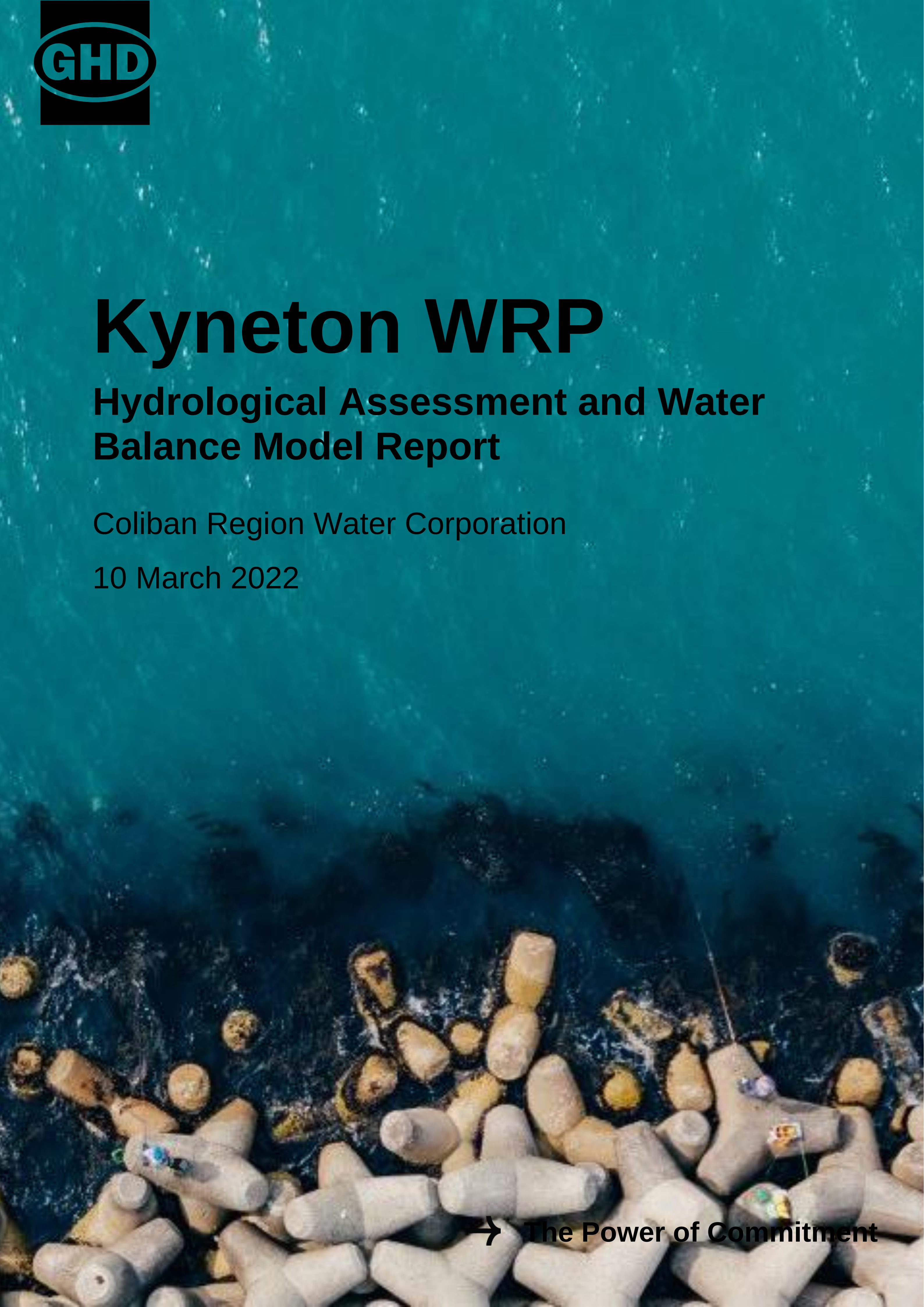
Kyneton WRP

Hydrological Assessment and Water Balance Model Report

Coliban Region Water Corporation

10 March 2022



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Executive summary

The purpose of this report is to document the following:

- Hydrological assessment of the Campaspe River at Kyneton now that additional gauging station data is available, including stream flow forecast estimates
- Outputs from the water balance for KWRP now that new storage assets have been completed and using the stream flow forecast estimates developed as part of the hydrological assessment

This information is used to determine the current and future storage requirements at the Kyneton WRP to enable operation within various adopted stream flow discharge limitations.

This report is subject to, and must be read in conjunction with, the limitations set out in section 1.4 and the assumptions and qualifications contained throughout the Report.

Hydrological Assessment

A hydrological assessment of recently available streamflow at the Campaspe River at Kyneton was undertaken with the objective of extending this streamflow record to be used within discharge ratio calculations in the Kyneton WRP water balance model and for use in the discharge risk assessment.

Streamflow data was available for the Campaspe River at Kyneton spanning just over 2 years, which is relatively short compared to the upstream gauge at Ashbourne which has approximately 89 years of data. Redesdale streamflow gauge, downstream from the Kyneton gauge, has approximately 68 years of streamflow data available. The catchment area of the Kyneton gauging station is 270 km^2, some 8 times larger than the 33 km^2 catchment area at Ashbourne. Average annual rainfall in the Ashbourne catchment is approximately 1000 mm/year, higher than the average annual rainfall within the Kyneton catchment with approximately 850 mm/year. Average annual rainfall reduces the further north you travel within the Campaspe catchment. When comparing streamflow at Ashbourne and Kyneton during the two years in which streamflow records overlap, it is apparent that there is considerably more water at Kyneton and that the Ashbourne gauge stops flowing during dry spells whilst Kyneton continues to flow – i.e., the larger catchment at Kyneton provides more streamflow volume and reliability of flow compared to the smaller catchment at Ashbourne, even though there is typically more rainfall within the Ashbourne catchment.

Streamflow records at Ashbourne were examined to understand if any long-term changes were apparent. It was noted for Ashbourne that there is a considerable step change in median annual streamflow when comparing the 1933-1996 period to the 1997-2021 period in which there is an 83% reduction

Climate data was obtained and used as input into several different rainfall runoff models for the Campaspe River at Kyneton. The best models were further refined, and the adopted rainfall runoff model was the ‘Sacramento’ model. Results showed a good fit (statistically) between modelled and observed streamflows when considering the flow duration curve, however modelled data on any given day was less accurate than the observed data, particularly for lower streamflows (i.e., 5 ML/day and below). The fit between observed and modelled is considered statistically good enough to be used for analyses within the water balance and discharge risk assessment.

Streamflow at Kyneton was extended using the calibrated Sacramento model as shown in Figure 1. The modelled streamflow at Kyneton when examined over the 1950-2021 period showed a similar step change to Ashbourne, before and after 1997, with a 55% reduction in median annual streamflow. The step change in streamflow volumes noted for Ashbourne (measured data) and Kyneton gauge (modelled data) after 1997 means that the period post 1997 is the most appropriate period in which to predict future streamflow at these two gauges.

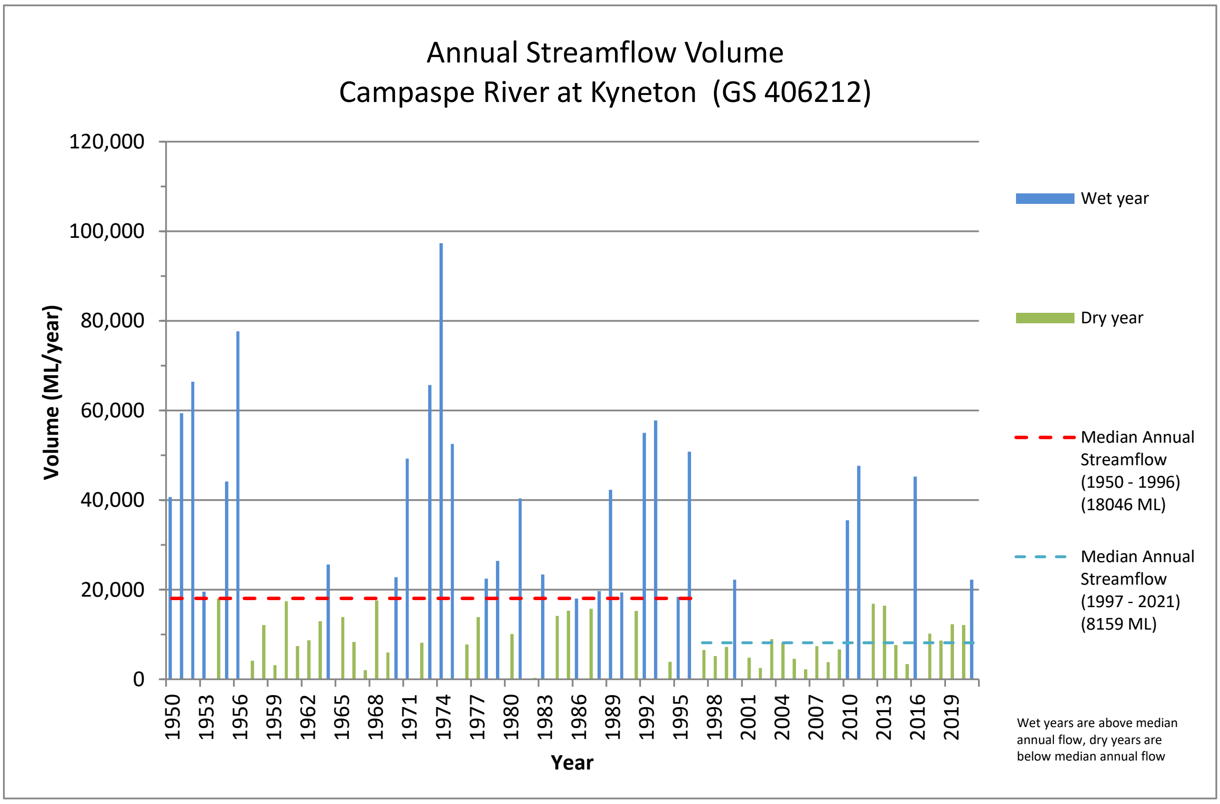

Figure 1 ***Modelled annual streamflow volume for Campaspe River at Kyneton – 1950 – 2021***

Water Balance Model

There are two sources of waste treated at Kyneton WRP– tradewaste and domestic waste, which are treated separately and produce tradewaste treated wastewater and domestic (BNR) treated wastewater. Tradewaste treated wastewater is blended with BNR treated wastewater to balance salinity before irrigation, while the remaining BNR treated wastewater is discharged to the Campaspe River.

An annual water balance model was developed which caters for three climate scenarios – a dry year (10th percentile); a typical rainfall year (50th percentile) and a wet year (90th percentile). The Kyneton modelled data was used as an input for the river flow and a series of scenarios for different climate conditions and years of inflows were run to observe the change in storage volumes over the year and the volume of treated wastewater discharged to Campaspe River.

The water balance model was developed to:

– Provide an operational tool to enable decision making
– Identify risk of overflows from water storages and/or over irrigation can be predicted and managed to the extent practicable
– Include a salinity balance to assist with operator decision making and help meet contractual requirements for electrical conductivity of Hardwicks irrigation water

The process flow diagram in Figure 2 illustrates how flows in the water balance model are transferred between lagoons and depicts the series of monthly calculations that are performed to reach a solution. Noting that this is a simplified approach and does not account for all possible operational approaches such as transfers from Lagoon 5 to Lagoon 4.

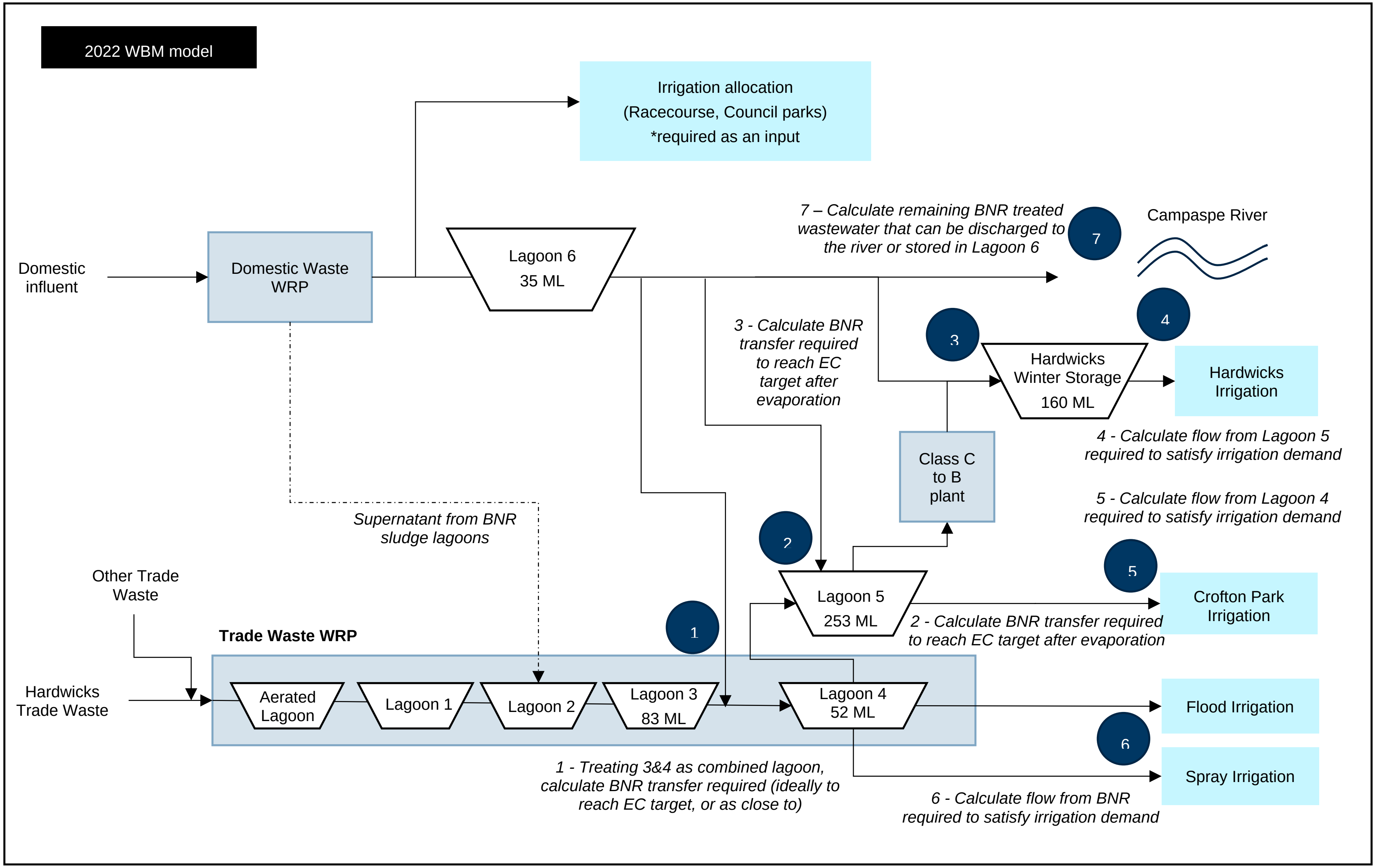

Figure 2 Water balance model simplified process flow and calculation series diagram

The model was used to run the following scenarios, assuming all assets are online, and Crofton Park is available for irrigation, to observe the monthly variation in storage levels over a year and the monthly discharge volume to river.

1. 2020 10th percentile year
2. 2020 50th percentile rainfall year
3. 2020 90th percentile year
4. 2036 10th percentile rainfall year
5. 2036 50th percentile rainfall year
6. 2036 90th percentile rainfall year

Table 1 shows the year corresponding to rainfall and estimated river flow at Kyneton used for the scenarios.

Table 1 Climate conditions

Climate condition	Year corresponding to rainfall and estimated river flow at Kyneton
10th percentile	2015
50th percentile	2004
90th percentile	2010

The scenarios represent the conditions that Kyneton WRP will need to be designed for now and into the future to enable operation within discharge limits.

A summary of the key annual outputs from the scenario analysis is provided in Table 2.

Table 2 Summary of annual balance for each scenario

Parameter	2020 10th percentile	2020 50th percentile	2020 90th percentile	2020 90th percentile	2036 10th percentile	2036 10th percentile	2036 50th percentile	2036 90th percentile	2036 90th percentile
Domestic inflow (ML/d)	1.6	1.6	1.6	1.6	2.4	2.4	2.4	2.4	2.4
Tradewaste inflow (ML/d)	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
Discharge rate (proportion of streamflow)	33.3%	33.3%	33.3%	66.7%	33.3%	66.7%	33.3%	33.3%	66.7%
Domestic influent (ML)	584	584	584	584	864	864	864	864	864
Tradewaste influent (ML)	401	401	401	401	401	401	401	401	401
Evaporation (rainfall) (ML)	-133	-77	33	33	-133	-133	-77	33	33
River discharge (ML)	-183	-267	-445	-469	-447	-463	-547	-624	-736
Irrigation (ML)	-669	-641	-501	-501	-669	-669	-641	-501	-501
Accumulation (ML)	0	0	72	48	16	0	0	173	61

The outputs of the water balance model for the different scenarios indicate the following:

– In 2020 with a domestic ADWF of 1.6 ML/d and tradewaste ADWF of 1.1 ML/d:
  - There is zero accumulation during a 50th percentile and 10th percentile year using a domestic treated wastewater discharge rate of 33.3% as a proportion of river flow. There is sufficient inflow to meet the total irrigation demand.
  - In a 90th percentile year a domestic treated wastewater discharge rate of 66.7% as a proportion of river flow is required to discharge sufficient domestic treated wastewater during summer months when there is low river flow. There is a tradewaste treated wastewater surplus of ~50 ML, with sufficient storage volume available within Coliban Water lagoons to store this volume. If two consecutive 90th percentile years were to occur, the storages would almost reach full capacity, with approximately 15 ML spare.

– In 2036 with a domestic ADWF of 2.4 ML/d and tradewaste ADWF of 1.1 ML/d:
  - There is zero accumulation during a 50th percentile year using a domestic treated wastewater discharge rate of 33.3% as a proportion of river flow. While a discharge rate of 66.7% is required to reach zero accumulation in a 10th percentile year. In both years there is sufficient inflow to meet all the irrigation demand.
  - In a 90th percentile year a domestic treated wastewater discharge rate of 66.7% as a proportion of river flow is required to discharge sufficient domestic treated wastewater during summer months when there is low river flow. There is a treated tradewaste wastewater surplus of ~60 ML, with sufficient storage volume available within Coliban Water lagoons to store this volume. If two consecutive 90th percentile years were to occur, the storages are likely to overflow, with an excess of approximately 15 ML.

– Similar results are observed when using the current operation that includes a discharge rate of 16.7% as a proportion of river flow (1 part discharge to 5 parts river flow) and river flows recorded at Redesdale for the same 90th percentile rainfall year (2010), with low river flows particularly in January and February resulting in the inability to discharge to the river during these months and hence requiring storage in the tradewaste lagoons. However, there is significant accumulation in 2020 and 2036 such that overflow from the tradewaste storages occurs.

Contents

Table index

Figure index

Appendices

1. Introduction

1.1 Background

Coliban Water owns and operates the Kyneton Water Reclamation Plant (WRP), which consists of two treatment plants that separately treat domestic and trade waste. The domestic waste is treated via a biological nutrient removal (BNR) plant, with chemical dosing (alum) to trim the treated wastewater phosphorus, clarification, tertiary filtration (Microscreen), and UV disinfection before being discharged to Campaspe River. The trade waste is treated via a series of lagoons and is used for irrigation.

Coliban Water have commenced negotiations with EPA regarding a licence amendment for the Kyneton Water Reclamation Plant (KWRP). GHD have been engaged to undertake a hydrological assessment of the Campaspe River at Kyneton, following the recent implementation of a gauging station at Kyneton, to provide stream flow forecast estimates. Using these flow estimates with the discharge dilution limits, GHD were tasked with producing outputs under different scenarios from the water balance model to represent the conditions that Kyneton WRP will need to be designed for now and into the future to enable operation within discharge limits.

1.2 Purpose of this report

This report documents the following:

- Hydrological assessment of the Campaspe River at Kyneton now that additional gauging station data is available, including stream flow forecast estimates
- Outputs from the water balance for KWRP now that new storage assets have been completed and using the stream flow forecast estimates developed as part of the hydrological assessment

1.3 Scope and limitations

This report: has been prepared by GHD for Coliban Region Water Corporation and may only be used and relied on by Coliban Region Water Corporation for the purpose agreed between GHD and Coliban Region Water Corporation as set out in section 1.1 of this report.

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1.4 Assumptions

The key assumptions for this report are outlined below:

- Streamflow estimated at the Kyneton WRP discharge point is an accurate representation of flows discharged to Campaspe River streamflow. Note that the available streamflow data for the Kyneton gauging station may not be a long enough dataset to provide confidence in using the data for extrapolation or for use within a rainfall runoff model. Additional data, over a wider range of climatic conditions, will improve confidence in model outputs.
- Residential and industrial flows as per the Kyneton Town Vision (GHD 2022) have been adopted
- Further assumptions for development of the water balance model are included in section 3.1.1.

2. Hydrological Assessment

This objective of the hydrological assessment is to essentially extend the relatively short two-year streamflow data available for the Campaspe River at Kyneton. The extended streamflow dataset will allow for discharge ratio calculations to be incorporated into the updated Kyneton WRP water balance including within wet and dry periods and for use within the discharge risk assessment for Kyneton.

Previous streamflow extension was undertaken based on a correlation of streamflow in the Campaspe River at Kyneton and Redesdale. A more robust method to estimate streamflow at Kyneton is undertaken below.

The Goulburn, Broken, Campaspe and Loddon (GBCL) source model was completed by DELWP in 2016. However, initial investigations of the model show that inflows upstream of Lake Eppalock (including the Campaspe River) appear to be 'lumped' together. As such, transposing streamflow from the Ashbourne gauge (which has data available from 1933 until present and is located upstream of the Kyneton streamflow gauge) was initially thought to be the most appropriate method, but for reasons set out below, the development of a rainfall runoff model ended up being the preferred method.

2.1 Streamflow Data

2.1.1 Overview of streamflow data available

A range of streamflow data is available for the Campaspe River above Lake Eppalock, including Redesdale (gauging station 406213), Ashbourne (gauging station 406208), and a relatively new gauge at Kyneton (gauging station 406212). An overview of the locations of these gauges and the streamflow data available is presented in Figure 3 and in Table 3.

Streamflow data available for the Campaspe River at Kyneton is relatively short term, spanning just over 2 years and with 723 days of data available. Ashbourne gauging station has considerably more data available than Kyneton, with approximately 89 years of streamflow data available (32,377 days of data). Redesdale has approximately 68 years of streamflow data available (24,868 days of data), although 5.9% of days (1,395 days) within that period are missing.

In order to undertake a water balance for the Kyneton WRP and to undertake calculations for the discharge risk assessment, statistics need to be determined on streamflow at the Campaspe River at Kyneton over a longer period of time than the two years available. Moreover, this allows calculations to incorporate different seasons and climatic periods.

Table 3 Available streamflow data for the Campaspe River above Lake Eppalock

Site Name	Ashbourne	Kyneton	Redesdale
Gauge Number	406208	406211	406213
Start Date	12/04/1933	14/11/2019	2/11/1953
Finish Date	2/12/2021	3/12/2021	3/12/2021
Total days in record	32377	723	24868
Total number of data	32377	723	23473
Blank / missing data	0	0	1395
Percentage blank data	0.0%	0.0%	5.9%
Zero flow data*	10012	0	3325
Percentage zero flow of data	30.9%	0.0%	14.2%
Catchment area (km^2)	33	270	629
Stream distance to next gauge	35.6 km to Kyneton	41.3 km to Redesdale	-

*Days when streamflow is zero

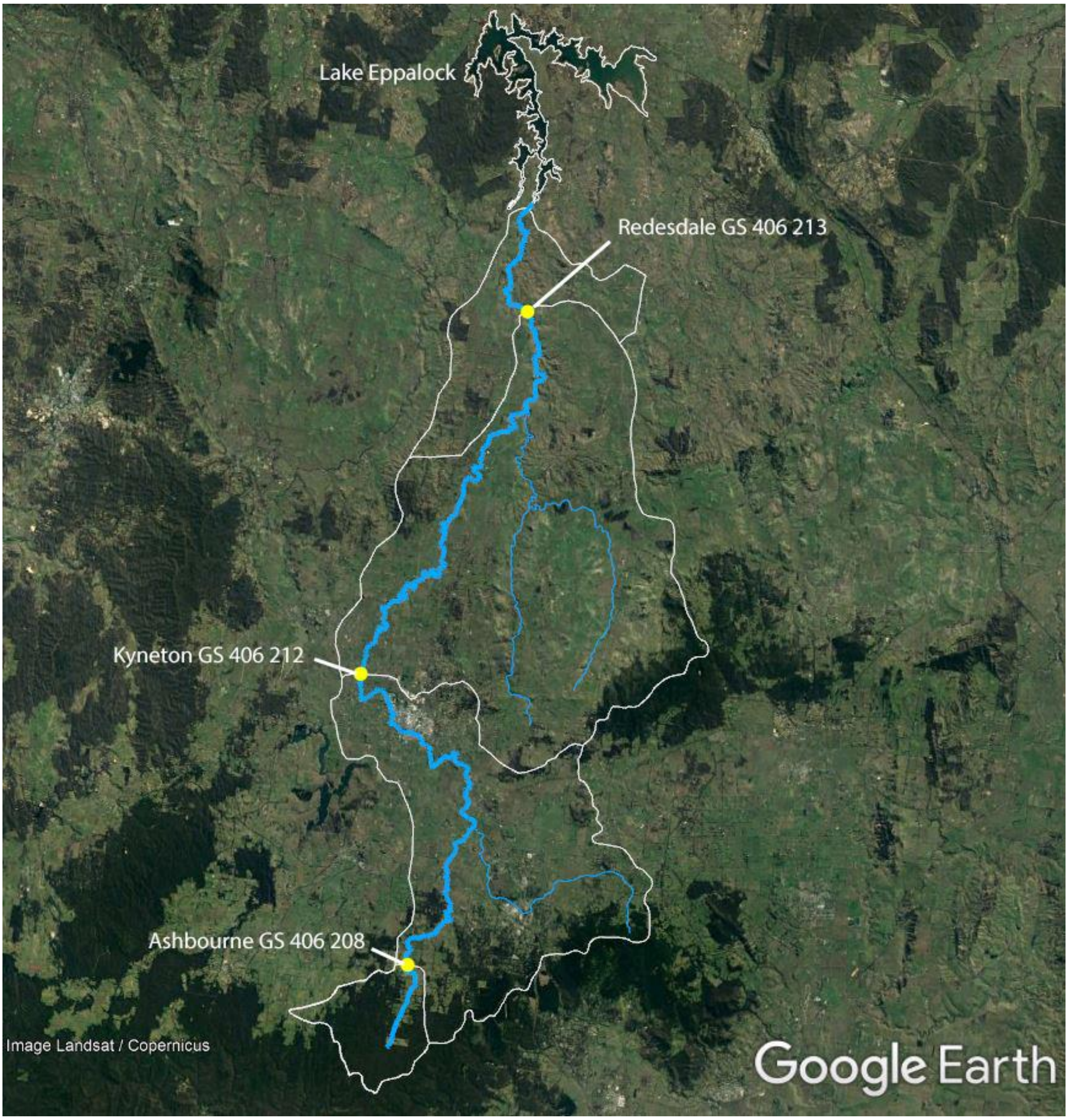

Figure 3 Campaspe River above Lake Eppalock – Streamflow gauging stations and catchment boundaries

2.1.2 Ashbourne, Kyneton and Redesdale gauged streamflows

Streamflow data at Ashbourne gauging station is of interest to this study as it is a gauge directly above the Kyneton gauging station and has a long record available. This gauge can be used as a basis to extend Kyneton streamflows, if an adequate relationship between the gauges was available.

Streamflow data (instantaneous (15 minute)) for both Ashbourne and Kyneton gauges are presented in Figure 4 for 2020 and in Figure 5 for 2021. It is apparent that the streamflow at Kyneton appears to be an 'amplified' version of streamflow at Ashbourne. This is due mainly to the larger catchment area above the Kyneton gauge (270 km^2) which is approximately eight times larger than the catchment at Ashbourne (33 km^2).

There are periods in both 2020 and 2021 in which Ashbourne gauge has no streamflow and Kyneton gauge has streamflow (sometimes significantly, as in March – April 2021). Localised storms within the catchment below Ashbourne gauge but above the Kyneton gauge will have contributed to this additional flow noted at the Kyneton gauge. The key outcome of this is that Ashbourne streamflow gauge by itself will not always allow for good prediction of streamflow at Kyneton. A rainfall runoff model for Kyneton, rather than an 'extrapolation' of streamflows between Ashbourne and Kyneton, is the preferred method.

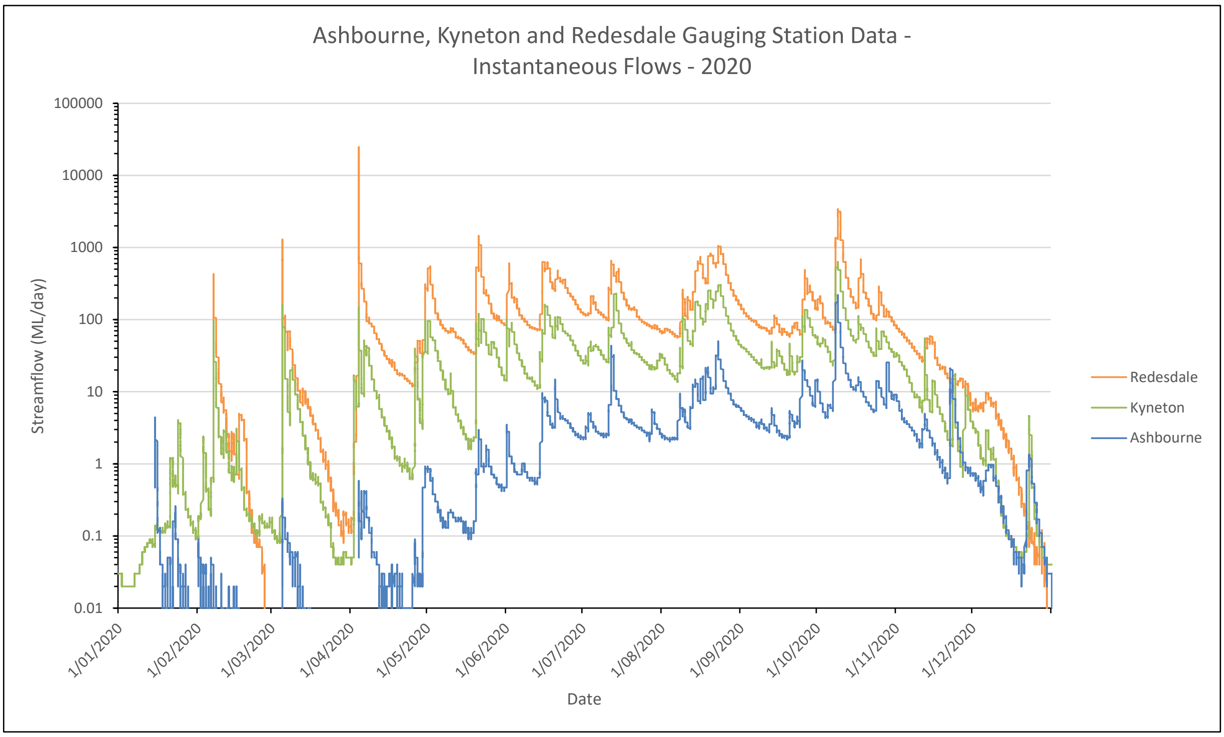

Figure 4 ***Streamflow data for Campaspe River at Ashbourne, Kyneton and Redesale (2020)***

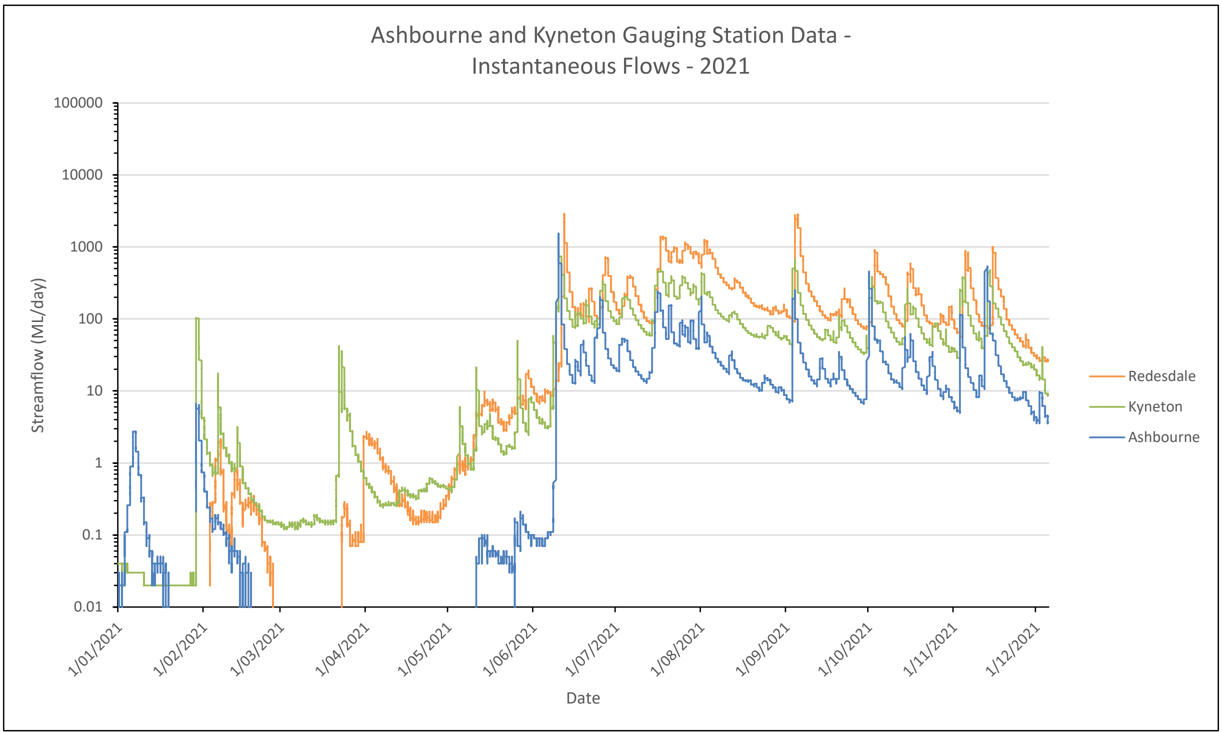

Figure 5 ***Streamflow data for Campaspe River at Ashbourne, Kyneton and Redesdale(2021)***

Flow duration curves for Ashbourne, Kyneton and Redesdale are presented in Figure 6 (December 2019 – December 2021 period for all gauges). The comparison shows that there is considerably more streamflow at Redesdale and Kyneton compared to Ashbourne (as expected given the difference in catchment areas), and that Ashbourne had zero streamflow for 25% of days, whereas Kyneton had measurable streamflow on all days during that same period. For higher streamflows there was more streamflow at Redesdale compared to Kyneton or Ashbourne, however at low streamflow Redesdale had zero streamflow (<0.01 ML/day) for about 17% of days, whereas Kyneton streamflow did not have any data below 0.02 ML/day (due to gauge zeroing issues, streamflow below 0.02 ML/day was determined to be zero streamflow at Kyneton) during that same period.

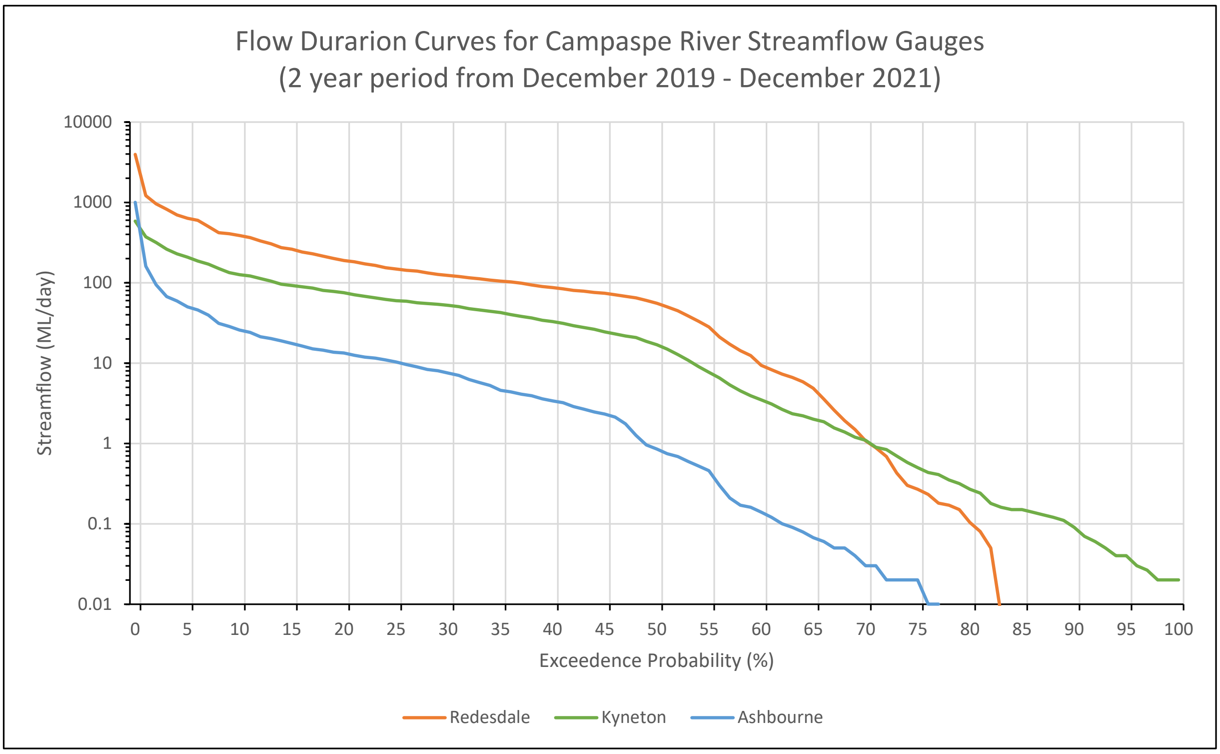

Figure 6 *Flow duration curves for Campaspe River at Redesdale, Ashbourne and Kyneton gauging stations (Dec 2019 – Dec 2021) – log y-axis*

Annual streamflow volumes for Ashbourne are presented in Figure 7. Of interest is the change in streamflows noted before and after 1997. During the 1933 – 1996 period, the median annual streamflow for the Campaspe River at Ashbourne was 7,918 ML/year, and for the 1997-2021 period this reduced to 1,336 ML/year, a reduction of 6,582 ML/year or approximately an 83% reduction. Annual streamflow for the year 2020 and 2021 would have been considered a dry and wet year respectively (i.e., below and above the 1933-1996 median annual streamflow). However, when considering the median annual streamflow for the 1997-2021 period, 2020 is considered to be approximately a median year and 2021 a wet year for streamflow.

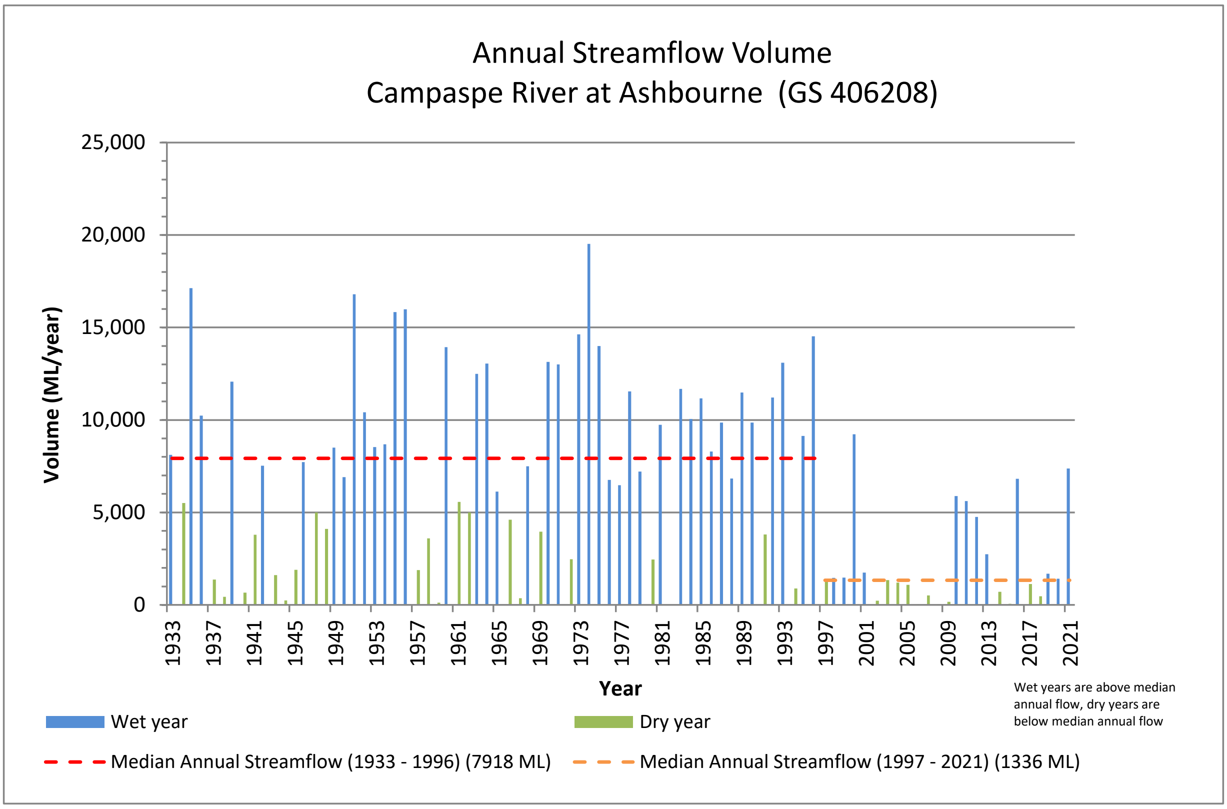

Figure 7 ***Annual streamflow volume for Campaspe River at Ashbourne streamflow gauging station***

2.1.2.1 Streamflow routing between Ashbourne and Kyneton gauge stations

Information on streamflow routing between Ashbourne and Kyneton gauges was obtained to assist in extrapolating streamflows between these gauges. From the available streamflow data, three separate events showed some form of in-stream routing from the Ashbourne gauge to the Kyneton gauge (a stream distance of 35.6 km apart). Instantaneous streamflow data showed there to be a variable lag in the peak of streamflow between the two gauges (ranging from 0.65 days to 1.15 days), the daily data showed a lag of 1 day is appropriate at this timestep i.e., a peak of streamflow takes approximately one day to travel to Kyneton from Ashbourne.

Whilst this information is interesting, it did not get used within the rainfall runoff modelling for Kyneton. However, it is presented in Appendix A, as it may be useful in future studies.

2.2 Climate Data

As development of a rainfall runoff model for Kyneton was the preferred method for streamflow extension, it was necessary to obtain climate data for the catchment.

2.2.1 Gridded climate data

Climate data (rainfall and evaporation data) used within the initial rainfall-runoff model was obtained from the Scientific Information for Land Owners (SILO) data warehouse (www.longpaddock.qld.gov.au/silo/ accessed in December 2021). Grided climatic data was available, and a map showing the locations of relevant data points across the upper Campaspe River catchment is presented in Figure 8. The catchment area located within each grid cell was calculated and is presented in Table 4.

Daily rainfall and evaporation from 1/1/1890 to 3/12/2021 was obtained for the 49 grid points. For each day, the areal weighted rainfall and evaporation data for the whole catchment was determined by multiplying the rainfall in each grid area by the catchment area within the grid cell and then adding them all up and dividing by the total catchment area. This was done for the catchment above the Kyneton Gauge station, the catchment above the Campaspe Reservoir and the catchment above the Ashbourne gauging station.

The average annual rainfall for each grid point was calculated and an isohyet map was developed and is presented in Figure 9 and a pan evaporation map is presented in Figure 10. Results show there is generally less rainfall in the north of the catchment (average annual rainfall 750-800 mm/year) increasing in the southwest of the catchment (average annual rainfall of 1050 mm/year) and higher evaporation in the north (average annual evaporation of 1200 mm) compared to the southwest (average annual evaporation of 1100 mm).

For the Kyneton gauging station catchment, the average annual rainfall is 851 mm, compared to 1005 mm for the Ashbourne gauging station catchment (and 972 mm for the Campaspe Reservoir catchment). Annual average pan evaporation for the Kyneton gauging station catchment is 1132 mm, 1080 mm for the Ashbourne catchment (and 1089 mm for the Campaspe Reservoir catchment, this reservoir is Greater Western Water's drinking water supply dam located near Woodend).

Table 4 Grid areas within the upper Campaspe River catchment used in calculating areal weighted rainfall and evaporation data

Kyneton gauging station catchment			Ashbourne gauging station catchment			Campaspe Reservoir catchment		
Grid Reference	Area (ha)	Proportion of total area	Grid Reference	Area (ha)	Proportion of total area	Grid Reference	Area (ha)	Proportion of total area
2	39	0.14%	29	22	0.08%	24	460	7.18%
3	29	0.11%	30	1134	28.17%	25	212	3.31%
9	964	3.54%	31	1426	35.44%	29	22	0.34%
10	2241	8.22%	37	502	1.84%	30	1134	17.69%
11	1416	5.20%	38	941	23.38%	31	2183	34.05%
12	218	0.80%				32	844	13.16%
13	7	0.03%				37	502	7.83%
17	1218	4.47%				38	1012	15.79%
18	2450	8.99%				39	41	0.65%
19	2420	8.88%						
20	559	2.05%						
24	1056	3.87%						
25	2450	8.99%						
26	2450	8.99%						
27	2145	7.87%						
29	22	0.08%						
30	1134	4.16%						
31	2193	8.05%						
32	2043	7.49%						
33	629	2.31%						
34	20	0.07%						
37	502	1.84%						
38	1012	3.71%						
39	41	0.15%						
Sum	27259	100%		4024	100%		6409	100%

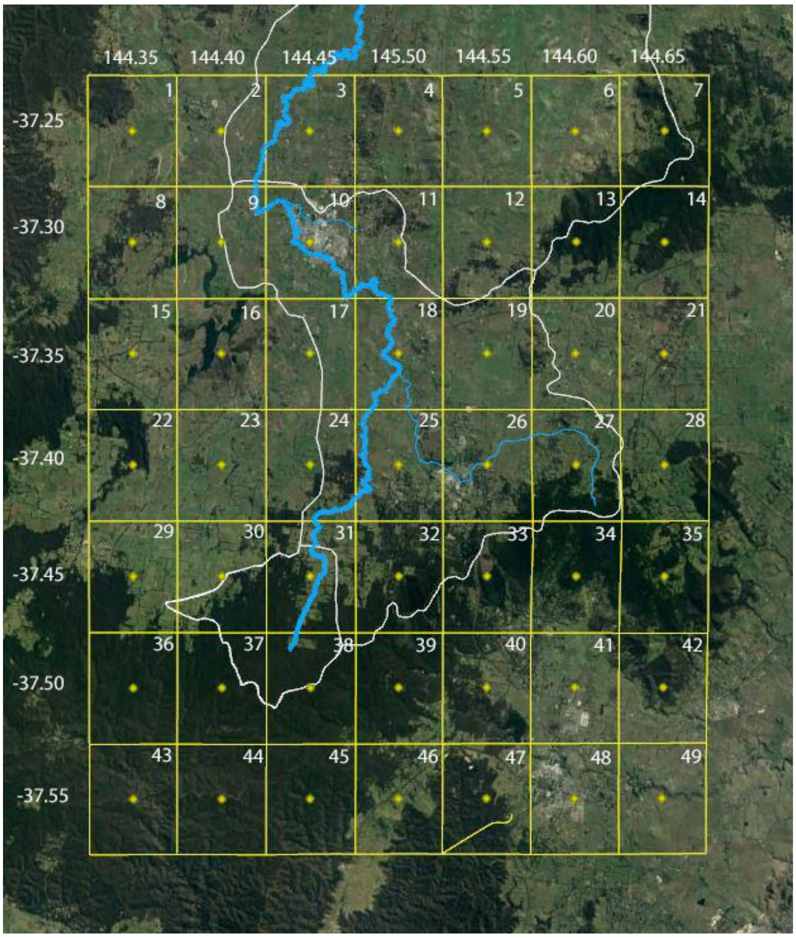

Figure 8 *SILO gridded data available for the upper Campaspe River*

Figure 9 *Average annual rainfall isohyets (mm) for the upper Campaspe River (source: SILO data)*

Figure 10 Average annual pan evaporation (mm) for the upper Campaspe River (source: SILO data)

2.2.2 Climate data used in the preferred rainfall runoff model

Whilst the grided data set provides a good overview of rainfall and evaporation for the upper Campaspe River catchment, there can be some issues with the dataset, particularly around 'smoothing' of data and interpolation between rainfall gauges.

SILO 'patched point data' is also available for a number of rainfall gauging station sites within and near to the Kyneton gauging station catchment. Patched point data essentially takes existing rainfall data at a location (and other climatic data) and where records are missing infills from nearby stations. This patched point data was used in the adopted rainfall runoff model. A map of the patched point climate sites is presented in Figure 11 and summarised in Table 5.

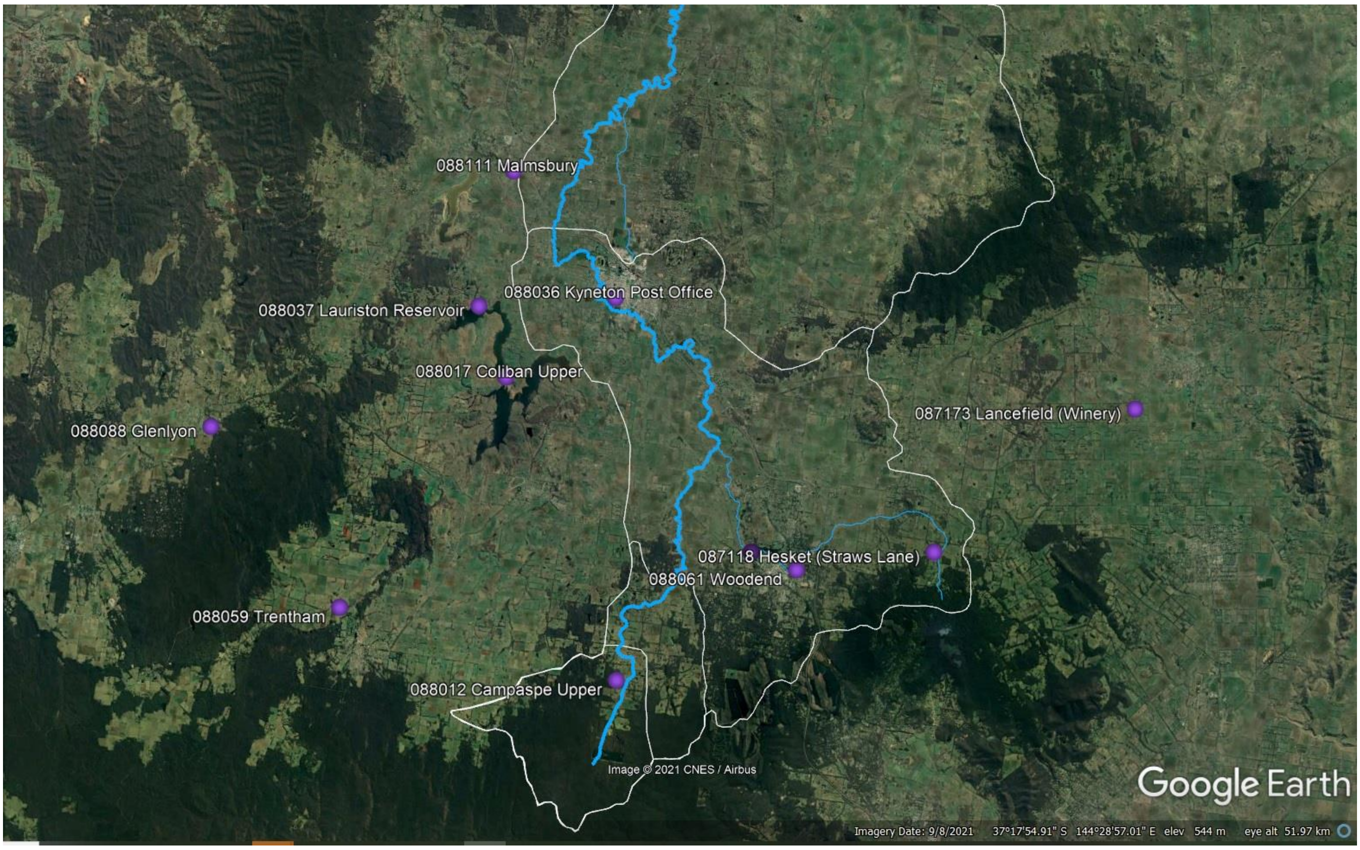

Figure 11 *SILO 'patched point' data sites within or near to the upper Campaspe River catchment (source: SILO data))*

Table 5 *Overview of SILO 'patched point' data sites within or near to the upper Campaspe River catchment*

Station Name	Station Number	Latitude	Longitude
Hesket (Straws Lane)	87118	-37.35	144.6067
Lancefield (Winery)	87173	-37.294	144.7066
Campaspe Upper	88012	-37.4	144.45
Coliban Upper	88017	-37.281	144.3958
Kyneton Post Office	88036	-37.25	144.45
Lauriston Reservoir	88037	-37.253	144.3825
Trentham	88059	-37.371	144.3137
Woodend	88061	-37.357	144.539
Woodend (Corinella Rd)	88062	-37.35	144.5167
Glenlyon	88088	-37.3	144.25
Malmsbury	88111	-37.2	144.4

*Shaded sites in table above were those used in the adopted rainfall runoff model

2.3 Rainfall runoff modelling

2.3.1 Initial modelling

Initial modelling was undertaken using the Rainfall-Runoff Library tool developed by eWater to assist in generating catchment runoff from daily rainfall and evaporation data. The Library has several lumped rainfall models for use within it, including Australian Water Balance Model (AWBM), Sacramento, Simhyd, SMAR and Tank.

Inputs for the rainfall-runoff analysis were streamflow record for the Campaspe River at Kyneton (2019-2021) and daily rainfall and evaporation over the same period available from the SILO grided climate data analysis and the catchment area of 270 km^2. Results (using Nash-Sutcliffe criteria, where the higher the number, the better the calibration) using the five different runoff models with a number of different optimisation methods are presented in Table 6.

The result with the highest Nash-Sutcliffe value of 0.797 is the Sacramento model, using a pattern search multi start optimisation method.

Table 6 Rainfall-runoff model Nash-Sutcliffe criterion value calibration results from Rainfall Runoff Library

Model →	AWBM	Sacramento	Simhyd	SMAR	Tank
Optimisation method ↓					
Generic	0.749	0.521	0.692	<0	N/A
Pattern Search Multi Start	0.447	0.797	0.329	0.034	0.177
Uniform Random Sampling	<0	<0	<0	<0	<0
Rosenbrock Multi-Start Optimiser	N/A	<0	0.094	<0	<0
Rosenbrock Single Start	0.557	0.679	0.235	0.036	N/A
SCE-UA	0.706	<0	0.014	0.027	0.244
Pattern Search	0.727	0.739	0.731	0.027	0.272

Note N/A = not available / error in modelling.

2.3.2 Adopted rainfall runoff model

The initial modelling was undertaken using gridded climate data, which as discussed in Section 2.2.2, can have some limitations in accuracy across each grid point. Using the best rainfall runoff model selected from the initial modelling (Sacramento), a calibration optimisation tool was used – 'FORS' to further refine the rainfall runoff relationship for the upper Campaspe River at Kyneton.

From the available patched point data sites, the FORS tool determined which combination of rainfall and evaporation sites provided the best calibration. Three rainfall sites were used in the adopted calibration run: - Campaspe Upper (88012), Coliban Upper (88017) and Woodend (88061). The FORS tool used 'Morton wet environment areal evapotranspiration over land' data as evaporation data from Kyneton Post Office (88036).

An overview of calibration results is presented as a comparison of observed and modelled streamflow in Figure 12 (linear y-axis) and Figure 13 (log y-axis). Flow duration curves for observed and modelled flows are presented in Figure 14 (linear y-axis) and in Figure 15 (log y-axis).

The calibration results show that whilst the modelled and observed streamflows have similar patterns, on any given day the modelled and observed may be different (in some cases the lower streamflows provided less accurate calibration). The flow duration curves show that whilst there is generally close alignment, the model tends to underestimate flows above 5 ML/d streamflows and overestimate flows below this point. Importantly, the very short calibration period is a factor in determining whether this apparent weakness in the rainfall runoff estimate is persistent across a wider range of plausible hydro-climatic conditions. Comparison of calibration metrics for the initial model (NSE log daily value of 0.725 and SDEB (square root daily exceedance and bias) of 960) and the adopted rainfall runoff model (NSE log daily value of 0.774 (high value is better) and SDEB of 320 (lower value is better)) shows the adopted rainfall runoff model having better calibration than the initial model Overall statistically, the calibrated rainfall runoff model is able to provide good flow estimates and can be used to extend the Kyneton streamflow record, noting that a very short calibration period was adopted.

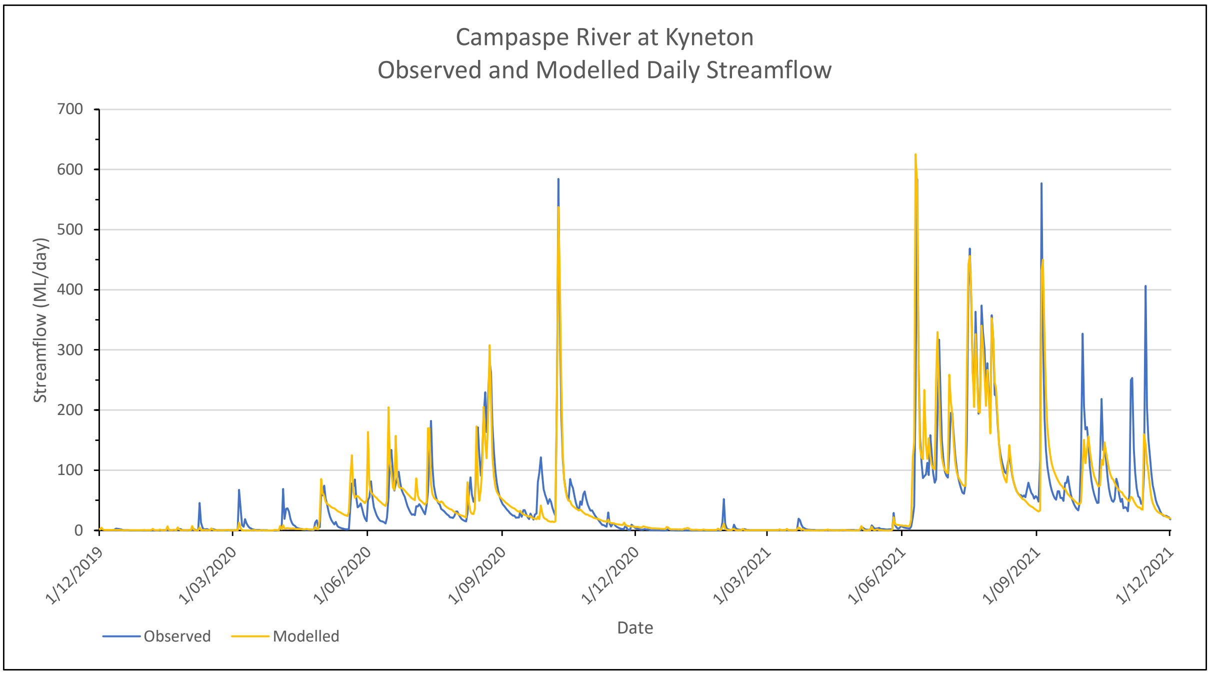

Figure 12 Observed and modelled daily streamflow for Campaspe River at Kyneton (Dec 2019 – Dec 2021) – linear y-axis

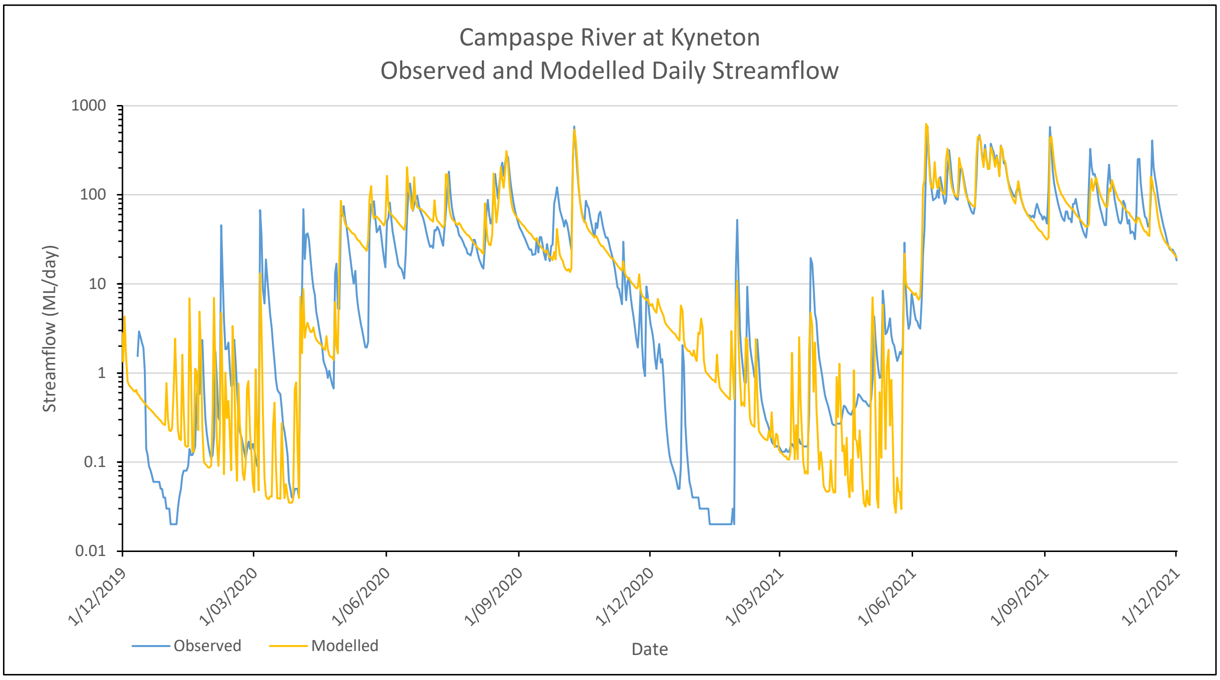

Figure 13 Observed and modelled daily streamflow for Campaspe River at Kyneton (Dec 2019 – Dec 2021) – log y-axis

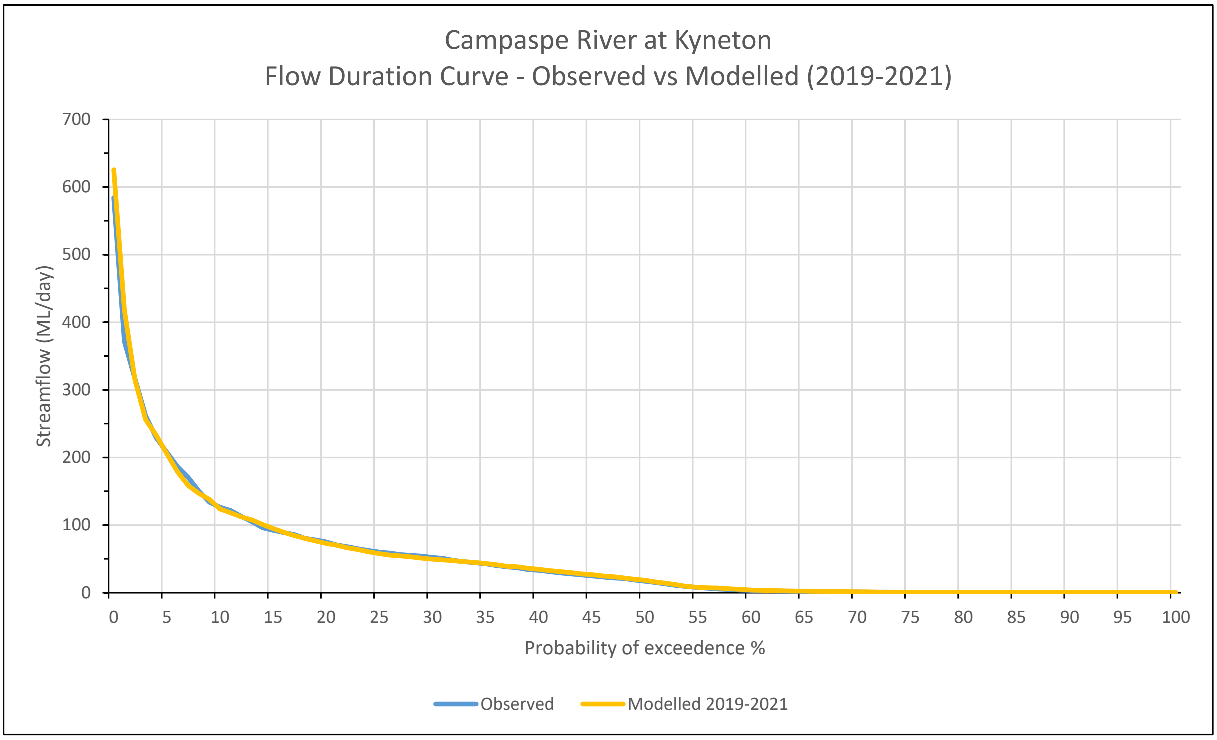

Figure 14 *Observed and modelled daily streamflow for Campaspe River at Kyneton – flow duration curve (linear y-axis)*

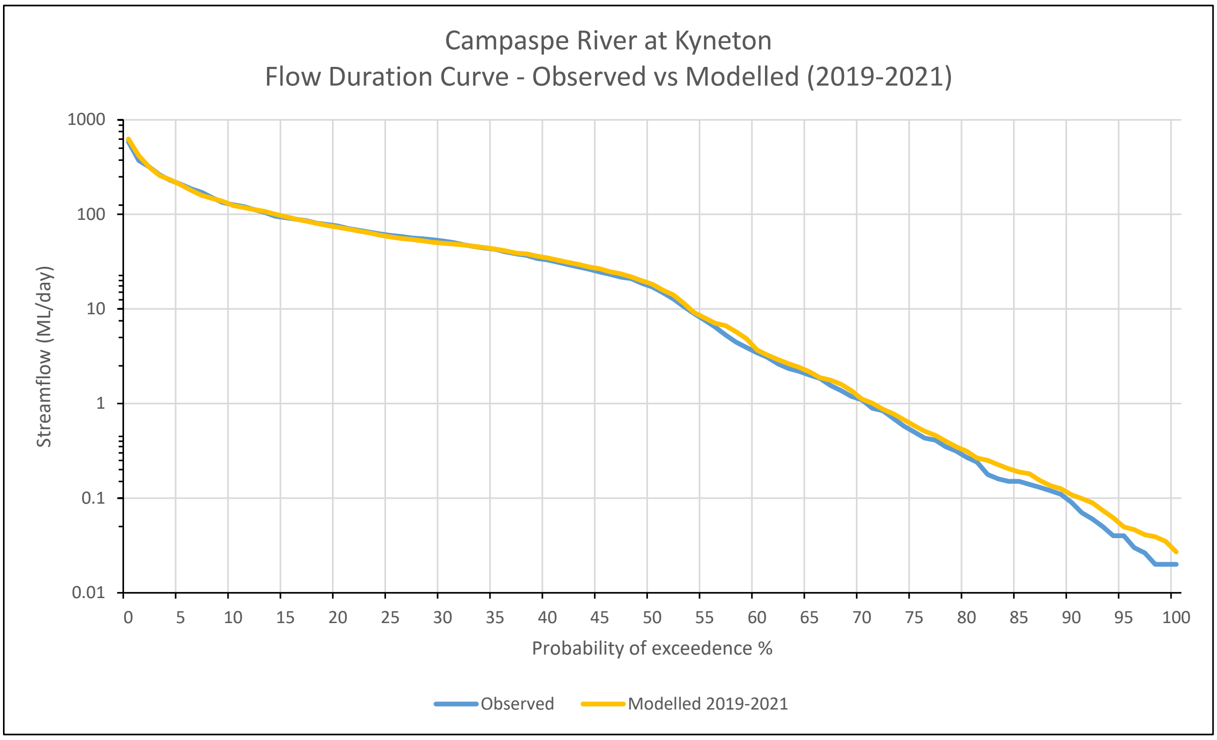

Figure 15 *Observed and modelled daily streamflow for Campaspe River at Kyneton – flow duration curve (log y-axis)*

Values for input parameters for the calibrated Sacramento model are presented in Table 7.

Table 7 Sacramento parameters used in the calibrated model

Parameter	Value	Parameter	Value
Adimp	0.000479	Rserv	-
Lzfpm	1.000	Sarva	9.03E-06
Lzsfm	252.819	Side	1E-05
Lzpk	0.00217	Ssout	0.000128
Lzsk	0.0444	Uzfwm	33.871
Lztwm	364.327	Uzk	0.100
Pctim	0.00117	Uztwm	126.308
Pfree	0.127	Zperc	34.891
Rexp	5.999		

2.4 Extended streamflow record for the Campaspe River at Kyneton

Using the calibrated Sacramento model, streamflows at Kyneton were extended. Figure 16 shows modelled streamflow data at Kyneton from 1950-2021.

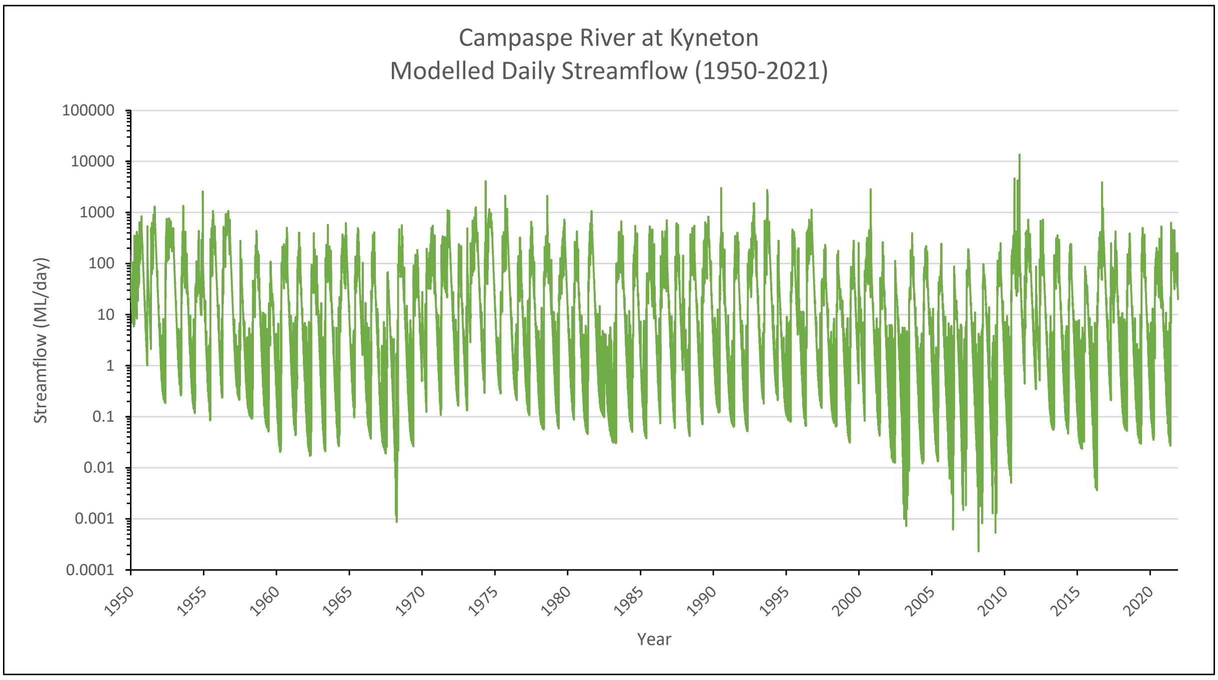

Figure 16 Modelled daily streamflow for Campaspe River at Kyneton – 1950 – 2021

Annual streamflow volumes from 1950 – 2021 for the Campaspe River Kyneton are presented in Figure 17. Similar to the Ashbourne gauging station (see Figure 7), a change in median streamflow is noted before and after 1997. During the 1950 – 1996 period the median annual streamflow for the Campaspe River at Kyneton was 18,046 ML/year and for the 1997-2021 period this reduced to 8,159 ML/year, a reduction of 9,887 ML/year or approximately 55%. Annual streamflow for the year 2020 and 2021 would have been considered a dry and wet year respectively when considering the pre 1997 streamflows (i.e., 2020 and 2021 were below and above the 1950-1996 median annual streamflow). However, when considering the median annual streamflow for the 1997-2021 period, both 2020 and 2021 were above the median and considered to be a wet year for streamflow.

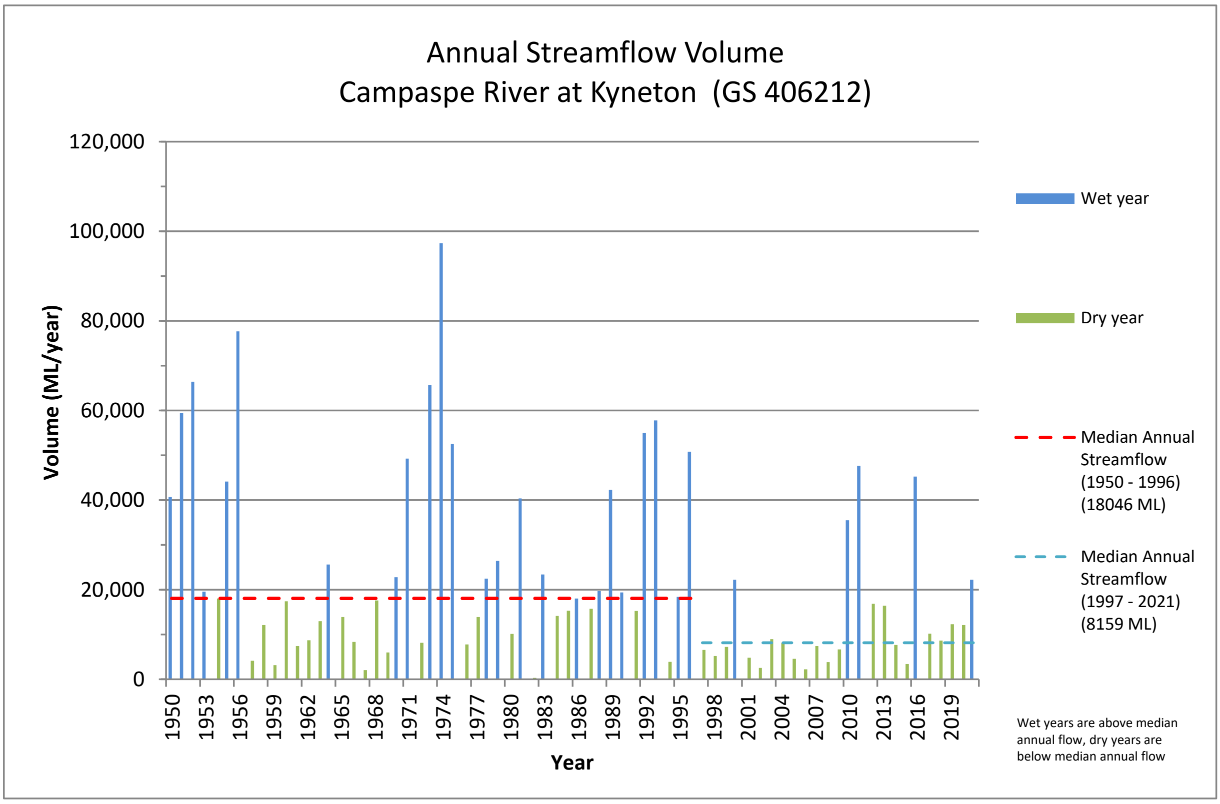

Figure 17 ***Modelled annual streamflow volume for Campaspe River at Kyneton – 1950 – 2021***

For comparison to flows at Kyneton, annual streamflow volumes for Redesdale are presented in Figure 17. Similar to Ashbourne (see Figure 7) and Kyneton modelled streamflow (Figure 18) change in median annual streamflows are noted before and after 1997. During the 1957 – 1996 period, the median annual streamflow for the Campaspe River at Redesdale was 84,944 ML/year, and for the 1997-2021 period this reduced to 16,152 ML/year, a reduction of 68,792 ML/year or approximately an 81% reduction. Annual streamflow for the year 2020 and 2021 would have been considered dry years when compared to pre-1997 conditions (i.e., below the 1957-1996 median annual streamflow), however, when considering post 1997 conditions, 2020 and 2021 would be considered as wet years (i.e. above the the median annual streamflow for the 1997-2021 period).

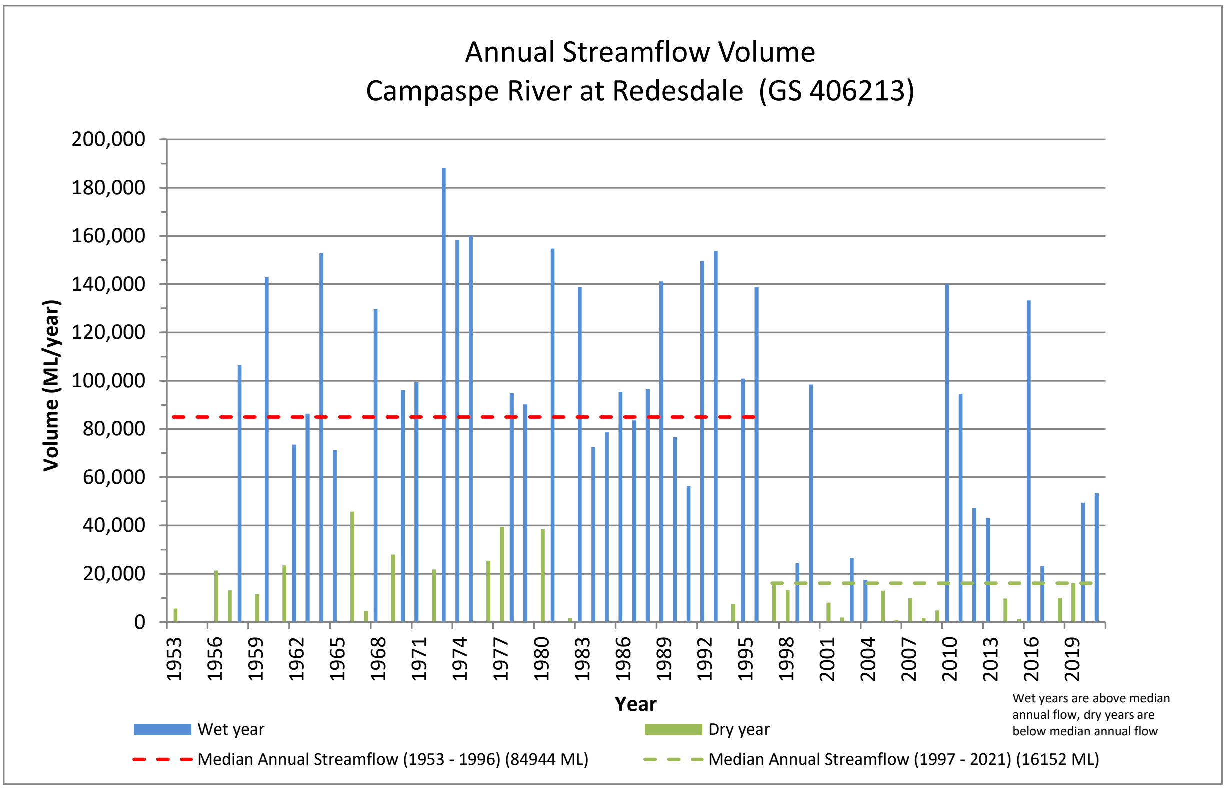

Figure 18 Annual streamflow volume for Campaspe River at Redesdale streamflow gauging station

For the purposes of being conservative, the post 1997 period has been selected to provide streamflow statistics for use in the water balance model and discharge risk assessment for Kyneton. Daily streamflow statistics (grouped by month) for the 1997-2021 period are presented in Figure 19 and in Table 8. A red dashed line is included in the figure at 5 ML/day as this is the threshold level above which flows tend to be underestimated and below which flows tend to be overestimated. It is noted that the Campaspe River at Kyneton has in the recent past (prior to installation of the streamflow gauge) regularly stopped flowing.

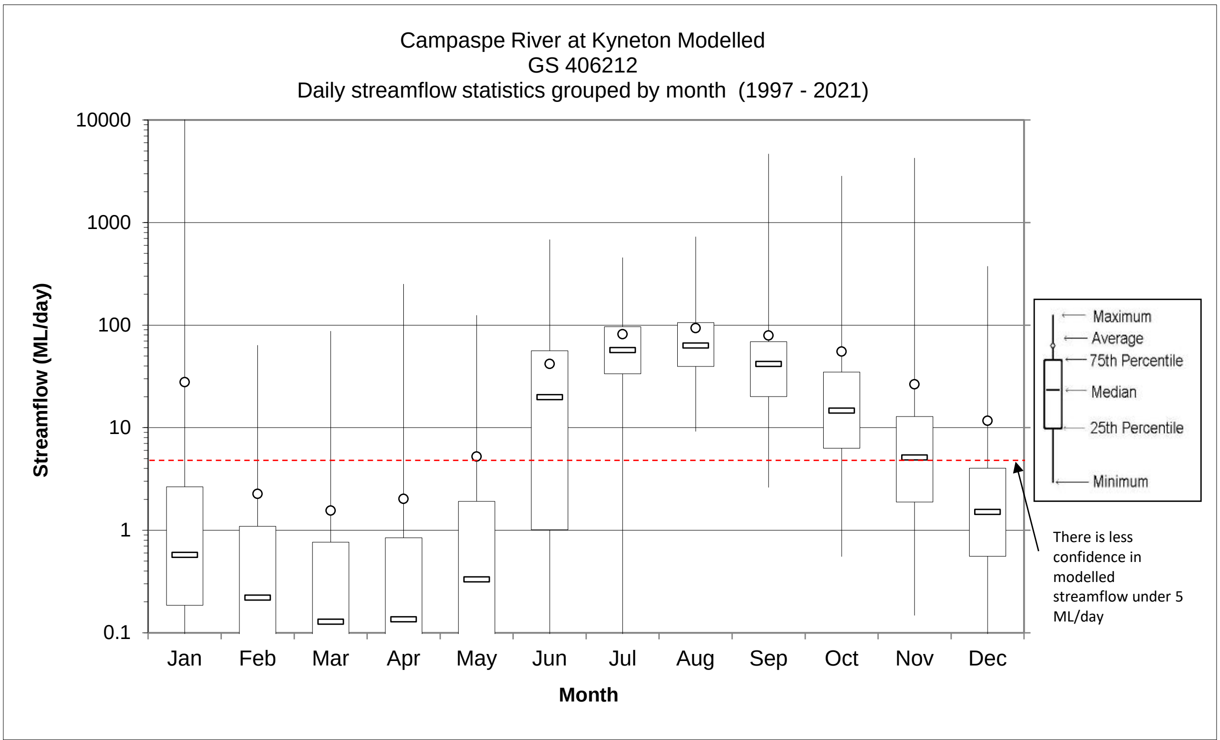

Figure 19 Modelled daily streamflow statistics grouped by month for Campaspe River at Kyneton – 1997 – 2021

Table 8 Modelled daily streamflow statistics grouped by month for Campaspe River at Kyneton (ML/d) – 1997 – 2021

Statistic	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Maximum*	13551	63.8	87.7	251.5	125.0	682.4	456.4	727.1	4680	2850	4274	376.3
90th percentile	9.4	4.3	4.1	3.2	18.6	99.6	187.3	212.4	136.3	107.8	49.0	17.4
75th % percentile	2.6	1.1	0.8	0.8	1.9	56.1	96.7	105.7	69.0	34.8	12.8	4.0
Median	0.6	0.2	0.1	0.1	0.3	19.8	56.9	63.0	41.7	14.7	5.1	1.5
25th percentile	0.2	0.1	0.0	0.0	0.1	1.0	33.4	39.6	20.1	6.3	1.9	0.6
10th percentile	0.1	0.0	0.0	0.0	0.0	0.1	22.3	25.6	11.4	3.0	0.9	0.2
Minimum	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9.2	2.6	0.6	0.1	0.0
Average	27.9	2.3	1.6	2.0	5.2	42.0	81.8	93.8	79.5	55.4	26.6	11.7
Number (days)	775	706	775	750	775	750	775	775	750	775	750	745

*Note this maximum modelled value for January seems unusually large however it represents streamflow during a rainfall event from 11th to 14th January 2011 in which there was a total of 258 mm of rain

Daily streamflow statistics grouped by month for the 1997 – 2021 period are presented in Figure 20 and in Table 9 for the Campaspe River at Redesdale as a comparison to Kyneton statistics. As expected, Redesdale values are higher than those for Kyneton.

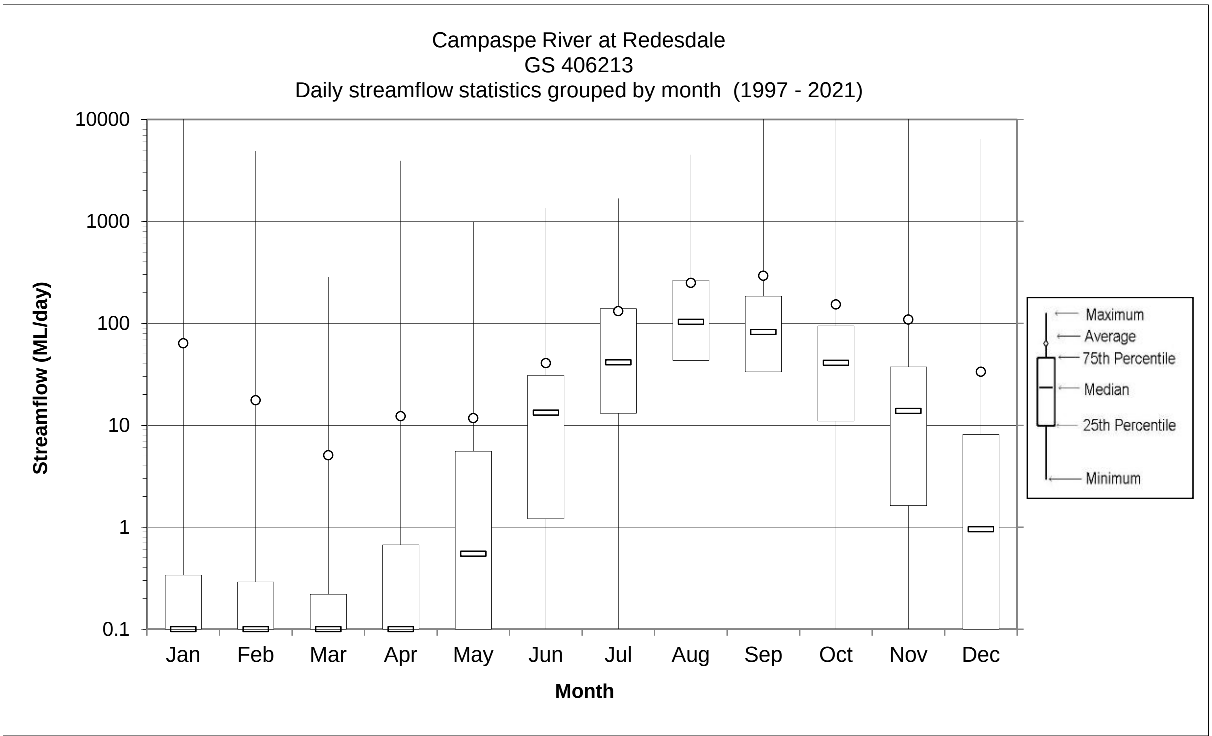

Figure 20 Daily streamflow statistics grouped by month for Campaspe River at Redesdale– 1997 – 2021

Table 9 Daily streamflow statistics grouped by month for Campaspe River at Redesdale (ML/d) – 1997 – 2021

Statistic	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Maximum*	20447	4931	284	3944	988	1354	1675	4508	18120	11511	12490	6434
90th percentile	6.4	3.2	7.5	14.8	22.5	86.3	361.6	624.8	460.9	251.7	108.3	22.3
75th % percentile	0.3	0.3	0.2	0.7	5.6	30.8	138.9	265.4	184.7	94.2	37.4	8.1
Median	0.0	0.0	0.0	0.1	0.6	13.3	41.3	103.5	82.3	41.0	13.9	1.0
25th percentile	0.0	0.0	0.0	0.0	0.0	1.2	13.1	43.2	33.3	11.0	1.6	0.0
10th percentile	0.0	0.0	0.0	0.0	0.0	0.0	5.8	12.1	13.9	2.6	0.1	0.0
Minimum	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.2	4.1	0.0	0.0	0.0
Average	63.7	17.6	5.1	12.3	11.8	40.8	132.2	250.3	293.8	153.6	109.0	33.6
Number (days)	775	706	775	750	775	750	775	775	750	775	750	746

*Note this maximum modelled value for January seems unusually large however it represents streamflow during a rainfall event from 11th to 14th January 2011 in which there was a total of 258 mm of rain

Daily streamflow statistics for the Campaspe River at Kyneton for the 1997 – 2021 period (grouped by season) are presented in Figure 21 and in Table 10.

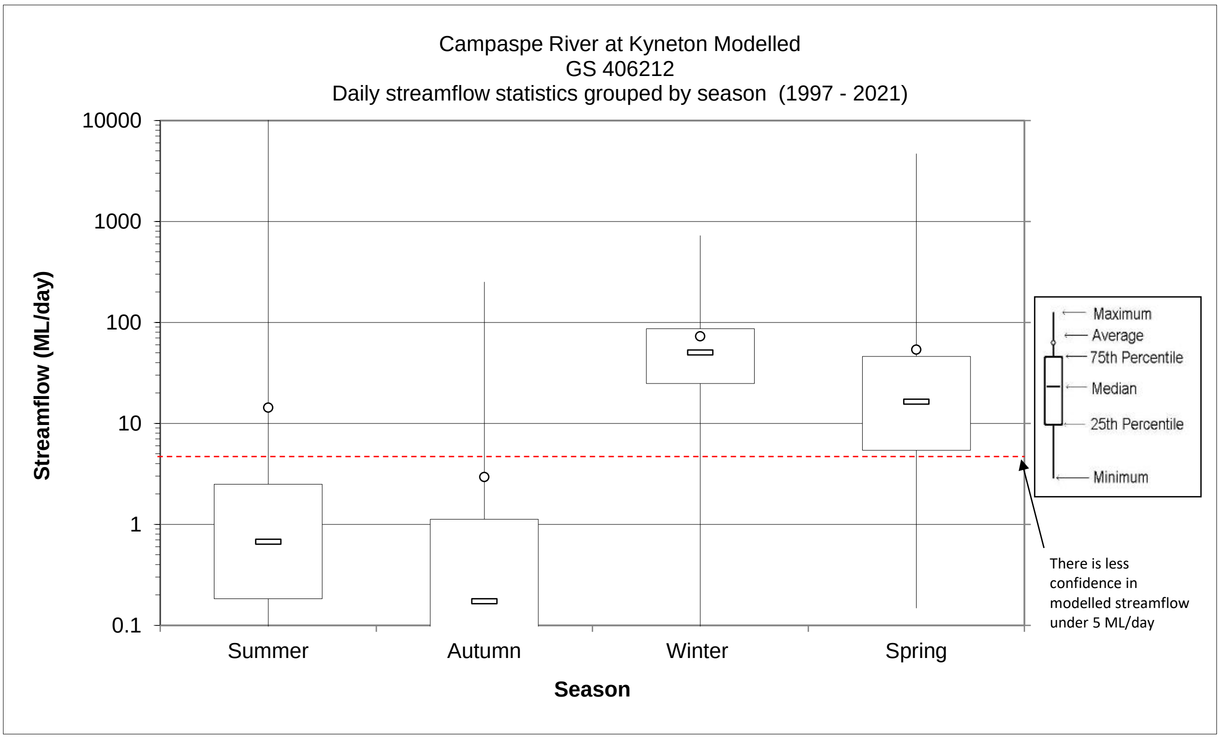

Figure 21 Modelled daily streamflow statistics grouped by season for Campaspe River at Kyneton – 1997 – 2021

Table 10 Modelled daily streamflow statistics grouped by season for Campaspe River at Kyneton (ML/d) – 1997 – 2021

Statistic	Summer	Autumn	Winter	Spring
Maximum*	13551.0	251.5	727.1	4680.1
90th percentile	9.1	5.4	163.1	101.5
75th % percentile	2.5	1.1	86.7	45.9
Median	0.7	0.2	50.3	16.3
25th percentile	0.2	0.0	24.8	5.4
10th percentile	0.1	0.0	2.1	1.9
Minimum	0.0	0.0	0.0	0.1
Average	14.3	2.9	72.8	53.8
Number (days)	2226	2300	2300	2275

*Note this maximum modelled value for summer seems unusually large however it represents streamflow during a rainfall event from 11th to 14th January 2011 in which there was a total of 258 mm of rain

Data on the number of days that streamflow is above certain vales (1, 2, 5 and 10 ML/day) for Kyneton and Redesdale for the 1997-2021 period is presented in Table 11. Results show a higher value for Kyneton for 1 ML/day and 2 ML/day when compared to Redsdale but lower at Kyneton for 5 ML/day and 10 ML/day.

Table 11 Number of days of streamflow above various values for Kyneton and Redesdale using data from 1997 – 2021

Streamflow	Kyneton		Redesdale	
	Number of Days	Proportion of total	Number of Days	Proportion of total
>1 ML/day	5799	64%	5363	59%
>2 ML/day	5176	57%	5100	56%
>5 ML/day	4333	48%	4635	51%
>10 ML/day	3723	41%	4054	45%
All data	9101	100%	9101	100%

3. Water Balance Model

There are two sources of waste treated at Kyneton WRP– tradewaste and domestic waste, which are treated separately and produce tradewaste treated wastewater and domestic (BNR) treated wastewater. Tradewaste treated wastewater is blended with BNR treated wastewater to balance salinity before irrigation, while the remaining BNR treated wastewater is discharged to the Campaspe River.

GHD have developed an annual Water Balance Model (WBM) in MS Excel for Kyneton WRP based on monthly calculations. The WBM was developed to:

– Provide an operational tool to enable decision making
– Identify risk of overflows from water storages and/or over irrigation can be predicted and managed to the extent practicable
– Include a salinity balance to assist with operator decision making and help meet contractual requirements for electrical conductivity of Hardwicks irrigation water

3.1 Water balance model overview

The WBM model caters for three climate scenarios – a dry year (10^{th} percentile rainfall); a typical year (50^{th} percentile rainfall) and a wet year (90^{th} percentile based on historical rainfall records).

The main outputs of the water balance are:

– Storage volumes in monthly timesteps over the year in Tradewaste Lagoons 3-5 and Hardwicks and the amount of tradewaste treated wastewater irrigated
– The storage volume in monthly timesteps over the year in domestic storage and the amount of BNR treated wastewater discharged to Campaspe River

To provide the above key outputs, the WBM includes a series of calculations with accompanying macros. The calculations use a combination of the goal seek function, solver function, while loops, for statements and if statements to iteratively alter the storage volumes and flows between storage to arrive at a solution which satisfies the requirements of dead storage, maximum storage volumes and transfer limitations. The model is conservative in calculating the discharge volumes and attempts to reduce the volume and number of spills by transferring flows between lagoons.

The process flow diagram in Figure 22 illustrates how flows in the WBM are transferred between lagoons and depicts the series of monthly calculations that are performed to reach a solution. Noting that this is a simplistic approach and does not account for all possible operational approaches such as transfers from Lagoon 5 to Lagoon 4.

The WBM relies on the following series of inputs:

– Domestic and tradewaste influent flow rates as ADWF and average electrical conductivity concentrations
– Annual irrigation allocations for Council and Racecourse
– Daily Campaspe river flow at Kyneton from the hydrological assessment, aggregated on a monthly basis
– Constant domestic treated wastewater discharge rate as a % proportion of river flow
– Lagoon capacity, dead storage, and surface area
– Irrigation area for Hardwicks, Crofton Park, and Coliban Water (Spray and Flood)
– Class C to B plant capacity which limits the maximum transfer between Lagoon 5 and Hardwicks
– Monthly rainfall and evaporation data from BOM (used for storage net evaporation calculation)
– Monthly effective irrigation demand per ha using EPA Publication 168, Table 7A, Kc's for pasture and application efficiency

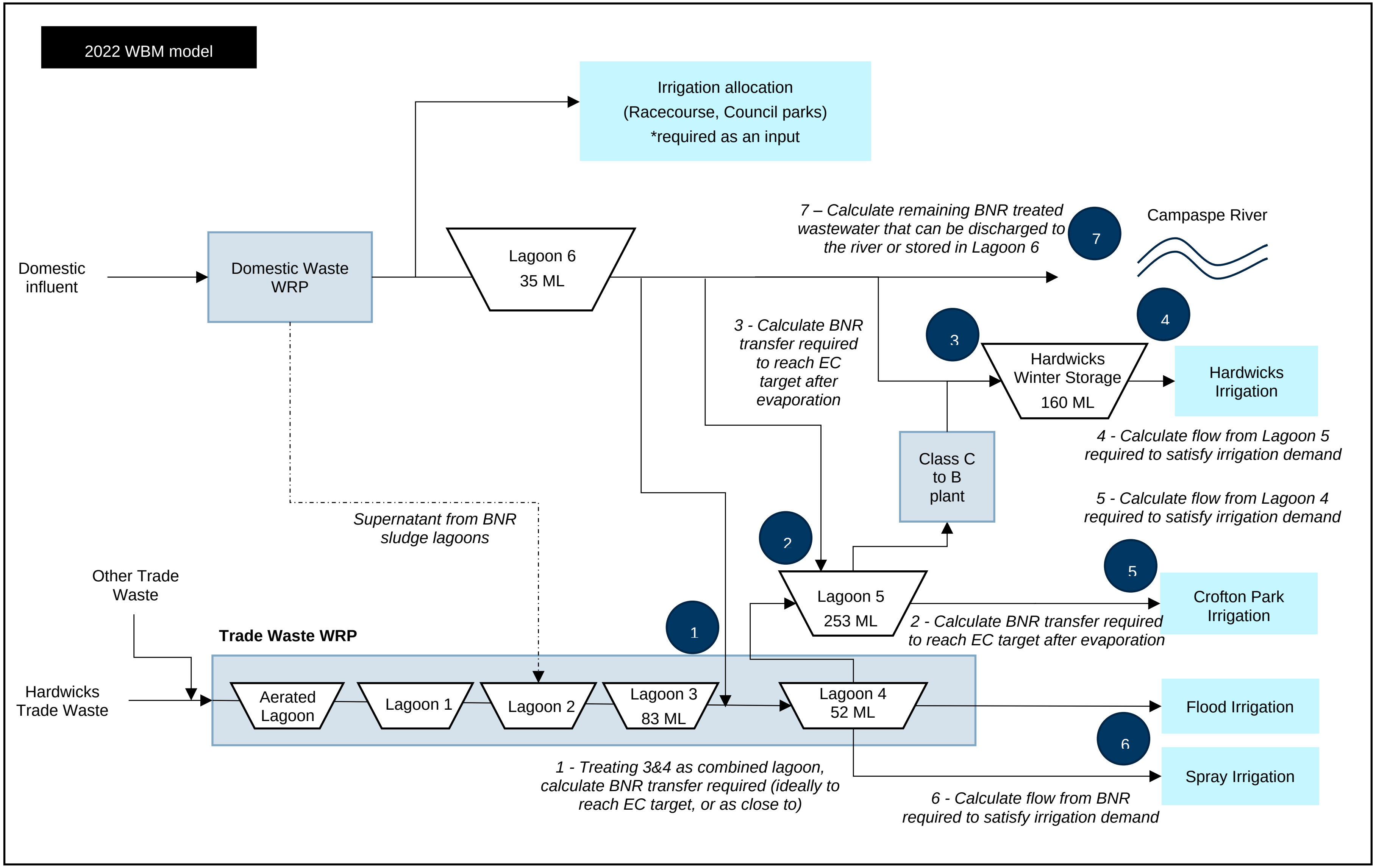

Figure 22 Water balance model simplified process flow and calculation series diagram

3.1.1 Assumptions and limitations of the MS Excel Water Balance Model

GHD has prepared the MS Excel Water Balance Model based on a number of key assumptions, with associated limitations, as follows:

- Surface area of the lagoons and storages are used to calculate rainfall and evaporation accumulation on a monthly basis.
- BNR treated wastewater from the domestic waste WRP is preferentially used for irrigation to the Racecourse and Council before being available for tradewaste blending. This irrigation volume is calculated from an annual volume, which is assumed to be supplied in equal portions over the irrigation months (i.e. from Oct to April).
- BNR treated wastewater is preferentially held in the domestic storage for use in blending with tradewaste treated wastewater, rather than discharging to Campaspe River at every opportunity. The allowable volume to be discharged to Campaspe River is calculated on a monthly basis as the aggregate of daily river flows for that month, from which the actual volume discharged to the river is calculated before being converted to a daily discharge volume based on the river flow variation for that month.
- Aerated lagoon, lagoon 1 and lagoon 2 have a constant volume and are not used for storage
- Lagoons 3&4 are treated as a combined lagoon. As such the individual storage volume and EC in each of lagoon 3 and lagoon 4 is not provided.
- Tradewaste flows in series through the storages, from Lagoon 3&4 to Lagoon 5 to Hardwicks Storage. Therefore, it is assumed that tradewaste treated wastewater stored in Lagoon 5 cannot be used to irrigate spray or flood irrigation areas. Likewise, tradewaste treated wastewater stored in Hardwicks storage can only be used to irrigate Hardwicks irrigation area.
- Where there is accumulation, any surplus volume is stored in the Coliban Water storage lagoons (i.e., lagoons 3-5). For every year the annual volume transferred to Hardwicks storage is equal to the irrigation demand of the Hardwicks irrigation area. Transfer from Lagoon 5 to Hardwicks is limited by the capacity of the Class C to B plant. Therefore, to provide the annual irrigation demand for Hardwicks irrigation area, sufficient volume must be regularly transferred to Hardwicks storage lagoon.
- When the EC target is applied to all storages, BNR treated wastewater is blended primarily in Lagoon ¾ to balance the tradewaste EC. However, there are some scenarios where insufficient BNR treated wastewater is available. If this occurs the BNR treated wastewater will be supplied to Hardwicks and Lagoon 5 preferentially to ensure compliance with the EC target at these storages.
- Total BNR demand used to satisfy EC balancing demand is calculated and combined with the available storage volume at the domestic storage to provide an indication of the volume required to be discharged to Campaspe River.
- Irrigation demand is calculated on a monthly basis using the input of irrigation area and rainfall scenario. The irrigation demand is assumed to be met at all times, except under scenarios when there is insufficient inflow. In this case the model will calculate the minimum area that can be met with the volume of inflow and use this as the basis for the remaining model calculations.

3.2 Scenario analysis

The model was used to run the following scenarios, assuming all assets are online, and Crofton Park is available for irrigation, to observe the monthly variation in storage levels over a year and the monthly discharge volume to river.

1. 2020 10th percentile year
2. 2020 50th percentile rainfall year
3. 2020 90th percentile year
4. 2036 10th percentile rainfall year
5. 2036 50th percentile rainfall year

6. 2036 90th percentile rainfall year

Table 12 shows the year corresponding to rainfall and estimated river flow at Kyneton used for the scenarios.

Table 12 Climate conditions

Climate condition	Year corresponding to rainfall and estimated river flow at Kyneton
10th percentile	2015
50th percentile	2004
90th percentile	2010

The basis for domestic influent flows were taken from the Kyneton Town Vision, 2020 as 1.6 ML/d in 2020 to be representative of current flows and 2.4 ML/d in 2036 to be representative of future flows. The model accounts for a variation between average winter and summer flows. From current inflow data the ratio between winter and summer flows was found to be 1.7 on average. This ratio has been applied to the 2020 and 2036 scenarios to derive the winter and summer average flows as presented in Table 13.

Table 13 Flow basis for summer and winter conditions

Parameter	2020	2036
Kyneton Town Vision domestic ADWF (ML/d)	1.6 ML/d	2.4 ML/d
Domestic winter ADWF (Jun-Sep)	2.2 ML/d	3.3 ML/d
Domestic summer ADWF (Oct – May)	1.3 ML/d	1.9 ML/d
Tradewaste inflow	1.1 ML/d	1.1 ML/d

In addition, the following inputs were implemented as the basis for all scenarios as provided by Coliban Water:

– Efficiency of river discharge 90%
– Annual irrigation allocation to Council and Racecourse of 90 ML
– Tradewaste influent of 1.1 ML/d
– Constant EC concentration in domestic influent of 625 µS/cm
– Constant EC concentration of tradewaste influent as 2000 µS/cm
– Constant EC target concentration for irrigation of 1400 µS/cm
– Class C to B plant capacity of 1 ML/d
– Crop type of pasture with an application efficiency of 90%
– Aerated lagoon volume of 42 ML and a surface area of 18,000 m^2
– Lagoon 1 volume of 25.8 ML and a surface area of 17,000 m^2
– Lagoon 2 volume of 53.7 ML and a surface area of 30,000 m^2
– Lagoon 3&4 storage volume of 135 ML with 45 ML dead storage and a combined surface area of 105,000 m^2
– Lagoon 5 storage volume of 253 ML, with 50 ML dead storage and a surface area of 64,000 m^2
– Lagoon 6 storage volume of 35 ML with no dead storage and a surface area of 17,500 m^2
– Hardwicks storage volume of 160 ML, with 10% (16 ML) dead storage and a surface area of 46,000 m^2
– Combined spray and flood irrigation area of 36 ha
– Crofton Park irrigation demand of up to 200 ML / year
– Hardwicks irrigation area of 32 ha

The scenarios and model outputs are described in further detail in the following sections. Table 14 provides a description of the terminology used in the key outputs of the water balance model.

Table 14 Terminology

Terminology	Description
Domestic treated wastewater discharge	The maximum allowable discharge rate of domestic treated wastewater as a proportion of river flow. For a discharge rate of 33.3%, this equates to 1 part treated wastewater to 2 parts river flow.
Net evaporation (rainfall)	The net annual volume lost to evaporation (or gained from rainfall) in the storages.
River discharge	Annual volume of domestic treated wastewater that is discharged to Campaspe River
Irrigation	Annual volume of tradewaste treated wastewater that is irrigated
Accumulation	The sum of net inflows and outflows on an annual basis. A positive number indicates that net inflows were higher than net outflows.

3.2.1 2020 inflows, 10th percentile year

The key conditions for scenario 1 include:

- Domestic winter ADWF of 2.2 ML/d
- Domestic summer ADWF of 1.3 ML/d
- Campaspe River Flow conditions 10th percentile year (2015)
- Rainfall conditions to meet river 10th percentile year (2015)
- 33.3% domestic treated wastewater discharge rate

The outputs for storages, irrigation and key volumes are summarised in Table 15. Further outputs, including representations of monthly flows and storages are provided in Appendix B.

Table 15 Scenario 1 – annual balance

Annual Irrigation	Units	33.3% discharge rate
Domestic influent	ML	584
Tradewaste influent	ML	401
Net Evaporation (rainfall)	ML	-133
River discharge	ML	-183
Irrigation	ML	-669
Net Accumulation	ML	0

There is zero accumulation with a domestic treated wastewater discharge rate of 33.3% as a proportion of total river flow. There is sufficient inflow to meet all the irrigation demand.

3.2.2 2020 inflows, 50th percentile year

The key inputs for scenario 2 include:

- Domestic winter ADWF of 2.2 ML/d
- Domestic summer ADWF of 1.3 ML/d
- Campaspe River Flow conditions 50th percentile year (2004)
- Rainfall conditions to meet river 50th percentile year (2004)
- 33.3% domestic treated wastewater discharge rate

The outputs for storages, irrigation and key volumes are summarised in Table 16. Further outputs, including representations of monthly flows and storages are provided in Appendix B.

Table 16 Scenario 2 – annual balance

	Units	33.3% discharge rate
Domestic influent	ML	584
Tradewaste influent	ML	401
Net Evaporation (rainfall)	ML	-77
River discharge	ML	-267
Irrigation	ML	-641
Net Accumulation	ML	0

There is zero accumulation with a domestic treated wastewater discharge rate of 33.3% as a proportion of total river flow. There is sufficient inflow to meet all the irrigation demand.

3.2.3 2020 inflows, 90th percentile year

The key inputs for scenario 3 include:

– Domestic winter ADWF of 2.2 ML/d
– Domestic summer ADWF of 1.3 ML/d
– Campaspe River Flow conditions 90th percentile year (2010)
– Rainfall conditions to meet river 90th percentile year (2010)
– 33.3% and 66.7% domestic treated wastewater discharge rate

The outputs for storages, irrigation and key volumes are summarised in Table 17. Further outputs, including representations of monthly flows and storage levels are provided in Appendix B.

Table 17 Scenario 3 – annual balance

	Units	33.3% discharge rate	66.7% discharge rate
Domestic influent	ML	584	584
Tradewaste influent	ML	401	401
Net Evaporation (rainfall)	ML	33	33
River discharge	ML	-445	-469
Irrigation	ML	-501	-501
Net Accumulation	ML	72	48

A domestic treated wastewater discharge rate 66.7% as a proportion of river flow is required to discharge excess domestic treated wastewater during periods of low river flow. There is a tradewaste treated wastewater surplus of ~50 ML, with sufficient storage volume available within Coliban Water lagoons to store this volume. If consecutive 90th percentile years were to occur this would increase the risk of overflow from the storage lagoons. treated wastewater

Comparison to Redesdale

The same scenario was run but with river flows at Redesdale to compare with current operation where Redesdale is used as the gauging station and the discharge rate is 16.7% as a proportion of river flow (1 part discharge to 5 parts river flow). When using Redesdale 2010 river flows there was no flow recorded in January or February resulting in an accumulation of 123 ML, which results in an overflow from the Coliban Water storages.

However, if comparing to 2011 when there was more consistent river flow recorded at Redesdale throughout each month of the year, a domestic treated wastewater discharge rate of 16.7% as a proportion of river flow (as measured at Redesdale) is sufficient to discharge domestic treated wastewater, noting there is still a tradewaste treated wastewater surplus of 60 ML which is stored within Coliban Water lagoons.

Further outputs from the water balance undertaken using river flows at Redesdale are provided in Appendix C.

3.2.4 2036 inflows, 10th percentile year

The key inputs for scenario 4 include:

– Domestic winter ADWF of 3.3 ML/d
– Domestic summer ADWF of 1.9 ML/d
– Campaspe River Flow conditions 10th percentile year (2015)
– Rainfall conditions to meet river 10th percentile year (2015)
– 33.3% and 66.7% domestic treated wastewater discharge rate

The outputs for storages, irrigation and key volumes are summarised in Table 18. Further outputs, including representations of monthly flows and storage levels are provided in Appendix B.

Table 18 Scenario 4 – annual balance

	Units	33.3% discharge rate	66.7% discharge rate
Domestic influent	ML	864	864
Tradewaste influent	ML	401	401
Net Evaporation (rainfall)	ML	-133	-133
River discharge	ML	-447	-463
Irrigation	ML	-669	-669
Net Accumulation	ML	16	0

There is zero accumulation using a domestic treated wastewater discharge rate of 66.7% as a proportion of river flow. There is sufficient inflow to meet all the irrigation demand.

3.2.5 2036 inflows, 50th percentile year

The key inputs for scenario 5 include:

– Domestic winter ADWF of 3.3 ML/d
– Domestic summer ADWF of 1.9 ML/d
– Campaspe River Flow conditions 50th percentile year (2004)
– Rainfall conditions to meet river 50th percentile year (2004)
– 33.3% domestic treated wastewater discharge rate

The outputs for storages, irrigation and key volumes are summarised in Table 19 Further outputs, including representations of monthly flows and storage levels are provided in Appendix B.

Table 19 Scenario 5 – annual balance

	Units	33.3% discharge rate
Domestic influent	ML	864
Tradewaste influent	ML	401
Net Evaporation (rainfall)	ML	-77
River discharge	ML	-547
Irrigation	ML	-641
Net Accumulation	ML	0

There is zero accumulation using a domestic treated wastewater discharge rate of 33.3% as a proportion of river flow. There is sufficient inflow to meet all the irrigation demand.

3.2.6 2036 inflows, 90th percentile year

The key inputs for scenario 6 include:

– Domestic winter ADWF of 3.3 ML/d
– Domestic summer ADWF of 1.9 ML/d
– Campaspe River Flow conditions 90th percentile year (2010)
– Rainfall conditions to meet river 90th percentile year (2010)
– 33.3% and 66.7% domestic treated wastewater discharge rate

The outputs for storages, irrigation and key volumes are summarised in Table 20. Further outputs, including representations of monthly flows and storage levels are provided in Appendix B.

Table 20 Scenario 6 – annual balance

	Units	33.3% discharge rate	66.7% discharge rate
Domestic influent	ML	864	864
Tradewaste influent	ML	401	401
Net Evaporation (rainfall)	ML	33	33
River discharge	ML	-624	-736
Irrigation	ML	-501	-501
Net Accumulation	ML	173	61

A domestic treated wastewater discharge rate of 66.7% as a proportion of river flow is required to discharge sufficient domestic treated wastewater during periods of low river flow. There is a tradewaste treated wastewater surplus of ~60 ML, with sufficient storage volume available within Coliban Water lagoons to store this volume. If consecutive 90th percentile years were to occur this would increase the risk of overflow from the storage lagoons.

Comparison to Redesdale

As for scenario 3, the same scenario was run but with river flows at Redesdale to compare with current operation where Redesdale is used as the gauging station and the discharge rate is 16.7% as a proportion of river flow (1 part discharge to 5 parts river flow). When using Redesdale 2010 river flows there was no flow recorded in January or February resulting in an accumulation of 217 ML, resulting in an overflow from the Coliban Water lagoons.

However, if comparing to 2011 when there was more consistent river flow recorded at Redesdale throughout each month of the year, a domestic treated wastewater discharge rate of 16.7% as a proportion of river flow (as measured at Redesdale) is sufficient to discharge domestic treated wastewater, noting there is still a tradewaste treated wastewater surplus of 70 ML which is stored within Coliban Water lagoons. Further outputs from the water balance undertaken using river flows at Redesdale are provided in Appendix C.

These results are similar to what was observed for scenario 3 where the lack of river flow in January and February results in higher accumulation in 2010 compared with 2011 when there was more consistent river flow throughout the year.

3.3 Key findings

The water balance model was used with the river flow predicted at Kyneton from the hydrology assessment to run various scenarios. The scenarios represent the conditions that Kyneton WRP will need to be designed for now and into the future to enable operation within discharge limits.

A summary of the key annual outputs from the scenario analysis is provided in Table 21.

Table 21 Summary of annual balance for each scenario

Parameter	2020 10th percentile	2020 50th percentile	2020 90th percentile	2020 90th percentile	2036 10th percentile	2036 10th percentile	2036 50th percentile	2036 90th percentile	2036 90th percentile
Domestic inflow (ML/d)	1.6	1.6	1.6	1.6	2.4	2.4	2.4	2.4	2.4
Tradewaste inflow (ML/d)	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
Discharge rate (proportion of streamflow)	33.3%	33.3%	33.3%	66.7%	33.3%	66.7%	33.3%	33.3%	66.7%
Domestic influent (ML)	584	584	584	584	864	864	864	864	864
Tradewaste influent (ML)	401	401	401	401	401	401	401	401	401
Evaporation (rainfall) (ML)	-133	-77	33	33	-133	-133	-77	33	33
River discharge (ML)	-183	-267	-445	-469	-447	-463	-547	-624	-736
Irrigation (ML)	-669	-641	-501	-501	-669	-669	-641	-501	-501
Accumulation (ML)	0	0	72	48	16	0	0	173	61

The outputs of the water balance model for the different scenarios indicate the following:

– In 2020 with a domestic ADWF of 1.6 ML/d and tradewaste ADWF of 1.1 ML/d:
  - There is zero accumulation during a 50th percentile and 10th percentile year using a domestic treated wastewater discharge rate of 33.3% as a proportion of river flow. There is sufficient inflow to meet the total irrigation demand.
  - In a 90th percentile year a domestic treated wastewater discharge rate of 66.7% as a proportion of river flow is required to discharge sufficient domestic treated wastewater during summer months when there is low river flow. There is a tradewaste treated wastewater surplus of 50 ML, with sufficient storage volume available within Coliban Water lagoons to store this volume. If two consecutive 90th percentile years were to occur, the storages would almost reach full capacity, with approximately 15 ML spare.

– In 2036 with a domestic ADWF of 2.4 ML/d and tradewaste ADWF of 1.1 ML/d:
  - There is zero accumulation during a 50th percentile year using a domestic treated wastewater discharge rate of 33.3% as a proportion of river flow. While a discharge rate of 66.7% is required to reach zero accumulation in a 10th percentile year. In both years there is sufficient inflow to meet all the irrigation demand.
  - In a 90th percentile year a domestic treated wastewater discharge rate of 66.7% as a proportion of river flow is required to discharge sufficient domestic treated wastewater during summer months when there is low river flow. There is a treated tradewaste wastewater surplus of ~60 ML, with sufficient storage volume available within Coliban Water lagoons to store this volume. If two consecutive 90th percentile years were to occur, the storages are likely to overflow, with an excess of approximately 15 ML.

– Similar results are observed when using the current operation that includes a discharge rate of 16.7% as a proportion of river flow (1 part discharge to 5 parts river flow) and river flows recorded at Redesdale for the same 90th percentile rainfall year (2010), with low river flows particularly in January and February resulting in the inability to discharge to the river during these months and hence requiring storage in the tradewaste lagoons. However, there is significant accumulation in 2020 and 2036 such that overflow from the tradewaste storages occurs.

4. References

GHD (2022). *Kyneton Town Vision. Final Report*. Report produced for Coliban Water.

State of Victoria (Environment Protection Authority Victoria). (1991). *168.2: Guidelines for wastewater irrigation*.

Appendices

Appendix A

Additional Hydrology Information

Streamflow Routing

Table A.1 Streamflow events with routing characteristics

Event	Streamflow data type	Ashbourne		Kyneton		Difference	
		Timestamp of peak	Streamflow peak (ML/day)	Timestamp of peak	Streamflow peak (ML/day)	Travel time (days)	Difference in peak streamflow (ML/day)
June 2021	Daily	10/6/2021	1000.66	11/6/2021	1354.13	1	353.47
	Instantaneous	10/06/2021 4:00	1537.15	10/06/2021 23:30	740.78	0.81	796.37
October 2021	Daily	1/10/2021	281.24	2/10/2021	327.11	1	235.08
	Instantaneous	1/10/2021 17:15	455.34	2/10/2021 8:45	385.89	0.65	69.45
November 2021	Daily	13/11/20021	391.37	14/11/2021	393.61	1	2.24
	Instantaneous	13/11/2021 0:45	535.39	14/11/2021 4:15	474.71	1.15	60.68

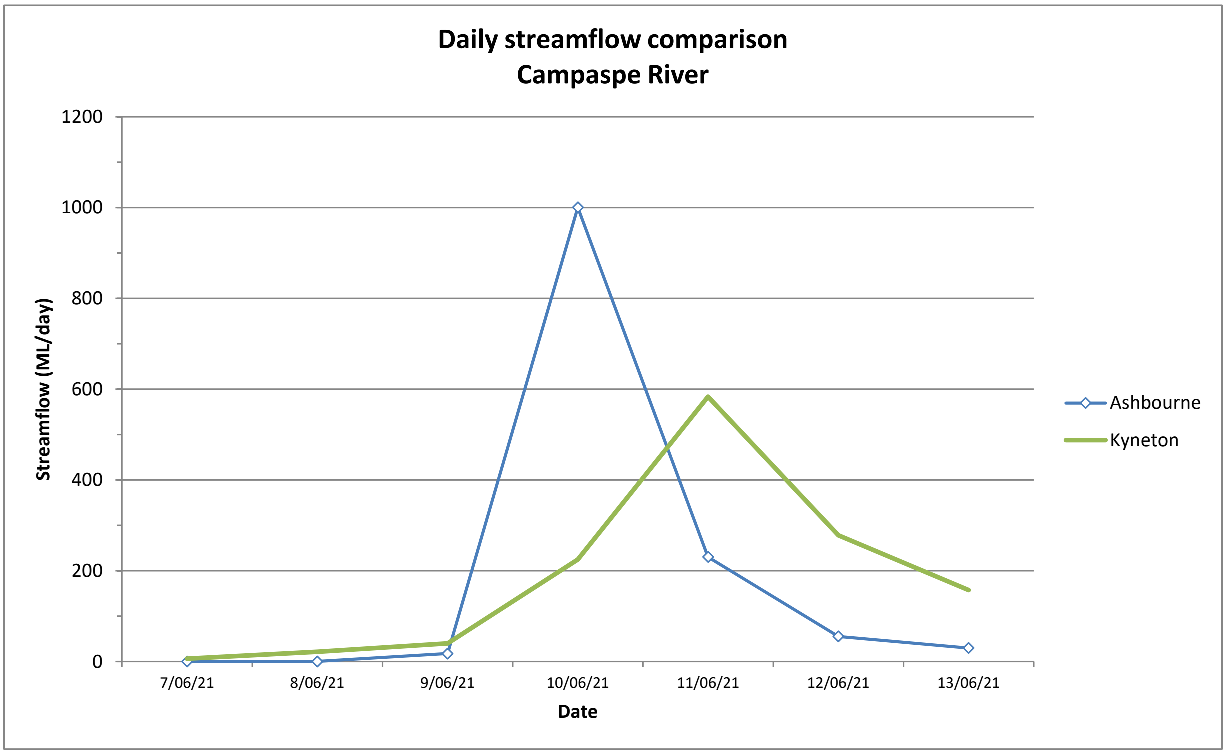

Figure A.1 Daily streamflow data for Campaspe River at Ashbourne and Kyneton (June 2021)

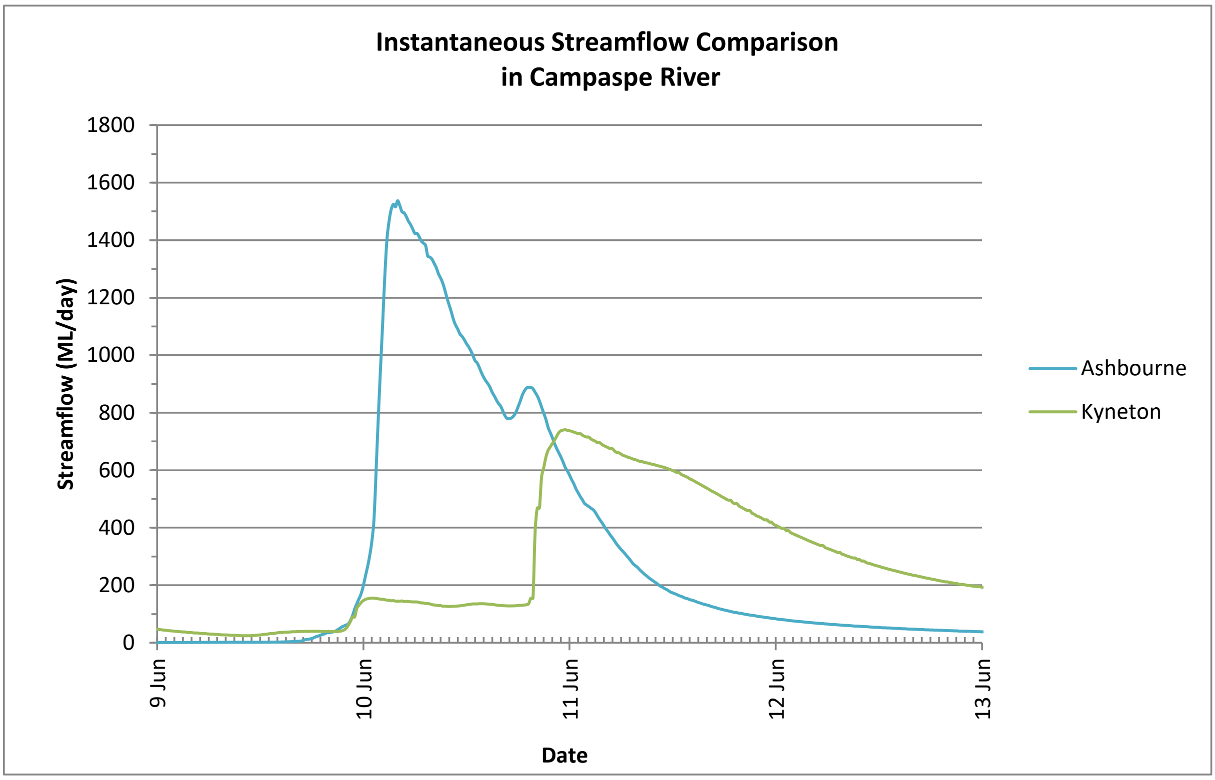

Figure A.2 *Instantaneous streamflow data for Campaspe River at Ashbourne and Kyneton (June 2021)*

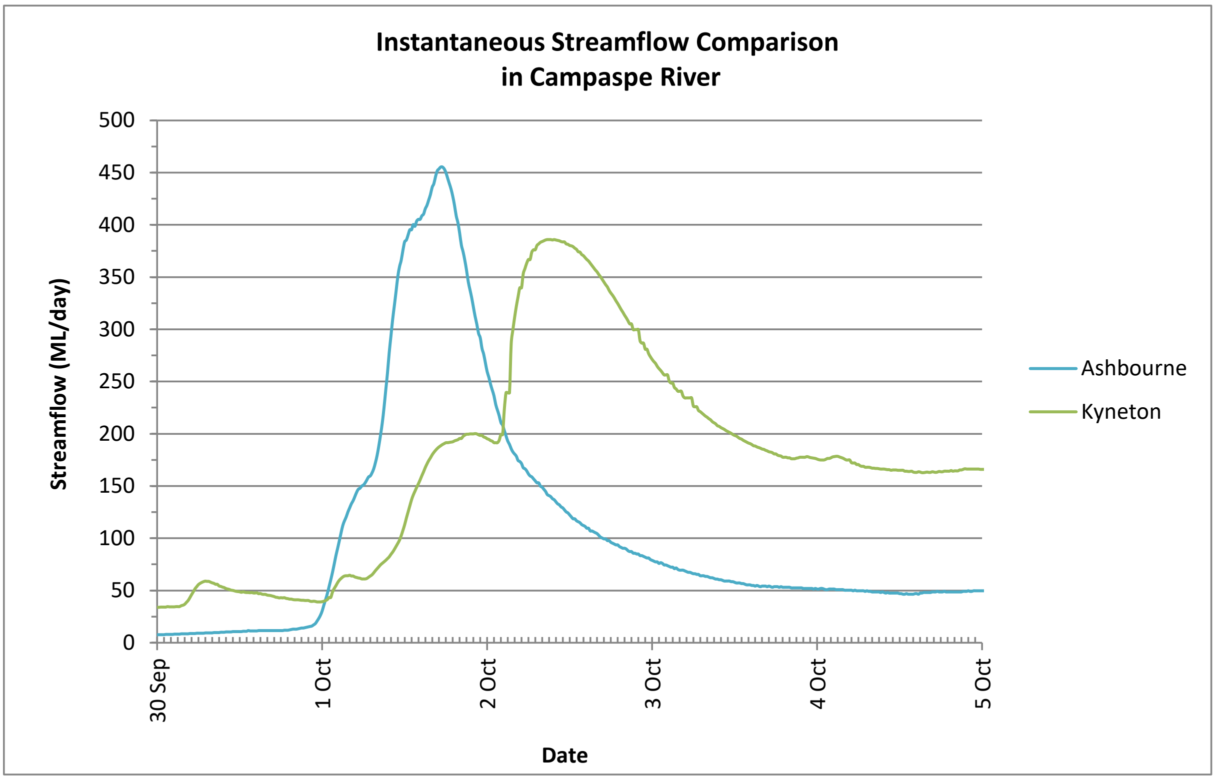

Figure A.3 *Daily streamflow data for Campaspe River at Ashbourne and Kyneton (October 2021)*

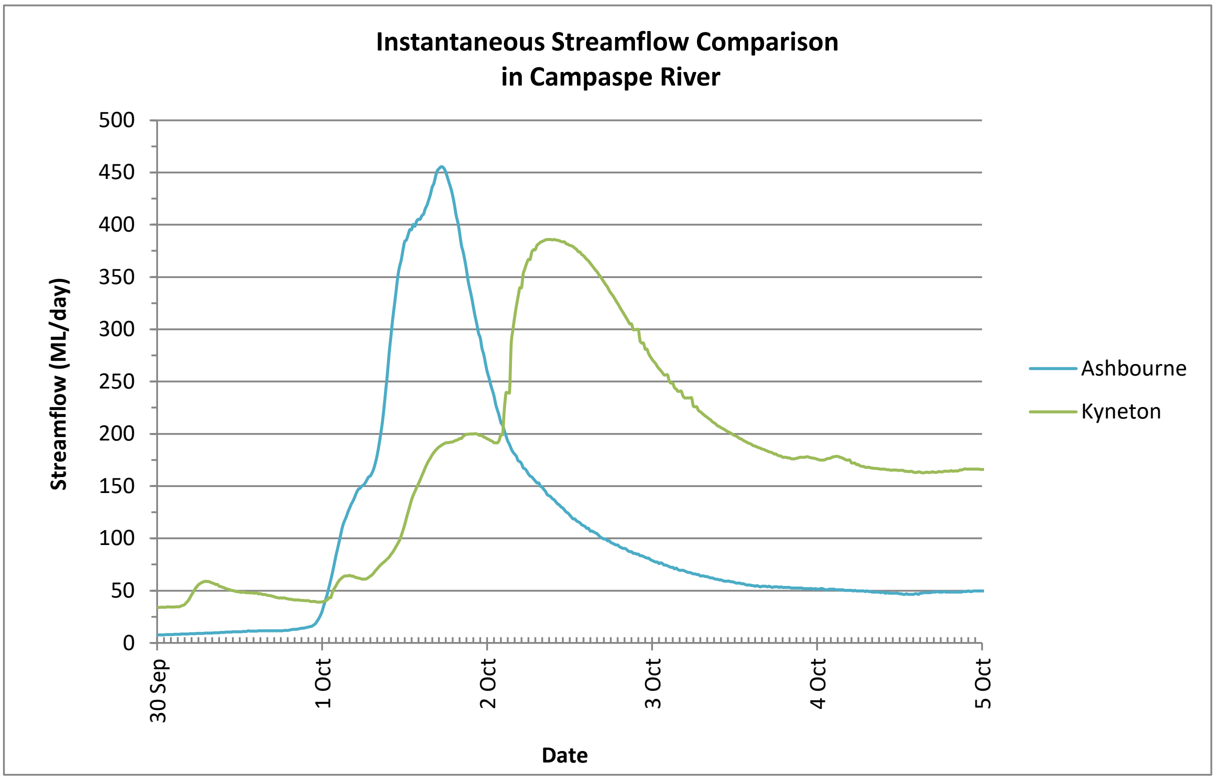

Figure A.4 Daily streamflow data for Campaspe River at Ashbourne and Kyneton (November 2021)

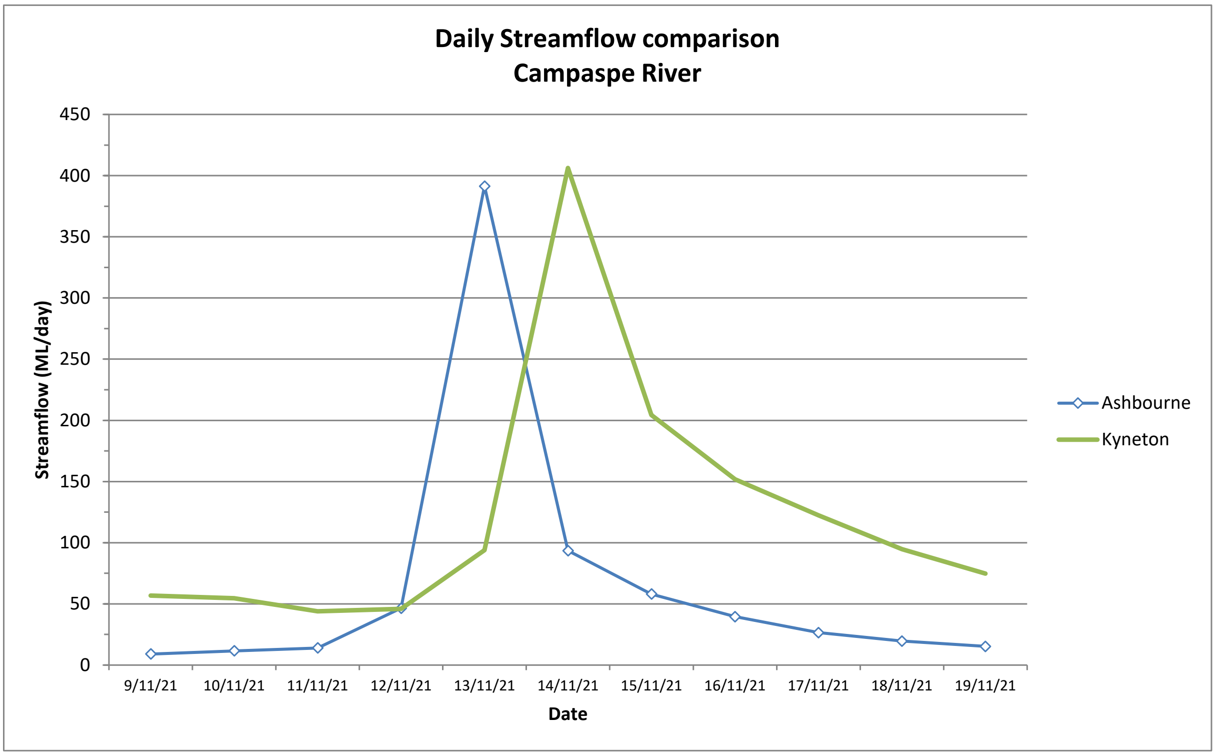

Figure A.5 Daily streamflow data for Campaspe River at Ashbourne and Kyneton (November 2021)

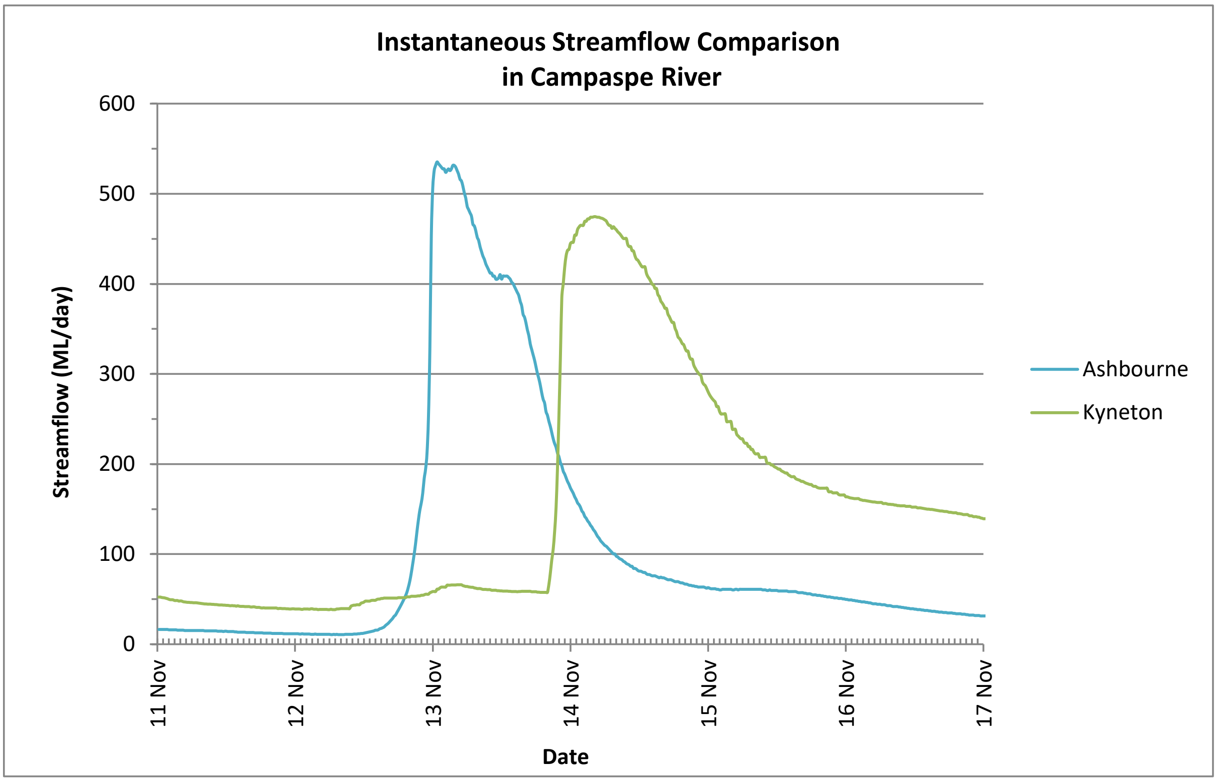

Figure A.6 Instantaneous streamflow data for Campaspe River at Ashbourne and Kyneton (November 2021)

Initial model run

Data and output from the initial calibration of Sacramento model is presented below. The model was further optimised using the FORS tool (and results are presented in the main body of this report)

Table A.2 Initial calibration parameters for Sacramento Model

Parameter	Value	Parameter	Value
Adimp	0.102	Rserv	0.300
Lzfpm	11.054	Sarva	0.010
Lzsfm	23.113	Side	0.000
Lzpk	0.165	Ssout	0.001
Lzsk	0.046	Uzfwm	79.666
Lztwm	302.502	Uzk	0.004
Pctim	0.011	Uztwm	94.765
Pfree	0.122	Zperc	18.997
Rexp	2.944		

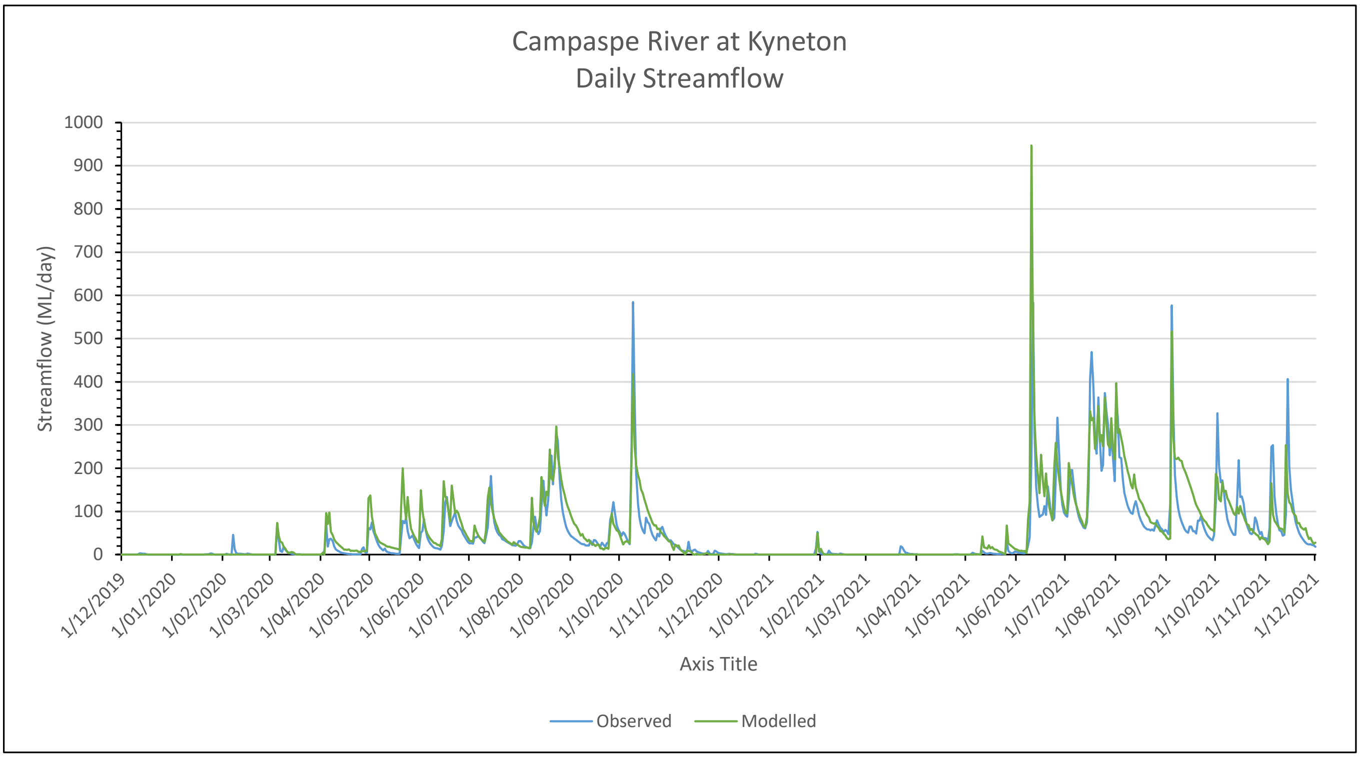

Figure A.7 Observed and modelled streamflow from initial Sacramento model run

Appendix B

Kyneton WRP Water Balance Model: Outputs

B-1 2020 inflows, 10th percentile year

The following outputs were obtained using a domestic treated wastewater discharge rate of 33.3% of river flow.

Table B.1 Scenario 1 - storage outputs

	Units	Required Capacity	Existing capacity	Excess
Lagoon 6 (Domestic) Storage Volume	ML	0	35	35
Lagoon 3&4 (Tradewaste) Storage volume	ML	135	135	0
Lagoon 5 (Tradewaste) Storage volume	ML	186	253	67
Hardwicks Storage volume	ML	160	160	0

Table B.2 Scenario 1 - irrigation outputs

Annual Irrigation	Units	Volume
Council	ML	20
Racecourse	ML	70
Coliban Irrigation Volume (Flood and Spray)	ML	202
Crofton Park Irrigation Volume	ML	198
Hardwicks Irrigation Volume	ML	179
Total Irrigation Volume	ML	669

Table B.3 Scenario 1 – annual balance

	Units	Volume
Domestic influent	ML	584
Tradewaste influent	ML	401
Net Evaporation (rainfall)	ML	-133
River discharge	ML	-183
Irrigation	ML	-669
Net Accumulation	ML	0

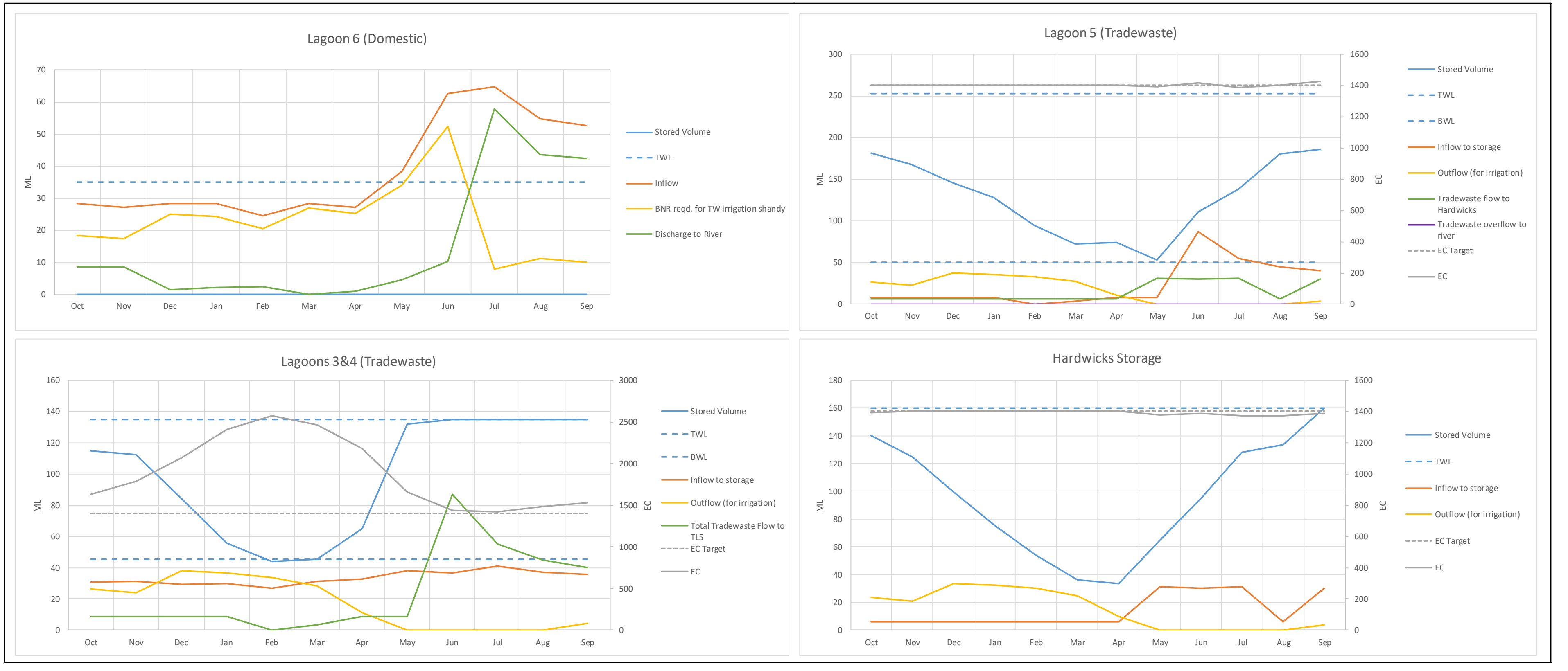

Figure B.1 Scenario 1 – 2020 10%ile rainfall year: summary of monthly storage levels and key flows

B-2 2020 inflows, 50th percentile year

The following outputs were obtained using a domestic treated wastewater discharge rate of 33.3% of river flow.

Table B.4 Scenario 2 - storage outputs

	Units	Required Capacity	Existing capacity	Excess
Lagoon 6 (Domestic) Storage Volume	ML	0	35	35
Lagoon 3&4 (Tradewaste) Storage volume	ML	135	135	0
Lagoon 5 (Tradewaste) Storage volume	ML	225	253	28
Hardwicks Storage volume	ML	160	160	0

Table B.5 Scenario 2 - irrigation outputs

Annual Irrigation	Units	Volume
Council	ML	20
Racecourse	ML	70
Coliban Irrigation Volume (Flood and Spray)	ML	186
Crofton Park Irrigation Volume	ML	199
Hardwicks Irrigation Volume	ML	166
Total Irrigation Volume	ML	641

Table B.6 Scenario 2 – annual balance

	Units	Volume
Domestic influent	ML	584
Tradewaste influent	ML	401
Net Evaporation (rainfall)	ML	-77
River discharge	ML	-267
Irrigation	ML	-641
Net Accumulation	ML	0

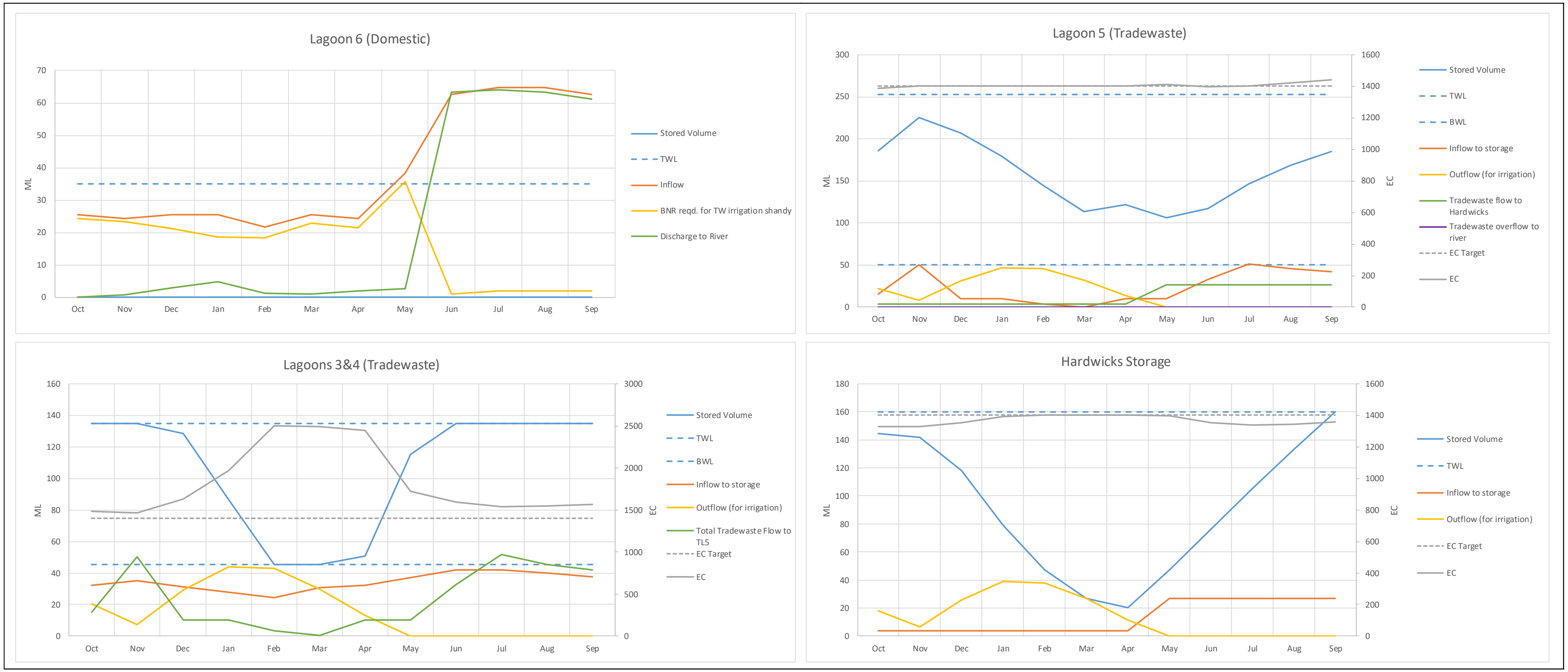

Figure B.2 ***Scenario 2 – 2020 50%ile rainfall year: summary of monthly storage levels and key flows***

B-3 2020 inflows, 90th percentile year

The following outputs were obtained using a domestic treated wastewater discharge rate of 33.3% of river flow.

Table B.7 Scenario 3a - storage outputs

	Units	Required Capacity	Existing capacity	Excess
Lagoon 6 (Domestic) Storage Volume	ML	35	35	0
Lagoon 3&4 (Tradewaste) Storage volume	ML	135	135	0
Lagoon 5 (Tradewaste) Storage volume	ML	219	253	35
Hardwicks Storage volume	ML	129	160	31

Table B.8 Scenario 3a - irrigation outputs

Annual Irrigation	Units	Volume
Council	ML	20
Racecourse	ML	70
Coliban Irrigation Volume (Flood and Spray)	ML	116
Crofton Park Irrigation Volume	ML	192
Hardwicks Irrigation Volume	ML	103
Total Irrigation Volume	ML	501

Table B.9 Scenario 3a – annual balance

	Units	Volume
Domestic influent	ML	584
Tradewaste influent	ML	401
Net Evaporation (rainfall)	ML	33
River discharge	ML	-445
Irrigation	ML	-501
Net Accumulation	ML	72

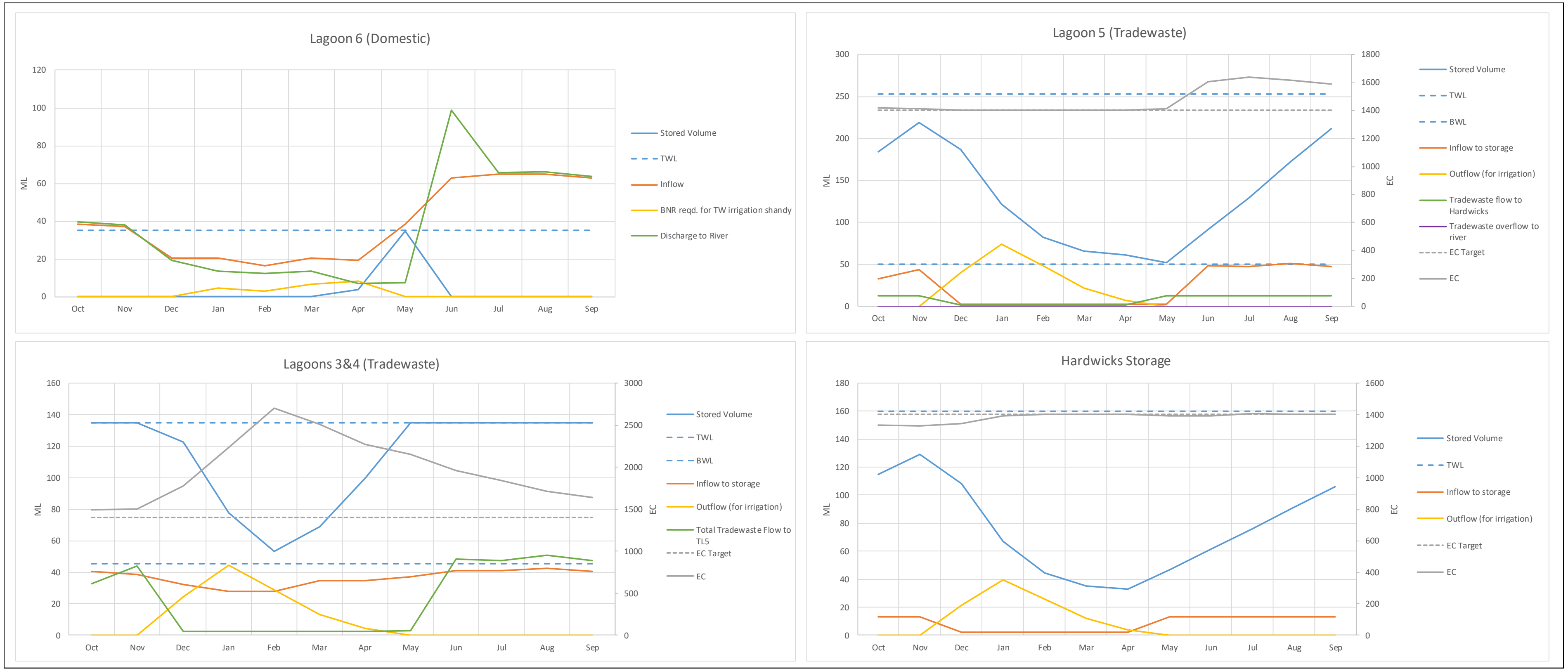

Figure B.3 Scenario 3a – 2020 90%ile rainfall year: summary of monthly storage levels and key flows (33.3% discharge rate)

The following outputs were obtained using a domestic treated wastewater discharge rate of 66.7% of river flow.

Table B.10 Scenario 3b - storage outputs

	Units	Required Capacity	Existing capacity	Excess
Lagoon 6 (Domestic) Storage Volume	ML	9	35	26
Lagoon 3&4 (Tradewaste) Storage volume	ML	135	135	0
Lagoon 5 (Tradewaste) Storage volume	ML	219	253	35
Hardwicks Storage volume	ML	129	160	31

Table B.11 Scenario 3b - irrigation outputs

Annual Irrigation	Units	Volume
Council	ML	20
Racecourse	ML	70
Coliban Irrigation Volume (Flood and Spray)	ML	116
Crofton Park Irrigation Volume	ML	192
Hardwicks Irrigation Volume	ML	103
Total Irrigation Volume	ML	501

Table B.12 Scenario 3b – annual balance

	Units	Volume
Domestic influent	ML	584
Tradewaste influent	ML	401
Net Evaporation (rainfall)	ML	33
River discharge	ML	-469
Irrigation	ML	-501
Net Accumulation	ML	48

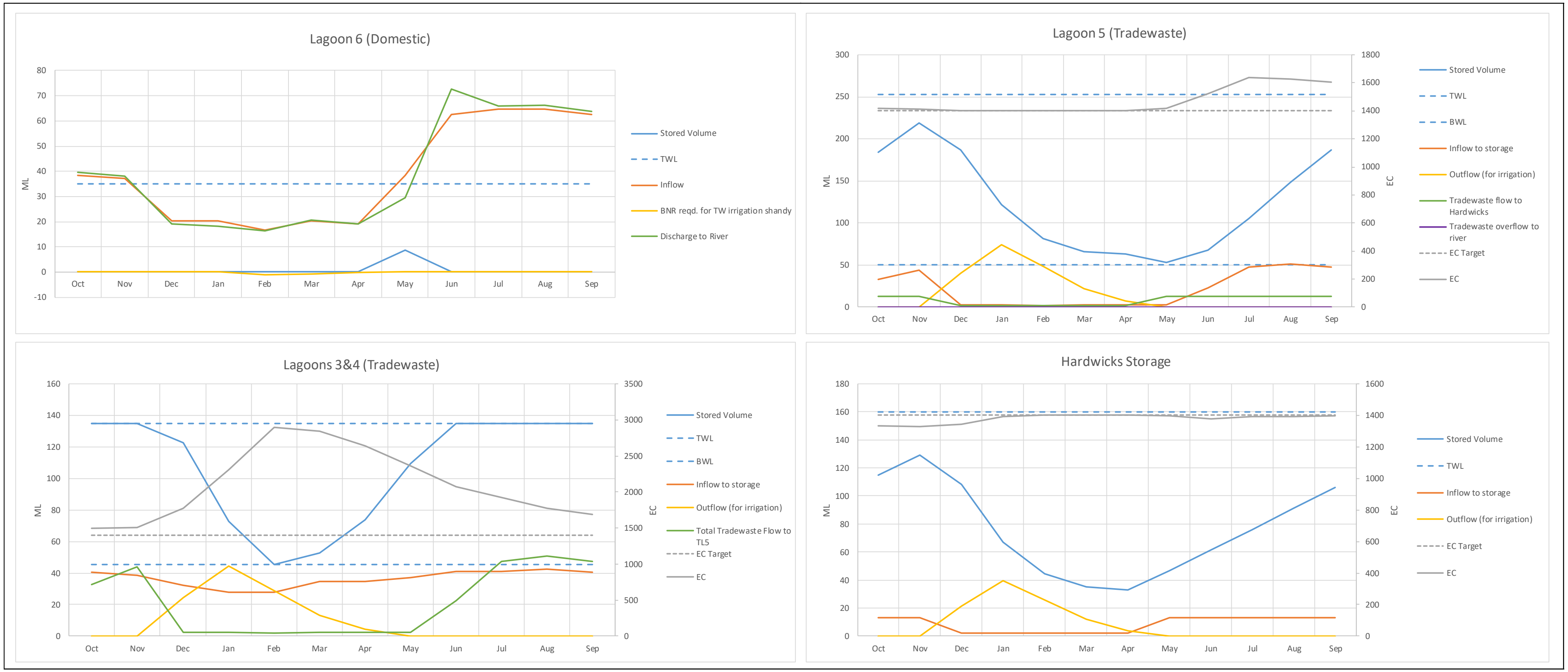

Figure B.4 Scenario 3b – 2020 90%ile rainfall year: summary of monthly storage levels and key flows (66.7% discharge rate)

B-4 2036 inflows, 10^{th} percentile year

The following outputs were obtained using a domestic treated wastewater discharge rate of 33.3% of river flow.

Table B.13 Scenario 4a - storage outputs

	Units	Required Capacity	Existing capacity	Excess
Lagoon 6 (Domestic) Storage Volume	ML	35	35	0
Lagoon 3&4 (Tradewaste) Storage volume	ML	135	135	0
Lagoon 5 (Tradewaste) Storage volume	ML	205	253	48
Hardwicks Storage volume	ML	158	160	2

Table B.14 Scenario 4a - irrigation outputs

Annual Irrigation	Units	Volume
Council	ML	20
Racecourse	ML	70
Coliban Irrigation Volume (Flood and Spray)	ML	202
Crofton Park Irrigation Volume	ML	198
Hardwicks Irrigation Volume	ML	179
Total Irrigation Volume	ML	669

Table B.15 Scenario 4a – annual balance

	Units	Volume
Domestic influent	ML	864
Tradewaste influent	ML	401
Net Evaporation (rainfall)	ML	-133
River discharge	ML	-447
Irrigation	ML	-669
Net Accumulation	ML	16

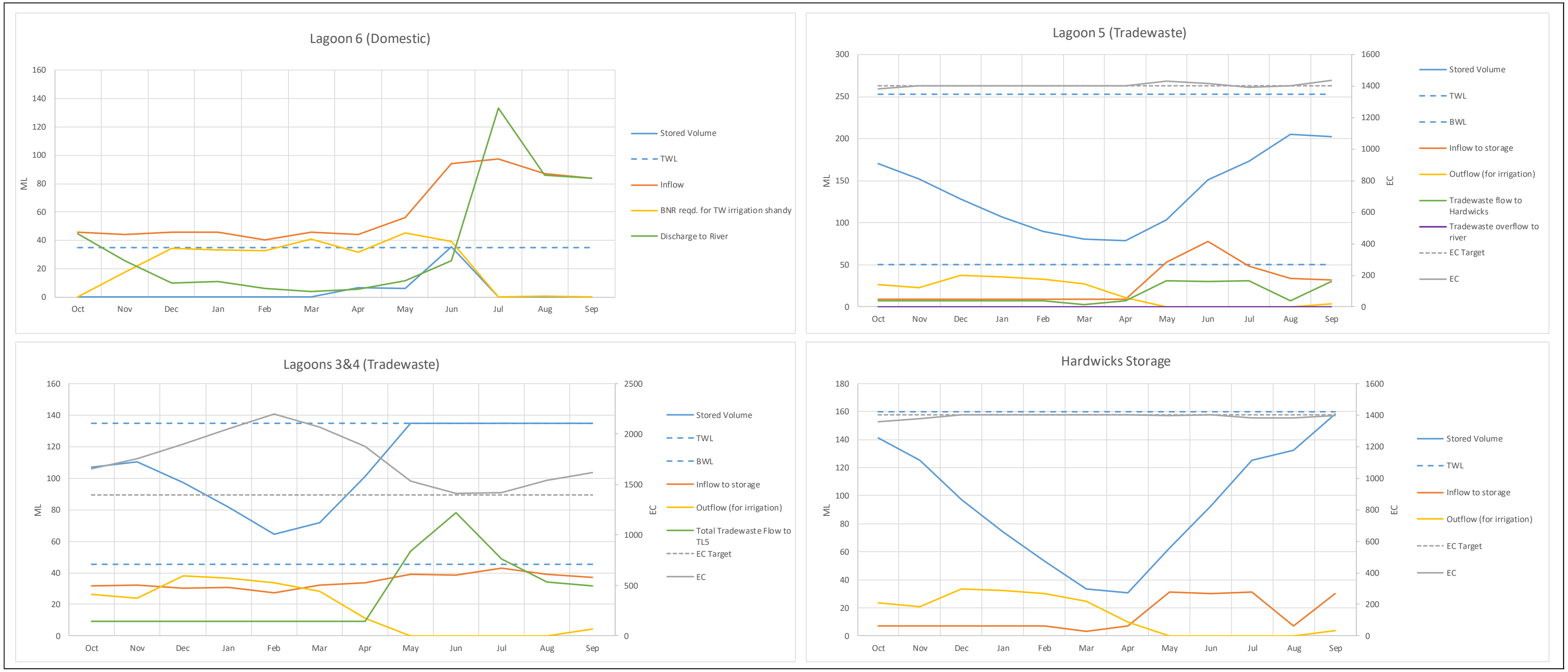

Figure B.5 Scenario 4a – 2036 10%ile rainfall year: summary of monthly storage levels and key flows (33.3% discharge rate)

The following outputs were obtained using a domestic treated wastewater discharge rate of 66.7.% of river flow.

Table B.16 Scenario 4b - storage outputs

	Units	Required Capacity	Existing capacity	Excess
Lagoon 6 (Domestic) Storage Volume	ML	0	35	35
Lagoon 3&4 (Tradewaste) Storage volume	ML	135	135	0
Lagoon 5 (Tradewaste) Storage volume	ML	191	253	62
Hardwicks Storage volume	ML	154	160	6

Table B.17 Scenario 4b - irrigation outputs

Annual Irrigation	Units	Volume
Council	ML	20
Racecourse	ML	70
Coliban Irrigation Volume (Flood and Spray)	ML	202
Crofton Park Irrigation Volume	ML	198
Hardwicks Irrigation Volume	ML	179
Total Irrigation Volume	ML	669

Table B.18 Scenario 4b – annual balance

	Units	Volume
Domestic influent	ML	864
Tradewaste influent	ML	401
Net Evaporation (rainfall)	ML	-133
River discharge	ML	-463
Irrigation	ML	-669
Net Accumulation	ML	0

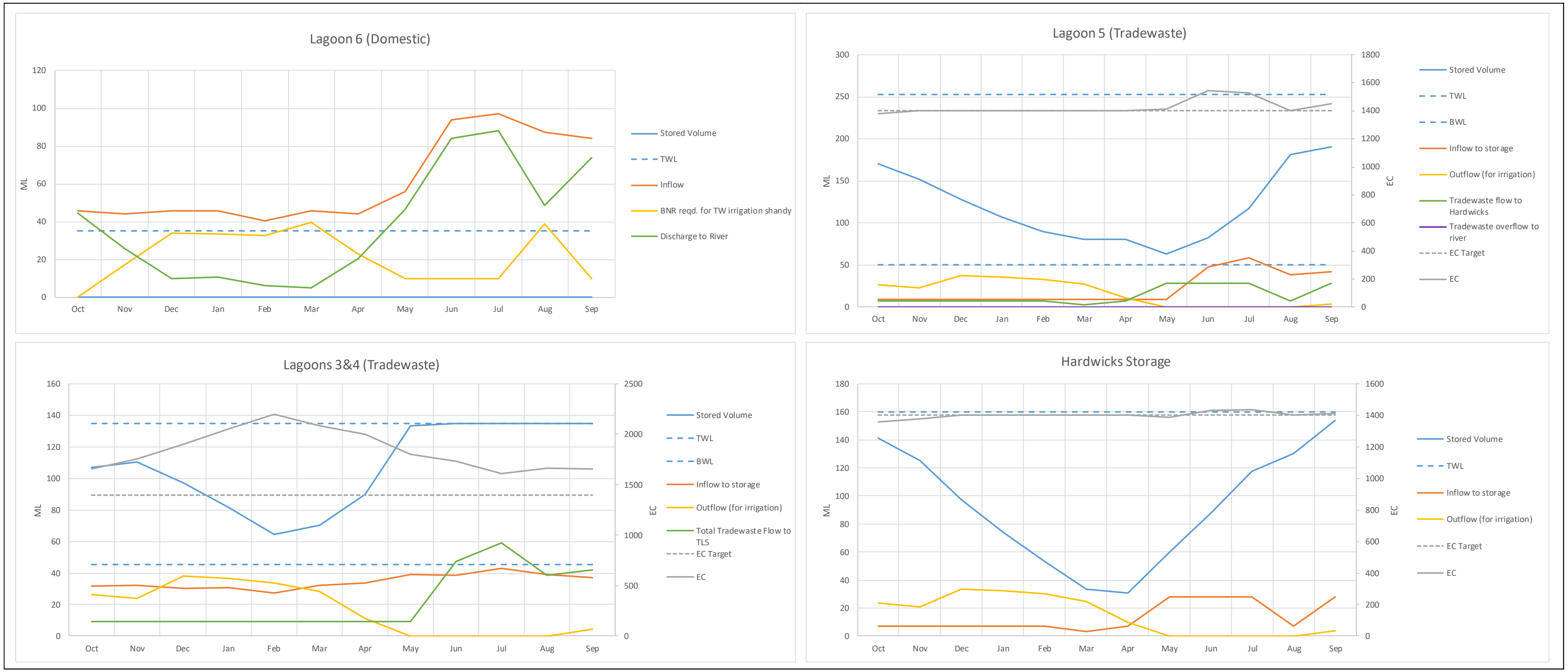

Figure B.6 Scenario 4b – 2036 10%ile rainfall year: summary of monthly storage levels and key flows (66.7% discharge rate)

B-5 2036 inflows, 50th percentile year

The following outputs were obtained using a domestic treated wastewater discharge rate of 33.3% of river flow.

Table B.19 Scenario 5 - storage outputs

	Units	Required Capacity	Existing capacity	Excess
Lagoon 6 (Domestic) Storage Volume	ML	35	35	0
Lagoon 3&4 (Tradewaste) Storage volume	ML	135	135	0
Lagoon 5 (Tradewaste) Storage volume	ML	186	253	67
Hardwicks Storage volume	ML	149	160	11

Table B.20 Scenario 5 - irrigation outputs

Annual Irrigation	Units	Volume
Council	ML	20
Racecourse	ML	70
Coliban Irrigation Volume (Flood and Spray)	ML	186
Crofton Park Irrigation Volume	ML	199
Hardwicks Irrigation Volume	ML	166
Total Irrigation Volume	ML	641

Table B.21 Scenario 5 – annual balance

	Units	Volume
Domestic influent	ML	864
Tradewaste influent	ML	401
Net Evaporation (rainfall)	ML	-77
River discharge	ML	-547
Irrigation	ML	-641
Net Accumulation	ML	0

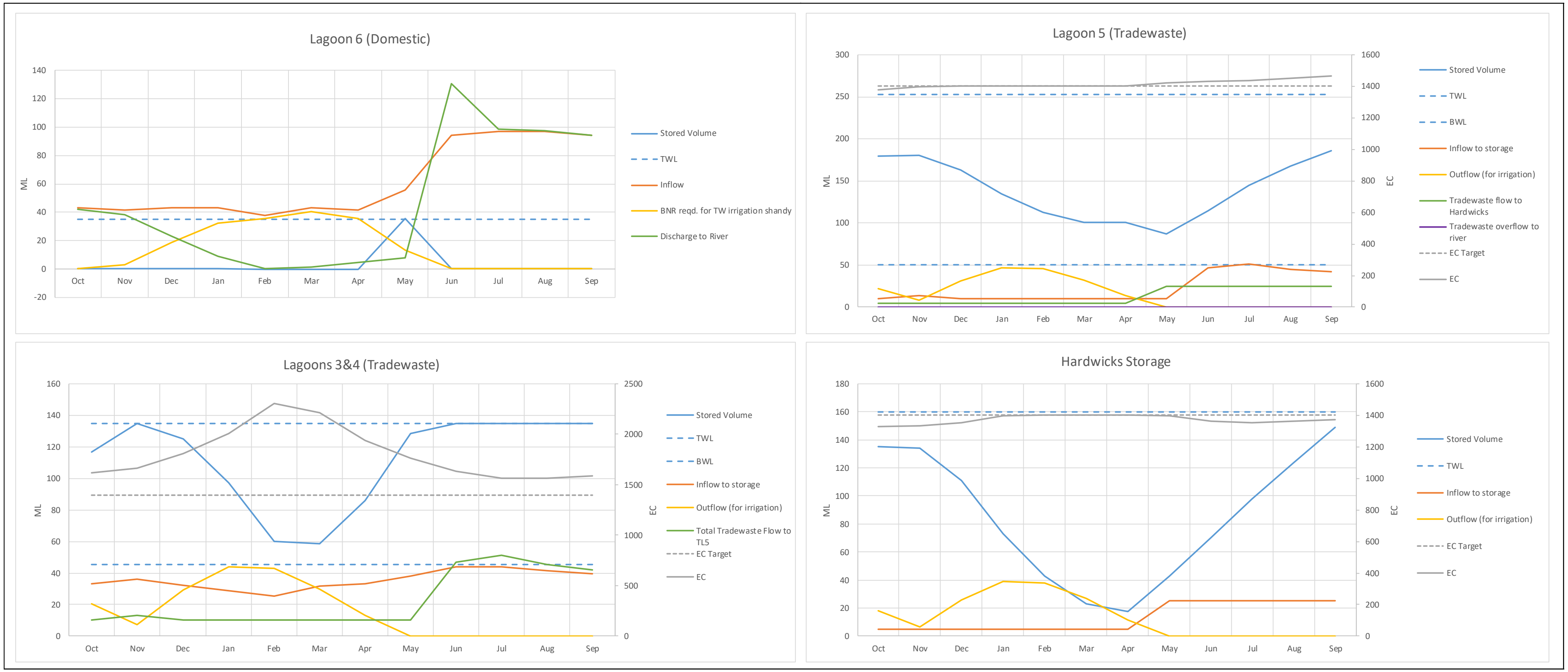

Figure B.7 Scenario 5 – 2036 50%ile rainfall year: summary of monthly storage levels and key flows

B-6 2036 inflows, 90th percentile year

The following outputs were obtained using a domestic treated wastewater discharge rate of 33.3% of river flow.

Table B.22 Scenario 6a - storage outputs

	Units	Required Capacity	Existing capacity	Excess
Lagoon 6 (Domestic) Storage Volume	ML	35	35	0
Lagoon 3&4 (Tradewaste) Storage volume	ML	135	135	0
Lagoon 5 (Tradewaste) Storage volume	ML	283	253	-30
Hardwicks Storage volume	ML	155	160	5

Table B.23 Scenario 6a - irrigation outputs

Annual Irrigation	Units	Volume
Council	ML	20
Racecourse	ML	70
Coliban Irrigation Volume (Flood and Spray)	ML	116
Crofton Park Irrigation Volume	ML	192
Hardwicks Irrigation Volume	ML	103
Total Irrigation Volume	ML	501

Table B.24 Scenario 6a – annual balance

	Units	Volume
Domestic influent	ML	864
Tradewaste influent	ML	401
Net Evaporation (rainfall)	ML	33
River discharge	ML	-624
Irrigation	ML	-501
Net Accumulation	ML	173

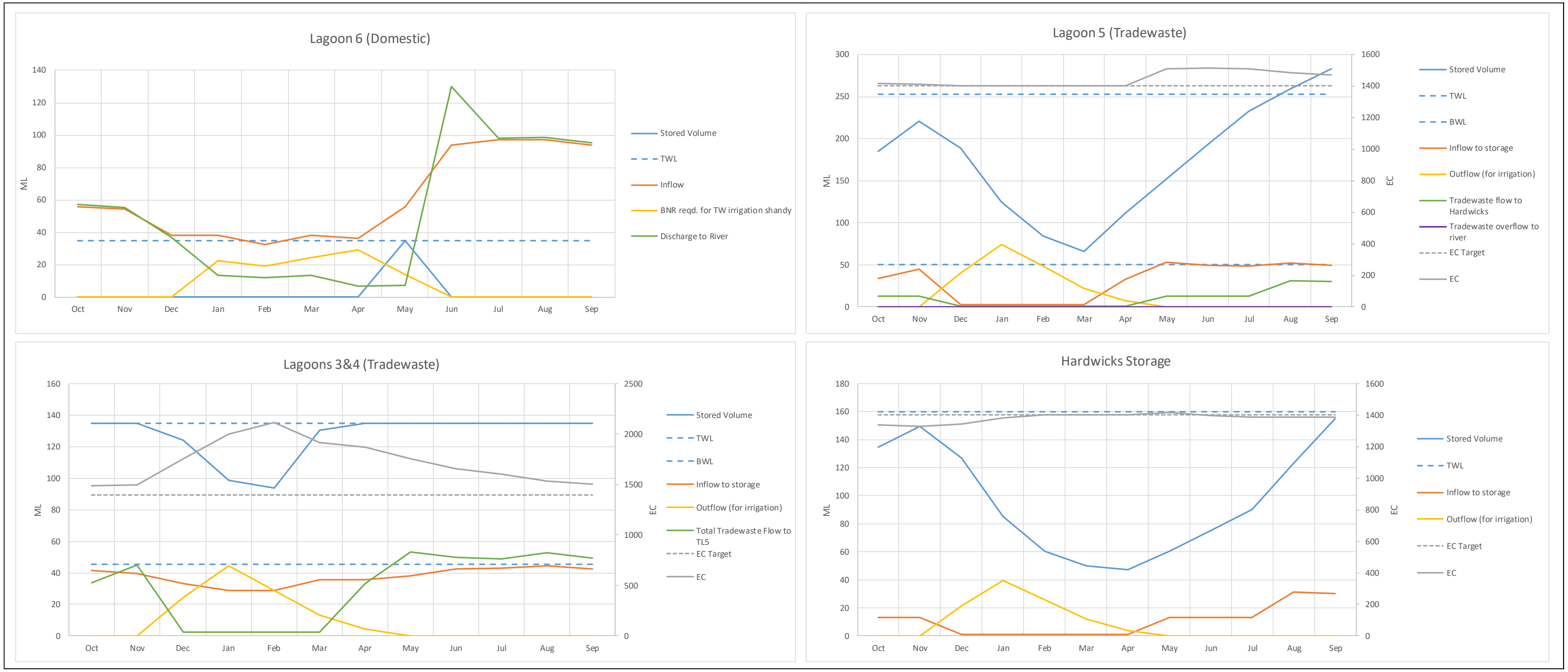

Figure B.8 *Scenario 6a – 2036 90% ile rainfall year: summary of monthly storage levels and key flows (33.3% discharge rate)*

The following outputs were obtained using a domestic treated wastewater discharge rate of 66.7% of river flow.

Table B.25 Scenario 6b - storage outputs

	Units	Required Capacity	Existing capacity	Excess
Lagoon 6 (Domestic) Storage Volume	ML	34	35	1
Lagoon 3&4 (Tradewaste) Storage volume	ML	135	135	0
Lagoon 5 (Tradewaste) Storage volume	ML	220	253	33
Hardwicks Storage volume	ML	149	160	11

Table B.26 Scenario 6b - irrigation outputs

Annual Irrigation	Units	Volume
Council	ML	20
Racecourse	ML	70
Coliban Irrigation Volume (Flood and Spray)	ML	116
Crofton Park Irrigation Volume	ML	192
Hardwicks Irrigation Volume	ML	103
Total Irrigation Volume	ML	501

Table B.27 Scenario 6b – annual balance

	Units	Volume
Domestic influent	ML	864
Tradewaste influent	ML	401
Net Evaporation (rainfall)	ML	33
River discharge	ML	-736
Irrigation	ML	-501
Net Accumulation	ML	61

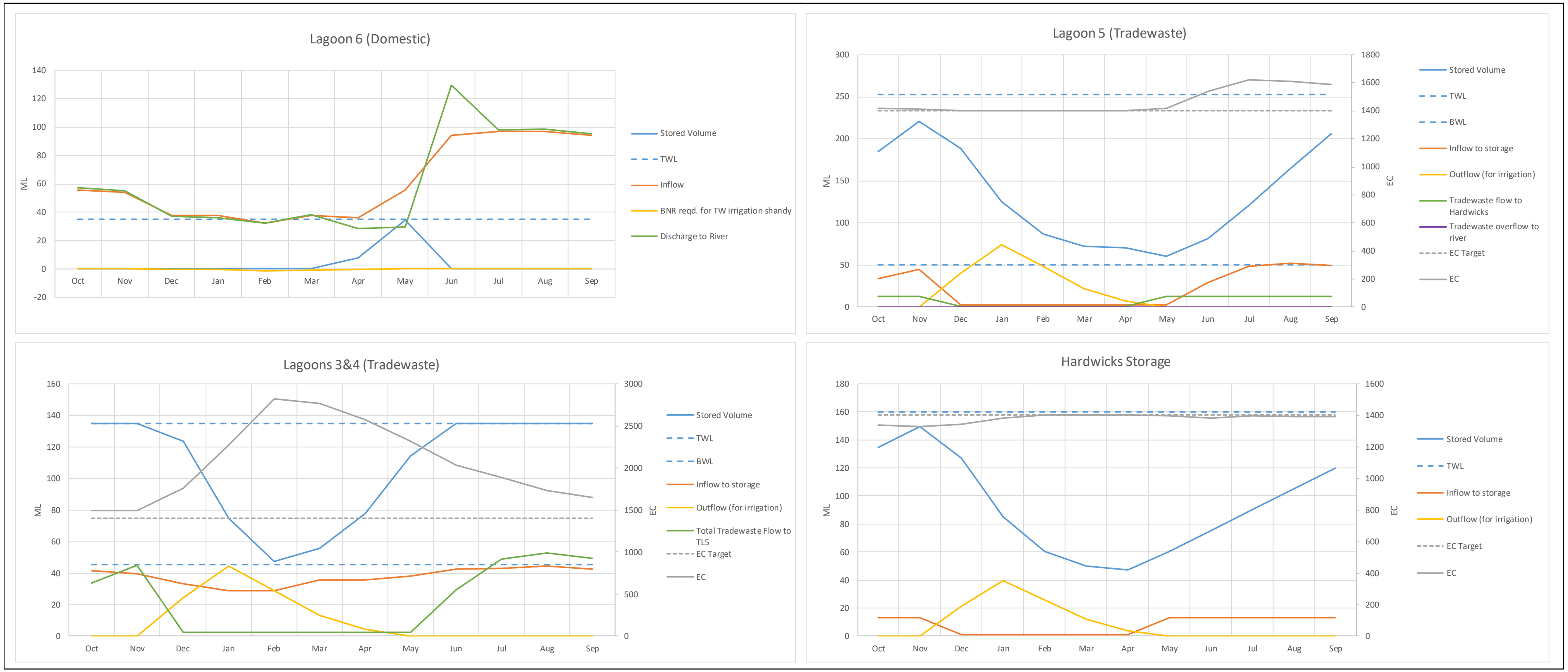

Figure B.9 Scenario 6b – 2036 90% ile rainfall year: summary of monthly storage levels and key flows (33.3% discharge rate)

Appendix C

Kyneton WRP (Redesdale river flow)

Water Balance Model: Outputs

C-1 2020 inflows, 90th percentile year (2010)

In this scenario the Campaspe River Flow conditions are taken as 2010 flows as measured at Redesdale.

The following outputs were obtained using a domestic treated wastewater discharge rate of 16.7% as a proportion of total river flow.

Table C.1 Scenario 7a - storage outputs

	Units	Required Capacity	Existing capacity	Excess
Lagoon 6 (Domestic) Storage Volume	ML	35	35	0
Lagoon 3&4 (Tradewaste) Storage volume	ML	135	135	0
Lagoon 5 (Tradewaste) Storage volume	ML	253	253	0
Hardwicks Storage volume	ML	149	160	11

Table C.2 Scenario 7a - irrigation outputs

Annual Irrigation	Units	Volume
Council	ML	20
Racecourse	ML	70
Coliban Irrigation Volume (Flood and Spray)	ML	116
Crofton Park Irrigation Volume	ML	192
Hardwicks Irrigation Volume	ML	103
Total Irrigation Volume	ML	501

Table C.3 Scenario 7a – annual balance

	Units	Volume
Domestic influent	ML	584
Tradewaste influent	ML	401
Net Evaporation (rainfall)	ML	33
River discharge	ML	-394
Irrigation	ML	-501
Net Accumulation	ML	123

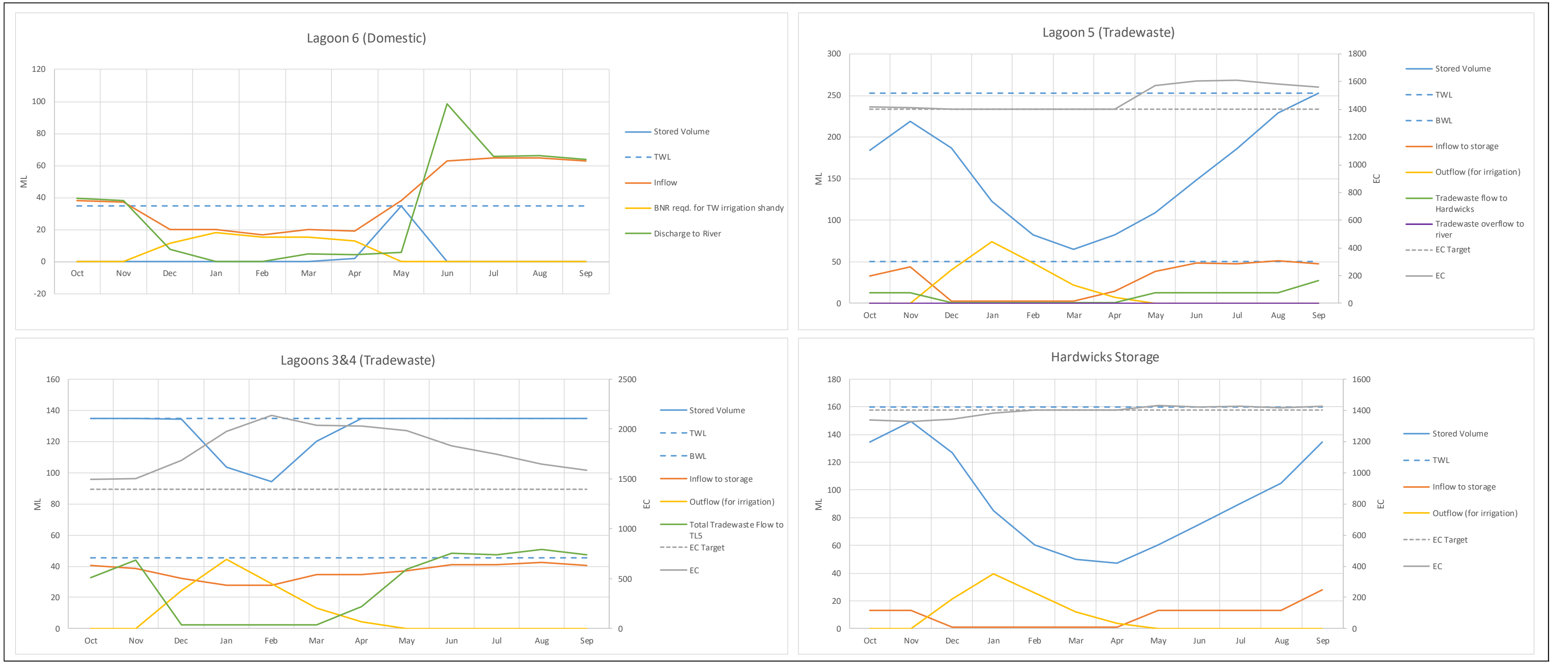

Figure C.1 Scenario 7a: 2020 90%ile rainfall year (Redesdale 2010): summary of monthly storage levels and key flows (16.7% discharge rate)

C-2 2020 inflows, 90th percentile year (2011)

In this scenario the Campaspe River Flow conditions are taken as 2011 flows as measured at Redesdale.

The following outputs were obtained using a domestic treated wastewater discharge rate of 16.7% as a proportion of total river flow.

Table C.4 Scenario 7b - storage outputs

	Units	Required Capacity	Existing capacity	Excess
Lagoon 6 (Domestic) Storage Volume	ML	0	35	35
Lagoon 3&4 (Tradewaste) Storage volume	ML	135	135	0
Lagoon 5 (Tradewaste) Storage volume	ML	220	253	33
Hardwicks Storage volume	ML	153	160	7

Table C.5 Scenario 7b - irrigation outputs

Annual Irrigation	Units	Volume
Council	ML	20
Racecourse	ML	70
Coliban Irrigation Volume (Flood and Spray)	ML	108
Crofton Park Irrigation Volume	ML	180
Hardwicks Irrigation Volume	ML	96
Total Irrigation Volume	ML	474

Table C.6 Scenario 7b – annual balance

	Units	Volume
Domestic influent	ML	584
Tradewaste influent	ML	401
Net Evaporation (rainfall)	ML	12
River discharge	ML	-465
Irrigation	ML	-474
Net Accumulation	ML	58

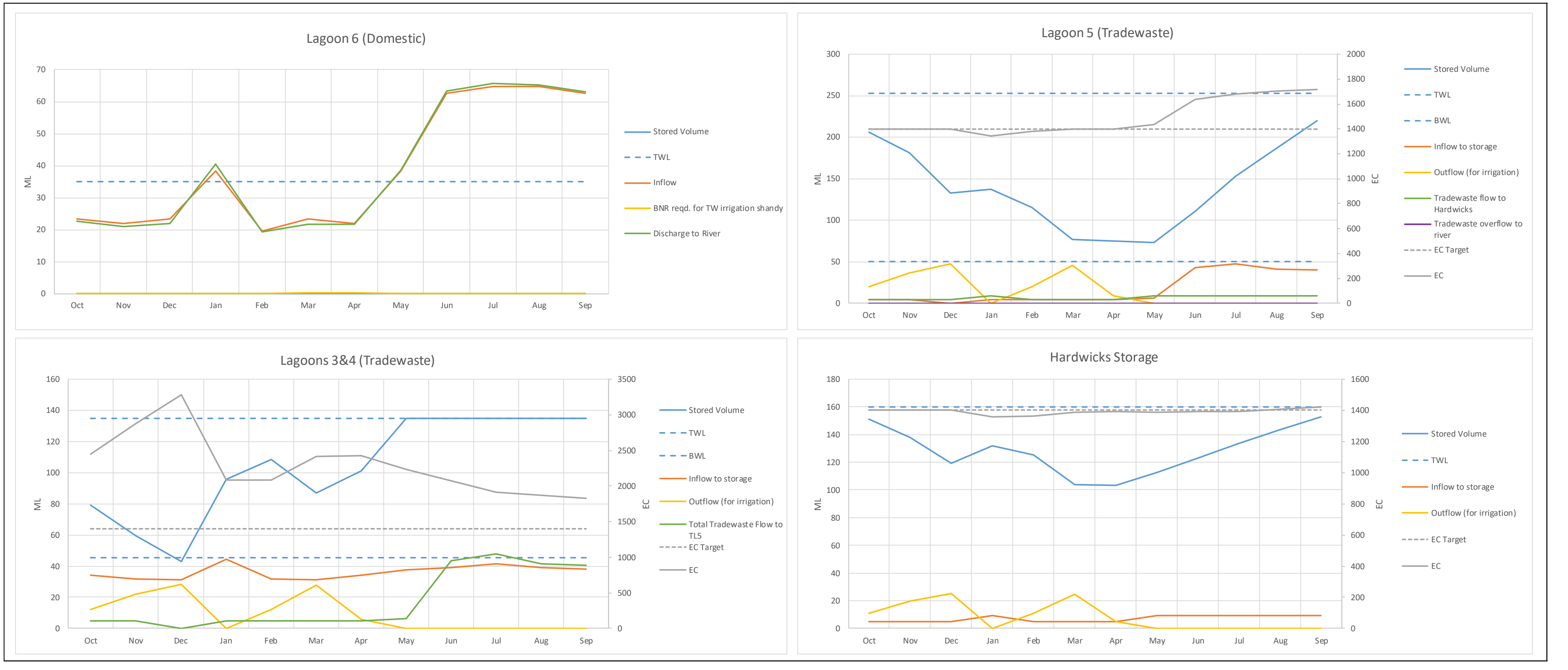

Figure C.2 Scenario 7b: 2020 90%ile rainfall year (Redesdale 2011): summary of monthly storage levels and key flows (16.7% discharge rate)

C-3 2036 inflows, 90th percentile year (2010)

In this scenario the Campaspe River Flow conditions are taken as 2011 flows as measured at Redesdale.

The following outputs were obtained using a domestic treated wastewater discharge rate of 16.7% as a proportion of total river flow.

Table C.7 Scenario 8a - storage outputs

	Units	Required Capacity	Existing capacity	Excess
Lagoon 6 (Domestic) Storage Volume	ML	35	35	0
Lagoon 3&4 (Tradewaste) Storage volume	ML	135	135	0
Lagoon 5 (Tradewaste) Storage volume	ML	309	253	-56
Hardwicks Storage volume	ML	173	160	-13

Table C.8 Scenario 8a - irrigation outputs

Annual Irrigation	Units	Volume
Council	ML	20
Racecourse	ML	70
Coliban Irrigation Volume (Flood and Spray)	ML	116
Crofton Park Irrigation Volume	ML	192
Hardwicks Irrigation Volume	ML	103
Total Irrigation Volume	ML	501

Table C.9 Scenario 8a – annual balance

	Units	Volume
Domestic influent	ML	864
Tradewaste influent	ML	401
Net Evaporation (rainfall)	ML	33
River discharge	ML	-580
Irrigation	ML	-501
Net Accumulation	ML	217

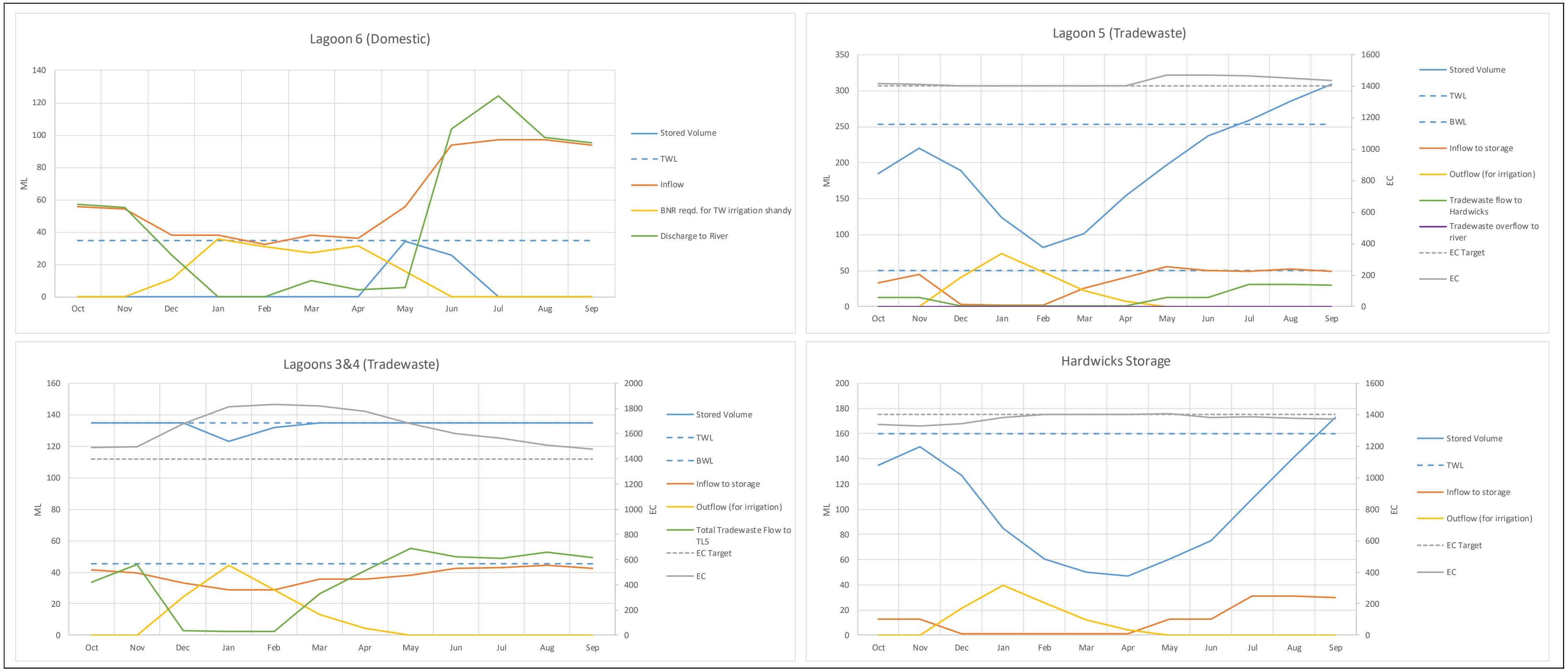

Figure C.3 Scenario 8a: 2036 90%ile rainfall year (Redesdale 2010): summary of monthly storage levels and key flows (16.7% discharge rate)

C-4 2036 inflows, 90th percentile year (2011)

In this scenario the Campaspe River Flow conditions are taken as 2011 flows as measured at Redesdale.

The following outputs were obtained using a domestic treated wastewater discharge rate of 16.7% as a proportion of total river flow.

Table C.10 Scenario 8b - storage outputs

	Units	Required Capacity	Existing capacity	Excess
Lagoon 6 (Domestic) Storage Volume	ML	0	35	35
Lagoon 3&4 (Tradewaste) Storage volume	ML	135	135	0
Lagoon 5 (Tradewaste) Storage volume	ML	234	253	20
Hardwicks Storage volume	ML	153	160	7

Table C.11 Scenario 8b - irrigation outputs

Annual Irrigation	Units	Volume
Council	ML	20
Racecourse	ML	70
Coliban Irrigation Volume (Flood and Spray)	ML	108
Crofton Park Irrigation Volume	ML	180
Hardwicks Irrigation Volume	ML	96
Total Irrigation Volume	ML	474

Table C.12 Scenario 8b – annual balance

	Units	Volume
Domestic influent	ML	864
Tradewaste influent	ML	401
Net Evaporation (rainfall)	ML	12
River discharge	ML	-731
Irrigation	ML	-474
Net Accumulation	ML	72

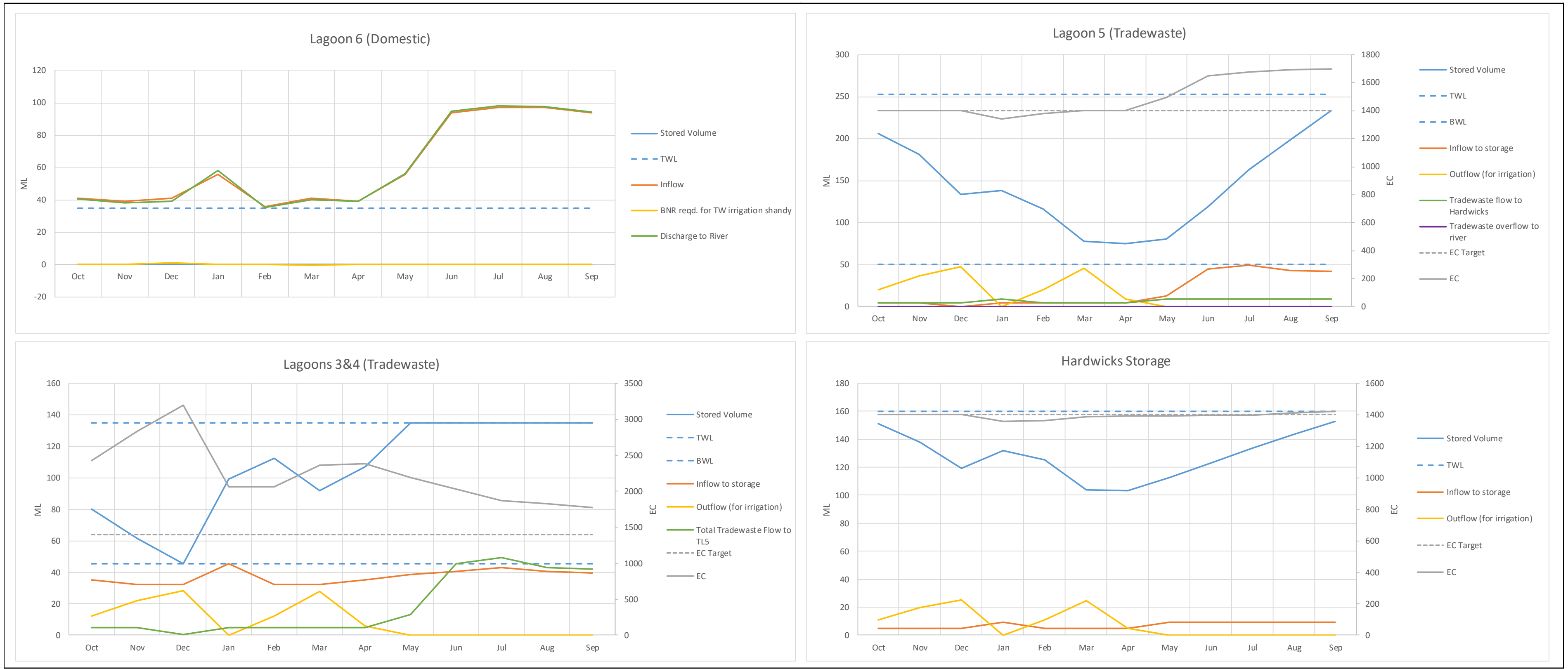

Figure C.4 *Scenario 8b: 2036 90%ile rainfall year (Redesdale 2011): summary of monthly storage levels and key flows (16.7% discharge rate)* ghd.com

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