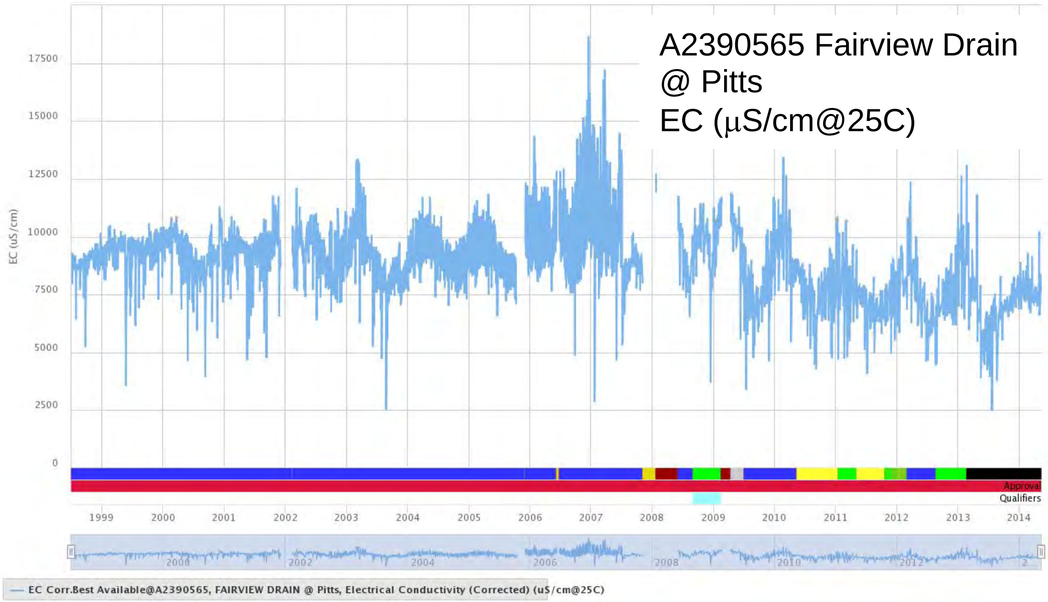
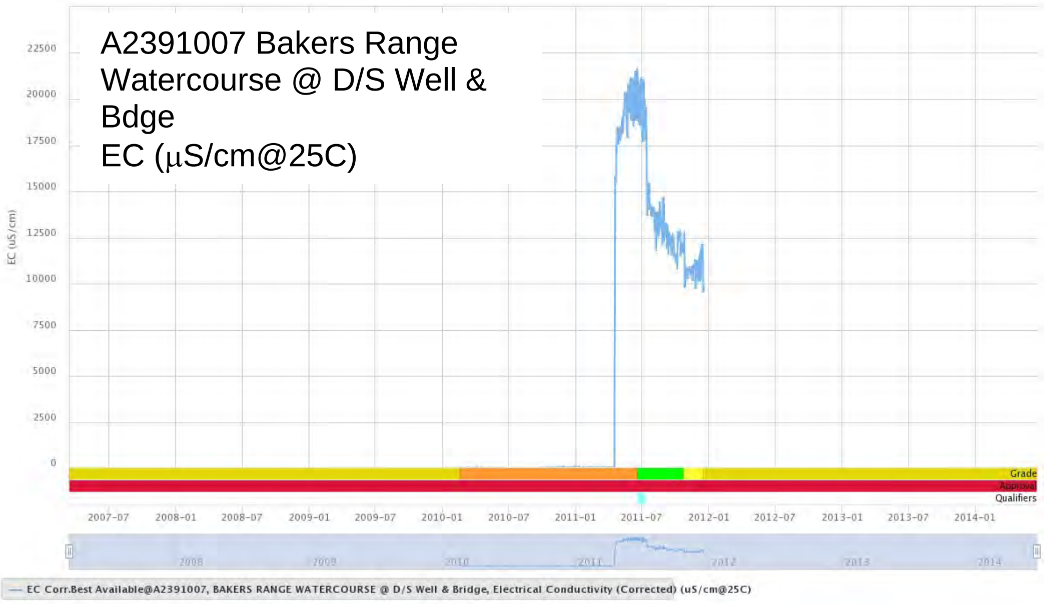
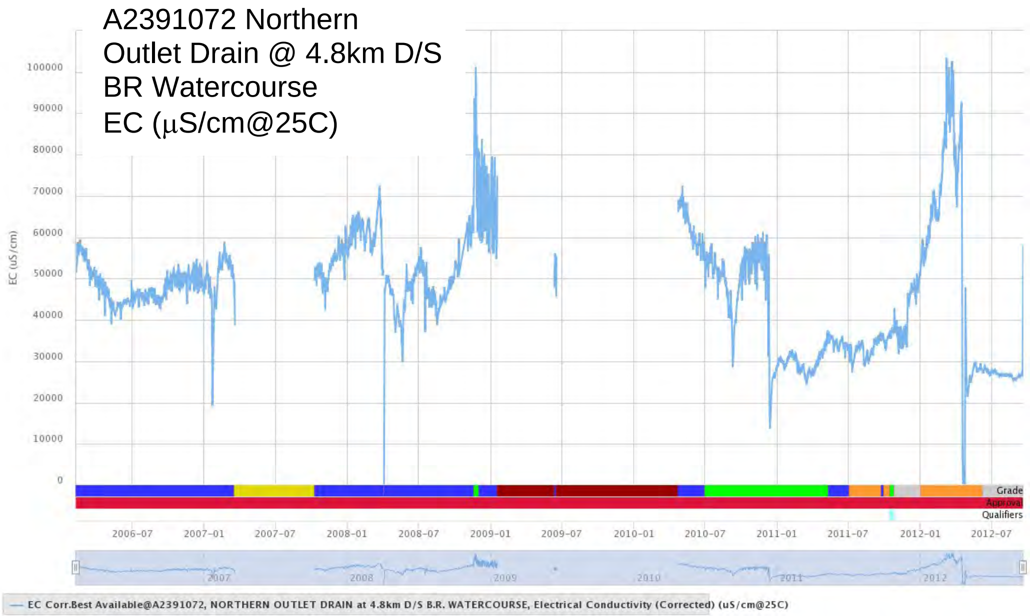
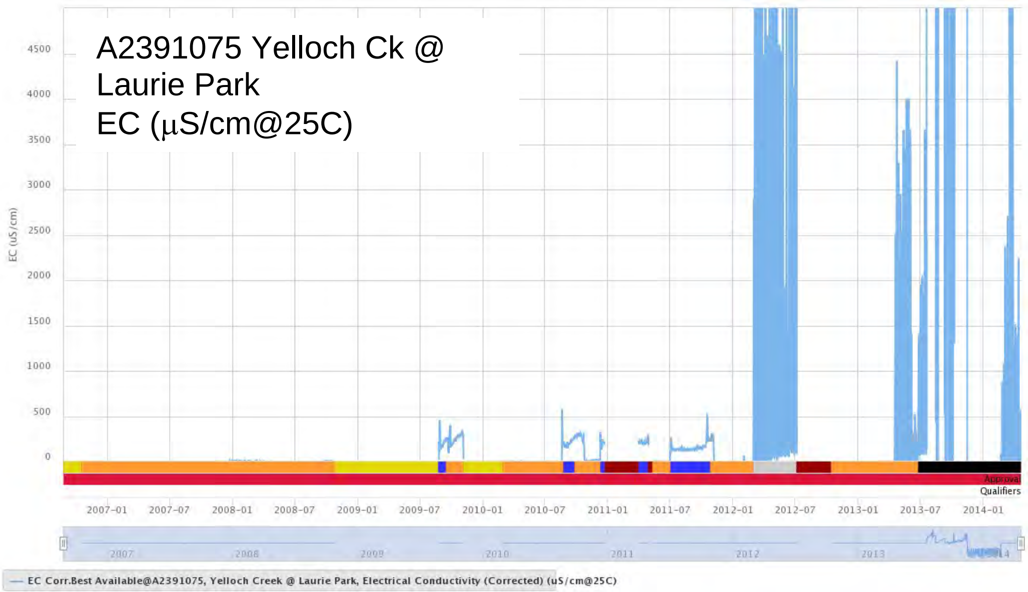
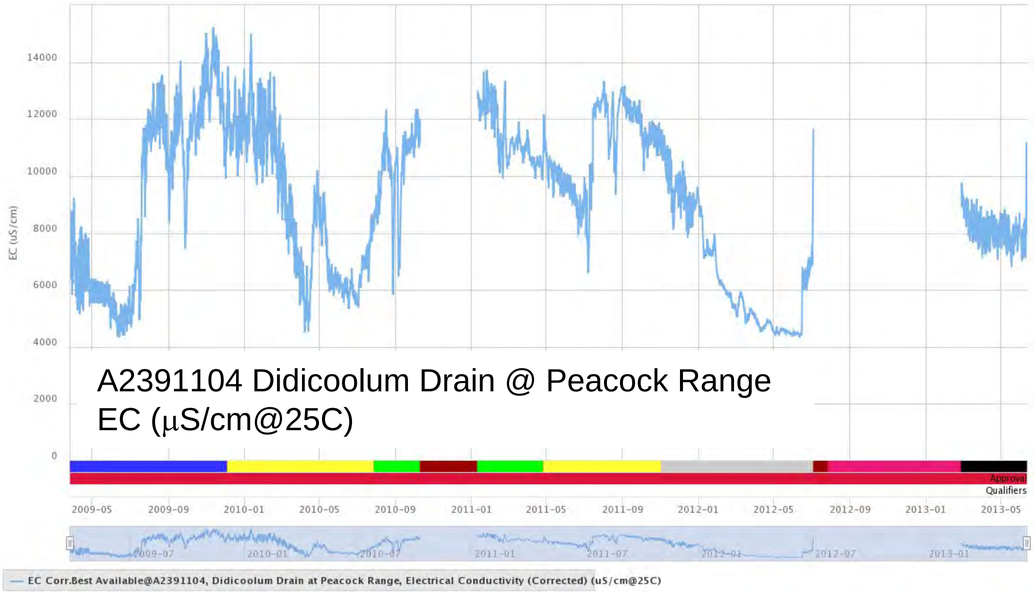

A2390563 Marcollat
Watercourse @
Rowney Rd
EC (µS/cm@25C)
17500
15000
12500
10000
7500
5000
2500
0
EC (uS/cm)
Qualifiers
2007-07
2008-01
2008-07
2009-01
2009-07
2010-01
2010-07
2011-01
2011-07
2012-01
2012-07
2013-01
2013-07
— EC Corr.Best Available@A2390563, MARCOLLAT WATERCOURSE @ Rowney Road, Electrical Conductivity (Corrected) (uS/cm@25C)

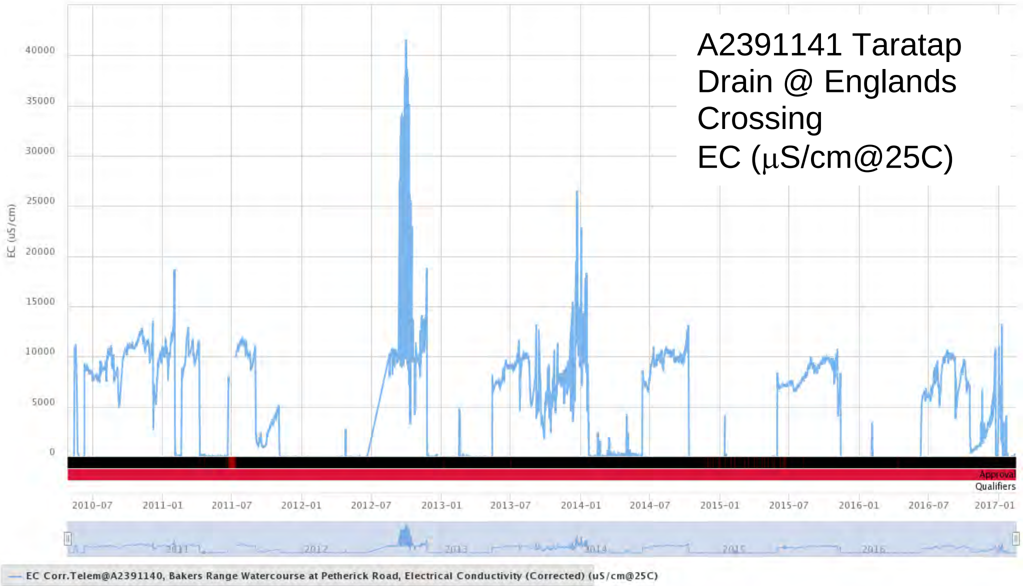

A2390565 Fairview Drain @ Pitts
EC (µS/cm@25C)
EC (uS/cm)
17500
15000
12500
10000
7500
5000
2500
0
Approval
Qualifiers
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
EC Corr.Best Available@A2390565, FAIRVIEW DRAIN @ Pitts, Electrical Conductivity (Corrected) (uS/cm@25C)

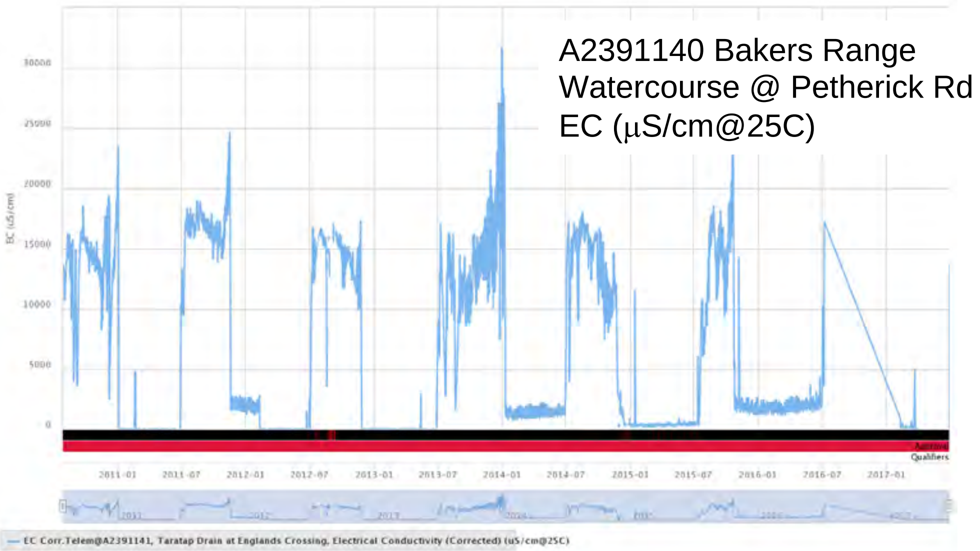

A2391007 Bakers Range Watercourse @ D/S Well & Bdge
EC (µS/cm@25C)
EC (uS/cm)
22500
20000
17500
15000
12500
10000
7500
5000
2500
0
Grade
Approval
Qualifiers
2007-07
2008-01
2008-07
2009-01
2009-07
2010-01
2010-07
2011-01
2011-07
2012-01
2012-07
2013-01
2013-07
2014-01
EC Corr.Best Available@A2391007, BAKERS RANGE WATERCOURSE @ D/S Well & Bridge, Electrical Conductivity (Corrected) (uS/cm@25C)

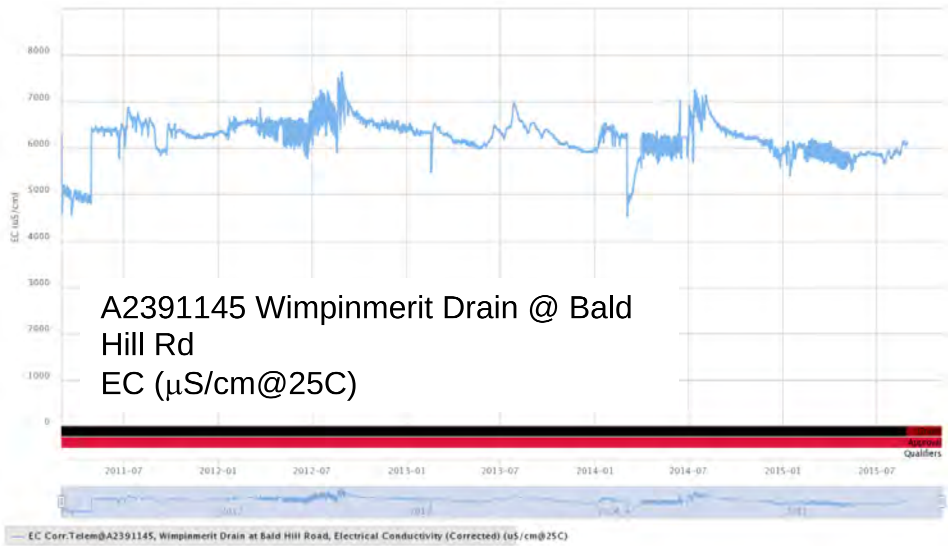

A2391072 Northern Outlet Drain @ 4.8km D/S BR Watercourse EC (µS/cm@25C)
EC (uS/cm)
100000
90000
80000
70000
60000
50000
40000
30000
20000
10000
0
Grade
Approval
Qualifiers
2006-07
2007-01
2007-07
2008-01
2008-07
2009-01
2009-07
2010-01
2010-07
2011-01
2011-07
2012-01
2012-07
EC Corr.Best Available@A2391072, NORTHERN OUTLET DRAIN at 4.8km D/S B.R. WATERCOURSE, Electrical Conductivity (Corrected) (uS/cm@25C)

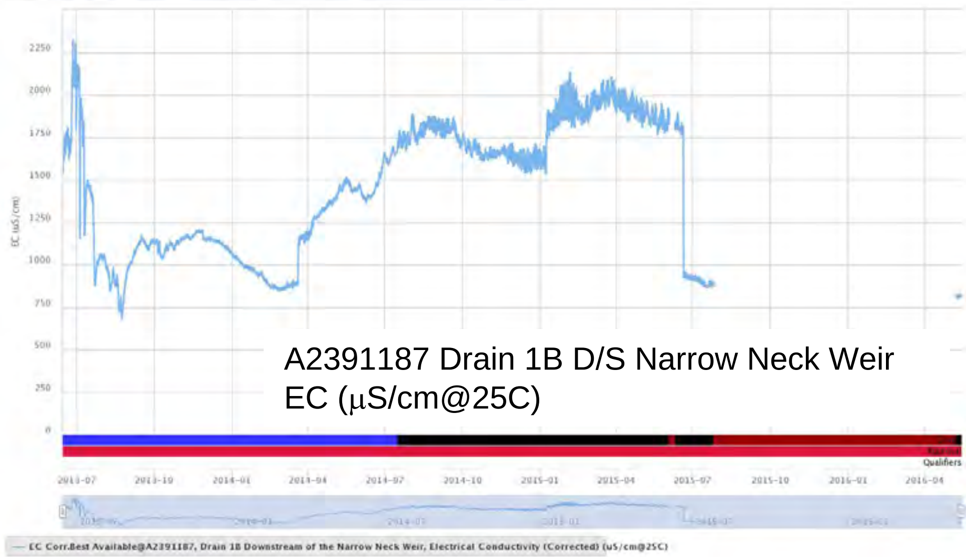

A2391075 Yelloch Ck @ Laurie Park EC (µS/cm@25C)
EC (uS/cm)
4500
4000
3500
3000
2500
2000
1500
1000
500
0
Approval
Qualifiers
2007-01
2007-07
2008-01
2008-07
2009-01
2009-07
2010-01
2010-07
2011-01
2011-07
2012-01
2012-07
2013-01
2013-07
2014-01
EC Corr.Best Available@A2391075, Yelloch Creek @ Laurie Park, Electrical Conductivity (Corrected) (uS/cm@25C)


A2391104 Didicoolum Drain @ Peacock Range
EC (µS/cm@25C)
EC (uS/cm)
14000
12000
10000
8000
6000
4000
2000
0
Approval
Qualifiers
2009-05 2009-09 2010-01 2010-05 2010-09 2011-01 2011-05 2011-09 2012-01 2012-05 2012-09 2013-01 2013-05
— EC Corr.Best Available@A2391104, Didicoolum Drain at Peacock Range, Electrical Conductivity (Corrected) (uS/cm@25C)


A2391141 Taratap Drain @ Englands Crossing
EC (µS/cm@25C)
EC (uS/cm)
40000
35000
30000
25000
20000
15000
10000
5000
0
Approval
Qualifiers
2010-07 2011-01 2011-07 2012-01 2012-07 2013-01 2013-07 2014-01 2014-07 2015-01 2015-07 2016-01 2016-07 2017-01
— EC Corr.Telem@A2391140, Bakers Range Watercourse at Petherick Road, Electrical Conductivity (Corrected) (uS/cm@25C)


A2391140 Bakers Range Watercourse @ Petherick Rd
EC (µS/cm@25C)
EC (uS/cm)
30000
25000
20000
15000
10000
5000
0
Approval
Qualifiers
2011-01 2011-07 2012-01 2012-07 2013-01 2013-07 2014-01 2014-07 2015-01 2015-07 2016-01 2016-07 2017-01
— EC Corr.Telem@A2391141, Taratap Drain at Englands Crossing, Electrical Conductivity (Corrected) (uS/cm@25C)


A2391145 Wimpinmerit Drain @ Bald Hill Rd
EC (µS/cm@25C)
EC (uS/cm)
8000
7000
6000
5000
4000
3000
2000
1000
0
2011-07
2012-01
2012-07
2013-01
2013-07
2014-01
2014-07
2015-01
2015-07
Qualifiers
EC Corr.Telem@A2391145, Wimpinmerit Drain at Bald Hill Road, Electrical Conductivity (Corrected) (uS/cm@25C)


A2391187 Drain 1B D/S Narrow Neck Weir
EC (µS/cm@25C)
EC (uS/cm)
2250
2000
1750
1500
1250
1000
750
500
250
0
2013-07
2013-10
2014-01
2014-04
2014-07
2014-10
2015-01
2015-04
2015-07
2015-10
2016-01
2016-04
Qualifiers
EC Corr.Best Available@A2391187, Drain 1B Downstream of the Narrow Neck Weir, Electrical Conductivity (Corrected) (uS/cm@25C)

Appendix C – Qualitative Assessment of Potential Scheme Locations

Table C1. Potential locations for Scheme Type 1 (Community or On-Farm MAR) identified through the spatial assessment, with comments regarding proximity to existing or previous GDEs, depth to water, groundwater use, proximity to surface drainage features and final suitability. Current unconfined aquifer management areas are also listed, with text colour indicating the risk to the groundwater resource identified at the last review of the Lower Limestone Coast Water Allocation Plan. Red = Very High, Orange = High, Yellow = Medium, Green = Low. Where this risk level was revised during the 2019 Risk Assessment, the revised risk level is indicated.

ID	Description	Management Area	Existing GDE Proximity	Previous GDE Proximity	DTW Comment	Use Comment	Proximity to Drainage Comment	Suitability Comment
1	Around Morambro Creek	Frances / Hynam East / Padthaway MA4	Cockatoo Lake is located down-gradient.		Naracoorte Ranges – good DTW	Extraction	Morambro Creek. Low flows.	Possible although water availability might be an issue. Available water already flows into closest GDE.
2	Around Naracoorte Creek.	Zone 5A / Stewarts	No but up-gradient of Lake Ormerod (northern part of Bool Lagoon complex).		Naracoorte Ranges.	Extraction	Naracoorte Creek. Low flows. Water already flows into Lake Ormerod.	Possible but available water already flows into GDE. Mullingers Swamp is in eastern portion. Not identified as a GDE in spatial analysis but identified by stakeholders as potential MAR location.
3	Around Mosquito Creek and Yelloch Creek	Joanna / Zone 5A	Yes. Mosquito Creek. Not proximal to Bool Lagoon but water flows into it.		Naracoorte Ranges.	Extraction and minor plantation forestry	Mosquito Creek. Low flows. Water already flows into Bool Lagoon.	Possible but available water already flows into GDE. This area ('around Wrattonbully') identified as potential for MAR by stakeholders.
4	Around Tatiara Swamp.	Woolumbool	Adjacent Tatiara Swamp and upgradient of Deep Swamp complex, incl. Schofields Swamp. Also upgradient of Chimney Pots Swamp.		There are some areas of deeper groundwater (on ranges) in amongst some shallower GW (flats).	Small area of high abstraction (1,279 ML/yr).	Reflows and associated minor drains. Regulators nearby. No discharge data.	Possible.
5	Western side of Blackford Drain	Minecrow / Townsend	No. Rushy Swamp is approx 12 km to south west.	Immediately (4 km) south of Mount Scott Floodplain, artificially dry but Very High EVA.	On a range next to a flat.	Significant abstraction immediately to west and south-west.	Blackford Drain and minor drains feeding in from east. Blackford Drain is along eastern margin of the range that the sites are located on.	Possible. No local existing GDE benefit, although artificially dry Mount Scott Floodplain to north. Prev. High GDE Likelihood, now Low. Potential site based on DTW and proximity to Blackford Drain.
6	7-8 km west /south west of Lucindale.	Townsend	No.		Small area of higher DTW but located on the flats.	One abstraction licence of 748 ML/yr. No forestry plantations nearby.	West and south west of Jackie White Drain plus north of Drain K.	No obvious benefits. Water availability uncertain.

7	18 km west of Lucindale.	Townsend	No.		Small area of higher DTW but located on the flats.	Abstraction occurring further north (area 5 is closer).	Upper reaches of Blackford Drain.	Benefits and water availability are not obvious.
8	North-western tip of Coles-Short plantation forestry area. Single point.	Joyce	Immediately west of wetland on Southern Bakers Range Watercourse.	Broadlands on Southern Bakers Range Watercourse. Previous very high likelihood, now low GDE likelihood. Very High EVA.	Small area of localised deeper groundwater.	Just north of significant use for pivots, just north west of major plantation forestry area.	Reflows immediately to east – this flows into the high value GDE already.	No obvious benefit. Reflows already supporting wetland. Very small area of adequate DTW.
9	Single point, similar to above.	Joyce						As above. Not close to a GDE. Very small area of adequate DTW
10	East of Coles-Short plantation forestry area.	Killanoola / Monbulla	No.	Penola Conservation Park and Green Swamp are to the south east. High and Very High EVA. Previously High Likelihood GDEs.	Small scattered areas of adequate DTW.	Major plantation forestry.	Drain B. No discharge data.	Potential to offset plantation forestry impacts and support artificially dry GDEs to south but may be limited by depth to water. Depth to water at GDE is 4.8 m, although nearby it is 8.3 m and 10.6 m at feasible point. Hydraulics of providing benefit to degraded GDEs to south and south east are unclear. Localised areas of adequate DTW – within forest zone. The historical GDEs have forest to the west of them and Coonawarra irrigation upgradient.
11	East of Coles-Short plantation forestry area.	Monbulla	No.	Yes, to south east.	V. small area of adequate DTW.	Near forestry plantation but not within 2 km. Significant pivot irrigation to north and west.	East of Grey Monbulla Drain. No discharge data.	Benefits not clear. Localised area of adequate depth to water only.
12	Small area 4.5 km west of Tarpeena.	Young	No.	Not close – not likely to have much influence here.	V. small area of adequate DTW.	Significant GW use around this location. Sites are within / adjacent small area of plantation forestry.	Drain A. Small drain, no discharge info.	Benefits not clear. Localised area of adequate depth to water.

13	Single point adjacent Border. 17 km NE of Mt Gambier.	Zone 2A	No.	To the north and west but too far away to have significant effect.	Single point of adequate DTW.	Significant GW use around this location, pivot at the location. Areas of forestry plantation to the north and south.	Small unnamed drains flowing from over / adjacent the border. No discharge data.	No benefits to GDEs, could offset abstraction impacts in very high risk Management Area. Localised area of adequate depth to water. Unlikely water source.
14	Southern Coastal Creeks	Donovans	Yes. LSE Rising Springs East. Bones Pond and Dead Pond located amongst pivots.		Areas of adequate DTW inland of coast and amongst pivots.	Significant GW abstraction.	Coastal outflows.	Possible to intercept water at high flows from coastal outflows to alleviate drawdown associated with abstraction, incl. around Bones Pond and Dead Pond.
15	Blackfellows Caves	Kongorong	Yes. Blackfellows Caves Wetland		Areas of adequate DTW present throughout this area. Points have been selected based on proximity to small outflow drain.	Forestry plantation is the selected feature, although there is also significant abstraction a little further away around this location.	Small private (?) coastal outflow drain. No discharge information.	Possible to intercept water at high flows from coastal outflows to alleviate drawdown associated with regional abstraction and local plantation forestry.
16	Single point near southern edge of Lake Bonney.	Benara	Lake Bonney		Small area of adequate DTW near drain. Larger areas further away.	Adjacent plantation forestry. Also significant GW abstraction upgradient of this.	Small private drain. Flows already supply Lake Bonney.	Possible but available water already flows into GDE.
17	In southern part of Mt Burr Forest zone.	Hindmarsh	No but upgradient of Lake Bonney.		Western edge of high DTW zone associated with plantation forestry area. Just close enough to drain to be selected.	Plantation forestry. Within buffer zone for significant abstraction.	Drain 63.	Water from this drain flows into Lake Bonney. No obvious benefit to GDE.
18	Adjacent northern part of Lake Bonney.	Mayurra	Lake Bonney.		Deeper water tables associated with dune ridge.	Significant abstraction. Forestry is also up-gradient.	Extensive network of small drains.	Possible to offset abstraction and up-gradient plantation forestry impacts but drain water already flows into Lake Bonney.
19	As above for 18.	As above for 18.	As above for 18.		As above for 18.	As above for 18.	As above for 18.	
20	North eastern edge of Mt Burr Forest	Young/Hindmarsh/Riddoch/Mt Muirhead/Kennion	No, but up-gradient of Lake Bonney	At south-eastern end: Claypans East (prev. High Likelihood, High	Extensive area of deeper water tables around forest with shallower water	Mostly forest, but some areas of high abstraction around this –	Network of mainly private drains that drain to NE then join	Possible to restore previous GDEs although water source uncertain. Stakeholders identified Mt

				EVA), Everglades (prev. Very High Likelihood, Very High EVA)	table flats to the north-east.	some sites located within buffer zones for these.	NW flowing drains. No discharge data.	Burr Swamp as a priority wetland.
21	Western edge of Mt Burr forest – within forest.	Hindmarsh/Riddoch	Snuggery Drain Spring – tiny GDE near edge of forest.		Extensive area of deeper water tables within forest area.	Forest plus high abstraction.	Network of drains that flow into Lake Bonney.	May not be practical as deeper water tables are within forest. Drains flow into Lake Bonney. Possible benefit to Snuggery Drain Spring.
22	Similar to 21 but further from GDE.	Mount Muirhead / Riddoch	No.		Extensive area of deeper water tables within forest area.	Forest only.	Network of drains that flow into Lake Bonney.	May not be practical as deeper water tables are within forest. Drains flow into Lake Bonney.
23	South east of Lake George.	Symon/Rivoli Bay	Mullins Swamp, Burks Island, Lake George.		Small areas of deeper water tables along dune ridge.	Forest.	Drain M and associated private drains – already flow into Lake George. Drain M has high discharge but also high Biological Value.	Drains already flow into Lake George. Possible benefits to Burks Island, which is adjacent to forest area, and NW end of Mullins Swamp.
24	East of Lake George	Lake George	Lake George		Small areas of deeper water tables along dune ridge.	Groundwater abstraction just up-gradient of sites (884 ML/yr).	Drain M and associated private drains – already flow into Lake George. Drain M high discharge but also high Biological Value.	Drains already flow into Lake George.
25	South of Lake Hawdon South.	Bray	Lake St. Clair		Small areas of deeper water tables along dune ridge.	Plantation forestry area. High GW abstraction up-gradient.	Very small private drains. No flow data.	Local water source uncertain. Available drainage water already flows into Lake St. Clair.
26	South of Lake Hawdon South.	Bray	Lake Hawdon South		Small areas of deeper water tables along dune ridge.	Plantation forestry area. High GW abstraction up-gradient.	Very small private drains. No flow data.	Local water source unlikely.
27	Single point adjacent Reedy Creek Wilmot Drain.	Smith	Reedy Creek LF		Very small area.	Small area of plantation forestry immediately to the west.	Reedy Creek Wilmot Drain. Likely good flows but drain has Biological Value of 7. Flows into Drain L.	Very isolated area of adequate water table (adjacent drain interestingly). Not likely a real benefit. Drain itself has Biological Value of 7.
28	East of Reedy Creek Wilmot Drain.	Kennion / Fox	Reedy Creek LF		Small areas of deeper water tables along dune ridge.	Small area of plantation forestry.	Bellinger Swamp Drain, Drain M. Weir nearby. No flow data.	Possible. Small area of adequate DTW, no large use near site besides plantation forestry.

29	West of Wilmot Drain	Smith/Conmurra	No		Small areas of deeper water tables along dune ridge.	Groundwater abstraction to the east and north east.	Wilmot Drain. Good Flows but Biological Value of 3.	Possible – west and south west of irrigation area where water tables are shallow. No GDE benefit. Drain has Biological Value of 3.
30	Various sites around forested areas just west of Coles-Short.	Fox/Kennion/Short	No		Very isolated areas of adequate DTW, must be topography related.	Plantation forestry. Some higher abstraction in north (Fox).	Drain M in the north, minor drains in south.	Possible to offset impacts of groundwater use but no GDE benefit.
31	Plantation forestry area in Conmurra	Conmurra	No		Very isolated areas of adequate DTW, must be topography related.	Plantation forestry but also surrounded by abstraction.	Private drain – unknown flow.	Unlikely water source, no GDEs although significant pressure on aquifer. Sparse areas of adequate DTW.
32	Next dune ridge to NE of site 24, adjacent same area of abstraction.	Symon	No		Isolated areas of deeper water tables along dune ridge.	Groundwater abstraction just down-gradient of sites (884 ML/yr).	Biscuit Flat Drain and associated private drains. These drain north into Lake Hawdon South	Very isolated areas of adequate water table depth, not sure what it would achieve.
33	East of Lake Hawdon North	Ross	Lake Hawdon North		Only two isolated points, although area of 5-10 m in between.	One bore 571 ML/yr	Minor natural drainage that flows into Lake Hawdon North and Drain L.	Unlikely water source. Unlikely to achieve much – may offset impacts of local abstraction.
34	North of Robe.	Waterhouse	McInnes Wetland		Small areas of deeper water tables along dune ridge.	Groundwater abstraction to north, north west and north east. Plantation forestry to north.	Mount Benson Drain – drains this wetland?	Possible – protection for wetland if needed.
35								Falls within GDE buffer for McInnes Wetland but right on coast so not useful.
36		Ross	No but Rushy swamp to the west.		Western edge of dune ridge selected as close to drain. Other areas of adequate DTW on dune ridge.	Groundwater abstraction to the north.	Minor drains that flow into Rushy Swamp and then Kingston Main Drain.	Benefit is not clear.
37		Bowaka	No but Rushy swamp to the north-west.		Western edge of dune ridge selected as close to drain to the west. Other areas of adequate DTW on dune ridge.	Groundwater abstraction to the north east and south east.	Minor drains that flow into Rushy Swamp and then Kingston Main Drain.	No benefit to GDEs – could offset drawdown but very limited area with adequate DTW. Other areas available to the north and east away from drains (Scheme Type 2).

38	Mount Benson	Mount Benson	Maria Creek Swamp		Some adequate DTW scattered around here – two points picked for proximity to drain. These are the closest to the swamp.	Plantation forestry immediately to the south, groundwater abstraction further to the south.	Barooka Drain and Wongalina Drain.	Could offset plantation forestry impacts.

Table C2. Potential locations for Scheme Type 2 (Regional Transfer and MAR) identified through the spatial assessment, with comments regarding proximity to existing or previous GDEs, depth to water, groundwater use, proximity to infrastructure and final suitability. Current unconfined aquifer management areas are also listed, with text colour indicating the risk level identified at the last review of the Lower Limestone Coast Water Allocation Plan. Red = Very High, Orange = High, Yellow = Medium, Green = Low. Where this risk level was revised during the 2019 Risk Assessment, the revised risk level is indicated.

ID	Description	Management Area	Existing GDE Proximity	Previous GDE Proximity	DTW Comment	Use Comment	Proximity to Infrastructure Comment	Suitability Comment
1	Northern Hynam East and Frances.	Frances / Hynam East / Padthaway MA4	Cockatoo Lake is down-gradient.		Naracoorte Ranges.	Extraction	Morambro Creek. Low flows.	Possible.
2	Southern Zone 5A.	Zone 5A / Stewarts	No but up-gradient of Lake Ormerod (northern part of Bool Lagoon complex)		Naracoorte Ranges.	Extraction	Naracoorte Creek. Low flows. Water already flows into Lake Ormerod.	Possible to alleviate drawdown and protect down-gradient GDE. Mullingers Swamp is in eastern portion. Not identified as a GDE in spatial analysis but identified by stakeholders as potential MAR location.
3	Around Mosquito Creek and Yelloch Creek. Northern part of Joanna.	Joanna / Zone 5A	Yes. Mosquito Creek. Bool Lagoon doen-gradient.		Naracoorte Ranges.	Extraction and minor forestry plantations	Mosquito Creek. Low flows. Water already flows into Bool Lagoon.	Possible to alleviate drawdown and protect down-gradient GDE. This area ('around Wrattonbully') identified as potential for MAR by stakeholders.
4	Around Tatiara Swamp.	Woolumbool	Adjacent Tatiara Swamp and upgradient of Deep Swamp complex, incl. Schofields Swamp. Also upgradient of Chimney Pots Swamp.		There are some areas of deeper groundwater (on ranges) in amongst some shallower GW (flats).	Small area of high abstraction (1,279 ML/yr).	Reflows and associated minor drains. Regulators nearby. No discharge data.	Possible.
5	Western side of Blackford Drain.	Minecrow / Townsend / Bowaka / Ross / Conmurra / Murrabinna	No. Rushy Swamp is approx 5 - 12 km to west / south west.	Immediately (4 km) south of Mount Scott Floodplain, artificially dry but Very High EVA.	On a range next to a flat.	Significant abstraction.	Blackford Drain and minor drains flowing in from east. Blackford Drain is along eastern margin of the range that the sites are located on.	Possible. No local existing GDE benefit, although artificially dry Mount Scott Floodplain to north. Prev. High GDE Likelihood, now Low. That is a potential site based on DTW, although not very close to abstraction or plantation forestry (down-gradient). Rushy Swamp immediately to the west.
6	7-8 km west /south west of Lucindale.	Townsend	No.		Small area of higher DTW on the flats.	One abstraction of 748 ML/yr. No	West and south west of Jackie White Drain plus north of Drain K.	No obvious benefits.

						plantation forestry nearby.		
7	South-eastern Zone 3A	Zone 3A	Deadmans Swamp	Three within forestry plantation and several down-gradient.	Small area of higher DTW on the flats.	Isolated areas of adequate DTW.	Nil	Possible benefit to offset plantation forestry impacts and restore previous GDEs in SW corner of Zone 3A.
8	Northern edge of Coles-Short plantation forestry area.	Joyce / Spence	Wetland on Southern Bakers Range Watercourse.	Broadlands on Southern Bakers Range Watercourse. Previous very high likelihood, now low GDE likelihood. Very High EVA.	Small areas of localised deeper groundwater.	Just north of major plantation forestry area. Just north of pivots	Near Reflows – this flows into the high value GDE.	Possible to offset plantation forestry impacts but very small area of adequate DTW.
9	Single point adjacent Reflows and northern portion of major plantation forestry area.	Joyce	No.		Small area of adequate DTW.	Plantation forestry and abstraction.		Not close to a GDE. Very small area of adequate DTW
11	East of Coles-Short Forestry area.	Monbulla	No.	Yes, to south.	V. small area of adequate DTW.	Near forestry plantation but not within 2 km. Significant pivot irrigation to north and west.	East of Grey Monbulla Drain.	Benefits not clear. Localised area of adequate depth to water.
12	Small area 4.5 km west of Tarpeena.	Young	No.	Not close.	V. small area of adequate DTW.	Significant GW use around this location. Sites are within / adjacent small area of plantation forestry.	Drain A. Small drain, no discharge info.	Benefits not clear. Localised area of adequate depth to water.
13	Southern Zone 2A and northern margin of Myora	Zone 2A / Myora	No.	Scattered around several previous GDEs. In particular, Dismal Swamp.	Scattered points of adequate DTW.	Significant GW use. Areas of plantation forestry to the north and south.	Small unnamed flowing over / adjacent the border. No discharge info.	Possible benefit at Dismal Swamp to offset impacts of both plantation forestry and abstraction.
14	Donovans and Macdonnell Irrigation areas - Southern Coastal Creeks.	Donovans / Macdonnell	Yes. LSE Rising Springs East. Bones Pond and Dead Pond in amongst pivots.		Areas of adequate DTW inland of coast and amongst pivots.	Significant GW abstraction.	Coastal outflows.	Possible to intercept water at high flows from coastal outflows to alleviate drawdown associated with abstraction, incl. around Bones Pond and Dead Pond.

15	Inland of Blackfellows Caves and southern edge of Lake Bonney.	Kongorong / Benara	Yes. Upgradient of Blackfellows Caves Wetland, Lake Bonney		Areas of adequate DTW present throughout this area.	Plantation forestry and abstraction.	Small private (?) coastal outflow drain. No discharge information.	Possible to intercept water at high flows from coastal outflows to alleviate drawdown associated with regional abstraction and local forestry planttaions.
16	Forest area across Killanoola / Monbulla border (easten edge of Coles-Short plantation forest estate).	Killanoola / Monbulla	Nil	Penola Cons. Park, Green Swamp, Red Gum Pools to the south.	Isolated areas of adequate DTW.	Plantation forestry. Low GW use around this area but Coonawarra irrigation area is upgradient.	Drain B	Possible to offset plantation forestry impacts and restore previous GDEs but potentially limited by depth to water. Depth to water at GDE is 4.8 m. Upgradient is 8.3 m and 10.6 m at feasible point.
17	In southern part of Mt Burr Forest zone. Areas around previous GDEs in Young.	Hindmarsh / Young	No.	Yes, numerous in Young. At south-eastern end: Claypans East (prev. High Likelihood, High EVA), Everglades (prev. Very High Likelihood, Very High EVA). Dismal Swamp.	Western edge of high DTW zone associated with forestry area.	Plantation forestry and significant abstraction to north.	Drain A and minor drains feeding into it.	Possible to restore previous GDEs.
18	Mount Burr Forest.	Compton / Blanche Central / Benara / Hindmarsh / Riddoch / Mount Muirhead	Upgradient of Lake Bonney. Snuggery Drain Spring – tiny GDE near edge of forest.	One in Riddoch McRosties NFR	Extensive area of deeper water tables within forest area.	Mainly plantation forestry but also abstraction	Extensive network of small drains around forest.	Can alleviate drawdown – mainly plantation forest area. Possible benefit to Snuggery Drain Spring and previous GDE. Stakeholders identified Mt Burr Swamp as a priority wetland.
19	Adjacent Lake Bonney	Mayurra / Mount Muirhead	Adjacent Lake Bonney		Deeper water tables along dune ridge.	Abstraction – significant plantation forestry up-gradient.	Local drains that flow into Lake Bonney.	Possible to offset abstraction and up-gradient plantation forestry impacts but drain water already flows into Lake Bonney.
20	Nangwarry forest in Zone 2A.	Zone 2A	No.	Yes. Daveys LF and Penola Forest (previously both Moderate GDE Likelihood). Akoolya Swamp is down-gradient in Grey	Deeper water tables within forest.	Forest but surrounded by high GW abstraction.	Nil	Possible to restore previous GDEs and alleviate plantation forestry / abstraction impacts.

				(previously Moderate GDE Likelihood, High EVA)				
21	Mount Gambier area and forests to the east / south.	Myora / Glenburnie / Donovans	Blue Lake		Extensive area of deeper water tables.	Forest plus high abstraction.	Nil.	Possible to offset impacts from plantation forestry and abstraction (particularly in Myora). Blue Lake is the only GDE.
22	Moorak - Blanche Central	Moorak / Blanche Central / Benara	No.		Extensive area of deeper water tables.	Forest plantation to the north, surrounded by areas of high abstraction.	Nil.	Possible to offset plantation forestry / abstraction impacts but the benefit is not clear.
23	South east of Lake George.	Symon/Rivoli Bay	Mullins Swamp, Burks Island, Lake George.		Small areas of deeper water tables along dune ridge.	Forest plantation.	Drain M and associated private drains – already flow into Lake George. Drain M high discharge.	Drains already flow into Lake George. Possible benefits to Burks Island, which is adjacent to plantation forest area, and NW end of Mullins Swamp.
24	East of Lake George	Lake George	Lake George		Small areas of deeper water tables along dune ridge.	Groundwater abstraction just up-gradient of sites (884 ML/yr).	Drain M and associated private drains – already flow into Lake George. Drain M high discharge.	Drains already flow into Lake George.
25	South of Lake Hawdon South.	Bray	Lake St. Clair / Lake Eliza / Lake Hawdon South		Small areas of deeper water tables along dune ridge.	Plantation forestry area. High GW abstraction up-gradient.	Very small private drains. Unlikely that they flow.	Could offset local drawdown impacts from small plantation forestry area and abstraction.
27	Single point adjacent Reedy Creek Wilmot Drain.	Smith	Reedy Creek LF		Very small area	Small area of plantation forestry area immediately to the west.	Reedy Creek Wilmot Drain. Likely good flows. Flows into Drain L.	Very isolated area of adequate water table (adjacent drain interestingly). Not likely a real benefit.
28	East of Reedy Creek Wilmot Drain.	Kennion / Fox	Reedy Creek LF		Small areas of deeper water tables along dune ridge.	Small area of plantation forestry	Bellinger Swamp Drain, Drain M. Weir nearby.	Possible. Small area although not great pressure on aquifer here.
29	West of Wilmot Drain	Smith/Conmurra	No		Small areas of deeper water tables along dune ridge.	Groundwater abstraction to the east and north east.	Wilmot Drain. Good Flows	Possible – west and south west of irrigation area where water tables are shallow. No obvious benefit.
30	Various sites around forested areas	Fox/ Conmurra	No		Very isolated areas of adequate DTW, likely topography related.	Plantation forestry. Surrounded by abstraction.	Drain M runs through southern portion. Minor drains surround the area.	Possible.

	just west of Coles-Short.							
31	Western edge of Coles / Short plantation forestry area	Kennion/Short / Coles	No		Very isolated areas of adequate DTW, must be topography related.	Plantation forestry with some abstraction to north and south.	Private drain – unlikely to flow – and Robe-Penola Drains.	No GDEs although significant pressure on aquifer. Sparse areas of adequate DTW. One point is in Coles (considered High Risk MA).
32	NW Corner of Symon MA.	Symon	No		Isolated areas of deeper water tables along dune ridge.	Groundwater abstraction just down-gradient of sites (884 ML/yr).	Biscuit Flat Drain and associated private drains. These drain north into Lake Hawdon South	Very isolated areas of adequate water table depth, not sure what it would achieve.
33	East of Lake Hawdon North	Ross	Lake Hawdon North		Only two isolated points, although area of 5-10 m in between.	One bore 571 ML/yr	Minor natural drainage that flows into Lake Hawdon North and Drain L.	Unlikely to achieve much – may offset impacts of local abstraction.
34	North of Robe, Mount Benson plantation forestry area.	Waterhouse / Mount Benson	McInnes Wetland, Maria Creek Swamp		Small areas of deeper water tables along dune ridge.	Groundwater abstraction and plantation forestry.	Mount Benson Drain (south) and Wongalina Drain (north).	Possible – protection for wetland if needed, offset for plantation forestry impacts – benefit close to coast?
35								Near McInnes Wetland but right on coast so not useful.
36	Beeamma / Bangham	Beeamma / Bangham / Padthaway MA4	No		Naracoorte Ranges	Groundwater abstraction.	Nil	Possible to offset impacts from abstraction.
37	Hynam East / Northern Zone 5A.	Hynam East / Zone 5A	No but upgradient of Lochaber Swamp.		Naracoorte Ranges.	Groundwater abstraction.	Nil	Possible to offset impacts from abstraction.
38	Southern Joanna and Comaum.	Joanna / Comaum / Zone 3A	Dead Mans Swamp NFR, Taylors LF	Taylors Block (High EVA, previous VH GDE Likelihood)	Good DTW through here.	Plantation forestry. Not much use. High use down-gradient.	Nil	Could offset plantation forestry impacts to current and previous GDEs.

Appendix D – Preliminary Risk Analysis

Risk ID 1. There is potential for Managed Aquifer Recharge to cause localised water logging associated with water table mounding which in turn could lead to land becoming unsuitable for current land use.

Risk Source:	Managed Aquifer Recharge			Consequence:				Land becomes unsuitable for current land use.		
Consequence Criteria:				Land suitability						
Risk Factors: Sites for MAR selected based on DTW > 10 m. However, seasonal fluctuations are not captured. Unconfined aquifer generally has high transmissivity and storage, which reduces potential for mounding.										
Consequence	Percentage likelihood of occurrence during a 10 year period									
Catastrophic	0	10	20	30	40	50	60	70	80	90
Major	0	10	20	30	40	50	60	70	80	90
Moderate	0	10	20	30	40	50	60	70	80	90
Low	0	10	20	30	40	50	60	70	80	90
Insignificant	0	10	20	30	40	50	60	70	80	90

Likelihood	Consequence: Insignificant	Low	Moderate	Major	Catastrophic
Very Likely					
Likely					
Possible	X	X			
Unlikely			X	X	
Very Unlikely					X

	Low Confidence	Moderate Confidence	High Confidence
High level Risk	Undertake targeted new evidence collection or acquire greater knowledge and reassess risk	Monitor risk and treatment and re-evaluate risk based on monitoring	Monitor risk and treatment
Medium Level Risk	***Monitor risk and re-evaluate risk based on monitoring***	Monitor risk	Monitor risk
Low Level Risk	Monitor risk	Monitor risk	No action

Risk ID 2. There is potential for Managed Aquifer Recharge to cause localised water logging which in turn could lead to reduced benefit from investment in private drainage networks.

Risk Source:	Managed Aquifer Recharge	Consequence:	Reduced benefit from investment in private drainage networks.
Consequence Criteria:	Economic impact on private drainage systems		

Risk Factors:
Sites selected for MAR selected based on DTW > 10 m.
However, seasonal fluctuations are not captured.
These areas generally do not have private drainage networks although some may be adjacent to lower-lying areas containing private drainage.
Unconfined aquifer generally has high transmissivity and storage, which reduces potential for mounding.

Consequence	Percentage likelihood of occurrence over 10 year period									
Catastrophic	0	10	20	30	40	50	60	70	80	90
Major	0	10	20	30	40	50	60	70	80	90
Moderate	0	10	20	30	40	50	60	70	80	90
Low	0	10	20	30	40	50	60	70	80	90
Insignificant	0	10	20	30	40	50	60	70	80	90

Likelihood	Consequence: Insignificant	Low	Moderate	Major	Catastrophic
Very Likely					
Likely	X				
Possible					
Unlikely		X	X	X	
Very Unlikely					X

	Low Confidence	Moderate Confidence	High Confidence
High level Risk	Undertake targeted new evidence collection or acquire greater knowledge and reassess risk	Monitor risk and treatment and re-evaluate risk based on monitoring	Monitor risk and treatment
Medium Level Risk	***Monitor risk and re-evaluate risk based on monitoring***	Monitor risk	Monitor risk
Low Level Risk	Monitor risk	Monitor risk	No action

Risk ID 3. There is potential for the practice of holding water up in the SEDN at targeted locations to cause more frequent and/or longer-term inundation of localised areas upstream of regulators which in turn could lead to land becoming unsuitable for current land use.

Risk Source:	Holding water up in SEDN	Consequence:	Land becomes unsuitable for current land use.
Consequence Criteria:	Land suitability		
Risk Factors: Selected sites have water tables less than 10 m. However, seasonal fluctuations are not captured. Unconfined aquifer generally has high transmissivity and storage, which reduces potential for mounding. SEDN is located in areas that are prone to flooding.			

Consequence	Percentage likelihood of occurrence over 10 year period									
Catastrophic	0	10	20	30	40	50	60	70	80	90
Major	0	10	20	30	40	50	60	70	80	90
Moderate	0	10	20	30	40	50	60	70	80	90
Low	0	10	20	30	40	50	60	70	80	90
Insignificant	0	10	20	30	40	50	60	70	80	90

Likelihood \ Consequence	Insignificant	Low	Moderate	Major	Catastrophic
Very Likely					
Likely			X		
Possible					
Unlikely		X		X	X
Very Unlikely	X				

	Low Confidence	Moderate Confidence	High Confidence
High level Risk	Undertake targeted new evidence collection or acquire greater knowledge and reassess risk	Monitor risk and treatment and re-evaluate risk based on monitoring	Monitor risk and treatment
Medium Level Risk	***Monitor risk and re-evaluate risk based on monitoring***	Monitor risk	Monitor risk
Low Level Risk	Monitor risk	Monitor risk	No action

Risk ID 4. There is potential for the practice of holding water up in the SEDN at targeted locations to cause more frequent and/or longer-term inundation of localised areas upstream of regulators which in turn could lead to a reduced benefit from investment in private drainage networks.

Risk Source:	Holding water up in SEDN	Consequence:	Reduced benefit from investment in private drainage networks.
Consequence Criteria:	Economic impact on private drainage systems		
Risk Factors: Selected sites have water tables less than 10 m. However, seasonal fluctuations are not captured. Unconfined aquifer generally has high transmissivity and storage, which reduces potential for mounding. SEDN is located in areas that are prone to flooding with associated private drainage systems.			

Consequence	Percentage likelihood.									
Catastrophic	0	10	20	30	40	50	60	70	80	90
Major	0	10	20	30	40	50	60	70	80	90
Moderate	0	10	20	30	40	50	60	70	80	90
Low	0	10	20	30	40	50	60	70	80	90
Insignificant	0	10	20	30	40	50	60	70	80	90

Likelihood \ Consequence	Insignificant	Low	Moderate	Major	Catastrophic
Very Likely					
Likely			X		
Possible		X			
Unlikely				X	
Very Unlikely	X				X

	Low Confidence	Moderate Confidence	High Confidence
High level Risk	Undertake targeted new evidence collection or acquire greater knowledge and reassess risk	Monitor risk and treatment and re-evaluate risk based on monitoring	Monitor risk and treatment
Medium Level Risk	***Monitor risk and re-evaluate risk based on monitoring***	Monitor risk	Monitor risk
Low Level Risk	Monitor risk	Monitor risk	No action

Risk ID 5. There is potential for diversion of or holding up water in the SEDN for use in MAR or passive recharge to cause reduced frequency of moderate (and potentially high) flows at downstream regulators, environmental receptors and ocean outlets which in turn could lead to degradation of downstream terrestrial and coastal ecosystems.

Risk Source:	Diversion of or holding water up in SEDN	Consequence:	Degradation of downstream terrestrial and coastal ecosystems.
Consequence Criteria:	Ecosystems		
Risk Factors: Flows to high value downstream ecosystems are already protected. There is some flexibility in the SEDN to enable management of this. Criteria can be set for the percentage of flows that may be held up or diverted.			

Consequence	Percentage likelihood of occurrence over 10 year period									
Catastrophic	0	10	20	30	40	50	60	70	80	90
Major	0	10	20	30	40	50	60	70	80	90
Moderate	0	10	20	30	40	50	60	70	80	90
Low	0	10	20	30	40	50	60	70	80	90
Insignificant	0	10	20	30	40	50	60	70	80	90

Likelihood \ Consequence	Insignificant	Low	Moderate	Major	Catastrophic
Very Likely					
Likely					
Possible	X	X			
Unlikely			X	X	
Very Unlikely					X

	Low Confidence	Moderate Confidence	High Confidence
High level Risk	Undertake targeted new evidence collection or acquire greater knowledge and reassess risk	Monitor risk and treatment and re-evaluate risk based on monitoring	Monitor risk and treatment
Medium Level Risk	***Monitor risk and re-evaluate risk based on monitoring***	Monitor risk	Monitor risk
Low Level Risk	Monitor risk	Monitor risk	No action

Risk ID 6. There is potential for Managed Aquifer Recharge to cause higher groundwater levels leading to more prolonged baseflow in drains and thus increased frequency of low flows which in turn could lead to a new ecological diversity, most notably for aquatic flora and fauna, e.g. movement of invasive species.

Risk Source:	Managed Aquifer Recharge	Consequence:	Change in ecological diversity in drains, e.g. movement of invasive species.
Consequence Criteria:	Ecosystems		

Risk Factors:
Drains with high ecological values are ecosystems with regional or local significance.
Site selection for MAR based on DTW > 10 m.
However, seasonal fluctuations are not captured.
These areas generally do not co-exist with drainage features but may be nearby.
Unconfined aquifer generally has high transmissivity and storage, which reduces potential for mounding.
Any increase in water table elevation and baseflow is likely to be very localised.

Consequence	Percentage likelihood of occurrence over 10 year period									
Catastrophic	0	10	20	30	40	50	60	70	80	90
Major	0	10	20	30	40	50	60	70	80	90
Moderate	0	10	20	30	40	50	60	70	80	90
Low	0	10	20	30	40	50	60	70	80	90
Insignificant	0	10	20	30	40	50	60	70	80	90

Likelihood \ Consequence	Insignificant	Low	Moderate	Major	Catastrophic
Very Likely					
Likely					
Possible	X	X			
Unlikely					
Very Unlikely			X	X	X

	Low Confidence	Moderate Confidence	High Confidence
High level Risk	Undertake targeted new evidence collection or acquire greater knowledge and reassess risk	Monitor risk and treatment and re-evaluate risk based on monitoring	Monitor risk and treatment
Medium Level Risk	Monitor risk and re-evaluate risk based on monitoring	Monitor risk	Monitor risk
Low Level Risk	***Monitor risk***	Monitor risk	No action

Risk ID 7. There is potential for the recharge of surface runoff to the shallow aquifer via MAR or enhanced recharge around the SEDN to introduce contaminants to the shallow aquifer which in turn could lead to groundwater becoming unsuitable for uses such as domestic or stock watering.

Risk Source:	MAR or enhanced recharge of surface runoff	Consequence:	Groundwater unsuitable for domestic or stock uses
Consequence Criteria:	Water quality		
Risk Factors: EPA have indicated that no change in water quality will be allowed. This will have to be proven before a scheme is approved.			

Consequence	Percentage likelihood of occurrence over 10 year period									
Catastrophic	0	10	20	30	40	50	60	70	80	90
Major	0	10	20	30	40	50	60	70	80	90
Moderate	0	10	20	30	40	50	60	70	80	90
Low	0	10	20	30	40	50	60	70	80	90
Insignificant	0	10	20	30	40	50	60	70	80	90

Likelihood	Consequence					
		Insignificant	Low	Moderate	Major	Catastrophic
	Very Likely	X				
	Likely					
	Possible					
	Unlikely		X			
	Very Unlikely			X	X	X

	Low Confidence	Moderate Confidence	High Confidence
High level Risk	Undertake targeted new evidence collection or acquire greater knowledge and reassess risk	Monitor risk and treatment and re-evaluate risk based on monitoring	Monitor risk and treatment
Medium Level Risk	Monitor risk and re-evaluate risk based on monitoring	Monitor risk	Monitor risk
Low Level Risk	***Monitor risk***	Monitor risk	No action

Risk ID 8. There is potential for diversion of surface water flows in the SEDN for recharge to the shallow aquifer to cause reduced frequency and/or magnitude of freshening inflows from the SEDN to the south which in turn could lead to higher salinity regimes in the northern wetlands and outfall at Salt Creek.

Risk Source:	Diversion of surface water flows in SEDN				Consequence:			Higher salinity regimes in the northern wetlands and outfall at Salt Creek		
Consequence Criteria:				Ecosystems						
Risk Factors: This risk could easy be mitigated through alternative management of the Upper South East elements of the network. Criteria can be set for the percentage of flows that may be held up or diverted.										
Consequence	Percentage likelihood of occurrence over 10 year period									
Catastrophic	0	10	20	30	40	50	60	70	80	90
Major	0	10	20	30	40	50	60	70	80	90
Moderate	0	10	20	30	40	50	60	70	80	90
Low	0	10	20	30	40	50	60	70	80	90
Insignificant	0	10	20	30	40	50	60	70	80	90

Likelihood	Consequence: Insignificant	Low	Moderate	Major	Catastrophic
Very Likely					
Likely					
Possible	X	X			
Unlikely			X		
Very Unlikely				X	X

	Low Confidence	Moderate Confidence	High Confidence
High level Risk	Undertake targeted new evidence collection or acquire greater knowledge and reassess risk	Monitor risk and treatment and re-evaluate risk based on monitoring	Monitor risk and treatment
Medium Level Risk	Monitor risk and re-evaluate risk based on monitoring	Monitor risk	Monitor risk
Low Level Risk	***Monitor risk***	Monitor risk	No action

Appendix E – Decision Support Tool (Graphs) for MAR (Scheme Types 1 and 2)

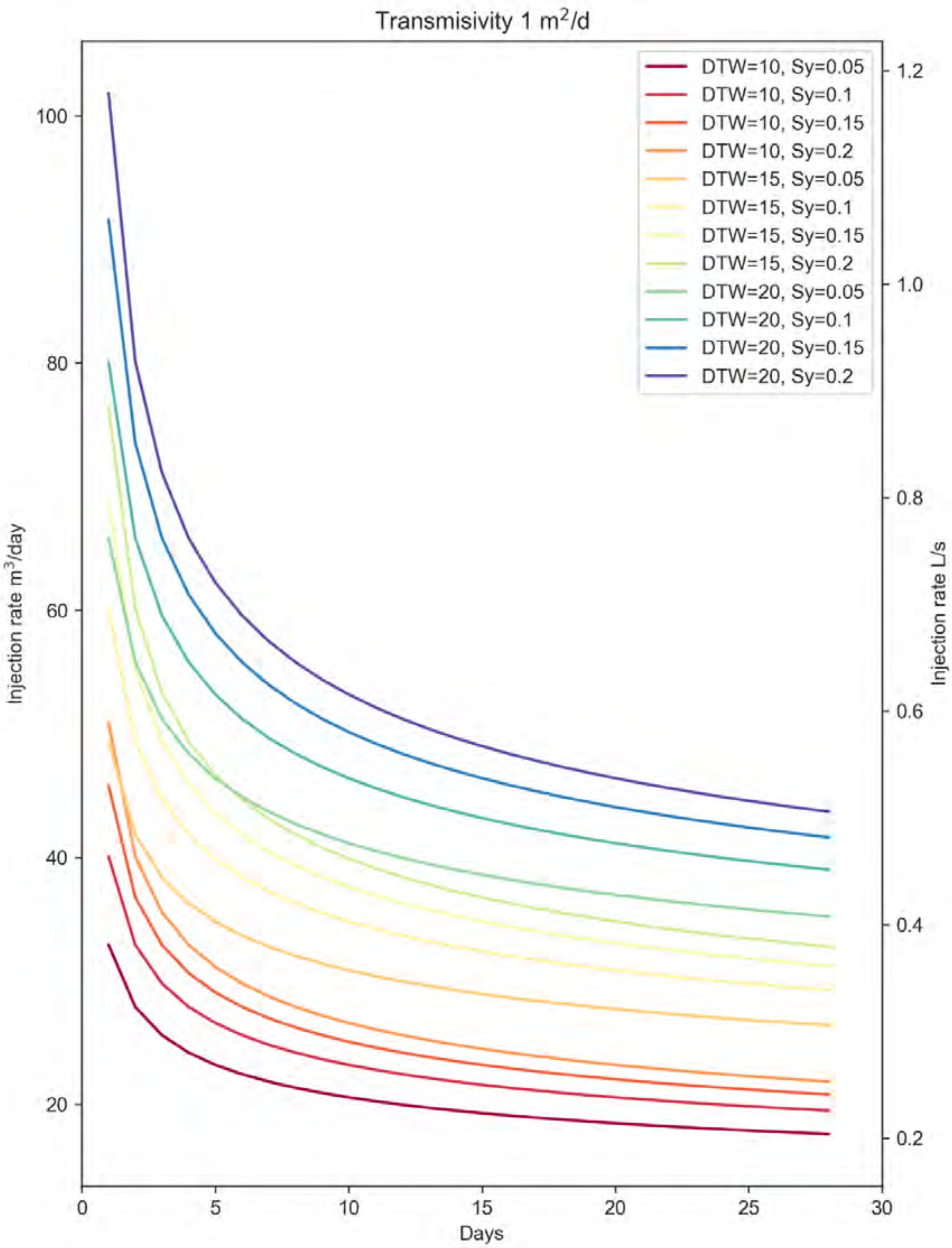


Figure E1. Injection rate vs injection duration curves for a transmissivity of 1 m^2/d. An appropriate curve may be selected for the relevant combination of depth to water (DTW) (m) and specific yield (Sy) with the optimum injection rate to avoid waterlogging for a selected injection duration read from the selected curve.

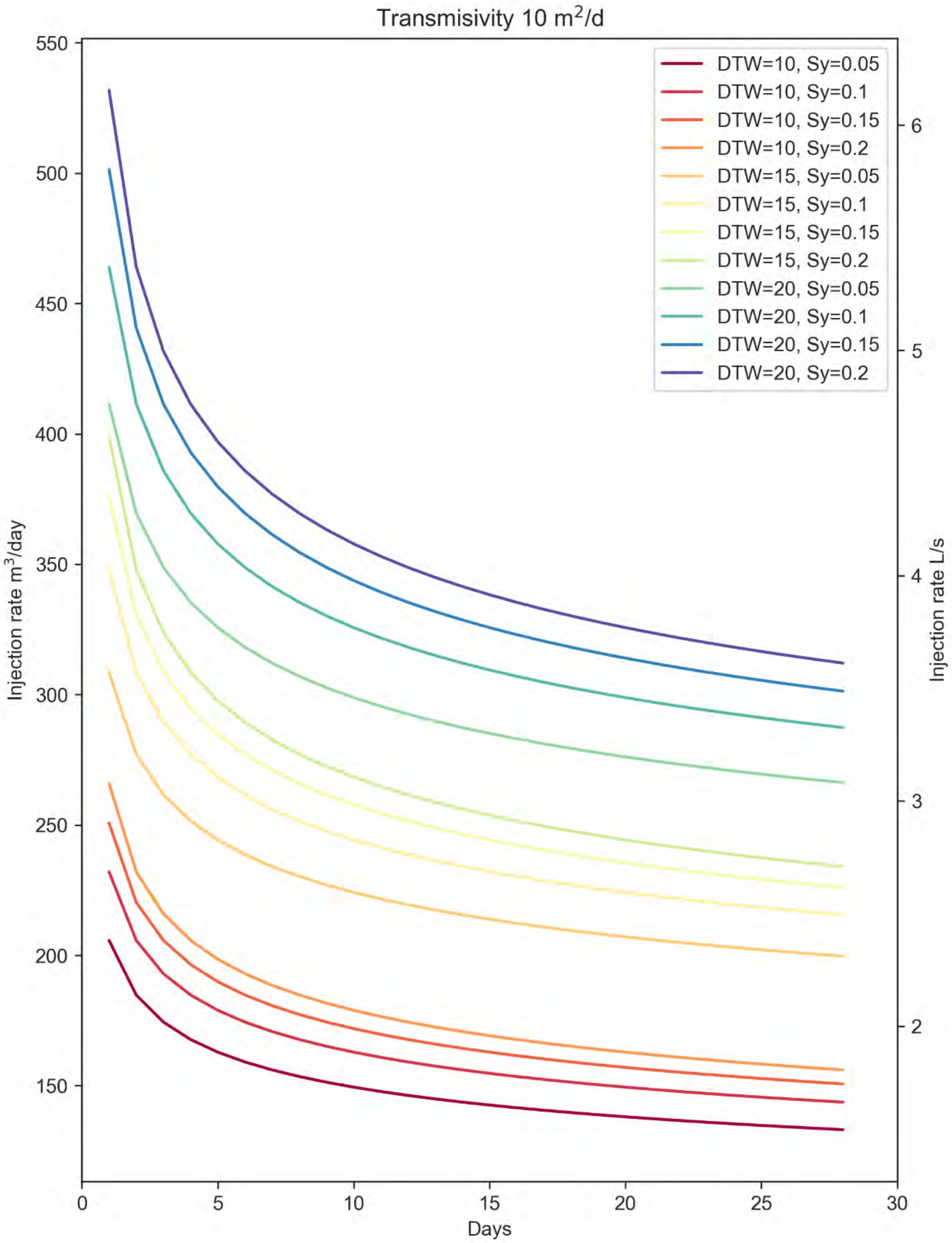


Figure E2. Injection rate vs injection duration curves for a transmissivity of 10 m^2/d. An appropriate curve may be selected for the relevant combination of depth to water (DTW) (m) and specific yield (Sy) with the optimum injection rate to avoid waterlogging for a selected injection duration read from the selected curve.

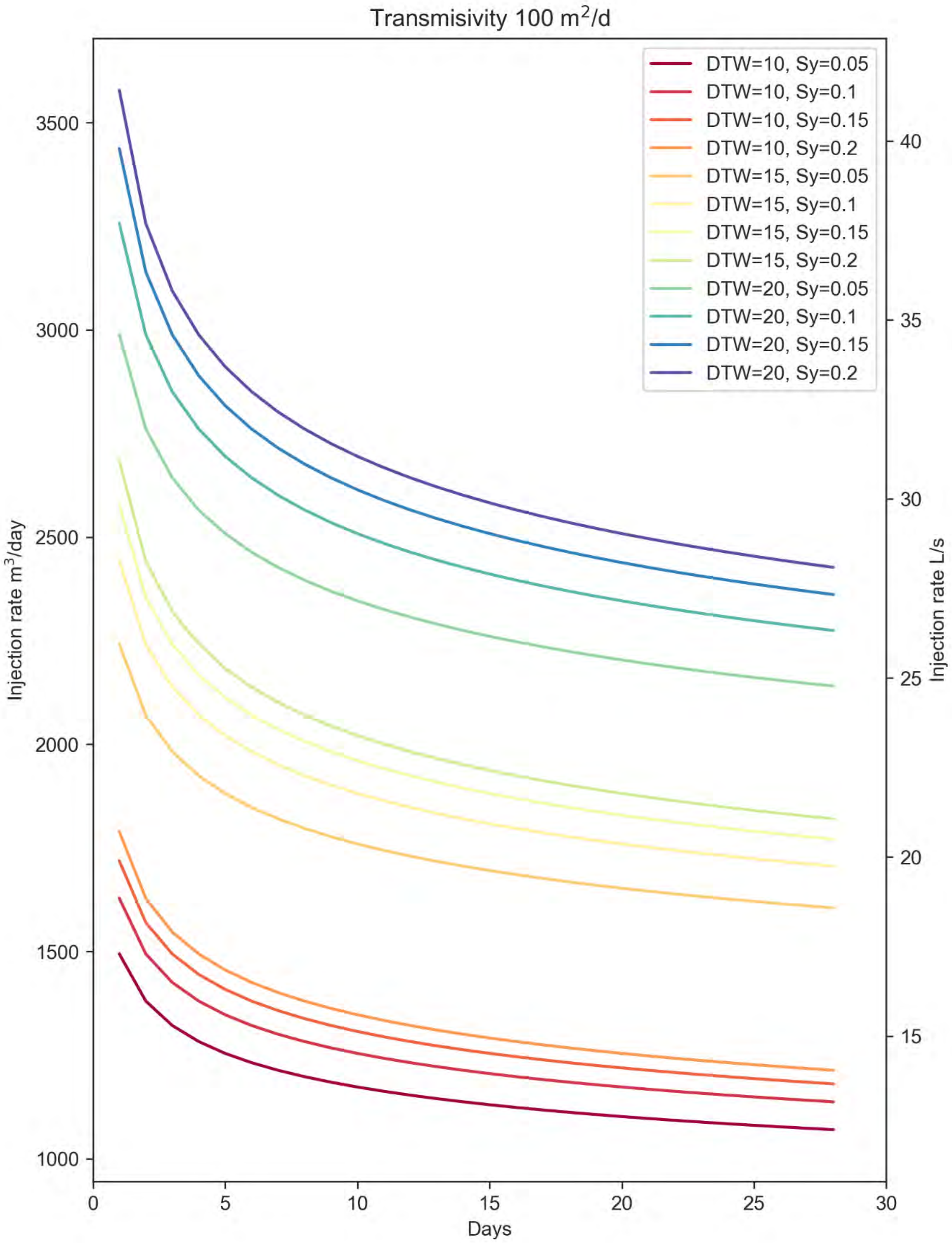


Figure E3. Injection rate vs injection duration curves for a transmissivity of 100 m^2/d. An appropriate curve may be selected for the relevant combination of depth to water (DTW) (m) and specific yield (Sy) with the optimum injection rate to avoid waterlogging for a selected injection duration read from the selected curve.

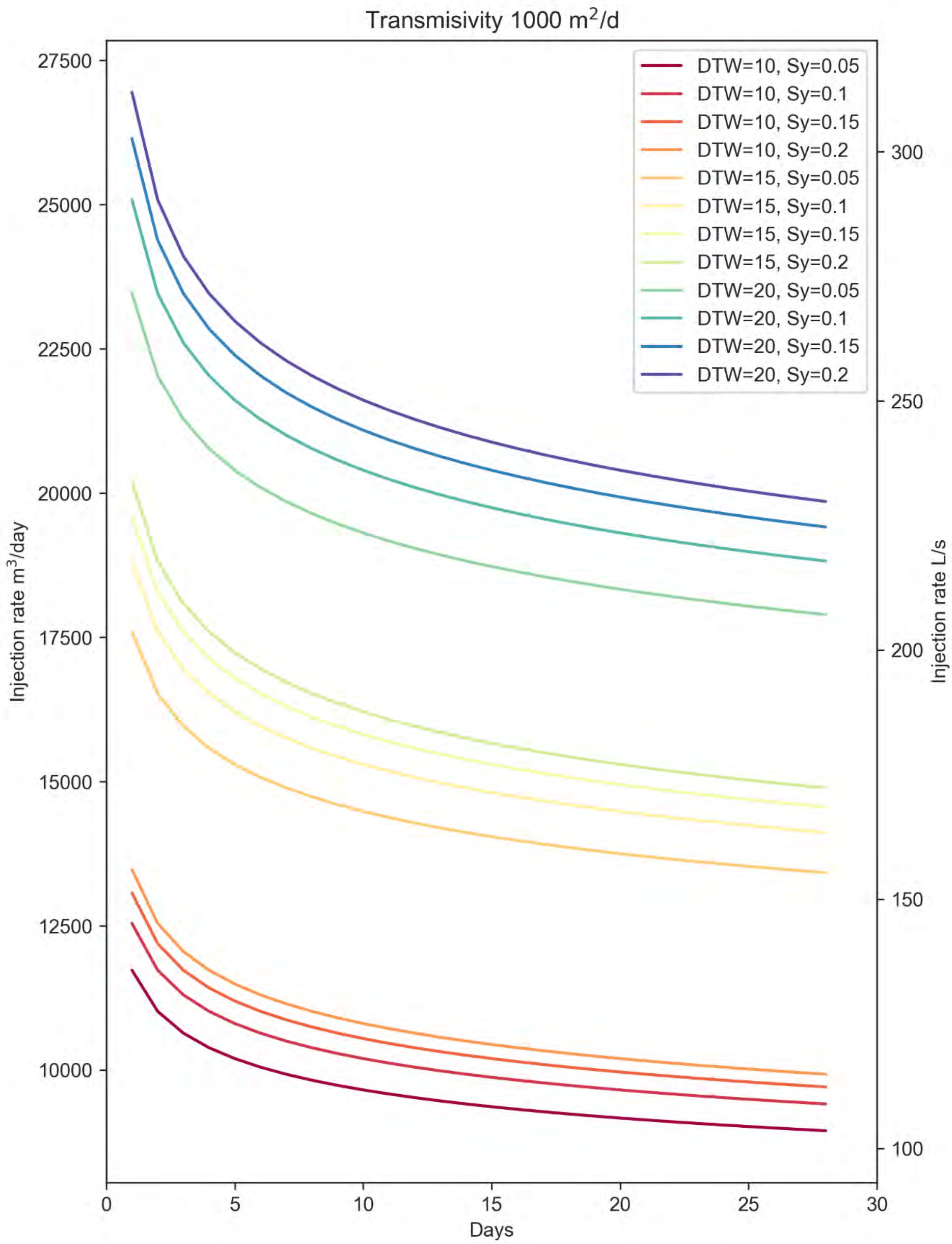


Figure E4. Injection rate vs injection duration curves for a transmissivity of 1,000 m^2/d. An appropriate curve may be selected for the relevant combination of depth to water (DTW) (m) and specific yield (Sy) with the optimum injection rate to avoid waterlogging for a selected injection duration read from the selected curve.

Appendix F – Decision Support Tool (Graphs) for Assessing Potential Extent of Waterlogging for Scheme Type 3 (Holding Water Up in the SEDN)

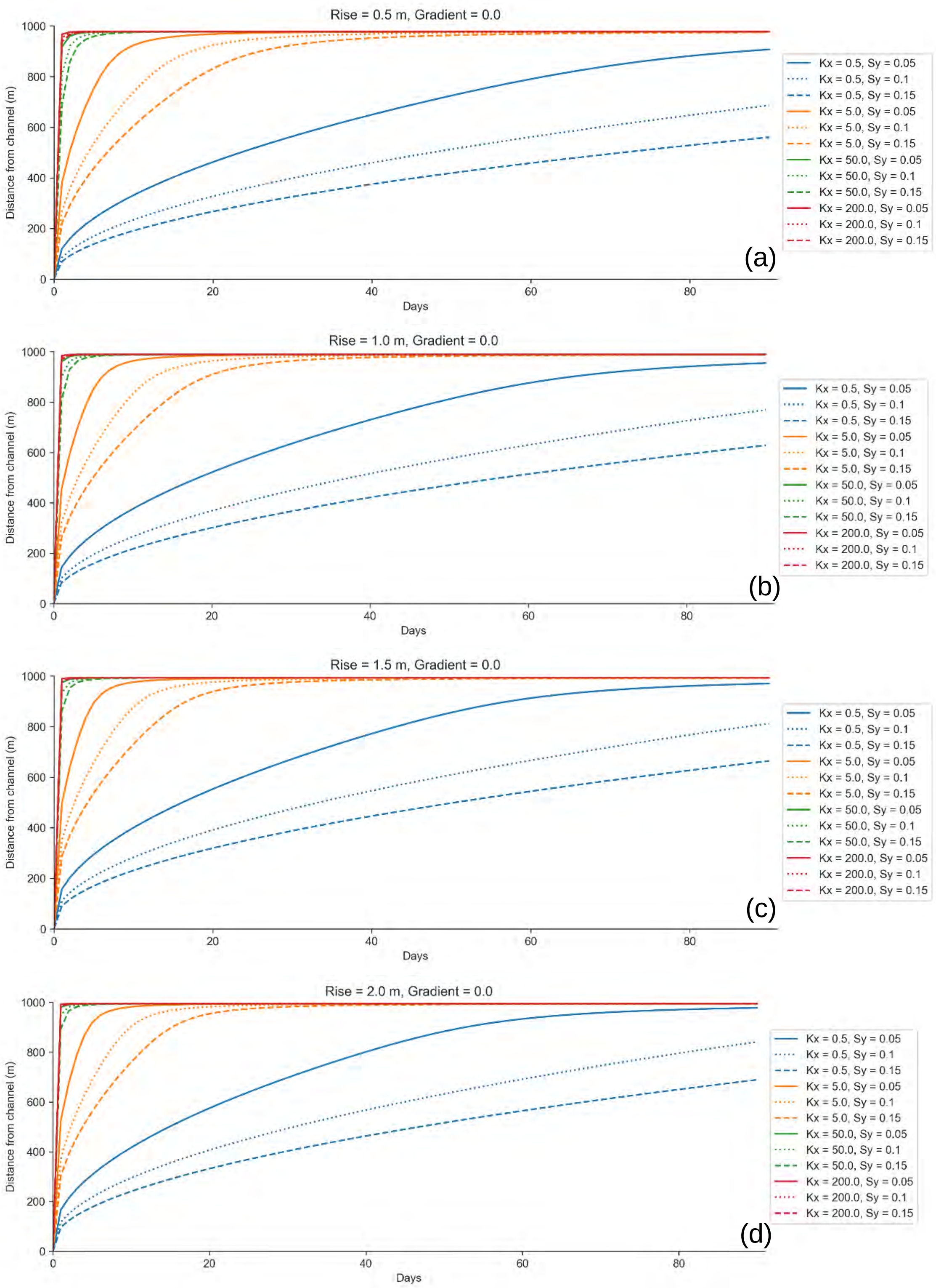


Figure F1. Graphs of predicted extent of waterlogging (as Distance from channel (m)) versus duration of the imposed drain water level increase (Days) for a hydraulic gradient of 0.0 (flat water table) and drain water level increase of (a) 0.5 m (b) 1.0 m (c) 1.5 m (d) 2.0 m above the base. An appropriate curve may be selected for the relevant combination of hydraulic conductivity (Kx in m/d) and specific yield (Sy) to determine the potential distance of impact from the channel for a given duration of the water level increase.

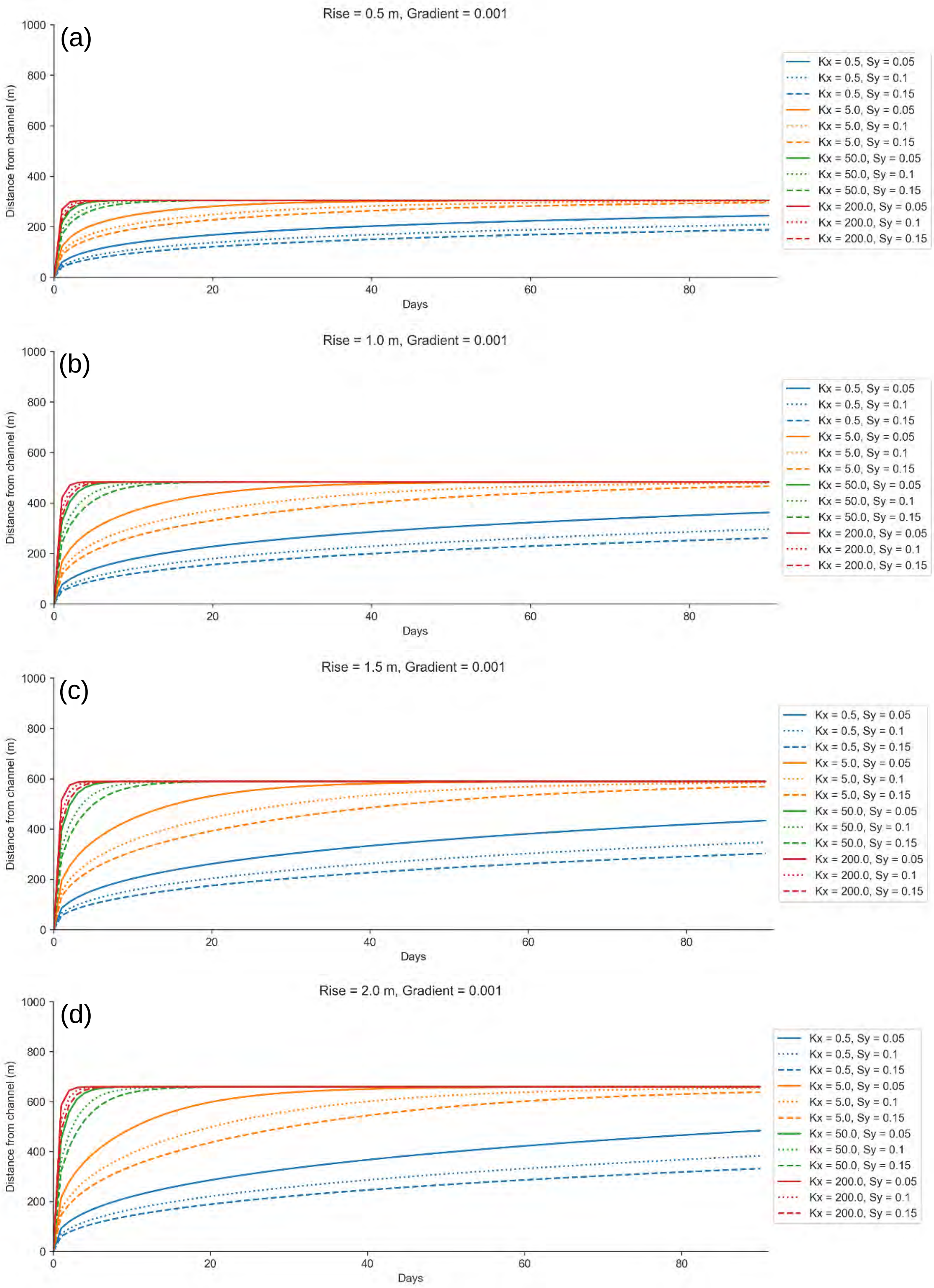


Figure F2. Graphs of predicted extent of waterlogging (as Distance from channel (m)) versus duration of the imposed drain water level increase (Days) for a hydraulic gradient of 0.001 and drain water level increase of (a) 0.5 m (b) 1.0 m (c) 1.5 m (d) 2.0 m above the base. An appropriate curve may be selected for the relevant combination of hydraulic conductivity (Kx in m/d) and specific yield (Sy) to determine the potential distance of impact from the channel for a given duration of the water level increase.

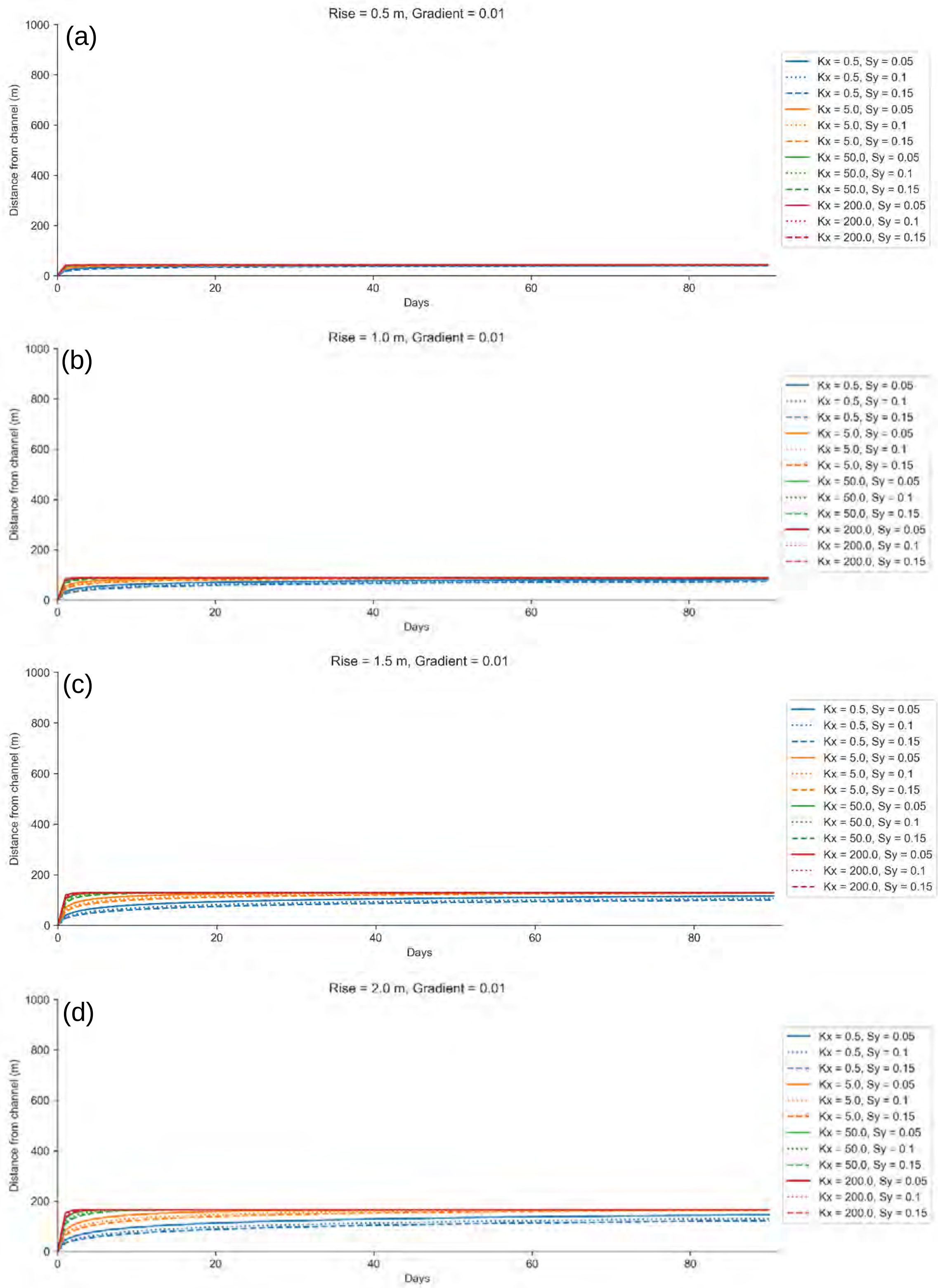


Figure F3. Graphs of predicted extent of waterlogging (as Distance from channel (m)) versus duration of the imposed drain water level increase (Days) for a hydraulic gradient of 0.01 and drain water level increase of (a) 0.5 m (b) 1.0 m (c) 1.5 m (d) 2.0 m above the base. An appropriate curve may be selected for the relevant combination of hydraulic conductivity (Kx in m/d) and specific yield (Sy) to determine the potential distance of impact from the channel for a given duration of the water level increase.

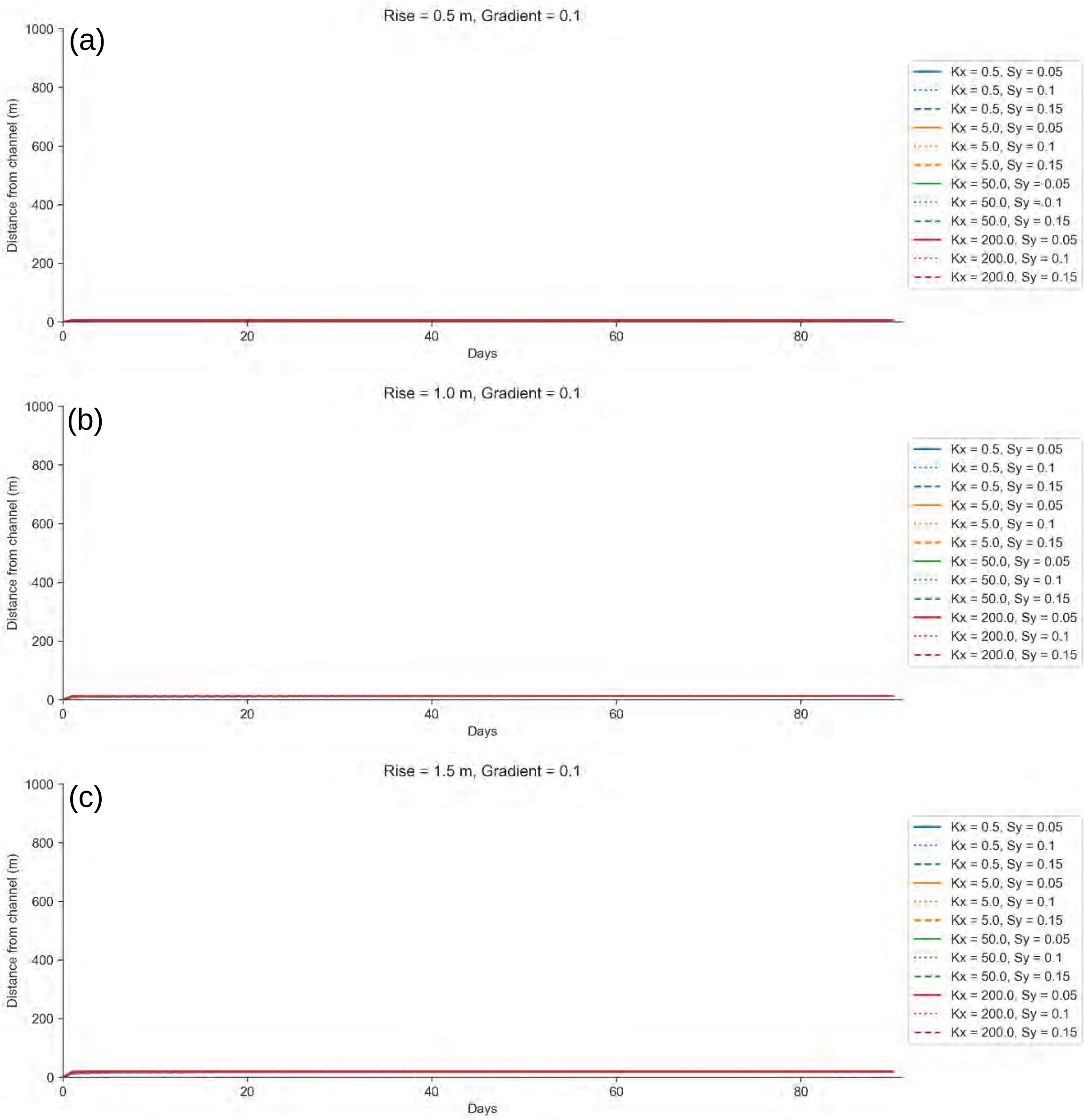


Figure F4. Graphs of predicted extent of waterlogging (as Distance from channel (m)) versus duration of the imposed drain water level increase (Days) for a hydraulic gradient of 0.1 and drain water level increase of (a) 0.5 m (b) 1.0 m (c) 1.5 m above the base. An appropriate curve may be selected for the relevant combination of hydraulic conductivity (Kx in m/d) and specific yield (Sy) to determine the potential distance of impact from the channel for a given duration of the water level increase.

Appendix G – Updated Risk Analysis for Risk IDs 1 to 4

Risk ID 1. There is potential for Managed Aquifer Recharge to cause localised water logging associated with water table mounding which in turn could lead to land becoming unsuitable for current land use.

Risk Source:	Managed Aquifer Recharge	Consequence:	Land becomes unsuitable for current land use.
Consequence Criteria:	Land suitability		
Risk Factors: Sites for MAR selected based on DTW > 10 m. However, seasonal fluctuations are not captured. Unconfined aquifer generally has high transmissivity and storage, which reduces potential for mounding. **Decision support tool available to select optimum injection rate and duration to minimise risk of waterlogging. However, the presence of heterogeneity in aquifer properties may limit the accuracy of outcomes.**			

Consequence	Percentage likelihood of occurrence during a 10 year period									
Catastrophic	0	10	20	30	40	50	60	70	80	90
Major	0	10	20	30	40	50	60	70	80	90
Moderate	0	10	20	30	40	50	60	70	80	90
Low	0	10	20	30	40	50	60	70	80	90
Insignificant	0	10	20	30	40	50	60	70	80	90

Likelihood	Consequence: Insignificant	Low	Moderate	Major	Catastrophic
Very Likely					
Likely	X				
Possible					
Unlikely		X			
Very Unlikely			X	X	X

	Low Confidence	Moderate Confidence	High Confidence
High level Risk	Undertake targeted new evidence collection or acquire greater knowledge and reassess risk	Monitor risk and treatment and re-evaluate risk based on monitoring	Monitor risk and treatment
Medium Level Risk	Monitor risk and re-evaluate risk based on monitoring	Monitor risk	Monitor risk
Low Level Risk	***Monitor risk***	Monitor risk	No action

Risk ID 2. There is potential for Managed Aquifer Recharge to cause localised water logging which in turn could lead to reduced benefit from investment in private drainage networks.

Risk Source:	Managed Aquifer Recharge	Consequence:	Reduced benefit from investment in private drainage networks.
Consequence Criteria:	Economic impact on private drainage systems		

Risk Factors:
Sites selected for MAR selected based on DTW > 10 m.
However, seasonal fluctuations are not captured.
These areas generally do not have private drainage networks although some may be adjacent to lower-lying areas containing private drainage.
Unconfined aquifer generally has high transmissivity and storage, which reduces potential for mounding.
Decision support tool available to select optimum injection rate and duration to minimise risk of waterlogging. However, the presence of heterogeneity in aquifer properties may limit the accuracy of outcomes.

Consequence	Percentage likelihood of occurrence over 10 year period									
Catastrophic	0	10	20	30	40	50	60	70	80	90
Major	0	10	20	30	40	50	60	70	80	90
Moderate	0	10	20	30	40	50	60	70	80	90
Low	0	10	20	30	40	50	60	70	80	90
Insignificant	0	10	20	30	40	50	60	70	80	90

Likelihood \ Consequence	Insignificant	Low	Moderate	Major	Catastrophic
Very Likely					
Likely	X				
Possible					
Unlikely		X			
Very Unlikely			X	X	X

	Low Confidence	Moderate Confidence	High Confidence
High level Risk	Undertake targeted new evidence collection or acquire greater knowledge and reassess risk	Monitor risk and treatment and re-evaluate risk based on monitoring	Monitor risk and treatment
Medium Level Risk	Monitor risk and re-evaluate risk based on monitoring	Monitor risk	Monitor risk
Low Level Risk	***Monitor risk***	Monitor risk	No action

Risk ID 3. There is potential for the practice of holding water up in the SEDN at targeted locations to cause more frequent and/or longer-term inundation of localised areas upstream of regulators which in turn could lead to land becoming unsuitable for current land use.

Risk Source:	Holding water up in SEDN	Consequence:	Land becomes unsuitable for current land use.
Consequence Criteria:	Land suitability		

Risk Factors:
Selected sites have water tables less than 10 m.
However, seasonal fluctuations are not captured.
Unconfined aquifer generally has high transmissivity and storage, which reduces potential for mounding.
SEDN is located in areas that are prone to flooding.
Decision support tool is available to understand potential extents of impacts so that appropriate decisions may be made regarding potential waterlogging impacts versus objective of the scheme.
Decision support tool indicates that potential waterlogging impacts may extend beyond 1 km where the water table is flat and between 300 m and 650 m for a gradient of 1 cm in 10 m.

Consequence	Percentage likelihood of occurrence over 10 year period									
Catastrophic	0	10	20	30	40	50	60	70	80	90
Major	0	10	20	30	40	50	60	70	80	90
Moderate	0	10	20	30	40	50	60	70	80	90
Low	0	10	20	30	40	50	60	70	80	90
Insignificant	0	10	20	30	40	50	60	70	80	90

Likelihood \ Consequence	Insignificant	Low	Moderate	Major	Catastrophic
Very Likely					
Likely					
Possible				X	X
Unlikely			X		
Very Unlikely	X	X			

	Low Confidence	Moderate Confidence	High Confidence
High level Risk	***Undertake targeted new evidence collection or acquire greater knowledge and reassess risk***	Monitor risk and treatment and re-evaluate risk based on monitoring	Monitor risk and treatment
Medium Level Risk	Monitor risk and re-evaluate risk based on monitoring	Monitor risk	Monitor risk
Low Level Risk	Monitor risk	Monitor risk	No action

Risk ID 4. There is potential for the practice of holding water up in the SEDN at targeted locations to cause more frequent and/or longer-term inundation of localised areas upstream of regulators which in turn could lead to a reduced benefit from investment in private drainage networks.

Risk Source:	Holding water up in SEDN	Consequence:	Reduced benefit from investment in private drainage networks.
Consequence Criteria:	Economic impact on private drainage systems		

Risk Factors:
Selected sites have water tables less than 10 m.
However, seasonal fluctuations are not captured.
Unconfined aquifer generally has high transmissivity and storage, which reduces potential for mounding.
SEDN is located in areas that are prone to flooding with associated private drainage systems.
Decision support tool is available to understand potential extents of impacts so that appropriate decisions may be made regarding potential waterlogging impacts versus objective of the scheme.
Decision support tool indicates that potential waterlogging impacts may extend beyond 1 km where the water table is flat and between 300 m and 650 m for a gradient of 1 cm in 10 m. The potential effect of this on the performance of private drainage systems has not been investigated.

Consequence	Percentage likelihood.									
Catastrophic	0	10	20	30	40	50	60	70	80	90
Major	0	10	20	30	40	50	60	70	80	90
Moderate	0	10	20	30	40	50	60	70	80	90
Low	0	10	20	30	40	50	60	70	80	90
Insignificant	0	10	20	30	40	50	60	70	80	90

Likelihood	Consequence				
	Insignificant	Low	Moderate	Major	Catastrophic
Very Likely					
Likely					
Possible			X	X	X
Unlikely		X			
Very Unlikely	X				

	Low Confidence	Moderate Confidence	High Confidence
High level Risk	***Undertake targeted new evidence collection or acquire greater knowledge and reassess risk***	Monitor risk and treatment and re-evaluate risk based on monitoring	Monitor risk and treatment
Medium Level Risk	Monitor risk and re-evaluate risk based on monitoring	Monitor risk	Monitor risk
Low Level Risk	Monitor risk	Monitor risk	No action