Government of **Western Australia**
Department of **Water**

Warren–Donnelly

surface water allocation plan methods report

Department of Water

April 2012

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Supporting information for the Warren–Donnelly surface water allocation plan

Looking after all our water needs

Department of Water

April 2012

Department of Water
168 St Georges Terrace
Perth Western Australia 6000
Telephone +61 8 6364 7600
Facsimile +61 8 6364 7601
National Relay Service 13 36 77
www.water.wa.gov.au

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Project team: Felicity Bunny (District Manager), Emily Harrington (Senior Water Planning Officer), Rob Donohue (Senior Environmental Officer), Mark Pearcey and Jacqui Durrant (Supervising engineers), Michael Braccia (Engineer), Steve DeMunck (Surface Water Licensing) and Lanie Ayers (Natural Resource Management Officer).

Project board: Patrick Seares (Acting Director), Liz Western (Acting Director), Wayne Tingey (Regional Manager), Bev Thurlow (Strategic Projects Manager), Susan Worley (Branch Manager), John Connolly (Branch Manager) and Rick Bretnall (Branch Manager).

Project assurance: Matthew Awang (Section Manager, Water Allocation Planning).

For more information about this report, contact the Department of Water's Water Allocation Planning branch, telephone 08 6364 7600. Email allocation.planning@water.wa.gov.au.

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Summary

The Department of Water has prepared this document to explain how we developed the allocation limits for each of the 25 surface water subareas covered in the *Warren–Donnelly surface water allocation plan* (DoW 2012a).

The allocation limits for consumptive use from the rivers in the Warren–Donnelly area were shaped by four characteristics of the area:

- the different land uses in the different parts of the catchments
- the distributed and independently operated nature of the on-stream dams
- the annual variation in rainfall and streamflow
- the current level of use (licensed and exempt) and the future water demand.

These characteristics are reflected in the department's water resource objectives for the Warren–Donnelly area. The objectives are also based on:

- consultation with stakeholders
- the department's assessment of the hydrology, water use and water demand in the area
- agricultural priority management areas identified by the Department of Agriculture and Food WA.

There are more than 480 on-stream dams distributed across the Warren–Donnelly catchments. The dams are operated independently and the current infrastructure does not enable water to be shared evenly in dry years. Therefore allocation limits are set to provide a high level of reliability so water entitlements are secure.

There are 72.86 GL per year, across 23 subareas, allocated for consumptive use across the plan area. Of this, about 35 GL per year is currently issued as licence entitlements.

1 Introduction

The Department of Water manages water abstraction by issuing water licences under the *Rights in Water and Irrigation Act 1914*. Water allocation plans guides our licensing decisions.

During 2009 and 2010, the department prepared the *Warren–Donnelly surface water allocation plan: for public comment* (DoW 2010b). The department completed the *Warren–Donnelly surface water allocation plan* in 2011 by considering the issues raised through consultation and submissions on the plan for public comment as well as new work on reliability of supply and a review of the ecologically sustainable yields method.

1.1 Plan area

The plan area covers the Warren and Donnelly river basins (Figure 1), an area of almost 6100 km^2, in the south-west of Western Australia. About one third of the land is cleared with about two-thirds (4000 km^2) of the Warren–Donnelly area covered by state forest, national park and nature reserve (Figure 2). The towns of Manjimup and Pemberton are located within the plan area.

In the Warren–Donnelly area, irrigated agriculture is the primary user of surface water. Irrigated agriculture in the area is a self-supply industry which depends almost entirely on river water stored in on-stream (gully wall) dams. Most of the more than 480 on-stream dams in the plan area are concentrated into six subareas. These dams support a variety of irrigated agriculture enterprises. The reliability of the water supply depends on variations in streamflow and the size and operation of up-stream dams.

In both conservation and irrigation areas, the rivers support water-dependent ecological values. While dams provide some habitat in irrigation areas, streamflow is necessary to support social and ecological values and to carry water to downstream dams.

Figure 1 Warren–Donnelly surface water allocation plan area and proclaimed areas

1.2 Water resources managed under the plan

The plan applies to all watercourses in the Warren–Donnelly area. In areas that are proclaimed under the *Rights in Water and Irrigation Act 1914* (Figure 1), the department actively manages water resources by licensing the take of water. The plan area includes the:

- Warren River and tributaries surface water area, proclaimed in 1959
- Donnelly River System surface water area, proclaimed in 1968.

For allocation planning and licensing purposes, the department has divided the Warren–Donnelly area into 25 surface water subareas, based on hydrological catchment boundaries (Figure 2).

For administrative purposes, the subarea is the water resource unit. We have set an allocation limit for each resource, which is the total amount of surface water available for take at the most downstream point of the subarea.

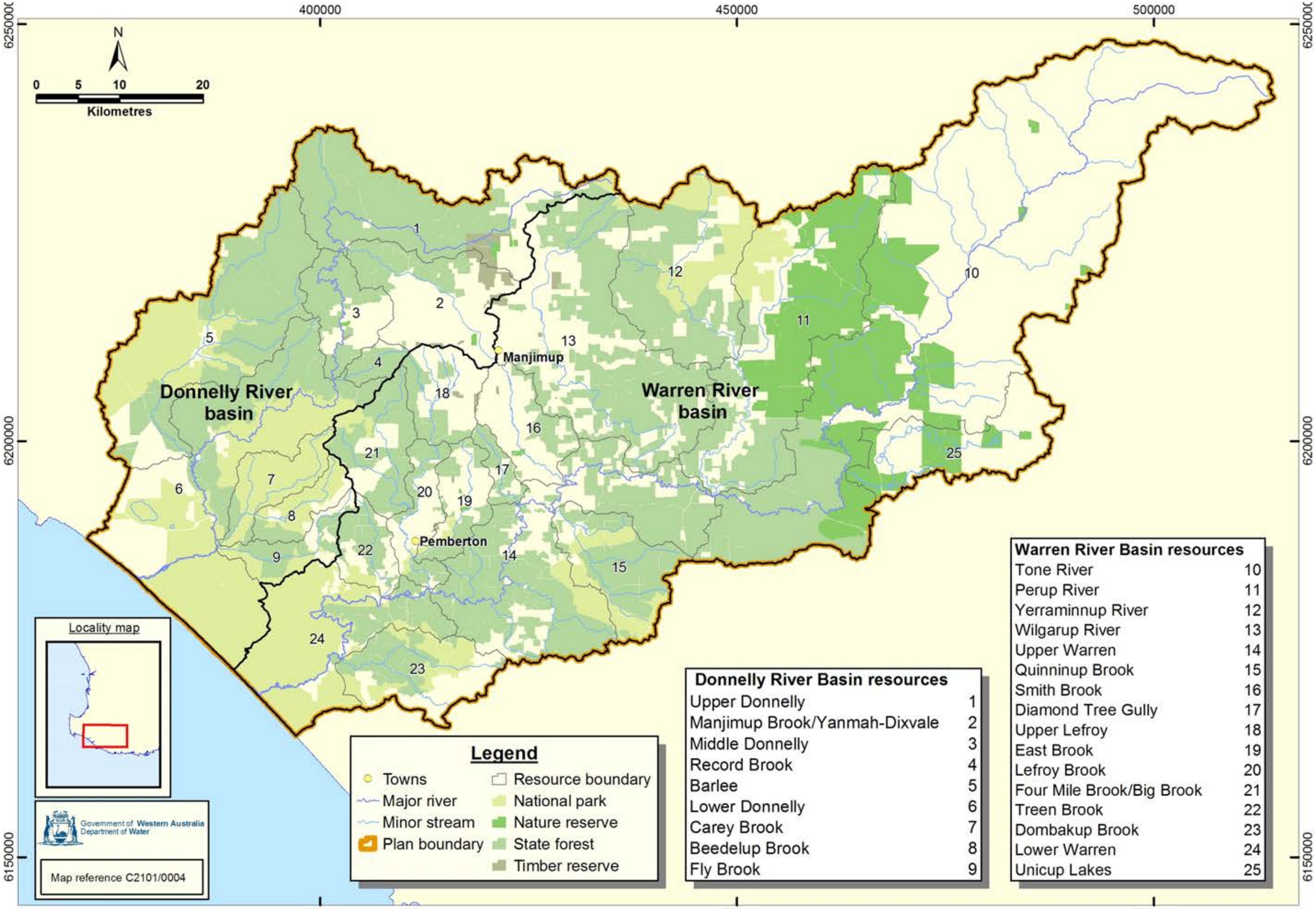


Figure 2 Warren–Donnelly surface water resources (subareas)

1.3 Allocation limits

The allocation limit is the annual volume of water set aside for consumptive use from a water resource. For administrative purposes, the allocation limit includes components for:

- water that is available for licensing
  - general licensing
  - public water supply licensing
- water that is exempt from licensing
- water that is reserved for future public water supply.

The allocation limit does not include water to be left in the river.

The department uses allocation limits to manage the whole resource sustainably and to maintain security to individual licence entitlements. Water is allocated within the allocation limit through the department's licensing process and is complemented by water resources monitoring, investigations and licence compliance monitoring. This management approach is set out in the Warren–Donnelly plan. Managing through a combination of allocation limits, licensing and monitoring minimises the impacts of water abstraction on other users and the environment.

1.4 Our process for allocation planning

We follow the process shown in Figure 3 when developing a water allocation plan. The first part of this report (Part A of the process) describes how we assessed the information on the water resource in the Warren–Donnelly area, including the current water use and future demand. The second part of the report (Part B of the process) describes how we set the objectives and allocation limits for the *Warren–Donnelly surface water allocation plan*. Our management approach (Part C of the process) is defined in the *Warren–Donnelly surface water allocation plan*.

For more information about allocation planning see *Water allocation planning in Western Australia: a guide to our process* (DoW 2011), which is available online at <www.water.wa.gov.au>.

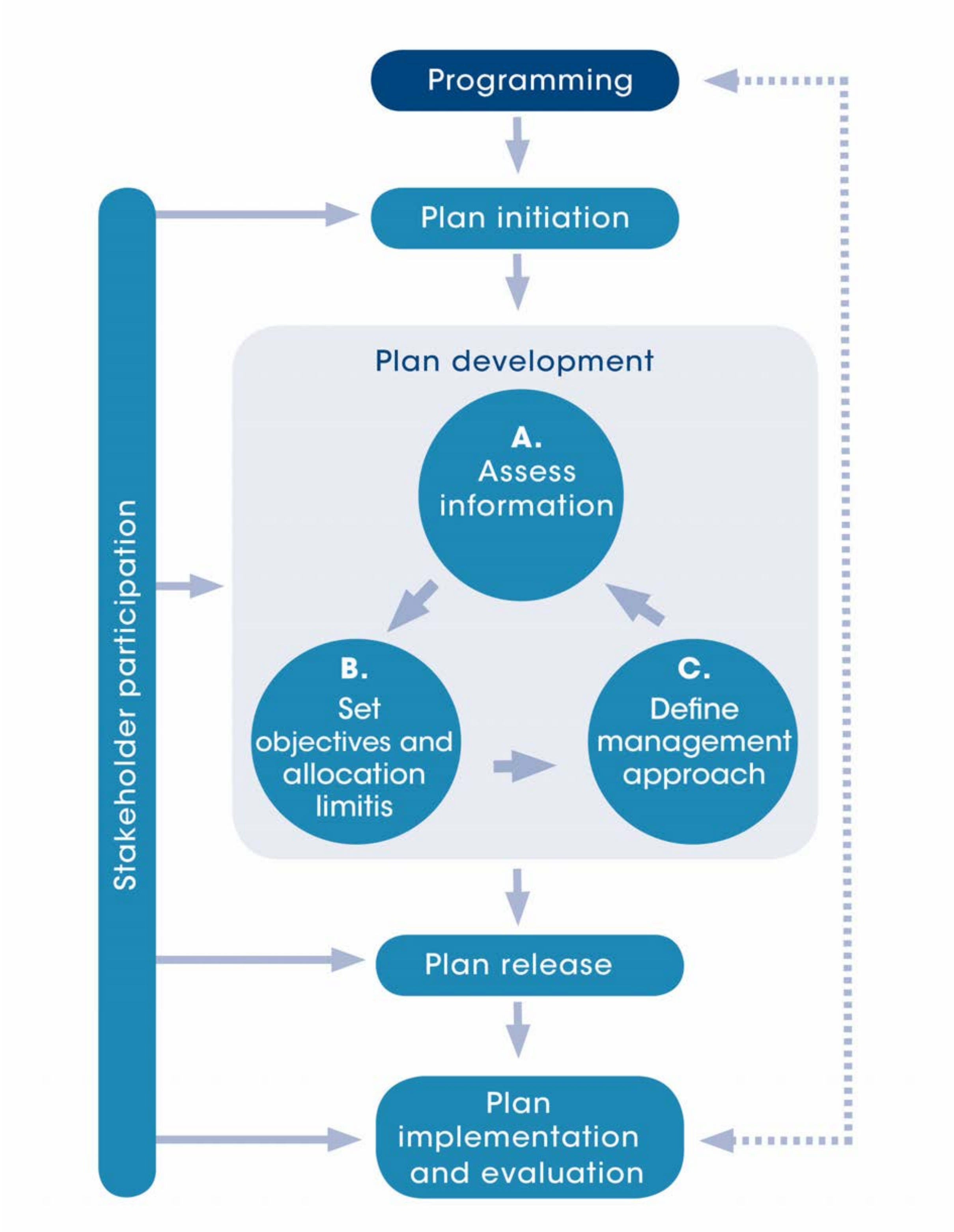
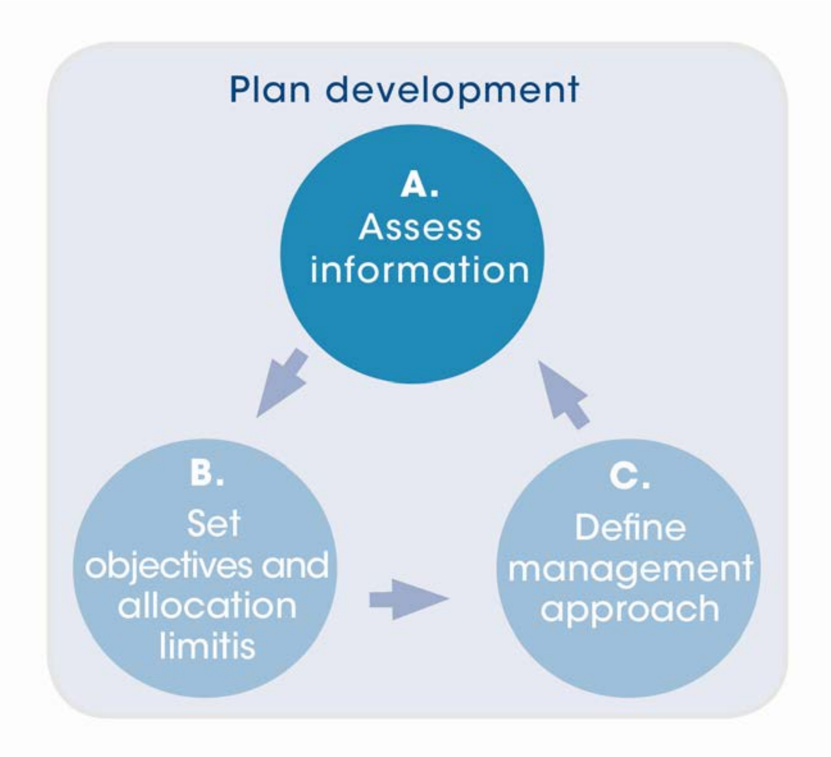


Figure 3 Water allocation planning process

Part A – Assess information



This stage of the allocation planning process looks at:

- community interests in water
- the water resource, its hydrology and how it varies
- the environment and how much water needs to be left in the rivers
- how water is currently used and the water demand trends.

This information is used to shape the plan objectives and informs the Department of Water's allocation limit decisions.

2 Community interests in water

Understanding how water is used and valued by the community is an important consideration in how the Department of Water sets water resource objectives and makes allocation limit decisions. This information is used at every stage of the planning process.

Our main sources of information on community interests were:

- an issues scoping report (Beckwith Environmental Planning 2007)
- submissions responding to the plan for public comment (2010)
- consultation with the Warren Donnelly Water Advisory Committee and other stakeholders prior to and after the release of the plan for public comment.

2.1 Findings of the issues scoping study

In 2006, the department commissioned Beckwith Environmental Planning to prepare an issues scoping report (Beckwith Environmental Planning 2007) to gain an understanding of stakeholder issues about surface water resource management for the Lefroy Brook and catchment.

Water for agriculture

Water availability in the Lefroy Brook catchment was seen by some as a limiting factor in its ability to compete in the market place and one that would determine if agriculture in the catchment remains a viable industry in the longer term.

Most of those who discussed the future of agriculture believed the current agricultural areas would remain, with the usual shifts in crops in response to market forces. Stakeholders expected some rationalisation of the viticulture sector and predicted fewer but larger farms, with many expecting greater agribusiness or corporate farming investment.

Many stakeholders commented that the Lefroy Brook catchment has the natural resources (i.e. soils and water) to be a priority horticultural area.

The Beckwith study highlighted the importance of agriculture and indicated that farm amalgamation, diversification and changes in crop types would change the future agricultural demand for water.

Water for the environment

Many of those interviewed indicated that the water needs of downstream ecosystems are already satisfied by the incidental releases of water from dams and the significant rainfall in the catchment. A few stakeholders expressed a concern that if less water is available in the future, due to increased demand or climate change, river ecology would come out second best to consumptive uses.

The interviewees were concerned about water quality and the obstruction to the passage of aquatic life imposed by dams. There was strong support for explicit consideration of ecological water requirements as part of surface water management and allocation in the Lefroy Brook catchment. There was general agreement on the need for a better scientific understanding of the water-dependent ecological values. Many were concerned that little is known about the aquatic invertebrate and fish populations of the Lefroy Brook.

Many viewed the setting of environmental management objectives as important but challenging. There were some comments on the need to set the ‘right balance’ between consumptive and non-consumptive uses, including sustaining ecological values. It was generally accepted that Lefroy Brook is not pristine and attempting to mimic pre-settlement conditions would be unreasonable.

Water quality

Many stakeholders were aware that fresh flows from the Lefroy Brook are important in diluting the saline water from higher in the Warren River catchment. Two distinct views were expressed as to what obligation, if any, the Lefroy Brook water users have to helping address the salinity problems of the Warren River. The most commonly expressed view was that water users in the Lefroy Brook catchment have some responsibility to protect the quality of the Warren River. Most saw the maintaining of fresh flows in the Lefroy Brook catchment as being good resource management for the local catchment and the Warren River as a whole.

A few interviewees indicated that the salinity problems of the Warren River system should be solely the concern of those in the subcatchments contributing high salinity levels to the Warren River.

2.2 Public submissions

The department released the *Warren–Donnelly surface water allocation plan: for public comment* in June 2010 (DoW 2010b). We received 52 submissions responding to the plan. Most comments focused on:

- the balance of water for agriculture and water for the environment
- having sufficient consultation and stakeholder involvement
- having a balance between economic, social and environmental considerations
- having clear and transparent processes
- the need to investigate options for taking more water in wetter years.

For further information on the issues stakeholders raised during the public comment period and how they’ve been addressed, see *Warren–Donnelly surface water allocation plan: Statement of Response* (DoW 2012b).

2.3 Consultation

During the development of the plan, the department has regularly met with the Warren Donnelly Water Advisory Committee, peak industry representatives and chairs of sector groups to discuss:

- plan objectives
- allocation limit decisions
- public submissions
- the planning process.

These discussions have helped us develop the water resource objectives and allocation limits presented in this report.

2.4 Points to consider from community interests

Feedback from stakeholders shows that in setting the water resource objectives and limits we should consider the following:

- Different catchments have different priorities for water use.
- Water for agriculture is the most important priority in some catchments.
- Ecological water requirements are more important in the more pristine and forested catchments.
- The needs of consumptive and non-consumptive uses should be balanced.
- Freshwater flows contribute to managing the salinity of the Warren River.

3 Understanding the water resource

Understanding the distribution and variability of the quantity and quality of water resources in the plan area was the first step in deciding how much could be abstracted. This section provides a summary of the rainfall, streamflow and water quality information used to develop the objectives, calculate river yields and set allocation limits for the Warren–Donnelly area.

3.1 Climate and rainfall

The Warren–Donnelly area has a temperate climate with distinctly dry, hot summers and wet, cool winters. Rainfall generally reduces with distance from the coast, with mean annual rainfall for 1975–2003 varying from 1200 mm near Pemberton to 700 mm in the north-east of the Donnelly River basin to 500 mm in the north-east of the Warren River basin (see isohyets in Figure 6).

There has been a seven per cent decline in mean annual rainfall at the Pemberton rainfall gauging station for the period 1975 to 2010 compared to the long-term average (Figure 4). The mean annual rainfall for the period 1997 to 2010 is almost identical to 1975 to 2010 (Figure 4). Despite this, mean annual flow has declined further since 1997, even in undeveloped catchments (see Section 3.3). The reliability of supply to on-stream dams in the area is influenced by the annual rainfall variability and its relationship to river flow.

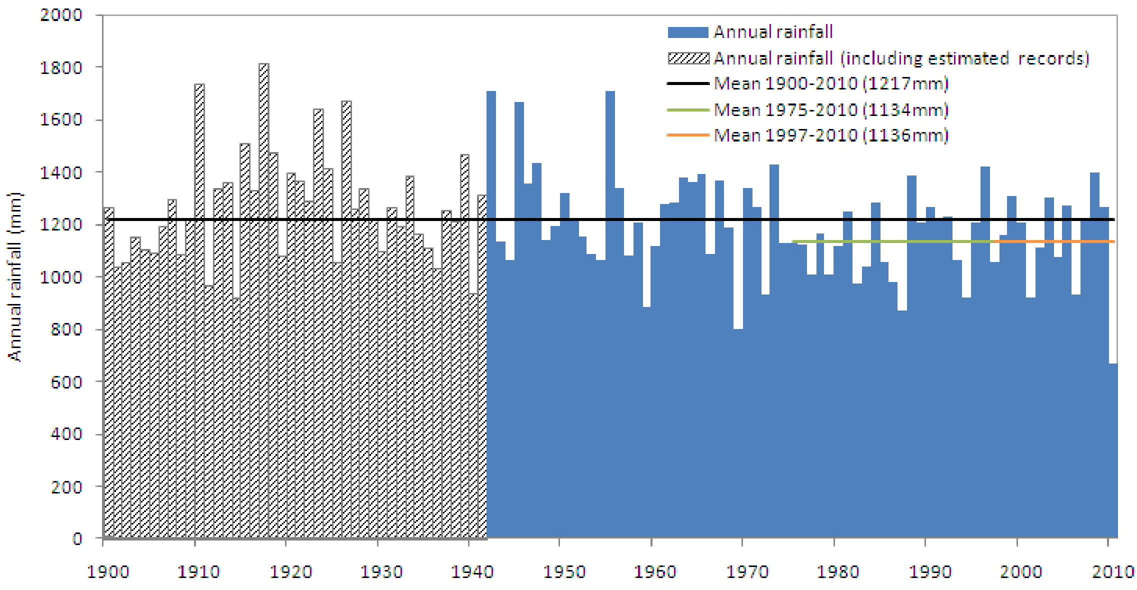


Figure 4 Annual rainfall at Pemberton rainfall gauging station (009592)

Rainfall in the region is also highly seasonal with about 70 per cent of annual rainfall occurring between May and September. The highest average monthly rainfall occurs in July (Figure 5). Since 1975, the seasonal distribution of rainfall has changed, with less rainfall occurring in autumn and early winter (April to June) and more rainfall in spring (September to November).

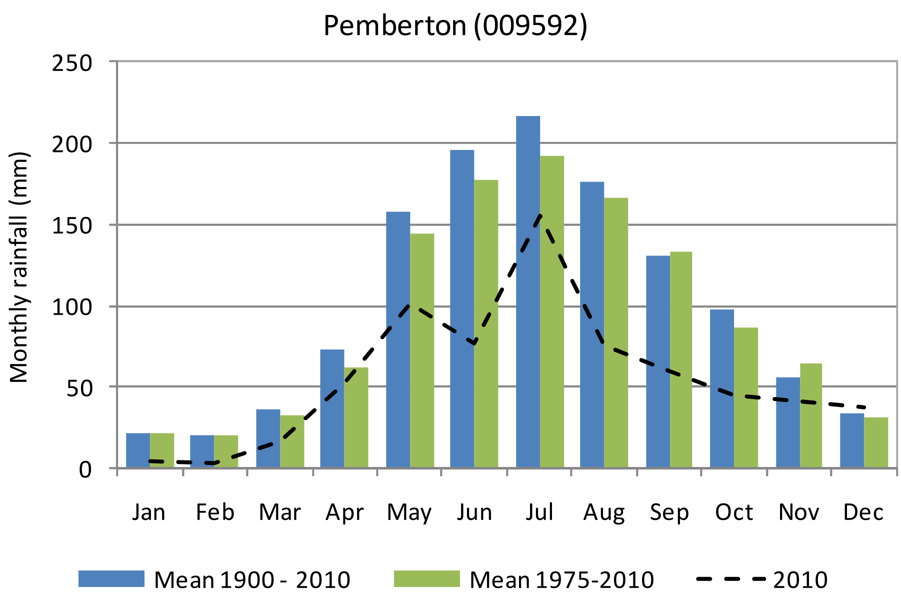


Figure 5 Monthly rainfall at Pemberton rainfall station (009592)

3.2 Streamflow gauging

The department has used data from streamflow gauges to assess the volume and variability of streamflow in the Warren–Donnelly plan area. Appendix A lists the streamflow gauging stations and their periods of record. Only the gauges with an adequate observed record post-1975 were used for the assessment of river yield (usually over 10 years). Pre-1975 data was not used because of the observed reduction in rainfall, and subsequently reduced runoff.

Figure 6 shows the location of the streamflow gauges in the Warren–Donnelly area installed prior to 2010. Some newer water level monitoring probes and loggers installed within the Manjimup catchment are not shown in Figure 6.

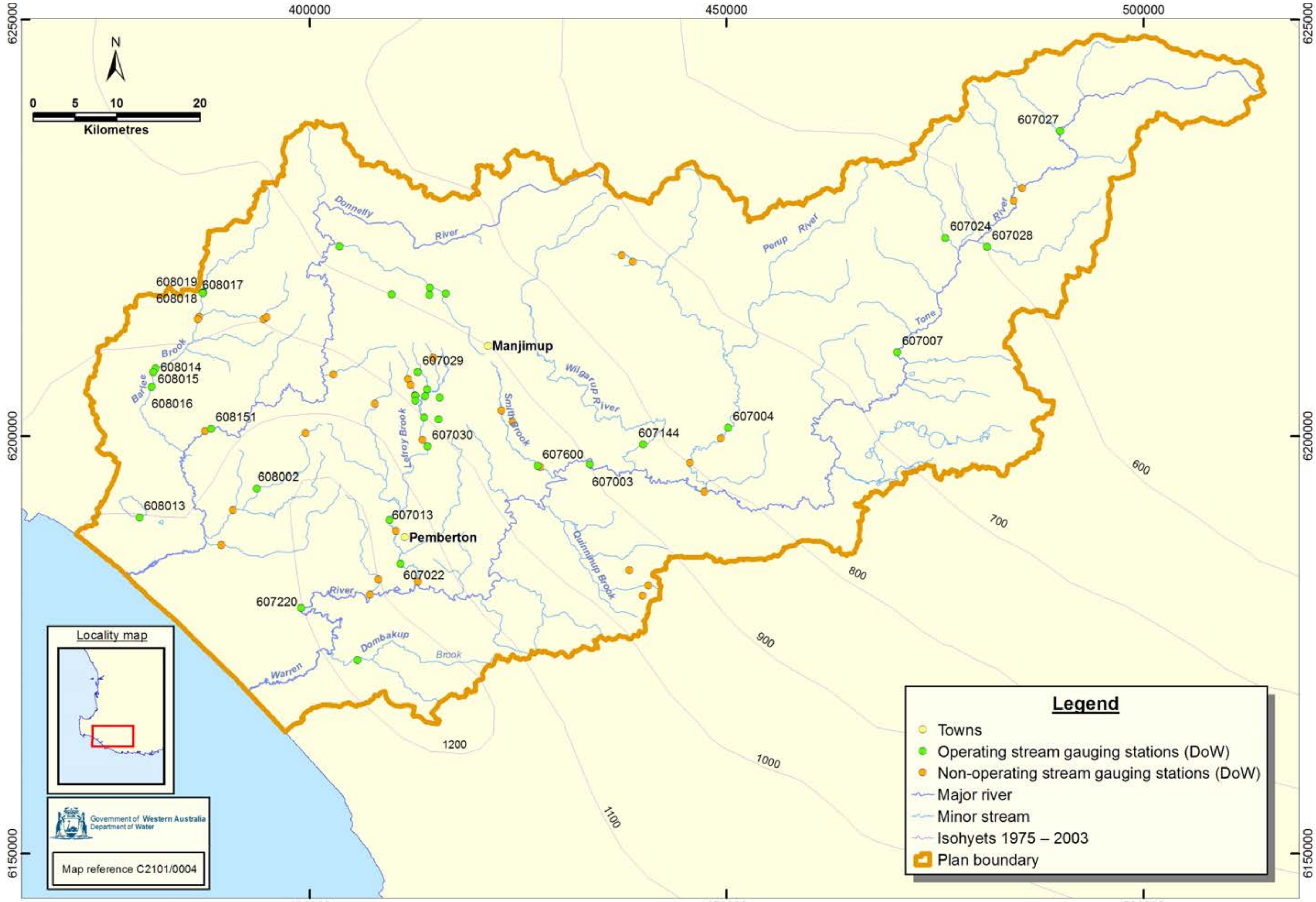


Figure 6 Stream gauging stations and mean annual rainfall across the Warren–Donnelly area

3.3 Variations in annual streamflow

River flow in the Warren–Donnelly area is influenced by factors such as rainfall, catchment clearing and the interception of runoff by on-stream (gully-wall) dams in areas important for irrigation. Although mean annual rainfall has not significantly altered between 1975 and 2010 (Figure 4), average annual streamflow has declined. Variation in annual flow in an undeveloped catchment is illustrated by the flow record for the Strickland gauging station on the Donnelly River (608151) (Figure 7). The flows are natural, unaffected by increasing farm dam development or expansion of plantations.

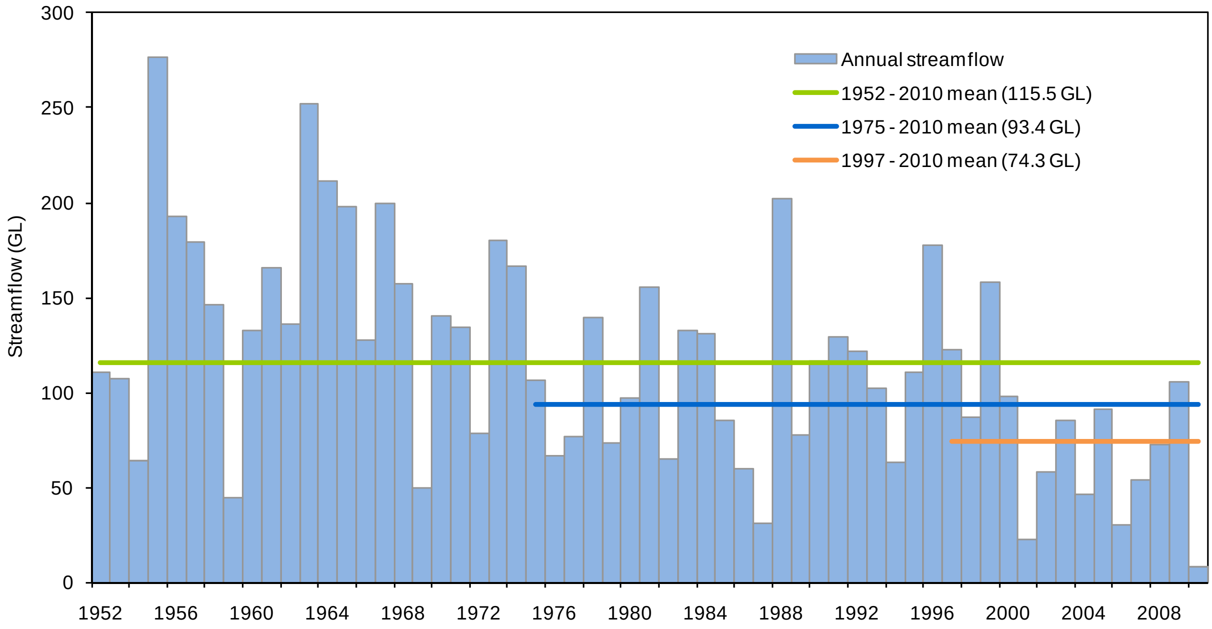


Figure 7 Annual Streamflow record at Strickland gauge (608151)

Figure 8 further illustrates the annual flow variability in the Warren–Donnelly area. The annual cumulative flow at Rainbow Trail gauging station (607013) in Figure 8 shows:

- annual flow is very variable
- annual flows during the last decade have generally been lower than in the 1990s and 1980s
- prior to 2010, 1987 was the lowest flow year
- in the drier years such as 2010 and 1987, total flow was very low and what significant flow there was occurred later in the year.

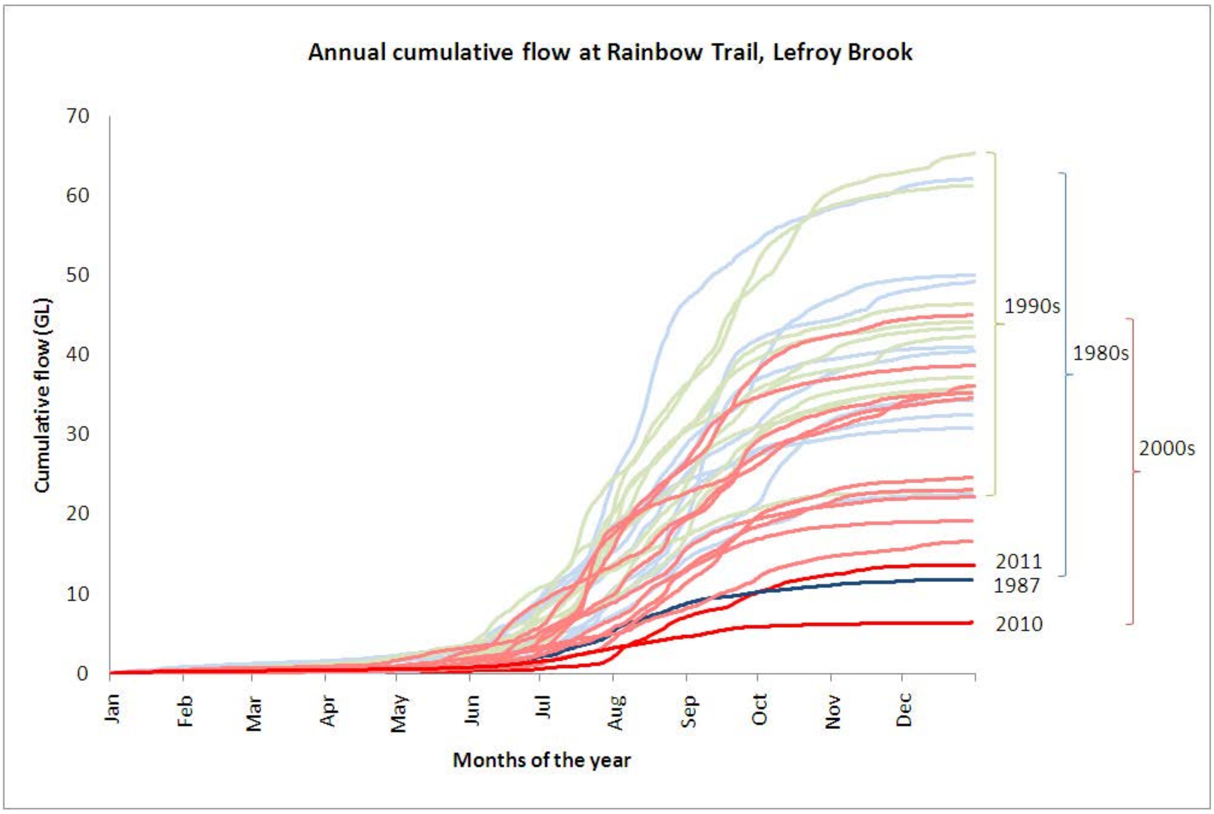


Figure 8 Cumulative flows at Rainbow Trail, Lefroy Brook

Annual flows for the period 1975–2010 for each of the 25 surface water subareas in the Warren–Donnelly area are shown in Appendix A (Table A-1 and Table A-2). Yields and allocation limits are based on river flow data for the period 1975–2007. Data for 2008 to 2010 is included in Appendix A for information only. For ungauged catchments, annual streamflow is calculated by correlating flow with a hydrologically similar and nearby gauged catchment.

Effects of clearing and farm dams on annual flows

The department commissioned Sinclair Knight Merz to investigate the effect of farm dams on streamflow in seven catchments in the south-west of Western Australia (SKM 2007) and in the Upper Lefroy subarea (SKM 2008c). Modelling indicates that flows are affected by farm dams proportionally more in dry years (SKM 2007). The modelling in the Upper Lefroy subarea suggested that farm dams have reduced post-clearing flows in winter (June, July, August) by 10 per cent on average during 1975 to 2005. This work also found that in the driest year (1987) farm dams reduced post-clearing winter flow by up to 43 per cent.

In 2008, the department modelled the effects of farm dams and catchment clearing on flows in the Upper Lefroy subarea using flow data from 1975–1998 at Channybearup (607002, closed in 1999). This work suggested that after clearing, annual flows in the Upper Lefroy subarea increased by an average of 6.4 GL/yr (Table 1).

Table 1 Comparison of annual flow in the Upper Lefroy subarea as a result of clearing of native vegetation and construction of farm dams

	Annual flow in the Upper Lefroy subarea GL					
Year	**Uncleared, no dams (A)**	**Cleared, no dams (B)**	**Cleared, with dams (C)**	**Increase in flow post-clearing (B – A)**	**Reduction in cleared flows from dams (B-C) Volume**	**%**
1975	10.0	16.3	13.3	6.2	3.0	18
1976	9.1	15.0	10.3	5.9	4.7	31
1977	8.3	13.8	9.8	5.5	4.0	29
1978	16.1	23.8	19.8	7.7	4.0	17
1979	10.2	16.3	12.1	6.1	4.2	26
1980	11.5	17.8	14.1	6.3	3.7	21
1981	17.8	26.2	22.7	8.5	3.5	13
1982	8.1	13.7	10.0	5.6	3.7	27
1983	13.0	19.6	15.7	6.6	3.9	20
1984	15.7	23.5	19.3	7.8	4.2	18
1985	9.7	15.8	12.1	6.1	3.7	23
1986	6.8	11.7	8.3	4.8	3.4	29
1987	**4.0**	**7.4**	**3.4**	**3.5**	**4.0**	**54**
1988	18.5	26.7	23.1	8.2	3.6	13
1989	9.1	15.0	11.3	6.0	3.7	25
1990	13.1	20.2	16.5	7.1	3.7	18
1991	13.3	20.3	17.0	7.1	3.3	16
1992	13.9	20.6	17.2	6.8	3.4	17
1993	11.8	17.9	14.9	6.0	3.0	17
1994	7.6	11.9	8.4	4.3	3.5	29
1995	10.4	15.7	12.0	5.3	3.7	24
1996	**19.2**	**27.7**	**24.8**	**8.5**	**2.9**	**10**
1997	13.6	20.6	17.5	7.0	3.1	15
1998	11.5	17.5	14.0	6.0	3.5	20
Min (1987)	4.0	7.4	3.4			
Mean	11.8	18.1	14.5	6.4	3.6	22
Max (1996)	19.2	27.7	24.8			

Notes: Flow data used is 1975–1998. Channybearup gauging station closed in 1999.

The figures in bold are the effects on flow for the year with the highest (1987) and lowest (1996) per cent reductions in cleared flows from dams.

The mean reduction in cleared flows from dams (column B – column C) is 3.6 GL/yr or 22 per cent. This is a 56 per cent decrease in the additional flows produced from clearing (B - A).This means that on average over the period 1975 to 1998, dams intercepted over half of the increase in flows from clearing the land of native vegetation. However, in the driest year in the study record (1987), the reduction in flow by dams (4.0 GL) exceeded the increases following clearing (3.4 GL).

In years of average flow, the reductions in annual flow caused by dams are less than the increases in flow following clearing. However, in periods of low rainfall, decreases in flow due to farm dams either matches or slightly exceeds the increase in flows due to clearing.

3.4 Variations in monthly streamflow

The long-term, monthly flow record indicates that peak flows generally occur in August (Figure 9). The peak rainfall month is July.

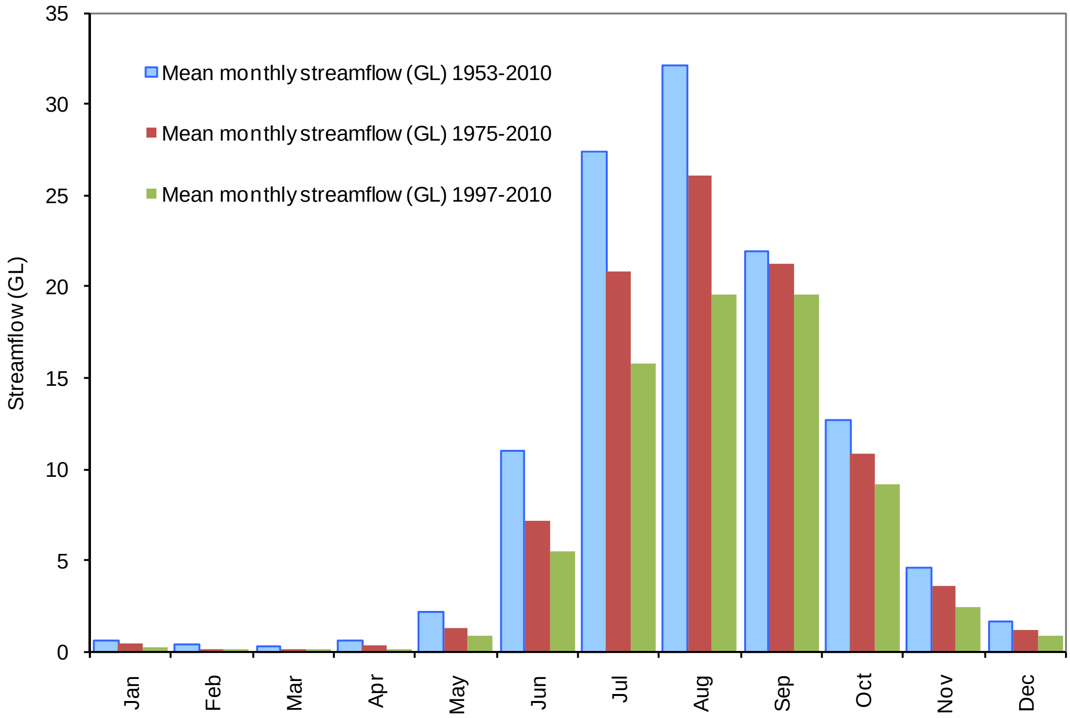


Figure 9 Variation in mean monthly streamflow for the Donnelly River at Strickland gauging station (608151)

Monthly streamflow has decreased for all months. There has also been a shift in the seasonal pattern of flow, with peak flows now occurring later in the year (Figure 9).

In the upper reaches of the Warren and Donnelly rivers, flow typically ceases in February or March. In contrast, in the lower, wetter parts of the catchments, the rivers tend to flow all year with the exception of the dry years (1975, 1988, 1995, 2002, 2003, 2004, 2005, 2006 and 2010) when flows have ceased during March or April.

Effects of clearing and farm dams on monthly flows

The department modelled the effects of clearing and then of on-stream dams on seasonal flows in the Upper Lefroy subarea for the period of 1975–1998. Modelling shows that flows increased after clearing in all months (compare 'Cleared, no dams' scenario with 'Uncleared, no dams' scenario in Figure 10).

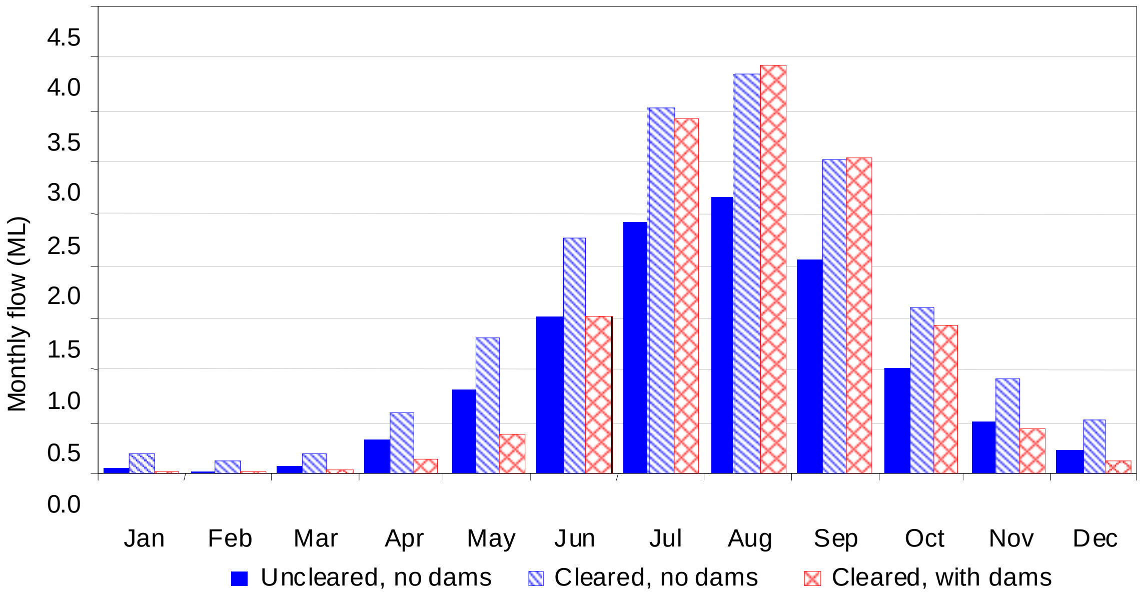


Figure 10 Average changes to seasonal patterns of flow from catchment clearing and on-stream farm dams in Upper Lefroy subarea for the period 1975–1998

Late winter flows are not affected by interception as dams are full and spilling (July to October) (compare 'Cleared, with dams' scenario with 'Cleared, no dams' scenario in Figure 10). However, interception of water by farm dams has decreased flow below pre-clearing flows in the drier months from November and as the dams are filling (April, May). This shows that even though farm dams generally do not take up the total volume of water produced from clearing annually, they have reduced average monthly flows to below pre-clearing levels in the drier months and as dams fill.

3.5 How streamflow contributes to ecological water requirements

The ecological water requirement (EWR) of a river is the water regime needed to maintain the current ecological values of water-dependent ecosystems.

In 2007, to support surface water planning and management in the Warren–Donnelly area, the department completed an environmental flow study to determine the ecological water requirement for the Lefroy Brook catchment (Donohue et al. 2009a). The environmental flow study did not seek to isolate or quantify the ecological impact of the change in flow regimes from clearing, farm dams and other effects of development.

Clearing and development for agriculture is concentrated in the middle and upper parts of the Lefroy Brook catchment. The Cascades reach was selected as the representative reach for the study, as it is in good ecological condition and contains a gauging station with a good flow record. The study found that the Cascades reach has riparian vegetation in relatively healthy condition. It also has significant ecological values associated with a system that has adapted to a history of flow regulation and water abstraction.

The study also estimated the amount of additional water that may be available above the current level of abstraction. For this study, this additional yield is called the ecologically sustainable yield (ESY). The total ESY for the Lefroy Brook catchment (Upper Lefroy, Four Mile Brook, East Brook and Lefroy Brook), ranges between 7 GL in low flow years and 39 GL in high flow years. This range is important for decision making because variations in streamflow affect the reliability of on-stream dams and other objectives such as maintaining streamflow for recreational and social uses.

Catchment clearing, de-snagging and the presence of livestock in riparian areas has decreased the number, distribution and quality of in-stream and riparian habitats and of species that depend on them. Grazing has also introduced a number of exotic grasses and plants to riparian zones. Management of these issues is outside the scope of the *Warren–Donnelly surface water allocation plan*. Where appropriate, they can be managed through actions such as revegetation, exclusion of livestock from river channels and riparian areas, low-flow bypass systems and fish ladders on the larger dams.

3.6 River salinity

The Warren River was identified as a potential future water source for the South West region in the *Western Australian salinity action plan* (Government of Western Australia 1996) and is a designated water resource recovery catchment. Clearing controls have been in place under the *Country Areas Water Supply Act 1947* since 1978.

Clearing of native vegetation has resulted in salinity discharge to streams, particularly in the Tone, Perup and Yerraminnup rivers (Mayer et al. 2005). The department’s salinity recovery program is working with stakeholders in the upper parts of the Warren River Basin to implement salinity mitigation measures.

The long-term target for the Warren River is to reduce stream salinity from an annual average of 950 mg/L (1997–2007) to a potable level (500 mg/L) in the forested south-western part of the basin at Barker Road Crossing gauging station (607220) (Figure 6).

In setting allocation limits, we considered the impacts of further abstraction on salinity in the Warren River because freshwater flow from the Warren tributaries helps dilute salinity in the Warren River.

3.7 Future climate trends and resource trends

Almost all of the global climate models used by the Intergovernmental Panel on Climate Change (IPCC) predict that south-west Western Australia will experience a drier and warmer future (CSIRO 2009). The CSIRO south-west Western Australia sustainable yields project (CSIRO 2009) produced reports examining the likely water yield of south-west surface water and groundwater catchments as a result of future climate changes and land management changes. The report includes projected climate and runoff data representative of 2030 for the Warren and Donnelly river basins.

Table 2 shows the CSIRO (2009) projected changes in mean annual rainfall and mean annual runoff relative to the baseline period 1975 to 2007. The graphs in Figure 11 and Figure 12 show the projected changes in mean annual runoff for each basin. The wet, median and dry future climate scenarios all project a decline in mean annual rainfall and runoff across the Warren and Donnelly basins. This means that there is a risk that dry years similar to 1987 and 2010 could become more frequent and the reliability of existing dams could be different in the future.

Table 2 Percentage change in mean annual rainfall and runoff from the historical baseline of 1975 to 2007 (CSIRO 2009)

Projected future climate scenarios centred on 2030	**Per cent reduction**	
	Mean annual rainfall	**Mean annual runoff**
Warren Basin		
Wet	4	12
Median	7	25
Dry	13	41
Donnelly Basin		
Wet	4	10
Median	7	20
Dry	15	35

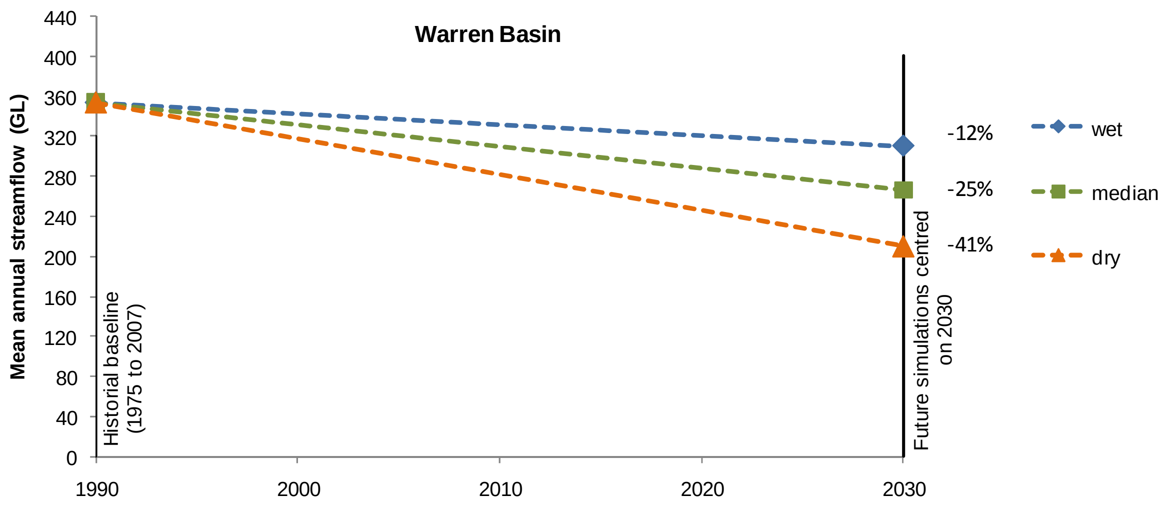


Figure 11 Future streamflow scenarios for the Warren river basin (CSIRO 2009)

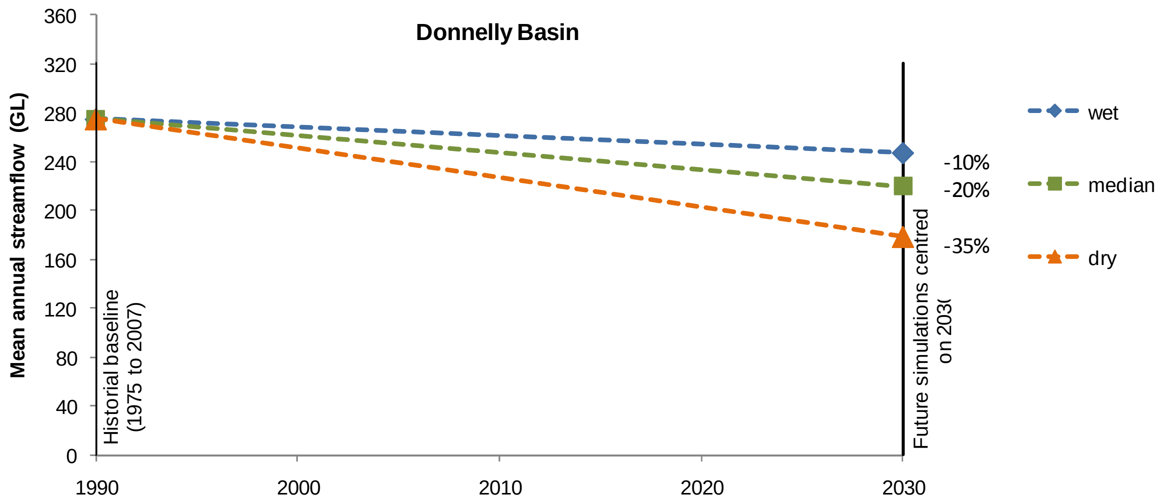


Figure 12 Future streamflow scenarios for the Donnelly river basin (CSIRO 2009)

3.8 Points to consider from understanding the water resource

From the information we have on the Warren–Donnelly water resources, there are a number of conclusions that we need to consider when setting objectives and allocation limits (see Part B).

- Mean annual rainfall and runoff across the Warren and Donnelly catchments are projected to decline further under all future climate scenarios.
- Average annual streamflow is variable and only post-1975 streamflow data should be used when considering allocation limits.
- On average, the annual volume of water intercepted by farm dams is just over half of the additional flows released by clearing.
- In very dry years farm dams intercept more than the flows released by clearing.
- Further abstraction from the Warren tributaries may affect salinity in the Warren River.

4 Understanding water demand

The Department of Water assesses current and future demand for water as part of the allocation planning process. In the Warren–Donnelly area, river flow is intercepted by on-stream dams and is used primarily for irrigated agriculture and public water supply. Some water is also used for aquaculture, for stock and for domestic purposes. Forests, including commercial plantations, also intercept rainfall and use soil water and shallow and deep groundwater which may otherwise discharge to rivers.

4.1 Irrigated agriculture

The irrigated agriculture industry is the largest user of water in the Warren–Donnelly area. It is a self-supply industry, which depends on water stored in farm dams to irrigate fruits such as grapes, apples and avocados, and vegetables such as potatoes, cauliflower and broccoli. The farm dams are typically gully wall dams that are constructed on the stream so that they intercept and store winter flow for the following irrigation season.

The irrigation season in the Warren–Donnelly area lasts from about November through to April, but this can vary depending on crop needs and the timing and duration of seasonal rainfall. In general, the period of highest water demand for irrigated agriculture is from about December to April, the driest part of the year.

As at December 2009, there were 484 licensed farm dams in the Warren–Donnelly area, of which 379 are located in the Warren River basin and 105 in the Donnelly River basin. In total, these dams are capable of storing 25.6 GL of the flow in the Warren River basin and 7.8 GL of the flow in the Donnelly River basin (licensed entitlements as at March 2010, Table 3). The size of individual dams generally ranges from about 50 ML to around 600 ML, with about 85 per cent of dams in the Warren–Donnelly area storing between 50 and 300 ML. There are a few larger dams of over 1 GL.

Some subareas, such as the Upper Lefroy, East Brook, Smith Brook and Manjimup Brook/Yanmah–Dixvale, have a large number of dams that collectively intercept large volumes of water (Table 3 and Figure 13).

Table 3 Licensed entitlements and storage density for each subarea

Subarea (resource)	Licensed entitlements[1] ML	Overall storage density[2] ML stored per km^2[i]	Storage density using cleared area upstream of use only ML/km^2
Warren River Basin			
Tone River	50	0	0
Perup River	478	1	1
Yerraminnup River	12	0	0
Wilgarup River	5 637	12	12
Upper Warren	1 172	3	4
Quinninup Brook	368	3	3
Smith Brook	3 139	30	30
Diamond Tree Gully	253	9	11
Upper Lefroy	5 967	65	76
East Brook	2 477	33	46
Lefroy Brook	1 546	20	26
Four Mile Brook / Big Brook	3 244	28	38
Treen Brook	799	13	13
Dombakup Brook	120	1	2
Lower Warren	312	1	1
Unicup Lakes	0	0	0
Warren River total	**25 574**		
Donnelly River Basin			
Upper Donnelly	370	1	4
Manjimup Brook / Yanmah–Dixvale	4 728	26	32
Middle Donnelly	1 115	11	12
Record Brook	0	0	0
Barlee	0	0	0
Lower Donnelly	13	0	0
Carey Brook	0	0	0
Beedelup Brook	739	14	14
Fly Brook	795	12	12
Donnelly River total	**7 760**		

Notes

[1]*Licensed entitlements as at 24 March 2010 excluding public water supply entitlements. Licensed entitlement volumes are generally based on dam storage volumes.*

[2]*Storage density calculations based on whole subarea and licensed entitlement volumes (does not include estimates of existing stock and domestic use in Section 4.5).*

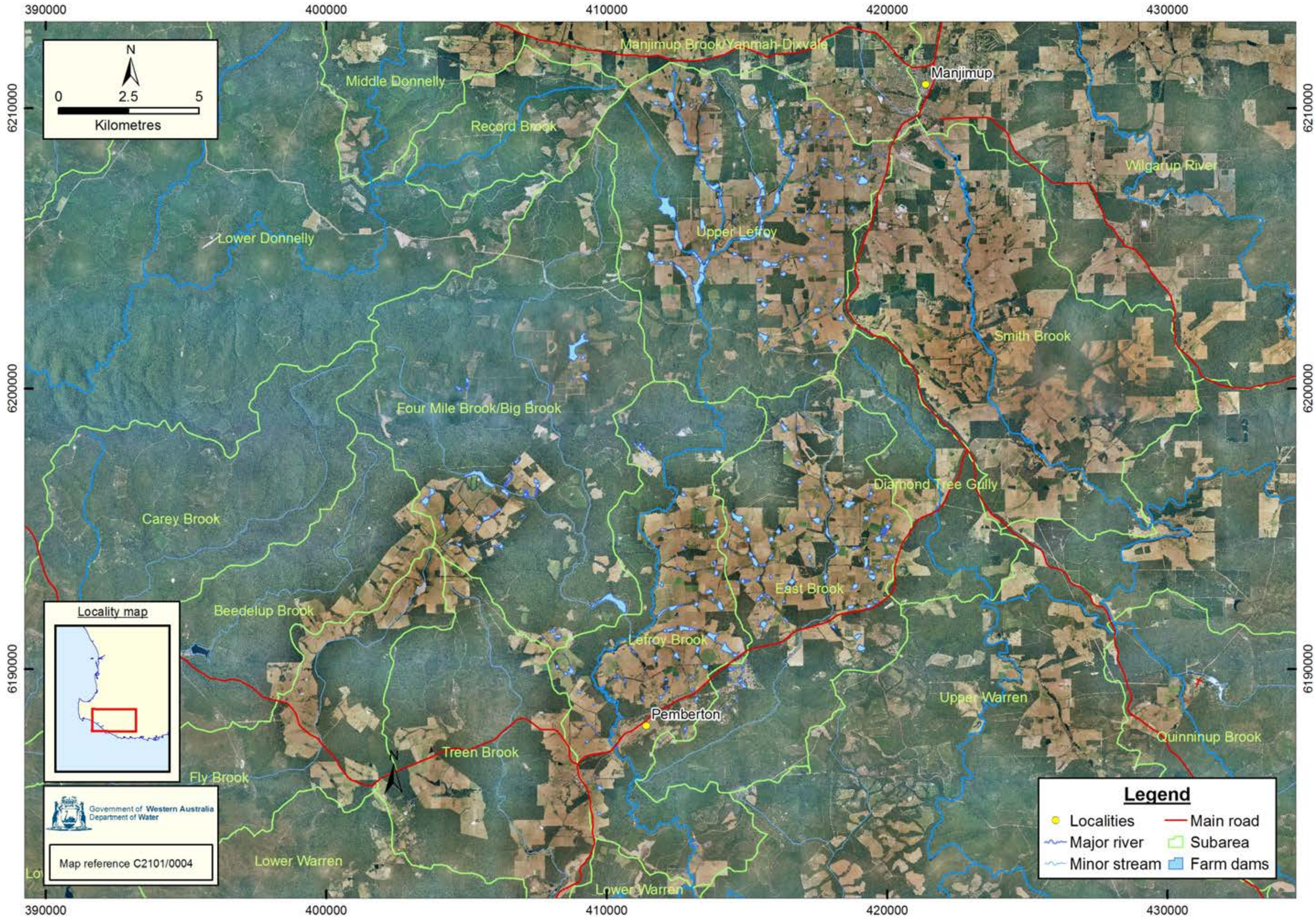


Figure 13 Farm dams of the Lefroy Brook, East Brook, Four Mile Brook and Upper Lefroy subareas

The Upper Lefroy subarea has the highest farm dam storage density (ML of water stored per km^2) in the Warren–Donnelly area. The farm dam storage density is also high when compared with catchments elsewhere in Australia. For example, the Upper Lefroy farm dam density is comparable to the highest 2 per cent of Victorian catchments with a similar rainfall (SKM 2008c, and as shown by Lefroy Brook at Channybearup, Figure 14).

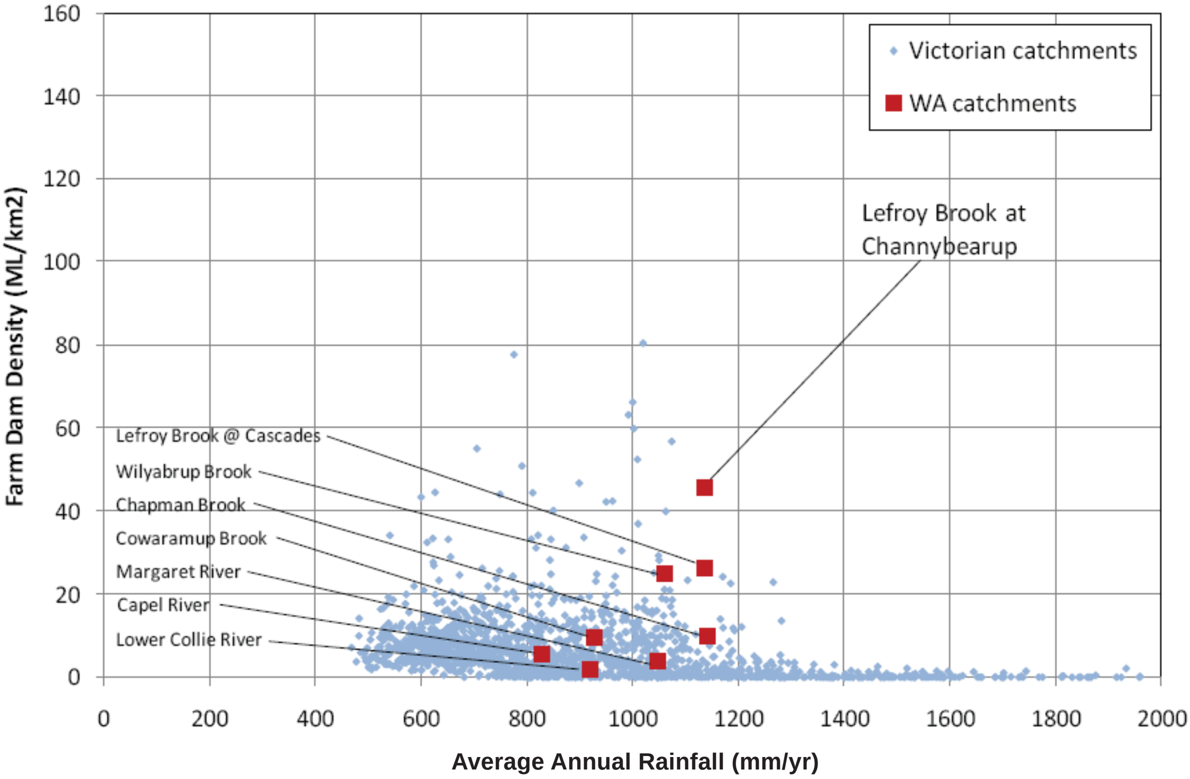


Figure 14 Comparison of farm dam density between Western Australian and Victorian catchments (SKM 2008c)

Use of water from farm dams varies. Based on our estimates and advice from irrigators, on average between 50 and 70 per cent of water in irrigation dams is used to water crops in a normal year. The remaining water in the dams is lost to evaporation or is either kept in reserve for the following irrigation season (e.g. 'drought proofing') or required to maintain structural integrity. Licence entitlements are generally set at dam capacity and entitlements can be fully used in any year.

Once a dam is full, inflows spill downstream via spillways at the edge of dam walls. Most irrigation dams have under wall scour valves that are used to release unused, poor quality water at the end of the irrigation season. Few dams have any other means to divert low flows or control the volume of river water intercepted every year.

4.2 Public water supply

Parts of the Warren–Donnelly area are declared public drinking water source areas or water reserves under the *Country Areas Water Supply Act 1947* (Figure 15).

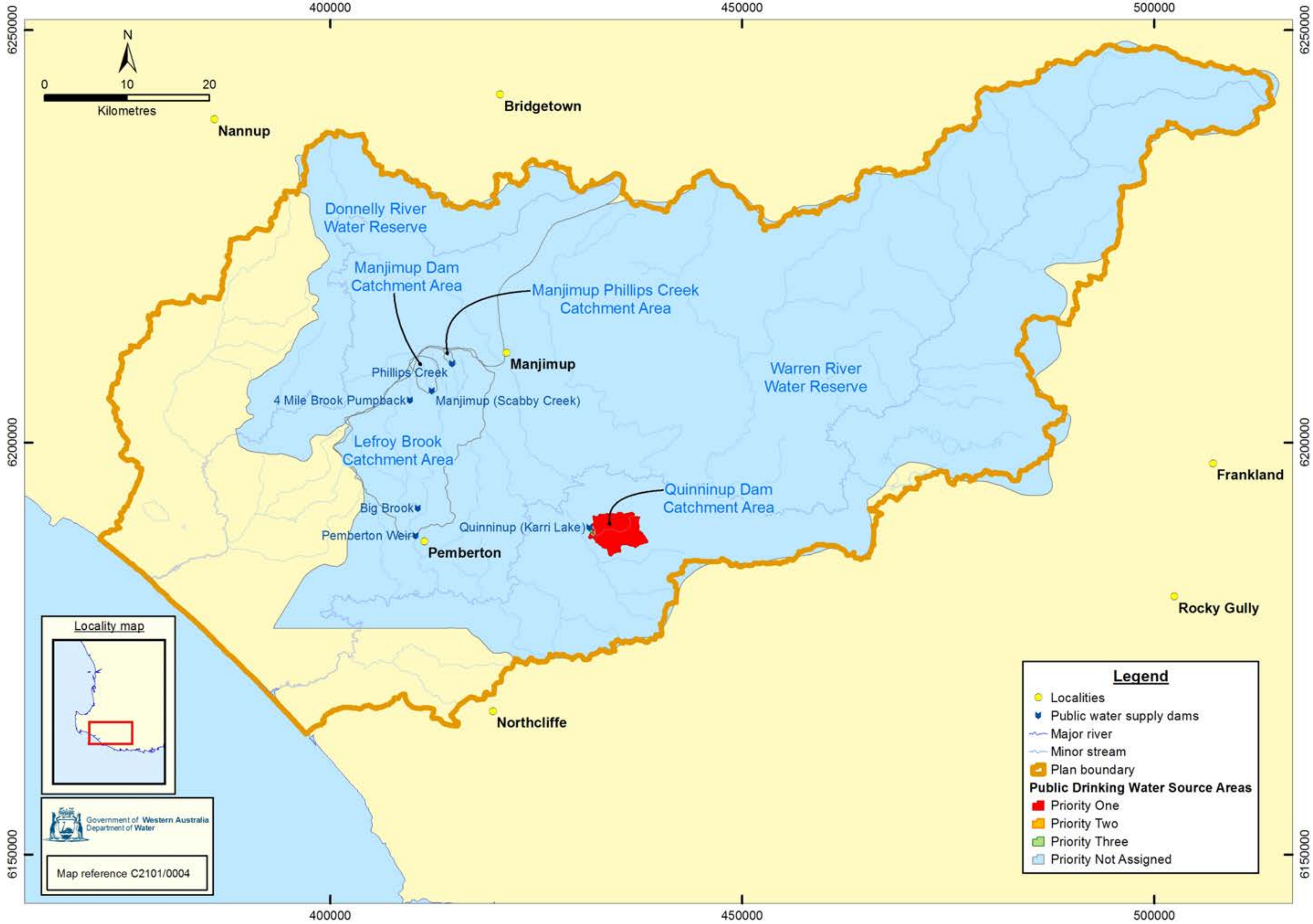


Figure 15 Public drinking water source areas in the Warren–Donnelly area

Public drinking water source areas are declared to protect the quality of surface water resources used for public drinking water supply. Water reserves are declared to protect future surface water resources.

The public drinking water source areas in the Warren–Donnelly area, shown in Figure 15, are:

- Lefroy Brook Catchment Area
- Manjimup Dam Catchment Area
- Phillips Creek Catchment Area
- Quinninup Dam Catchment Area.

The Water Corporation is licensed to take up to 1.8 GL/yr from public drinking water source areas for the townships of Manjimup, Pemberton and Quinninup. The Water Corporation also buys water in dry years from other licence holders. Potable water for the towns of Pemberton and Manjimup is obtained from dams in the Lefroy Brook and Four Mile Brook/Big Brook catchments. Pemberton water supply comes from both Big Brook Dam and a small weir downstream on Lefroy Brook (Figure 15). Manjimup water supply comes from Phillips Creek Dam and Manjimup/Scabby Gully Dam, which are located higher in the catchment. Town water supply for Quinninup usually comes from the Quinninup (Karri Lake) Dam.

4.3 Stock and domestic water

In the Warren–Donnelly area, water for stock and domestic use is taken from farm dams. Water from small farm dams (less than 8 ML), used only for domestic or household purposes and non-intensive stock watering, do not need a licence.

Mapping of farm dams in the Lefroy Brook catchment shows there are approximately 400 stock and domestic dams. This includes those in the Upper Lefroy, Four Mile Brook/Big Brook, Lefroy Brook and East Brook subareas.

4.4 Plantations

Forests, including commercial plantations, intercept rainfall and use soil water and shallow and deep groundwater which otherwise might be discharged to rivers. Plantations may affect the amount of water available for surface water users and the river environment.

In the Warren–Donnelly area, the area planted to commercial plantations has been increasing, especially in the Tone and Yerraminnup rivers (Table 4), where plantations are helping to reduce salinity.

Table 4 Plantations in the Warren–Donnelly area

Subarea	Area km^2	Area of cleared land km^2	Area of plantations km^2	Proportion of cleared land with plantations %
Warren River basin				
Upper Lefroy	92	44	1.6	4
Four Mile Brook /Big Brook	115	24	6.2	26
East Brook	76	45	0.5	1
Smith Brook	104	60	5.2	9
Lefroy Brook	75	26	0.6	2
Treen Brook	62	20	0.3	1
Wilgarup River	471	130	16.0	12
Diamond Tree Gully	29	5	0.3	6
Upper Warren	394	47	13.0	27
Quinninup Brook	146	4	1.9	49
Perup River	457	71	24.0	33
Lower Warren	256	43	0.5	1
Dombakup Brook	148	22	5.1	23
Yerraminnup River	287	32	26.0	83
Tone River	1435	668	141.0	21
Unicup Lakes	173		12.0	
Warren River total	**4320**	**1241**	**254.2**	**20**
Donnelly River basin				
Manjimup Brook / Yanmah–Dixvale	181	85	8.2	10
Fly Brook	66	13	0.4	3
Beedelup Brook	54	8	0.1	1
Middle Donnelly	99	25	1.2	5
Record Brook	25	6	0.3	4
Upper Donnelly	90	16	4.2	27
Lower Donnelly	511	63	9.5	15
Barlee	391	24	5.4	22
Carey Brook	80	3	0.0	0
Donnelly River total	**1497**	**243**	**29.3**	**12**

In accordance with the *Rights in Water and Irrigation Act 1914*, the department does not license the water used by plantations. However, the department does provide advice to local government on the potential effects of plantation development applications.

4.5 Current water use

The volume of water currently abstracted from the rivers in the Warren–Donnelly area is a combination of water captured in dams under licensed entitlements and water taken for uses that are exempt from licensing under the *Rights in Water and Irrigation Act 1914* (such as small scale stock and domestic water use). Our estimated current water use for each subarea is shown in column E of Table 11 and Table 12. The way we estimated current water use is explained below.

Licensed water use

The department has used licensed entitlements as at March 2010 to estimate the volume of current water use in the Warren–Donnelly area. This includes general licence entitlements (such as for irrigated agriculture, Table 3) and public water supply entitlements. As at March 2010, the department had licensed 25.6 GL in the Warren River basin and 7.8 GL in the Donnelly River basin to general licensing (Table 3). There are 1.8 GL/yr licensed for current public water supply (Section 4.2).

Water use exempt from licensing

Water uses exempt from licensing include water taken:

- for riparian rights or stock and domestic use only (i.e. water for household purposes and non-intensive stock watering)
- from springs and wetlands wholly within a property
- from streams arising on a property
- in unproclaimed areas
- by plantations.

Water that is taken from springs and wetlands wholly within a property, from streams arising on a property and by plantations in the Warren–Donnelly area is already accounted for in the department's streamflow records.

The department has estimated stock and domestic water use using mapping of farm dams in the Lefroy Brook catchment. Water in stock and domestic dams as a percentage of total water in farm dams (not including water in public water supply dams) ranges between 6 per cent and 13 per cent, with an average of 9 per cent (see Table 5).

Table 5 Water stored in dams < 8 ML as a percentage of total water stored in farm dams

Subarea	**Proportion of stock and domestic water stored in farm dams < 8 ML[1] %**
Upper Lefroy	8
Four Mile Brook/Big Brook	6
East Brook	11
Lefroy Brook	13
Average	9

Note: [1]Percentage does not include public water supply dams

For catchments that do not have farm dam mapping, the department has calculated unlicensed water use as 9 per cent of the private licensed entitlements (total licensed entitlements minus public water supply entitlements). For the four subareas in Table 5 where we have more detailed information, we have used the actual value rather than 9 per cent. The full list of stock and domestic use estimates are shown in Table 6.

Table 6 Estimates of stock and domestic water use for Warren–Donnelly subareas

Subarea	Exempt use as a proportion of private licensed entitlements[1] %	Estimate of exempt use[2] ML/yr
Warren River basin		
Tone River	9	5
Perup River	9	43
Yerraminnup River	9	1
Wilgarup River	9	507
Upper Warren	9	105
Quinninup Brook	9	33
Smith Brook	9	283
Diamond Tree Gully	9	23
Upper Lefroy	8	458
East Brook	11	273
Lefroy Brook	13	198
Four Mile Brook /Big Brook	6	184
Treen Brook	9	72
Dombakup Brook	9	11
Lower Warren	9	28
Unicup Lakes	9	0
Warren River total		**2224**
Donnelly River basin		
Upper Donnelly	9	33
Manjimup Brook /Yanmah–Dixvale	9	426
Middle Donnelly	9	100
Record Brook	9	0
Barlee	9	0
Lower Donnelly	9	1
Carey Brook	9	0
Beedelup Brook	9	67
Fly Brook	9	72
Donnelly River total		**699**

Notes:

[1]Exempt use refers to stock and domestic use only. Private licensed entitlements = total licensed entitlements – public water supply entitlements.

[2]Estimate of exempt use = private licensed entitlements x assumed percentage.

To calculate total current water use, we added the estimates of exempt use to the licence entitlements for each subarea. As at March 2010, total current water use was estimated to be 27.8 GL/yr in the Warren River Basin and 8.5 GL/yr in the Donnelly River Basin (see Section 8.5).

4.6 Future water demand

Estimates of future water demand in the Warren–Donnelly area are available from these sources:

- South West Development Commission (SWDC 2006)
- Water futures for Western Australia 2008–30 (REU 2008)
- Water yields and demands in south-west Western Australia (CSIRO 2009)

According to the Resource Economics Unit (2008), population growth in the Manjimup region has increased relatively slowly since 1981. Growth accelerated in the 1990s, but this has tailed off after 2000. The population in 2006 was close to the 1996 level.

The South West Development Commission figures show that the Manjimup population has been steady since 1995. There was a decline of 0.4 per cent in the ten-year period 1995–2005 (SWDC 2006). Both the Resource Economics Unit and the South West Development Commission refer to the recent population being relatively unchanged with little to no growth.

The South West Development Commission projection of future land use patterns shows little change from present land use in the catchment. There may be changes when properties shift out of agriculture to uses such as commercial tree plantations. Changes in land use patterns are market dependent but are not expected to be significant to 2020.

The Resource Economics Unit (2008) provides water demand figures for 2020 and 2030 for different demand regions across the state. The Warren–Donnelly area fits within the larger Blackwood demand region. Water demand in 2030 for agriculture across the Blackwood demand region is projected to be between 21.5 and 38.8 GL (Table 7).

Table 7 Water demand for agriculture in the Blackwood demand region (REU 2009)

Scenario	**Actual and predicted demand GL**		
	2008	**2020**	**2030**
Low demand	27.6	25.1	21.5
Medium demand	27.6	33.8	34.1
High demand	27.6	35.8	38.8
Climate-dependent demand	27.6	34.6	35.5

Water yields and demands in south-west Western Australia (CSIRO 2009) includes future water demand scenarios for high, medium and low demand scenarios to 2030. Modelling predicts self-extraction demand to be between 23.8 and 39.8 GL by 2030 (Table 8).

Table 8 Estimated self-extraction demand under low, medium and high demand scenarios (CSIRO 2009)

Surface water management area	**Base 2008–09 GL**	**Demand scenarios (2030) GL**		
		Low	**Medium**	**High**
Warren River	21.6	18.1	26.5	30.2
Donnelly River	6.8	5.7	8.5	9.6
Total	**28.4**	**23.8**	**35.0**	**39.8**

Future public water supply

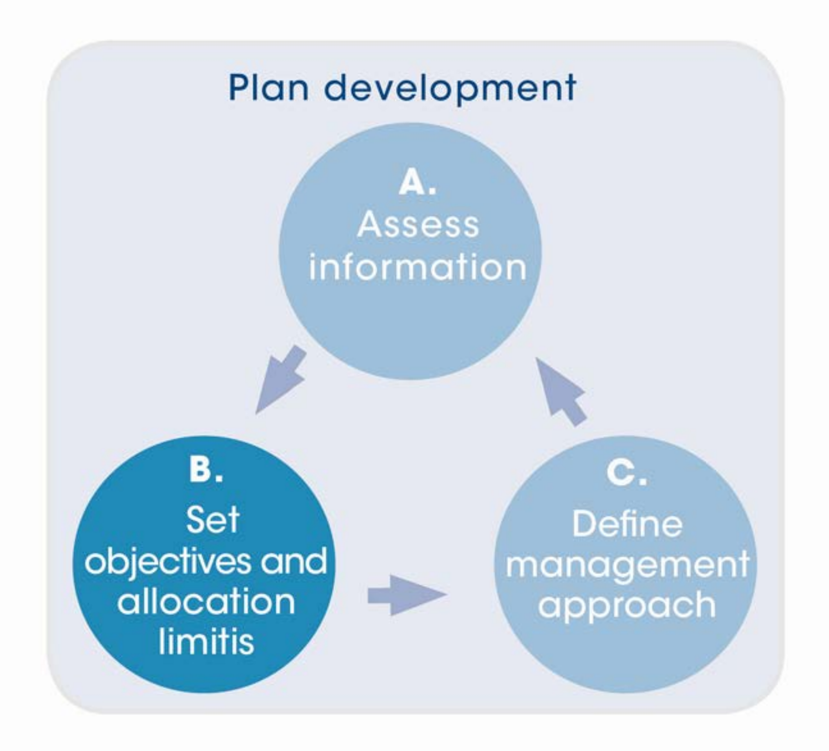
In consultation with the Water Corporation, the department has reserved 1.05 GL of water for future public water supply needs across Record Brook (500 ML), Upper Warren (500 ML) and Four Mile Brook/Big Brook (50 ML).

4.7 Points to consider from water demand

The main points for us to consider from the above water demand information, when we set the objectives and allocation limits, are:

- The biggest demand for water in the Warren–Donnelly area is for irrigated agriculture.
- Water for irrigated agriculture is self supplied, generally by storing water in on-stream (gully wall) dams. These intercept and store winter flows for the following irrigation season.
- Farm dam and water storage density is very high in some catchments, with the Upper Lefroy subarea having the highest storage density in Western Australia.
- Though the use of dams varies, licence entitlements are generally set at dam capacity and can be fully used in any year. To manage risk, we have to assume full licence entitlements are taken in any one year.
- Water uses exempt from licensing is already accounted for in the flow records. Stock and domestic use is approximately 9 per cent of the licensed entitlements.
- Demand for water for agriculture by 2030 is projected to be between 23.8 GL, a decrease from current use, and 39.8 GL, an increase from current use (CSIRO 2009).
- Water has been reserved for future public water supply.

Part B – Set objectives and allocation limits



This stage of the planning process consists of:

- defining the plan objectives
- calculating yields
- making allocation limit decisions.

These steps use the information gathered and analysed in the 'assess information' phase (Part A).

5 Water resource objectives

Water resource objectives relate to maintaining, increasing, improving, restoring, reducing or decreasing surface water flow, groundwater levels or water quality. In administering the *Rights in Water and Irrigation Act 1914*, the Department of Water provides for both the sustainable use and development of water resources and the protection of river ecosystems associated with water resources.

The water resource objectives for the Warren–Donnelly area are guided by the different land uses and water use priorities in the subareas. To set the objectives the department:

- categorised catchments based on their characteristics
- considered the information we assessed in Part A
- set objectives for each catchment category.

5.1 Land use categories

The department categorised each catchment according to its land use and water use priority (Table 9). We also considered stakeholder feedback and agricultural priority management areas identified in *Statement of planning policy no. 11* (DoP 2002).

Table 9 Subareas in each category

Category	Subareas	Characteristics
1. Important for irrigated agriculture	Beedelup Brook Diamond Tree Gully Dombakup Brook East Brook Fly Brook Four Mile Brook/ Big Brook Lefroy Brook Manjimup Brook/ Yanmah–Dixvale Middle Donnelly Perup River Smith Brook Upper Donnelly Upper Lefroy Wilgarup River Yerraminnup River	These catchments are important for irrigated agriculture and include agricultural priority management areas. Some may have large areas of uncleared, non-freehold land.
2. Future public water supply	Record Brook	The main demand for water from this catchment is future public water supply.

Category	Subareas	Characteristics
3. Mostly forest or conservation areas	Barlee Brook Carey Brook Lower Donnelly Unicup Lakes	These catchments are largely or completely covered in forest or conservation area. They have significant environmental and social values associated with them. Water for irrigation is limited by legal access to land.
4. Mostly forest or conservation areas and/or Warren River salinity improvement	Lower Warren Quinninup Brook Treen Brook Tone River Upper Warren	These catchments have low water use, less freehold land and contribute fresh water to Warren River (except Tone River, which is a source of salinity). They help dilute salinity in the Warren River.

5.2 How the objectives were set

The department's water resource objectives are based on statutory obligations, public consultation, the catchment categorisation and the hydrological and environmental assessment of the surface water resources in the plan area.

Our main considerations for setting water resource objectives in the Warren–Donnelly area are:

- maintaining reliability of supply to water users
- protecting existing river ecology and social values
- impacts of abstraction on salinity in the Warren River
- balancing the demands of consumptive and non-consumptive uses.

More information on our reasoning for maintaining reliability of supply and protecting ecological and social values is discussed below.

Reliability of water supply

The importance of irrigation in the Warren–Donnelly area and the economic activity that it supports was emphasised by stakeholders during public consultation on the allocation plan. Reliability of supply, expressed as the frequency at which the total volume of annual licence entitlements can be abstracted by all users, contributes to the economic future of irrigated agriculture in the Warren–Donnelly area.

Dams have different reliabilities depending on their location in the catchment, the size and density of dams upstream and the operation of bypass structures or valves. Dams with small catchment areas, and therefore small inflows, may not fill even in years of average rainfall. The risk to the reliability of water supply to existing licence holders also increases with a drying climate.

Currently, reliability of supply in the Warren–Donnelly irrigation areas is high. Further declines in rainfall and runoff will increase the risk that winter inflow to dams will be lower more often. Additionally, as the number of dams or the volume of water stored in dams increases relative to winter inflow, there is an increasing risk that some dams will not fill by the start of the irrigation season. The greatest risk of this happening is during low flow years (see Appendix A), when dams can intercept a significant proportion of streamflow (Section 3.4). This means that the allocation limits should be set according to low flow years to ensure the reliability of supply remains high in the future.

Protecting river ecology and social values

In administering the *Rights in Water and Irrigation Act 1914*, the department has to make provision for the protection of river ecosystems and the environment associated with water resources. This means the allocation of water should not affect the water available for maintaining river ecosystems.

Stakeholders and the Warren Donnelly Water Advisory Committee have relayed a variety of views on associated values of the rivers in the Warren–Donnelly area. One concern was the relative proportion of water that is allocated for abstraction compared to that left in the river for ecological or other non-consumptive purposes. They recommend that the department focus on the protection of the existing ecological and social values of the forested and conservation areas, rather than the irrigation subareas.

5.3 Water resource objectives and outcomes

Based on the above considerations, the department has set the following water resource objectives:

- Flow regimes in irrigated subareas that supply licence entitlements in almost all years. This includes leaving sufficient water in rivers to reach downstream users and to meet minimal environmental needs in dry years.
- Flow regimes in forested and conservation subareas that maintain existing environmental and social values. This includes retaining most or all of the water as environmental flow where land use zoning is not compatible with irrigation.
- Sufficient flow retained for the existing public water supply reserves.
- Sufficient freshwater flows in the Warren River to complement the salinity recovery targets.

The water resource objectives are related to the four catchment categories as shown in Table 10. The objectives reflect the main land uses for each part of the catchment, existing commitments for public water supply and salinity recovery, policy and legislation.

Table 10 Catchment categories, subareas in each category and objectives

Category	Subareas	Water resource objectives
1. Important for irrigated agriculture	Beedelup Brook Diamond Tree Gully Dombakup Brook Fly Brook Four Mile Brook/Big Brook East Brook Lefroy Brook Manjimup Brook/Yanmah–Dixvale Middle Donnelly Perup River Smith Brook Upper Donnelly Upper Lefroy Wilgarup River Yerraminnup River	a) Flow regimes that supply licence entitlements in almost all years. c) Sufficient flow retained for the existing public water supply reserves.
2. Future public water supply	Record Brook	c) Sufficient flow retained for the existing public water supply reserves.
3. Mostly forest or conservation area	Barlee Brook Lower Donnelly Carey Brook Unicup Lakes	b) Flow regimes that maintain existing environmental and social values.
4. Mostly forest conservation area and/or Warren River salinity improvement	Upper Warren Quinninup Brook Treen Brook Lower Warren Tone River	b) Flow regimes that maintain existing environmental and social values. c) Sufficient flow retained for the existing public water supply reserves. d) Sufficient freshwater flows in the Warren River to complement the salinity recovery targets.

These water resource objectives will support the department's desired outcomes for the *Warren–Donnelly surface water allocation plan*, which are:

- the long-term reliability of water allocation will be maintained
- existing river ecology and social values will be protected
- current public water supply reserves in the area will be maintained
- the future development and investment potential in the area will not be limited by the risk of over abstraction
- more innovative ways can be developed to take and store water at a lower reliability.

6 Yield method

For the development of the *Warren–Donnelly surface water allocation plan*, the department calculated yield using the ecologically sustainable yield (ESY) method. Further detail about this method and how it was used to inform allocation limits is provided in sections 6.1 and 7.

To date (see Appendix D), the department has managed licensing in the Warren–Donnelly plan area using estimates of water availability based on:

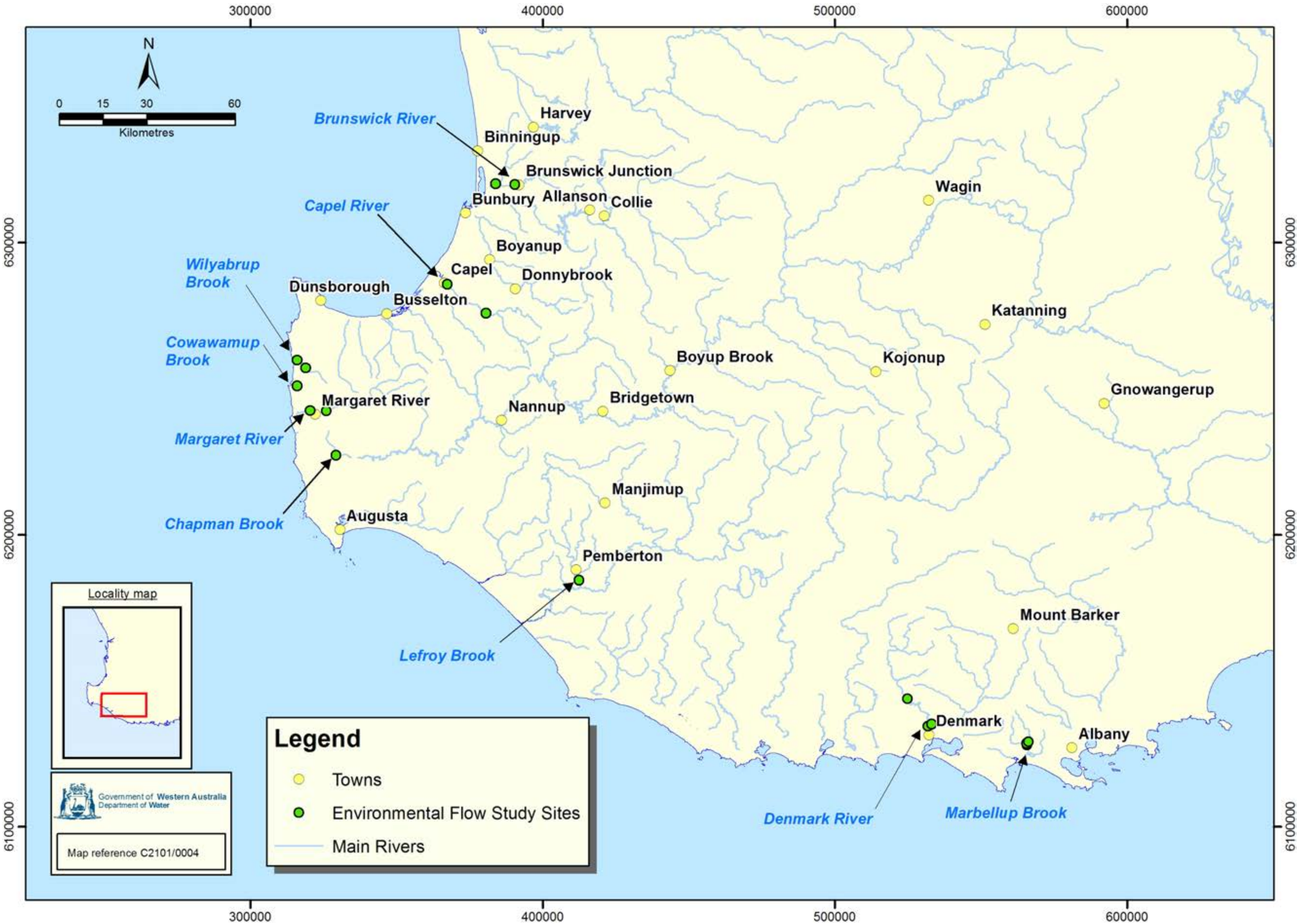
- a percentage of mean annual flow
- sustainable diversion limits.

As the number of water users increases and as water use nears reliable supply, a more specific method is useful. For the Warren–Donnelly area there are advantages to using the ESY method rather than the mean annual flow (MAF) or sustainable diversion limits (SDL) methods.

6.1 Ecologically sustainable yield

For this plan the ESY method is used to determine the amount of additional water that can be abstracted while maintaining flows that are important for river ecosystems and social values. The department developed this methodology to calculate the ESY of rivers in the south-west of Western Australia (Donohue et. al. 2009b). Unlike the SDL and MAF methods, the ESY method has been based on site-specific environmental flow studies.

The ESY method is based on environmental flow studies at 14 study sites in seven catchments in the south-west region between 2006 and 2008 (Figure 16). The study sites were in good ecological condition (see Section 3.5).



Note: There are three study sites on Marbellup Brook that are very close together, not one site as shown at this scale on the map.

Figure 16 Location of environmental flow study sites across the South West

The ESY method:

- considers daily, seasonal and annual flow variability and individual catchment characteristics
- incorporates the findings from the site-specific environmental flow studies in the south-west of Western Australia
- calculates the additional yield above the current level of use
- can be used for high use catchments.

The environmental flow studies use an approach known as PADFLOW (proportional abstraction of daily flow) to calculate environmental flow and the ecologically sustainable yield. PADFLOW is a holistic approach which accounts for water requirements at the ecosystem scale. This includes water dependency of suites of animals and plants, predator–prey relationships and recruitment processes to parent populations. Holistic approaches like this are now being used throughout Australia and other countries to determine environmental flows and yields that can be abstracted from rivers while maintaining ecosystems.

Using the PADFLOW approach, the environmental flow of a river is calculated by deducting a percentage volume of daily flows until the ecological function provided by that particular flow regime begins to be compromised. The difference between the environmental flow and the flow record determines the ESY (Figure 17). The department's Environmental Report No. 6 (Donohue et. al. 2009a) contains more information on PADFLOW and its application in the Lefroy Brook.

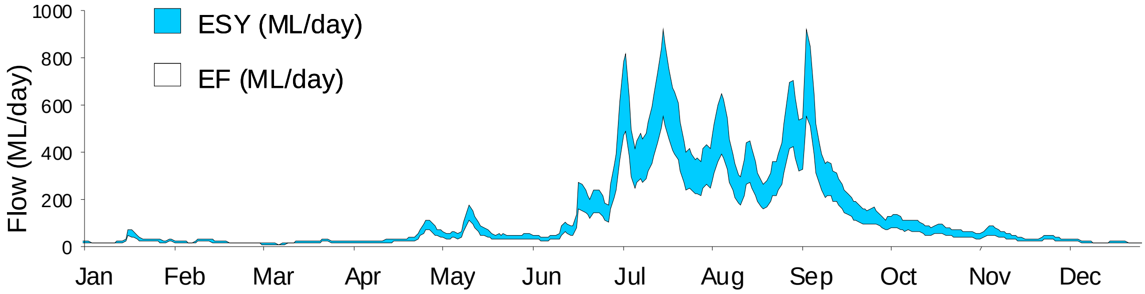


Figure 17 Environmental flow and ecologically sustainable yield for Lefroy Brook in 2000

We have used the 14 environmental flow studies to develop a regional model that can be used to calculate the ESY for the Warren–Donnelly subareas.

The ESY method uses the gauged streamflow record in the Warren–Donnelly area. This record implicitly includes the changes resulting from the current level of development. This includes changes to flows caused by catchment clearing, water abstraction and interception by on-stream farm dams. The department has therefore treated the ESY for Warren–Donnelly catchments as additional to current use (as at March 2010).

6.2 Mean annual flow

Mean annual flow is relatively easy to understand and communicate but as a yield method it has no scientific basis and doesn't account for variation in flows between years or for trends in flow. This means it is not well suited for determining allocation limits in the Warren–Donnelly area because:

- the current system of small on-stream dams is sensitive to variability in annual flow because little water is left in storage after a single dry year
- there is a long-term drying trend being observed in the south-west of Western Australia.

Yields based on a percentage of mean annual flow are useful in predicting the long-term reliability of very large dams associated with scheme irrigation and public water supply. This is in part due to the fact that the large storage capacity of these systems can buffer the effects of flow variability from year to year. Small farm dams do not have the carry-over storage capacity to cope with the variability of annual flows.

6.3 Sustainable diversion limits

The SDL method incorporates some general ecological principles (e.g. minimum flow threshold) but these are not site specific. As a regional scale yield method, it is intended to be used in the absence of local scale ecological information gathered during site-specific environmental studies.

The SDL method is better suited to assessing flow variability than a mean annual flow approach. However, the method is not suited for determining surface water yields in resources that have a high level of development and water use, such as the Upper Lefroy, Manjimup Brook and East Brook subareas.

7 Calculating yields in the Warren–Donnelly area

The Department of Water used information collected from the 14 environmental flow studies in the south-west to develop a regional ecologically sustainable yield (ESY) model. Figure 18 illustrates the process we followed to develop the regional model and calculate yields for the Warren–Donnelly subareas.

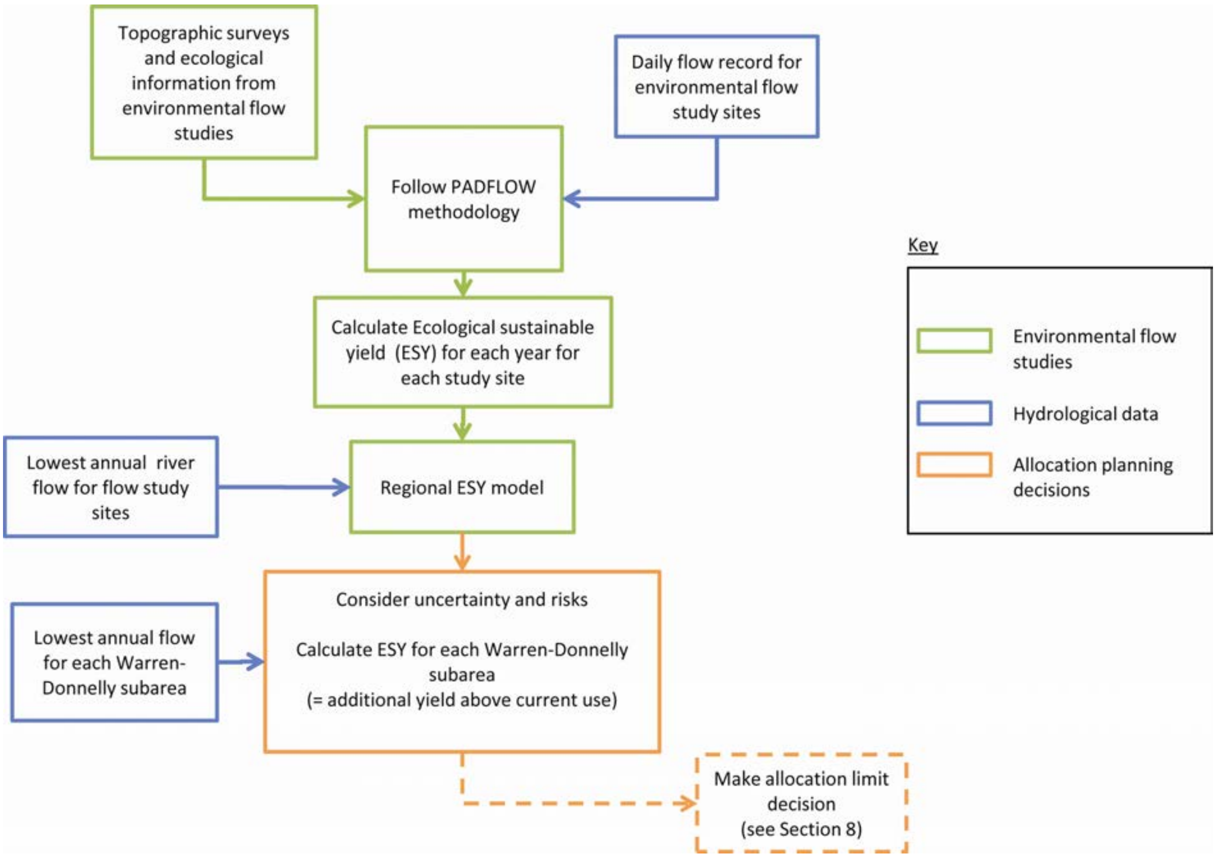


Figure 18 Approach to calculating yields for Warren–Donnelly subareas

7.1 Regional ESY model

The regional ESY model is based on a relationship between the ecologically sustainable yield and annual flow at each of the 14 study sites for the period 1975–2003 or 2005 depending on the site. The annual flow data and corresponding ecologically sustainable yield for each study site is shown in Appendix B. The years 1987, 2001, 2004 and 2006 were very low flow years for many of the rivers in the south-west in the study period.

Figure 19 shows the time series of annual flow and annual ecologically sustainable yield for Lefroy Brook.

To reduce the risk to reliability of supply and environmental flows, the regional ESY model is based on a benchmark dry year. It uses the minimum annual flow during the period 1975 to 2005 and its corresponding ecologically sustainable yield (the minimum ESY in Figure 19). If, for example, the average ESY in Lefroy Brook was allocated (red dashed line in Figure 19), there is a risk that dams would intercept all flow in the river in 14 out of 30 years.

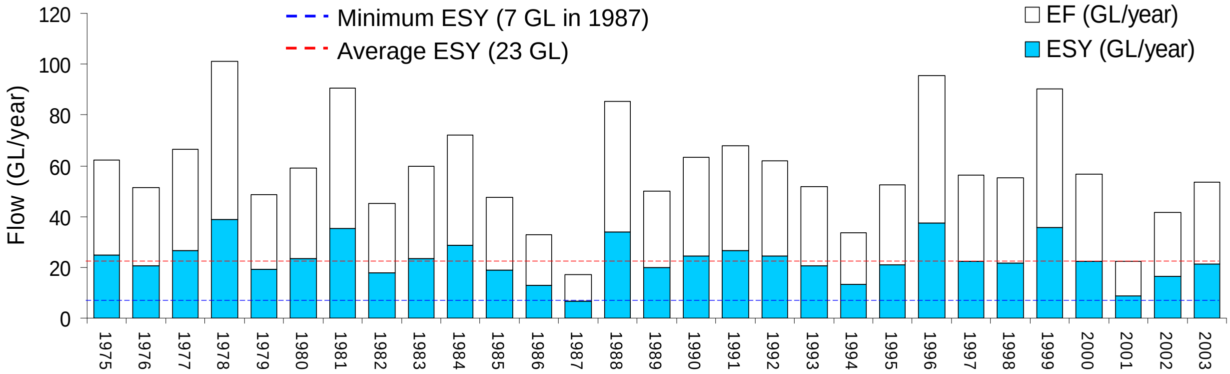


Figure 19 Annual environmental flow and ecologically sustainable yields for Lefroy Brook, 1975 to 2003 (after development)

There is a linear relationship between the minimum gauged flow and the corresponding ESY (Figure 20). The minimum ESY is the additional volume of water that can be allocated each year while maintaining current dam reliability and current ecosystems at a low level of risk.

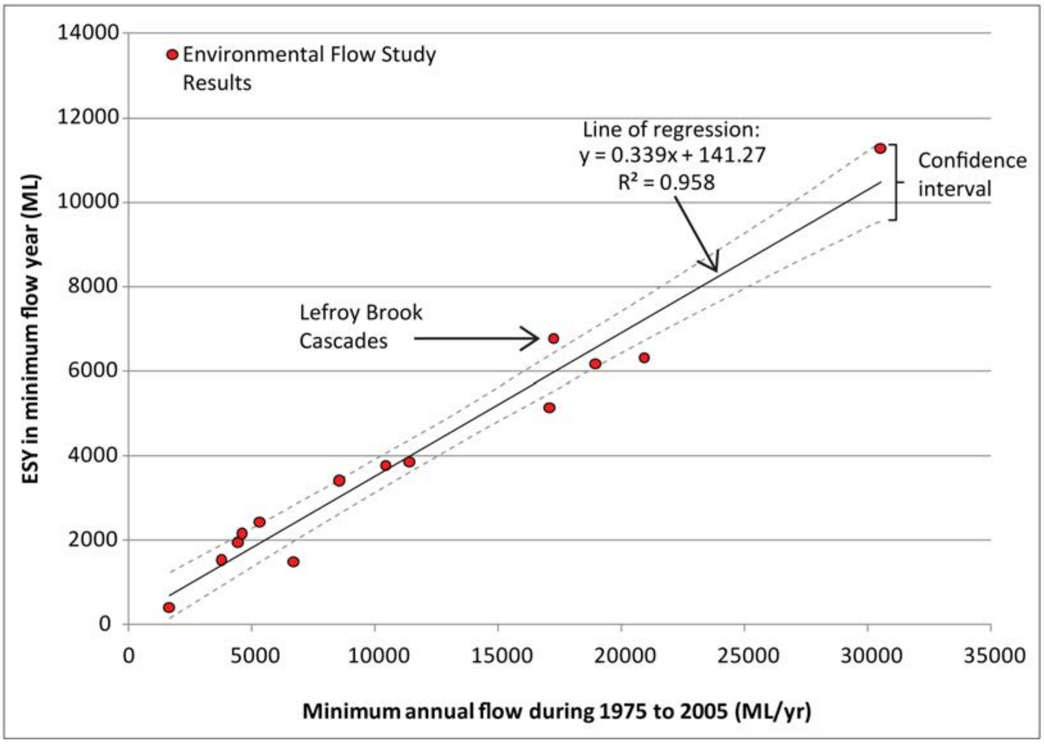


Figure 20 Relationship between minimum annual flow and minimum ecologically sustainable yield.

The minimum flow for each of the 14 sites did not occur in the same year (see Appendix B). As the volume of flow increases (horizontal axis), the ecologically sustainable yield (vertical axis) also increases. The best fit line though the study site data, the line of regression (solid line in Figure 20), is described by the following equation:

$$ESY = 0.339Q_{min} + 141.27$$

Where: ESY = ecologically sustainable yield (ML) in the year of minimum annual flow
Q_{min} = minimum annual flow (in ML/yr) of the study site catchment

Statistical analysis (the R^2 value) suggests that the minimum annual flow is a reasonable model for calculating ecologically sustainable yield.

The line of regression replaces the polynomial relationship used for the *Warren–Donnelly water allocation plan: for public comment*. The use of a straight line relationship was recommended by the University of Melbourne review of the department's ESY methodology (UoM 2011). Unlike the polynomial relationship, the line of regression is not forced to pass through zero. The mathematical relationship means that when flow, Q_{min}, is zero the ESY is approximately 141 ML. In making our allocation limit decisions we took into account that this mathematical relationship does not always accurately describe the real world relationship between river flow and ecologically sustainable yield, particularly at the extremes.

To calculate the ecologically sustainable yield for each Warren–Donnelly subarea, we applied the above formula to the minimum annual flow from 1975 to 2007 for each subarea (flow in the benchmark dry year for each subarea).

Uncertainty in the model

Calculating the ecologically sustainable yield using data from the representative study sites introduces uncertainty in the accuracy of the results. The results of the flow studies provide information on the variability and the range over which we would expect the ecologically sustainable yield of the studied rivers to occur.

The regional ESY model includes upper and lower confidence limits (dashed lines in Figure 20) around the line of regression. This range represents where the actual ecologically sustainable yield may lie for a given minimum annual river flow. The size of the confidence interval varies and is a measure of the uncertainty associated with using the 14 data points to determine the yields.

We have used the confidence interval as part of our risk management when making allocation limit decisions. This is described in Section 8.

The drying climate also introduces uncertainty in reliability of supply, because it depends on how the drying climate will impact on the variability and volume of annual flows. By basing the ESY model on a benchmark dry year, the year of minimum flow for 1975–2008, we are reducing the likelihood that the drying climate will unacceptably impact on reliability of supply. It also means that allocation limits will be more likely to provide a highly reliable supply throughout the life of the plan.

8 Allocation limits

The following sections describe how the Department of Water has used the yield calculations and considered the different land use characteristics, water resource objectives and risks to water supply and environmental and social values to determine the allocation limits for the Warren–Donnelly subareas. Figure 21 shows the main steps we took and the main factors taken into account when we set the allocation limits.

All our allocation limit decisions for the Warren–Donnelly area are based on the ecologically sustainable yield being additional to current use.

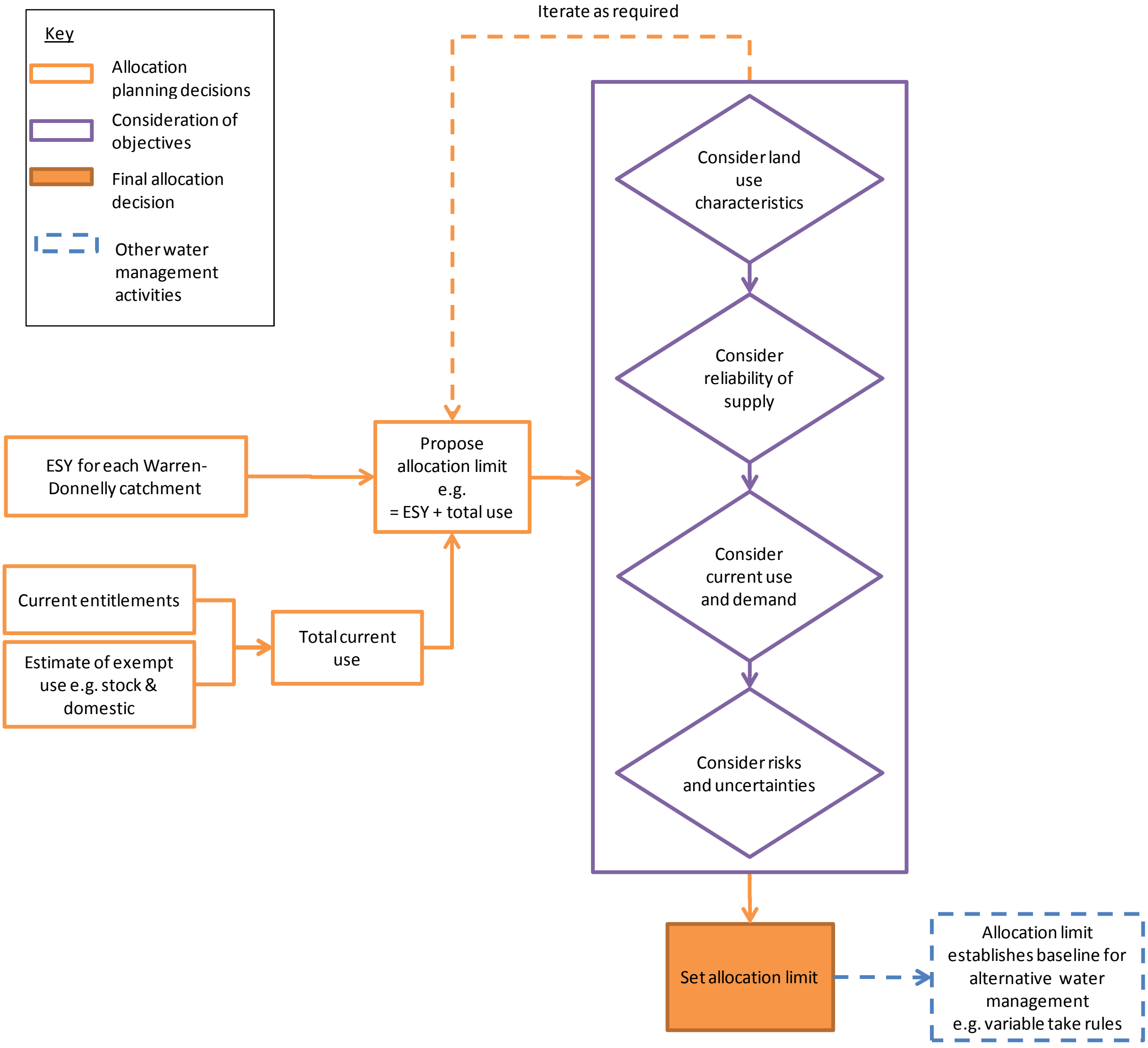


Figure 21 General process used to decide allocation limits for the Warren–Donnelly subareas

8.1 Catchments important for irrigated agriculture

In catchments important for irrigated agriculture (Category 1 subareas in Table 10), our main objective was to maintain flow regimes that supply licence entitlements in almost all years. In most areas, the reliability of dams filling each year is currently high, even in low flow years. The record dry winter of 2010 provided a test to the allocation limits established by the *Warren–Donnelly surface water allocation plan: for public comment* (DoW 2010b) and allowed an assessment of the current reliability of supply against very low inflows.

After considering feedback from licence holders following 2010, the department has used the upper confidence interval of the ESY model to set new allocation limits for the catchments important for irrigated agriculture. This approach maximises the amount of additional water that can be made available for licensing while meeting the water resource objective.

The exceptions to this approach are the Yerraminnup River and the Upper Lefroy subareas. For the Yerraminnup River, a very low flow subarea, the upper confidence level for the ecologically sustainable yield was greater than the minimum annual flow, so we set the allocation limit using the regression line value of ecologically sustainable yield.

In the Upper Lefroy subarea the ESY was calculated using the lower confidence interval because, given the high density of existing dam development, the risk to reliability is higher than elsewhere in the Warren–Donnelly area. Management advice from our licensing officers and the Warren Donnelly Water Advisory Committee was that no further dams should be built in the Upper Lefroy. The department has therefore kept the allocation limit at the volume set in the plan for public comment (ESY = 550 ML, see Table 11).

The allocation limit for the Four Mile Brook subarea includes a public water supply reserve of 50 ML/yr.

Managing to the allocation limit in the subareas important for irrigated agriculture ensures a highly reliable volume of water for use and a minimal environmental flow in a dry year. Because of the distributed and independent operation of the dams in the Warren–Donnelly area, it is necessary to leave water in the rivers for the downstream users. In wetter years, there will be water in excess of the high reliability allocation limits, leaving scope for the development of variable take rules (see the Warren–Donnelly plan).

8.2 Catchments important for future public water supply

Water has been reserved for future public water supply in the Four Mile Brook/Big Brook, Record Brook and Upper Warren subareas. Record Brook is the only subarea in the 'important for future public water supply' category because water is solely allocated to future public water supply. The allocation limit for Record Brook has been set at the public water reserve volume of 500 ML/yr. This is within the confidence interval of the ecologically sustainable yield.

8.3 Mostly forest or conservation areas

In the subareas that are mostly forest or conservation areas (Category 3 subareas in Table 10), our main objective is flow regimes that maintain existing environmental and social values. In these subareas, the department has used the upper confidence interval of the ESY model to determine the allocation limits.

For mostly forested and conservation subareas, the department has based allocation limits on the proportion of freehold land in the subarea. The ecologically sustainable yield has been adjusted because the land vesting in most of these subareas limits legal access to land and therefore the water available for general water licensing. The adjusted ESY is then added to the current water use to calculate the total yield. In subareas where there is no freehold land, an ecologically sustainable yield has been calculated but the allocation limit has been set at zero.

In the case of the Unicup Lakes subarea, there are no well defined drainage channels suitable for water supply development and the area includes wetland systems with significant conservation values. Because of this, the department has set the allocation limit at zero (current water use is zero).

The department will consider an application to take water from forested areas if an applicant can show they have legal access to the land. In this situation the department will consider allocating more water (see the Warren–Donnelly plan). This approach maintains current environmental and social values and reflects the amount of water that is easily accessible to private, freehold land.

8.4 Mostly forest or conservation areas and/or Warren River salinity improvement

In the subareas that are mostly forest or conservation areas and/or important for Warren River salinity improvement (Category 4 subareas in Table 10), our objectives are:

- flow regimes that maintain existing environmental and social values.
- sufficient flow retained for the existing public water supply reserves.
- sufficient freshwater flows in the Warren River to complement the salinity recovery targets.

Water use in these subareas is low because there is little or no freehold land available for development. Most of these catchments contribute fresh flows to the Warren River.

In these subareas, the department has used the upper confidence interval of the ecologically sustainable yield to calculate the total yield and followed the same approach as for the mostly forest or conservation area catchments to determine the allocation limits.

In the case of the Tone River subarea, the department has set the allocation limit at current use (licensed and exempt use). There is no irrigation demand in this area because of the high river salinity. The ecologically sustainable yield for the Tone River subarea is 3052 ML/yr. In the future, we expect the ecologically sustainable yield would be lower because more water will be intercepted by plantations as part of the salinity management for the Warren catchment.

8.5 Yield and allocation limit calculations

The information used for allocation limit calculations and decisions is provided in Table 11 for the Warren River Basin and Table 12 for the Donnelly River Basin.

Table 11 Warren River basin yield calculations and allocation limits.

Subarea	Catchment category	Risk	Minimum annual flow ML/yr	Ecologically sustainable yield: Modelled ML/yr	Lower confidence interval ML/yr (A)	Upper confidence interval ML/yr (B)	Yield decision ML/yr (C)	Percentage freehold (D)	Existing use ML/yr (E)	Public water supply reserve ML/yr (F)	Allocation limit ML/yr	Allocation calculation
Diamond Tree Gully	1	L	1 363	603	31	1 176	1 176	23.67	276	0	1 452	= C + E
Dombakup Brook	1	L	9 785	3 458	3 096	3 821	3 821	34.20	131	0	3 952	= C + E
East Brook	1	L	3 596	1 360	862	1 859	1 859	46.87	2 750	0	4 609	= C + E
Four-Mile Brook	1	L	8 016	2 859	2 472	3 245	3 245	21.17	3 428	50	6 673	= C + E
Lefroy Brook	1	L	3 569	1 351	852	1 851	1 851	46.93	1 744	0	3 595	= C + E
Lower Warren	4	L	6 808	2 449	2 038	2 860	2 860	6.25	340	0	519	= (C x D) +E
Perup River	1	L	2 679	1 050	522	1 578	1 578	21.05	521	0	2 099	= C + E
Quinninup Brook	4	L	4 160	1 552	1 070	2 033	2 033	6.61	401	0	535	= (C x D) +E
Smith Brook	1	L	3 840	1 443	952	1 934	1 934	69.36	3 422	0	5 356	= C + E
Tone River	4	L	7 413	2 654	2 256	3 052	3 052	63.02	55	0	55	= E
Treen Brook	4	L	7 170	2 572	2 169	2 975	2 975	34.20	871	0	1 888	= (C x D) +E
Upper Lefroy	1	H	3 396	1 292	788	1 292	550	54.92	6 425	0	6 975	= C + E
Upper Warren	4	L	15 335	5 339	4 948	5 731	5 731	21.30	1 277	500	2 497	= (C x D) +E
Wilgarup River	1	L	4 599	1 700	1 232	2 169	2 169	37.04	6 144	0	8 313	= C + E
Yerraminnup River	1	L	801	413	0	1 005	413	18.00	13	0	426	= C + E
Warren River total				**30 095**			**35 246**		**27 798**	**550**	**48 944**	

Note: The Upper Lefroy allocation limit has been kept at the volume set in the plan for public comment (see DoW 2010a and 2010b) as explained in Section 8.1.

Unicup Lakes is not included in this table because the allocation limit was set at zero as explained in Section 8.3.

Table 12 Donnelly River basin yield calculations and allocation limits.

Subarea	Catchment category	Risk	Minimum annual flow ML/yr	Ecologically sustainable yield: Modelled ML/yr	Lower confidence interval ML/yr	Upper confidence interval ML/yr	Yield decision ML/yr	Percentage freehold	Existing use ML/yr	Public water supply reserve ML/yr	Allocation limit ML/yr	Allocation calculation
					(A)	(B)	(C)	(D)	(E)	(F)		
Barlee	3	L	34 263	11 756	10 689	12 822	12 822	6.98	0	0	895	= (C x D) +E
Beedelup Brook	1	L	6 278	2 269	1 846	2 693	2 693	17.86	806	0	3 499	= C + E
Carey Brook	3	L	9 260	3 280	2 912	3 648	3 648	0.00	0	0	0	= (C x D) +E
Fly Brook	1	L	7 160	2 568	2 165	2 972	2 972	21.65	867	0	3 839	= C + E
Lower Donnelly	3	L	30 376	10 438	9 532	11 344	11 344	6.41	14	0	741	= (C x D) +E
Manjimup Brook	1	L	5 269	1 927	1 478	2 377	2 377	56.91	5 154	0	7 531	= C + E
Middle Donnelly	1	L	2 896	1 123	602	1 644	1 644	31.77	1 215	0	2 859	= C + E
Record Brook	2	L	1 175	539	0	1 119	1 119	9.94	0	500	500	= F
Upper Donnelly	1	L	9 282	3 288	2 920	3 655	3 655	18.62	403	0	4 058	= C + E
Donnelly River total				**37 189**			**42 274**		**8 459**	**500**	**23 922**	

8.6 Allocation limits and components

The allocation limits for each subarea (surface water resource) are shown in Table 13. Table 13 also indicates whether water is still available for licensing as at December 2011.

The allocation limits are subdivided into components to account for existing unlicensed water use and potential future public water supply. The general licensing component is calculated by subtracting existing unlicensed water use and future public water supply from the allocation limit.

The total water available for allocation across the Warren and Donnelly basins is 72.86 GL/yr. Of this, 67.07 GL/yr is available for general licensing, such as for irrigated agriculture. This is greater than the maximum self-extraction demand of 39.80 GL/yr by 2030, projected by CSIRO (see Section 4.6).

Table 13 Allocation limit, components of the allocation limit and resource status

Subarea	Allocation limit ML/yr	Allocation limit components ML/yr				Status of water availability for licensing[1] (as at December 2011)
		Licensable		Unlicensable	Reserved water	
		General licensing	Public water supply	Unlicensed use	Public water supply	
Warren River and tributaries surface water area						
Diamond Tree Gully	1452	1429	0	23	0	Yes
Dombakup Brook	3952	3941	0	11	0	Yes
East Brook	4609	4336	0	273	0	Limited water available
Four Mile Brook /Big Brook	6673	5989	450	184	50	Yes
Lefroy Brook	3595	2947	450	198	0	Yes
Lower Warren	519	491	0	28	0	Fully allocated – forested[2]
Perup River	2099	2056	0	43	0	Yes
Quinninup Brook	535	472	30	33	0	Fully allocated – forested
Smith Brook	5356	5073	0	283	0	Limited water available
Tone River	55	50	0	5	0	Fully allocated
Treen Brook	1888	1816	0	72	0	Yes – forested

[1] Please contact our Manjimup office on 08 9771 1878 for up-to-date information on the volume of water available for future use. Resource status indicates how much of the water available for general licensing has been allocated and whether water is available for new licences. Water available means < 70 per cent has been allocated and limited water available means 70 to 100 per cent has been allocated. Note that water available is assessed for each licence application at the local scale (see Section 4 of the plan).

[2] In mainly forested catchments, the allocation limit shown is based on the yield scaled to the area of freehold land. The department will consider an application to take water from forested areas if an applicant can show they have legal access to the land. Potential total allocations are up to 3200 ML/yr from Lower Warren, 2434 ML/yr from Quinninup, 7008 ML/yr from Upper Warren, 12 822 ML/yr from Barlee Brook, 3648 ML/yr from Carey Brook and 11358 ML/yr from Lower Donnelly.

Subarea	Allocation limit ML/yr	Allocation limit components ML/yr				Status of water availability for licensing[1] (as at December 2011)
		Licensable		Unlicensable	Reserved water	
		General licensing	Public water supply	Unlicensed use	Public water supply	
Unicup Lakes[3]	0	0	0	0	0	Not available – Conservation area
Upper Lefroy	6 975	5 581	894	500	0	Limited water available
Upper Warren	2 497	1 892	0	105	500	Yes – forested
Wilgarup River	8 313	7 806	0	507	0	Limited water available
Yerraminnup River	426	425	0	1	0	Yes
Warren totals	**48 944**	**44 304**	**1 824**	**2 266**	**550**	
Donnelly River System surface water area						
Barlee	895	895	0	0	0	Yes – forested
Beedelup Brook	3 499	3 432	0	67	0	Yes
Carey Brook	0	0	0	0	0	Not available – Conservation area
Fly Brook	3 839	3 767	0	72	0	Yes
Lower Donnelly	741	740	0	1	0	Yes – forested
Manjimup Brook /Yanmah–Dixvale	7 531	7 105	0	426	0	Limited water available
Middle Donnelly	2 859	2 759	0	100	0	Yes
Record Brook	500	0	0	0	500	Fully allocated
Upper Donnelly	4 058	4 025	0	33	0	Yes
Donnelly totals	**23 922**	**22 723**	**0**	**699**	**500**	

[3] The Unicup Lakes resource is proclaimed under the Warren River and tributaries surface water area but is within the Muir-Unicup surface water allocation area (water resource database information).

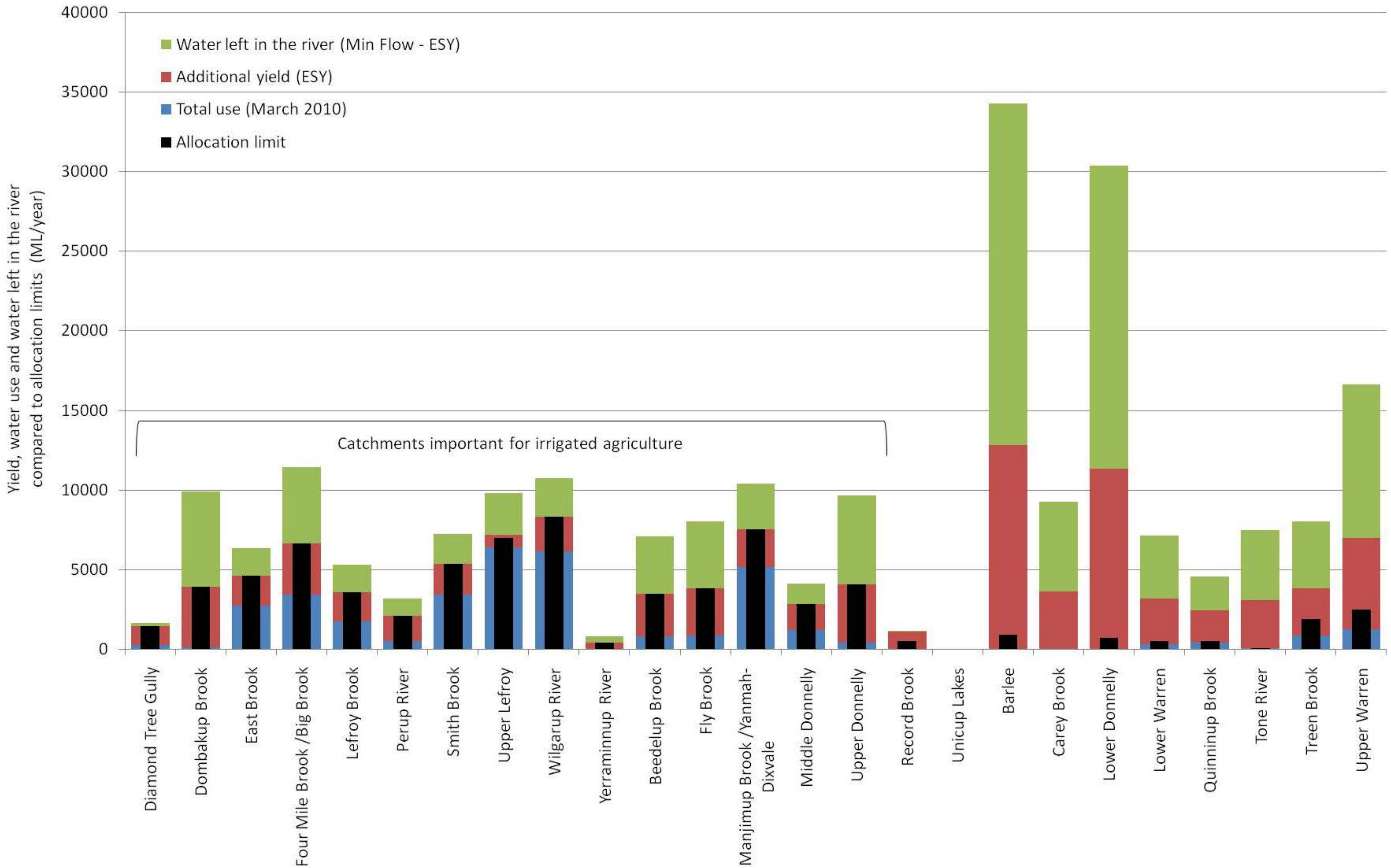


Figure 22 Allocation limits compared to total use, additional yield and water left in the river in the minimum flow year

8.7 Water left in the river

The allocation limits do not include water to be left in the rivers. The allocation limit is set to ensure there is sufficient water left in the river to maintain social and ecological values of rivers and to carry water to downstream dams.

Figure 22 and Figure 23 show the allocation limit in relation to the amount of water left in the river (the environmental water from the ESY method), the ecologically sustainable yield and our estimate of total use. In catchments important for irrigated agriculture, the water left in the river equals the environmental water calculated as part of the ESY approach. In the other catchments, more water is left in the river because we are not allocating all of the ecologically sustainable yield e.g. in forested catchments.

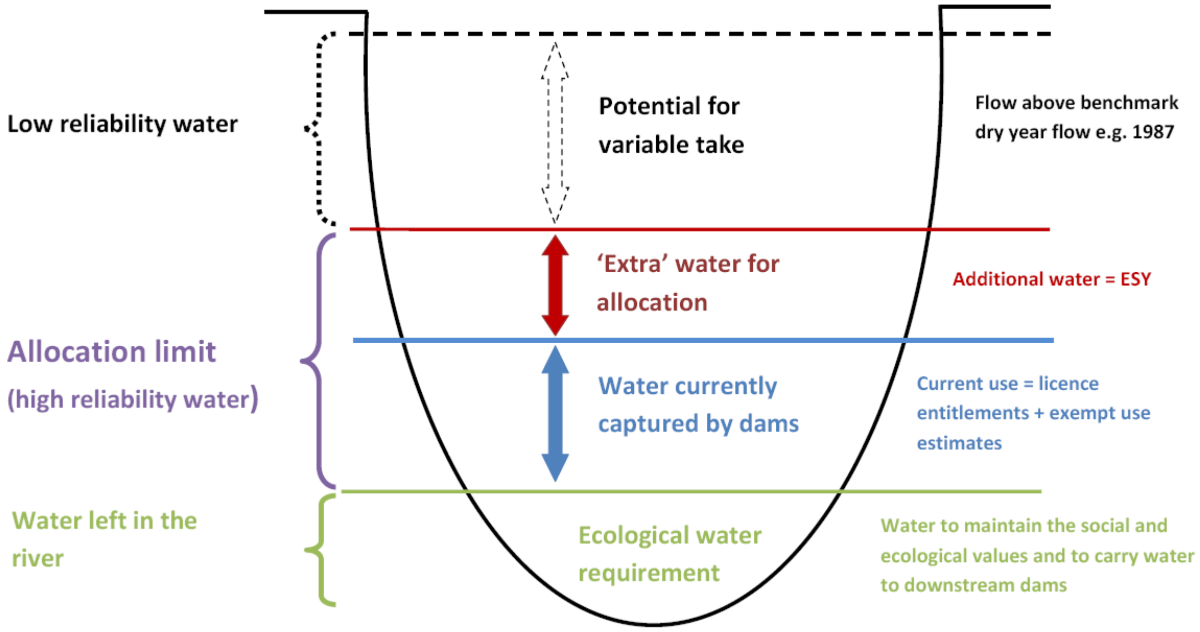


Figure 23 Conceptual model of river cross section and allocation limits in irrigated agriculture catchments

In the Warren–Donnelly area, on-stream farm dams effectively have priority on the water in the rivers because they fill first, before water is allowed to bypass or is released. In low flow years, such as 1987, farm dams intercept a high proportion of the water in the river but some water will be left.

By using the lowest flow year as the benchmark and allowing some water to remain in the rivers, we are also allowing for some underuse of the available dam storage. Not all farm dams are used to their full extent (e.g. 'sleeper licences' or aesthetic dams). Allocating all of the river water in the lowest flow year would risk water reliability if all dams were used to their full entitlement in the future. This is because unused water is not captured the following year, and is effectively registered as flow at gauging stations. In the highly developed subareas, the current high reliability of water to existing users is underpinned by this unused or under-used water.

The department does not re-allocate this water to alternative users as this water may be activated or traded at any time.

Appendices

Appendix A — Streamflow gauging in the Warren–Donnelly area

The department has used data from a number of streamflow gauges to assess the variability of streamflow in the Warren–Donnelly plan area. Figures A 1 and A 2 list the streamflow gauging stations and their respective period of record. The records highlighted in orange are from water level monitoring probes and loggers (not a complete gauging station) and were installed for project specific purposes (e.g. environmental water requirement studies, model calibration studies) rather than permanent flow gauging stations.

Only the gauges with an adequate observed record – typically at least 10 years – post-1975 were used for the assessment of river yield. Pre-1975 data was not used because of the observed reduction in rainfall, and subsequently reduced runoff since 1975. Figure 6 shows the location of the streamflow gauges in the Warren–Donnelly area installed prior to 2010. Some newer water level monitoring probes and loggers installed within the Manjimup catchment are not shown in Figure 6.

Tables A1 and A2 include the annual flows for each of the Warren–Donnelly subareas. Annual flows up to 2007 were used to calculate yields for each subarea. Flow data for 2008–10 is shown for information only.

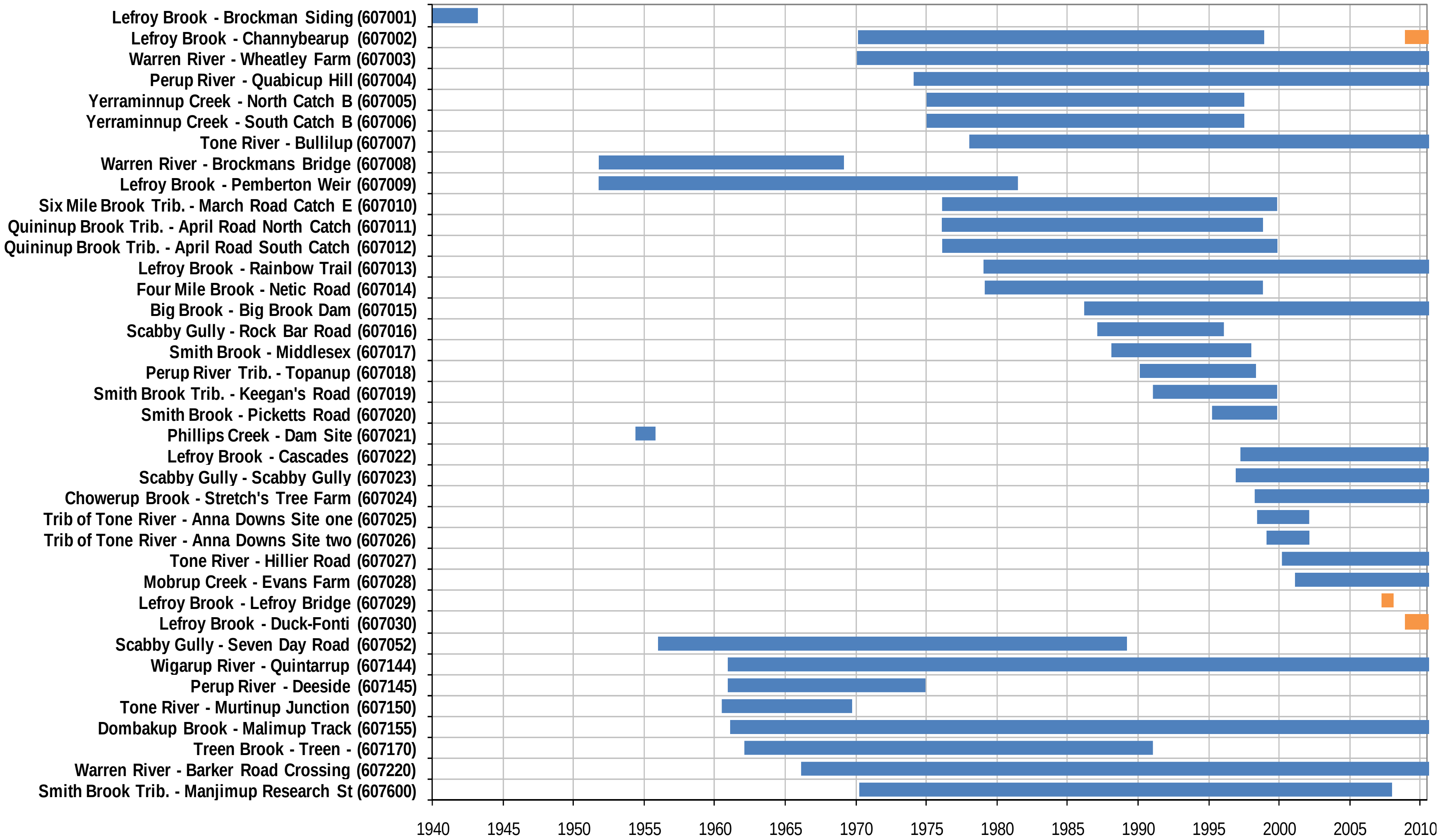


Figure A-1: Period of record of streamflow gauging stations in the Warren River basin

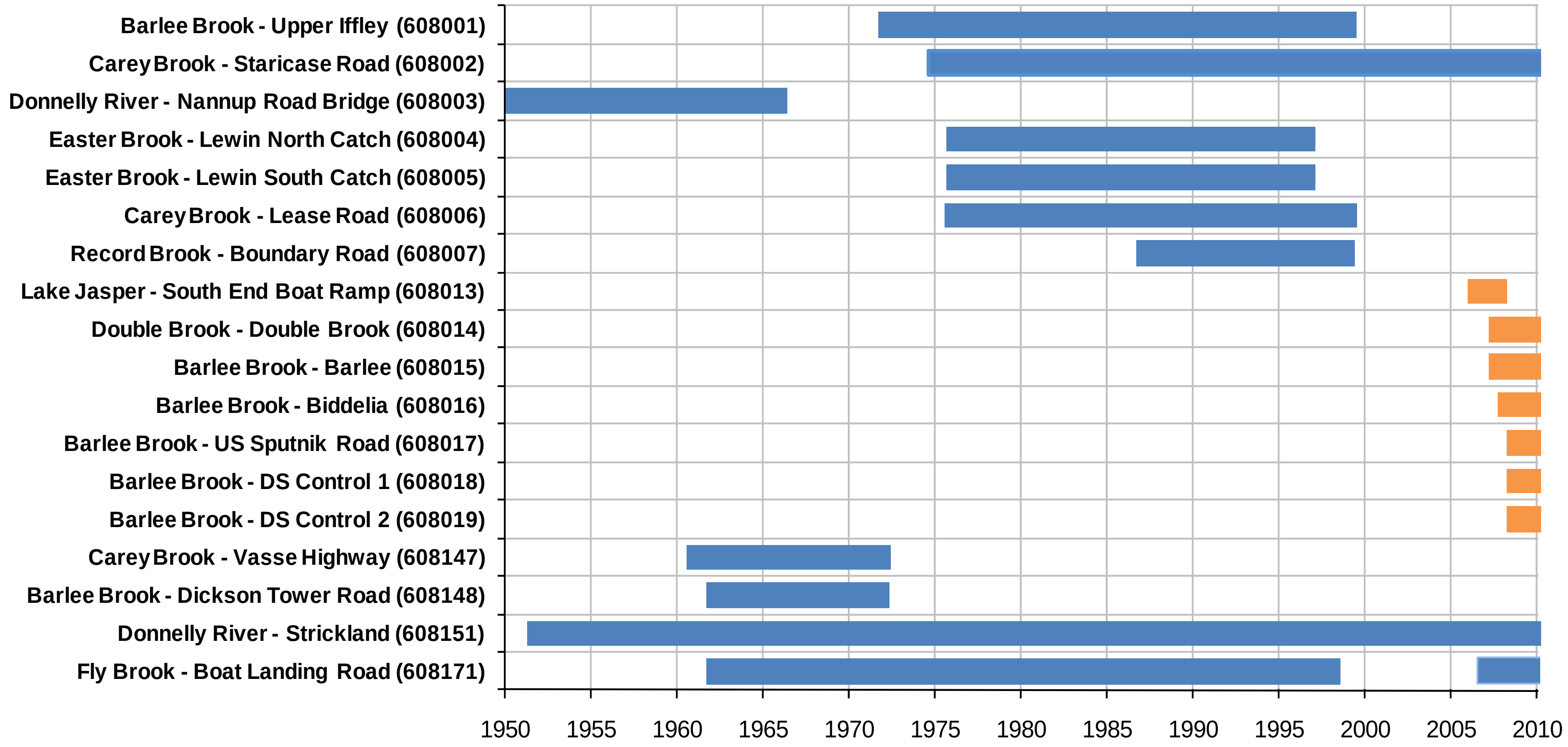


Figure A-2: Period of record of streamflow gauging stations in the Donnelly River basin

Table A-1: Annual flow in the Warren River basin subareas for 1975 to 2010 (after abstraction)

Annual flow in the Warren River basin subareas for 1975 to 2010
ML/yr[1]

Year	Tone River	Perup River	Yerraminnup River	Wilgarup River	Upper Warren	Quinninup Brook	Smith Brook	Diamond Tree Gully	Upper Lefroy	East Brook	Lefroy Brook	Four Mile Brook/ Big Brook	Treen Brook	Dombakup Brook	Lower Warren
1975	50 047	11 896	5 746	29 241	50 814	-	6 469	8 062	13 327	21 268	21 105	32 220	17 363	49 305	23 674
1976	27 485	7 025	3 272	19 726	38 799	-	4 364	5 825	10 334	15 369	15 251	23 283	12 546	36 466	16 342
1977	33 901	7 729	3 676	18 246	37 180	-	4 037	4 856	9 832	12 811	12 712	19 407	10 458	36 593	15 505
1978	74 907	19 451	10 438	48 782	64 809	-	10 793	8 605	19 773	22 702	22 528	34 392	18 533	71 720	28 644
1979	15 950	6 107	2 933	17 356	37 785	-	**3 840**	6 968	12 138	18 384	18 243	27 850	15 008	29 561	15 904
1980	18 119	6 405	2 863	19 489	41 705	32 340	16 922	4 675	14 061	12 333	12 238	22 432	17 017	37 725	18 725
1981	54 792	15 802	7 557	42 183	66 151	49 637	25 973	7 175	22 657	18 929	18 784	31 984	22 402	64 099	31 347
1982	32 181	5 546	2 343	13 594	34 799	24 637	12 892	3 561	10 015	9 396	9 323	18 844	15 414	37 233	15 952
1983	102 760	20 667	10 984	40 596	47 588	16 417	17 131	4 733	15 665	12 485	12 389	20 178	12 965	36 701	23 700
1984	49 299	11 488	5 151	35 491	52 565	25 342	20 587	5 687	19 342	15 004	14 889	24 273	16 117	50 802	24 122
1985	29 918	8 846	4 577	22 349	34 555	13 544	13 600	3 757	12 088	9 912	9 836	16 523	11 730	31 569	15 871
1986	12 141	4 122	1 886	13 666	24 968	7 036	9 382	2 592	8 309	6 838	6 785	12 859	10 645	24 158	11 449
1987	**7 413**	**2 679**	1 378	5 819	**15 335**	4 426	4 935	**1 363**	**3 396**	**3 596**	**3 569**	**8 016**	7 630	**9 785**	**6 808**
1988	112 476	27 354	13 799	63 780	78 338	42 284	24 737	6 834	23 076	18 029	17 890	30 717	22 265	66 598	38 969
1989	40 826	11 505	3 739	18 837	39 544	18 731	15 824	3 966	11 285	10 463	10 383	19 016	14 610	38 087	17 792
1990	58 946	15 574	7 203	37 484	48 683	21 147	19 113	5 008	16 506	13 213	13 112	21 981	14 742	42 828	23 380
1991	69 854	17 157	9 486	39 328	57 874	27 458	22 227	5 359	17 016	14 138	14 029	24 745	18 011	54 131	28 673
1992	69 900	16 462	8 446	38 765	49 848	22 223	21 373	4 890	17 181	12 902	12 802	21 326	14 841	46 549	24 556
1993	43 302	10 445	5 120	25 499	42 096	23 275	17 017	4 085	14 901	10 778	10 695	18 842	13 658	33 791	19 345
1994	32 887	7 871	3 990	15 138	27 017	9 973	9 741	2 648	8 372	6 985	6 931	12 844	9 390	37 657	13 287

Annual flow in the Warren River basin subareas for 1975 to 2010
ML/yr[1]

Year	Tone River	Perup River	Yerraminnup River	Wilgarup River	Upper Warren	Quinninup Brook	Smith Brook	Diamond Tree Gully	Upper Lefroy	East Brook	Lefroy Brook	Four Mile Brook/ Big Brook	Treen Brook	Dombakup Brook	Lower Warren
1995	46 607	12 304	6 207	27 413	44 350	21 766	14 517	4 156	11 991	10 965	10 881	20 150	14 805	41 157	21 421
1996	130 606	26 031	12 462	47 292	76 529	32 883	37 442	7 539	24 794	19 891	19 738	33 386	21 192	67 044	37 328
1997	52 762	11 307	5 206	31 489	47 198	17 238	18 323	5 103	17 536	13 462	13 359	24 277	15 658	39 431	22 036
1998	55 232	11 659	5 556	25 284	40 823	17 209	15 558	4 611	14 004	12 165	11 615	19 793	12 702	27 655	20 100
1999	82 509	21 441	10 907	47 863	66 342	28 119	25 631	7 522	22 616	19 845	19 048	30 832	19 247	63 417	32 060
2000	55 332	10 408	4 601	24 542	41 371	18 527	16 161	4 718	14 260	12 448	11 982	20 557	13 897	33 084	19 964
2001	14 476	3 161	1 301	**4 599**	15 839	7 955	6 934	1 854	6 119	4 891	4 943	9 585	**7 170**	17 069	7 518
2002	40 802	5 941	2 352	11 299	27 431	10 534	9 628	3 479	8 496	9 177	7 912	12 277	8 326	19 820	11 806
2003	75 467	8 069	2 914	19 984	39 182	21 566	14 712	4 463	12 982	11 775	11 102	17 421	10 611	25 259	17 896
2004	38 601	6 079	1 358	8 879	26 144	14 241	9 256	3 034	8 167	8 004	7 246	12 527	9 149	21 780	12 125
2005	128 303	16 869	5 759	22 434	44 736	24 945	14 442	4 256	12 743	11 228	10 753	19 127	13 612	32 405	22 859
2006	11 653	3 449	**801**	5 504	19 209	**4 160**	7 990	2 531	7 051	6 678	6 154	12 273	10 199	24 280	9 222
2007	25 335	5 509	1 634	12 111	26 957	10 834	10 268	3 386	9 060	8 933	8 062	14 169	10 579	25 183	12 129
2008	*69 957*	*13 630*	*3 293*	*19 997*	*44 037*	*22 536*	*15 120*	*5 246*	*13 342*	*13 839*	*12 173*	*19 497*	*13 418*	*54 829*	*19 484*
2009	*64 614*	*12 152*	*4 498*	*28 673*	*53 115*	*27 904*	*18 813*	*5 985*	*16 695*	*15 789*	*14 518*	*25 490*	*18 639*	*67 527*	*24 568*
2010	*8 300*	*1 344*	*253*	*1 679*	*7 053*	*5 430*	*2 666*	*785*	*1 602*	*2 071*	*1 984*	*5 655*	*5 865*	*9 571*	*4 000*
Min[2]	7 413	2 679	801	4 599	15 335	4 160	3 840	1 363	3 396	3 596	3 569	8 016	7 170	9 785	6 808
Mean[2]	51 357	11 405	5 323	25 881	42 623	20 302	14 601	4 767	13 609	12 576	12 312	20 852	14 015	38 574	20 015
Max[2]	130 606	27 354	13 799	63 780	78 338	49 637	37 442	8 605	24 794	22 702	22 528	34 392	22 402	71 720	38 969

[1] The lowest annual flows during 1975 to 2007 are highlighted in bold.

[2] Minimum, mean and maximum figures exclude the 2008–10 data in italics because only data for 1975–2007 has been used to calculate the ecologically sustainable yields for Warren–Donnelly subareas.

Table A-2: Annual flow in the Donnelly River basin subareas for 1975 to 2010 (after abstraction)

Year	Annual flow in the Donnelly River basin subareas for 1975 to 2010 ML/yr[1]								
	Upper Donnelly	**Manjimup Brook/ Yanmah–Dixvale**	**Middle Donnelly**	**Record Brook**	**Barlee**	**Lower Donnelly**	**Carey Brook**	**Beedelup Brook**	**Fly Brook**
1975	43 546	24 720	13 588	3 392	89 919	95 527	22 423	15 202	25 081
1976	27 057	15 360	8 443	2 107	59 751	64 431	16 203	10 985	16 208
1977	31 209	17 717	9 738	2 431	55 083	62 732	13 506	9 157	15 209
1978	57 453	32 615	17 927	4 475	97 060	113 408	23 934	16 227	28 746
1979	30 017	17 040	9 366	2 338	72 019	74 622	19 382	13 140	17 582
1980	39 500	22 424	12 325	4 028	87 915	90 313	21 977	14 900	19 884
1981	63 421	36 003	19 789	6 182	113 059	130 799	28 931	19 614	23 845
1982	26 509	15 049	8 272	3 068	73 831	72 138	19 906	13 496	18 496
1983	54 389	30 876	16 971	4 077	76 155	94 139	16 743	11 351	16 415
1984	53 399	30 314	16 662	4 900	85 576	102 208	20 814	14 112	22 003
1985	34 943	19 837	10 903	3 237	60 199	70 297	15 148	10 270	13 731
1986	24 337	13 816	7 594	2 233	52 159	56 106	13 747	9 320	14 702
1987	12 738	7 231	3 975	**1 175**	**34 263**	35 307	9 853	6 680	**7 160**
1988	83 353	47 318	26 009	4 541	124 864	151 190	28 754	19 495	30 302
1989	31 820	18 064	9 929	2 368	76 623	75 356	18 868	12 792	16 845
1990	47 866	27 172	14 936	3 297	82 711	92 467	19 038	12 907	20 456
1991	52 709	29 922	16 447	3 469	94 372	106 954	23 260	15 770	23 605
1992	49 767	28 252	15 529	3 499	79 643	94 735	19 166	12 994	21 271
1993	41 809	23 734	13 046	3 655	75 596	83 023	17 639	11 959	15 859
1994	25 773	14 631	8 042	2 207	48 845	53 981	12 127	8 222	13 061

Annual flow in the Donnelly River basin subareas for 1975 to 2010
ML/yr[1]

Year	Upper Donnelly	Manjimup Brook/ Yanmah–Dixvale	Middle Donnelly	Record Brook	Barlee	Lower Donnelly	Carey Brook	Beedelup Brook	Fly Brook
1995	45 270	25 699	14 126	3 615	78 974	89 942	19 119	12 962	19 428
1996	72 485	41 149	22 618	6 121	117 357	136 759	27 368	18 555	28 065
1997	49 990	28 379	15 599	5 650	88 101	97 327	20 221	13 709	18 803
1998	35 436	20 117	11 057	4 265	66 105	73 617	16 404	11 121	17 478
1999	64 308	36 507	20 066	5 945	104 978	122 617	24 856	16 852	20 337
2000	40 085	22 755	12 508	3 846	76 408	81 916	17 948	12 168	14 685
2001	**9 282**	**5 269**	**2 896**	1 650	35 325	**30 376**	**9 260**	**6 278**	7 576
2002	23 675	13 440	7 387	2 292	45 653	48 721	10 752	7 290	8 797
2003	34 823	19 768	10 866	3 502	59 853	66 941	13 703	9 290	11 212
2004	18 769	10 655	5 857	2 203	47 563	45 982	11 815	8 010	9 667
2005	37 353	21 204	11 655	3 437	74 154	78 244	17 580	11 918	14 383
2006	12 189	6 919	3 803	1 902	49 884	42 151	13 172	8 930	10 777
2007	22 065	12 526	6 885	2 444	55 126	53 545	13 662	9 262	11 178
2008	*69,957*	*13,630*	*3,293*	*19,997*	*44,037*	*22,536*	*15,120*	*5,246*	*13,342*
2009	*64,614*	*12,152*	*4,498*	*28,673*	*53,115*	*27,904*	*18,813*	*5,985*	*16,695*
2010	*8,300*	*1,344*	*253*	*1,679*	*7,053*	*5,430*	*2,666*	*785*	*1,602*
Min[2]	9 282	5 269	2 896	1 175	34 263	30 376	9 260	6 278	7 160
Mean[2]	39 314	22 318	12 267	3 441	73 913	81 451	18 099	12 271	17 359
Max[2]	83 353	47 318	26 009	6 182	124 864	151 190	28 931	19 614	30 302

[1] The lowest annual flow during 1975 to 2007 highlighted in bold.

[2] Min, Mean and Max figures exclude the 2008-2010 data in italics because only data for 1975-2007 has been used to calculate the ecologically sustainable yields for Warren–Donnelly subareas.

Appendix B — Flow data and yields for each environmental flow study site

Table B-1: Annual flow and ecologically sustainable yields for each environmental flow study site

	Annual flow and ecologically sustainable yields ML/yr																											
	Brunswick R.				Wilyabrup Br.				Cowaramup Br.		Margaret R.				Lefroy Br.		Marbellup Br.						Denmark R.					
	Site 1		Site 2		Site 1		Site 2		Site 1		Site 1		Site 2		Site 1		Site A		Site B		Site C		Powleys		Lindsay		Scottsdale	
Year	Flow	ESY	Flow	ESY	Flow	ESY	Flow	ESY	Flow	ESY	Flow	ESY	Flow	ESY	Flow	ESY	Flow	ESY	Flow	ESY	Flow	ESY	Flow	ESY	Flow	ESY	Flow	ESY
1975	73	24	50	16	28	8.3	18	4.9	4.1	0.7	123	32	101	30	62	25	13	5.0	6.8	2.8	5.6	2.1	22	6.5	12.8	6.0	12.0	5.5
1976	**31**	**11**	26	9	12	4.0	7	2.2	1.8	0.4	41	12	34	10	51	21	15	6.0	8.1	3.2	6.6	2.5	28	8.3	14.4	6.9	16.5	7.6
1977	58	18	34	11	16	5.8	11	3.1	2.5	0.6	52	15	42	13	66	27	16	6.2	8.4	3.2	6.9	2.5	38	11.1	19.7	9.2	16.2	7.0
1978	72	22	51	17	30	9.3	20	5.5	4.5	0.8	96	25	78	23	101	39	23	9.2	12.4	4.1	10.2	3.4	88	28.9	54.9	21.7	24.1	9.4
1979	42	14	28	9	22	7.2	14	4.1	3.4	0.7	59	17	48	14	49	19	18	7.3	9.7	3.7	8.0	2.9	38	10.7	18.3	8.9	17.4	7.7
1980	91	29	58	18	38	10.7	24	6.3	5.6	0.9	119	32	97	29	59	24	13	5.1	6.9	3.0	5.6	2.1	24	7.2	14.8	7.1	10.3	5.0
1981	123	36	85	29	24	7.5	15	4.3	3.5	0.7	99	27	81	24	91	35	16	6.5	8.8	3.0	7.2	2.7	42	11.7	24.4	11.6	15.0	6.3
1982	73	25	62	18	19	6.4	12	3.5	2.9	0.6	82	23	67	20	45	18	13	5.4	7.2	3.1	5.9	2.2	16	5.2	8.0	3.5	10.2	4.8
1983	183	57	112	40	29	8.5	19	5.1	4.3	0.7	112	30	91	27	60	23	11	4.5	6.0	2.8	5.0	1.9	19	5.7	11.6	5.4	7.0	3.3
1984	140	43	65	21	19	6.3	12	3.6	2.9	0.6	74	20	60	18	72	29	13	5.3	7.1	3.0	5.8	2.2	45	13.1	28.8	13.2	11.6	5.2
1985	92	30	48	16	17	5.7	11	3.2	2.6	0.6	70	20	57	17	48	19	13	5.0	6.8	3.0	5.5	2.1	22	6.6	14.4	6.9	8.4	4.0
1986	60	21	31	10	34	9.3	22	5.7	4.9	0.8	117	31	96	29	33	13	11	4.6	6.1	2.7	5.0	1.9	14	4.6	8.3	3.9	6.9	3.3
1987	42	14	23	7	**10**	**3.8**	**7**	**2.0**	**1.6**	**0.4**	42	13	35	10	**17**	**7**	10	4.0	5.4	2.3	4.4	1.7	**11**	**3.9**	6.6	3.0	**5.3**	**2.4**
1988	226	64	129	43	36	9.8	23	6.3	5.2	0.8	151	37	123	36	85	34	22	8.5	11.8	4.2	9.7	3.2	71	22.1	47.6	18.9	16.8	6.6
1989	105	34	49	16	18	6.0	11	3.3	2.7	0.6	52	15	42	13	50	20	16	6.6	8.9	3.7	7.3	2.7	30	8.9	16.6	8.1	12.7	6.0
1990	125	40	51	17	25	8.0	16	4.6	3.8	0.7	83	23	68	20	63	24	19	7.7	10.4	4.2	8.5	3.0	30	9.9	17.6	7.9	13.1	5.6
1991	199	58	108	34	36	10.4	23	6.2	5.3	0.8	118	32	96	29	68	27	16	6.5	8.8	3.4	7.2	2.5	31	9.8	18.5	8.5	11.7	5.0
1992	169	49	88	30	32	8.9	20	5.8	4.6	0.7	113	28	92	28	62	25	23	9.1	12.2	4.5	10.0	3.3	44	12.8	24.7	11.3	16.2	6.8
1993	137	42	44	14	16	5.3	10	3.0	2.3	0.6	60	17	49	15	52	21	20	8.1	10.8	4.4	8.9	3.3	36	10.0	20.1	9.8	14.9	6.6
1994	108	36	46	15	16	5.3	11	3.1	2.5	0.5	60	17	49	15	33	13	14	5.5	7.4	3.0	6.1	2.3	17	5.4	8.0	3.7	9.6	4.5
1995	159	48	87	30	25	7.4	16	4.4	3.8	0.6	87	23	71	21	53	21	13	5.2	7.0	3.1	5.8	2.2	25	7.5	12.9	6.1	11.6	5.4
1996	240	69	120	41	35	10.3	22	5.9	5.0	0.9	141	36	115	35	95	37	15	5.9	7.9	3.2	6.5	2.4	38	10.4	22.5	10.8	15.3	6.5
1997	94	32	50	16	24	7.2	15	4.2	3.6	0.7	92	25	75	23	56	22	14	5.5	7.3	3.0	6.0	2.2	28	7.9	15.0	7.2	13.5	5.6

Annual flow and ecologically sustainable yields
ML/yr

	Brunswick R.				Wilyabrup Br.				Cowaramup Br.		Margaret R.				Lefroy Br.		Marbellup Br.						Denmark R.					
	Site 1		Site 2		Site 1		Site 2		Site 1		Site 1		Site 2		Site 1		Site A		Site B		Site C		Powleys		Lindsay		Scottsdale	
Year	Flow	ESY	Flow	ESY	Flow	ESY	Flow	ESY	Flow	ESY	Flow	ESY	Flow	ESY	Flow	ESY	Flow	ESY	Flow	ESY	Flow	ESY	Flow	ESY	Flow	ESY	Flow	ESY
1998	86	29	50	16	30	8.9	19	5.3	4.4	0.8	101	28	83	25	55	22	14	5.6	7.6	3.1	6.2	2.3	45	13.8	27.9	12.4	16.3	6.8
1999	136	41	101	34	38	11.0	25	6.9	5.6	0.9	143	35	117	35	90	36	13	5.2	7.0	3.0	5.8	2.2	40	10.8	20.0	9.7	15.7	7.0
2000	117	34	68	23	22	6.6	14	4.0	3.2	0.6	89	22	73	22	57	22	11	4.4	5.9	2.6	4.9	1.9	35	9.5	16.5	7.9	15.5	6.5
2001	37	14	**19**	**6**	13	4.7	8	2.4	2.1	0.6	**21**	**6**	**17**	**5**	22	9	11	4.4	6.0	2.6	4.9	1.9	20	6.5	6.9	3.2	10.8	4.9
2002	100	33	54	17	11	4.1	7	2.2	1.8	0.5	40	12	33	10	42	17	10	4.0	5.3	2.5	4.4	1.7	19	6.0	6.2	2.8	9.7	4.6
2003	104	30	52	17	16	5.6	10	3.1	2.4	0.6	46	14	38	11	54	21	14	5.7	7.6	3.0	6.3	2.2	51	15.9	29.1	10.8	16.7	7.2
2004											43	13	35	11			**9**	**3.4**	**4.6**	**2.2**	**3.8**	**1.5**	14	4.5	**4.4**	**1.9**	8.6	4.1
2005											69	20	57	17			19	7.1	10.1	3.6	8.3	2.6	43	13.3	23.3	10.7	15.1	6.9
Min	31	11	19	6	10	3.8	7	2.0	1.6	0.4	21	6	17	5	17	7	9	3.4	4.6	2.2	3.8	1.5	11	3.9	4.4	1.9	5.3	2.4

Appendix C — Examples of yield calculations and allocation limit decisions

The equation for the regression line of the ESY model is:

$$ESY = 0.339\ Q_{min} + 141.27$$

ESY = ecologically sustainable yield (ML) in the year of minimum annual flow

Q_{min} = minimum annual flow (in ML/yr) at the outlet of the study site catchment

East Brook subarea example

This example illustrates how we calculated the yield and decided on the allocation limits for irrigated agriculture subareas other than Upper Lefroy.

The historical minimum annual flow in East Brook in the period between 1975 and 2007 was 3596 ML, which occurred in 1987 (see Table A1). Using the ESY regional model, we calculate the ecologically sustainable yield as:

$$\begin{aligned} ESY &= (0.339 \times 3596.46) + 141.27 \\ &= 1219.19 + 141.27 \\ &= 1360.46 \text{ ML/yr} \end{aligned}$$

The ecologically sustainable yield in East Brook is, after rounding, 1360 ML/yr.

The department's primary water resource objective in East Brook is for flow regimes that supply licence entitlements in almost all years. The department's evidence and advice provided from irrigators indicates there is a low risk to reliability of supply and the environmental values. Because the risk is low, we based the allocation limit on the upper boundary of the ESY confidence interval. For an ESY of 1360.46 ML/yr, the upper confidence boundary is 1859 ML/yr (498.54 ML/yr greater than the ESY).

The East Brook ecologically sustainable yield was adjusted as follows:

$$\begin{aligned} \text{Upper ESY} &= 1360.46 + 498.54 \\ &= 1859 \text{ ML/yr} \end{aligned}$$

The ecologically sustainable yield is additional to use. The allocation limit is the sum of the estimated total existing use (2750 ML/yr) and the upper ecologically sustainable yield (1859 ML/yr):

$$\begin{aligned} \text{Allocation limit} &= 2750 + 1859 \\ &= 4609 \text{ ML/yr} \end{aligned}$$

Lower Donnelly subarea example

This example illustrates how we calculated the yield and made allocation limit decisions for catchments that are mostly forested or conservation areas (other than Tone River).

The historical minimum annual flow in Lower Donnelly in the period between 1975 and 2007 was 30 376 ML, which occurred in 2001 (see Table A 2). Using the ESY regional model, we calculate the ecologically sustainable yield as:

$$\begin{aligned} \text{ESY} &= (0.339 \times 30\,375.91) + 141.27 \\ &= 10\,297.43 + 141.27 \\ &= 10\,438.7 \text{ ML/yr} \end{aligned}$$

The ecologically sustainable yield in the Lower Donnelly subarea, after rounding, is 10 439 ML/yr.

There is a low risk to environmental values because development is low. Because the risk is low, we based the allocation limit on the upper boundary of the ecologically sustainable yield confidence interval. For an ESY of 10 438.7 ML/yr, the upper confidence boundary is 11 344.1 ML/yr (905.4 ML/yr greater than the ESY). The Lower Donnelly ecologically sustainable yield was adjusted as follows:

$$\begin{aligned} \text{Upper ESY} &= 10\,438.7 + 905.4 \\ &= 11\,344.1 \text{ ML/yr} \end{aligned}$$

The ecologically sustainable yield was then adjusted by multiplying it by the percentage area of freehold land before adding it to the total current use. The allocation limit is therefore the upper ecologically sustainable yield (11 344.1 ML/yr) multiplied by the percentage of the catchment that is freehold land (6.41%) plus the sum of estimated existing use (14 ML/yr):

$$\begin{aligned} \text{Allocation limit} &= (11\,344.1 \times 0.0641) + 14 \\ &= 727.156 + 14 \\ &= 741 \text{ ML/yr} \end{aligned}$$

If use was larger than 727 ML/yr and still within the ecologically sustainable yield (e.g. in the Lower Warren subarea) or the risks are manageable, then the allocation limit would be set at the current use estimate.

Appendix D — Timeline of licensing and allocation planning in the Warren—Donnelly area

Figure D-1 provides a timeline of the allocation planning the department has undertaken in the Warren–Donnelly area and the changes to licensing and water availability assessment during that time.

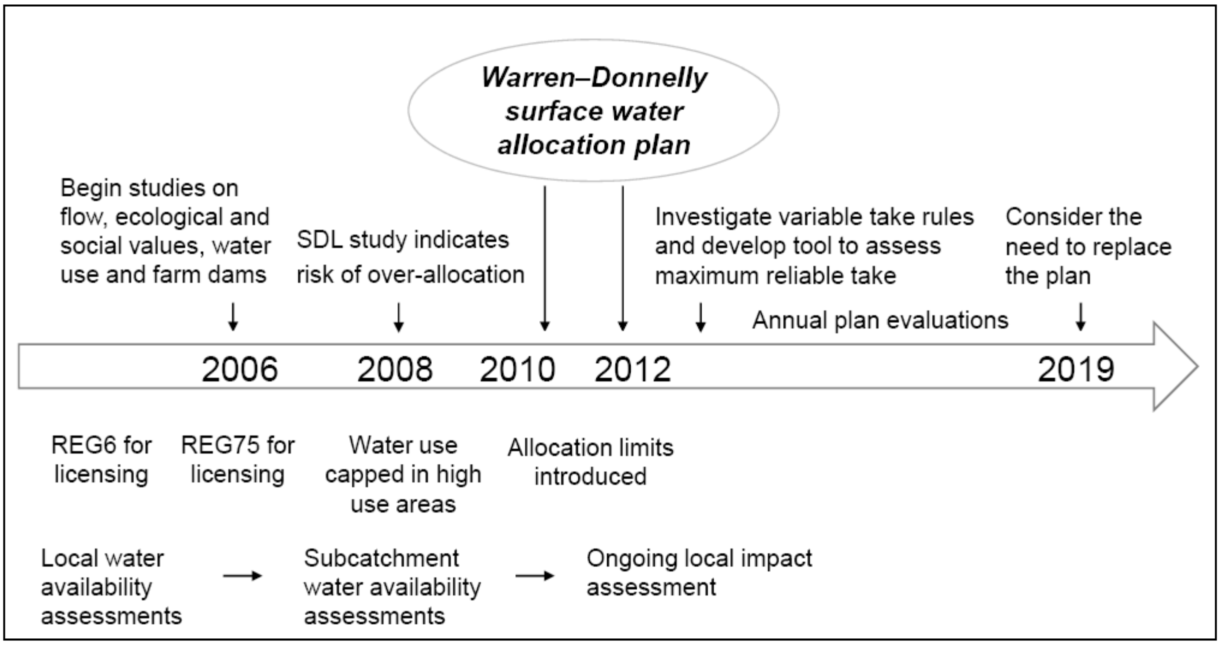


Figure D-1: Timeline for Warren–Donnelly surface water allocation planning

Prior to 2008, the department used a percentage of mean annual flow as a measure of water availability at the local scale for licence assessments. The department calculated the mean annual flow of rivers in the south-west using the regional models REG6 and REG75, which were based on land clearing and rainfall data.

The REG6 model used the minimum of the 10th percentile annual flow and 60 per cent of the mean annual flow. The REG75 model replaced the REG6 model and incorporated the lower average rainfall period of 1975–2003 (DoW 2007). REG75 used 18 per cent of the mean annual flow (30 per cent of 60 per cent, to reflect the reduction in rainfall in this period).

The sustainable diversion limits methodology was developed to provide yield estimates for catchments in south-west Western Australia in areas where there is low surface water use.

In May 2008, the department announced the SDL volumes in the Warren–Donnelly area. The department ‘capped’ the current level of abstraction in the Warren–Donnelly area where current licensed entitlements were higher than the SDL volumes. This reduced the risk of further allocations affecting supply to existing water users and the health of river ecosystems, while the department could investigate water availability further.

The SDL method identifies the acceptable limit of change to flow. It is calculated using daily flow duration curves at gauging stations where post-1975 flow data is available.

The SDL volume that could be diverted in each year is the sum of daily volumes of water that can be abstracted when flows are within a defined winter-fill period (June 15 to October 15), below a maximum abstraction rate and above a minimum flow threshold. The final SDL yield is the annual volume that can be abstracted with an 80 per cent reliability of supply. That is, in 20 per cent of years the full volume cannot be abstracted if the abstraction rules are maintained. See SKM (2008a, 2008b) for a more detailed explanation of the SDL methodology.

Appendix E — Map information and disclaimer

Datum and projection information

Vertical datum: Australian Height Datum (AHD)

Horizontal datum: Geocentric Datum of Australia 94

Projection: MGA 94 Zone 50

Spheroid: Australian National Spheroid

Project information

Client: Emily Harrington

Map author: Gary Floyd and Shona Shah

Filepath: J:\gisprojects\Project\330\80000_89999\3308440_WAP\00003_Warren_Donnelly_Map_Updates\mxd... For all maps.

Filename: J:\gisprojects\Project\330\80000_89999\3308440_WAP\00003_Warren_Donnelly_Map_Updates\mxd... For all maps.

Compilation date: 15 December 2011

Disclaimer

These maps are a product of the Department of Water, Water Assessment and Allocation Division and were printed as shown.

These maps were produced with the intent that they be used for information purposes at the scale as shown when printing.

While the Department of Water has made all reasonable efforts to ensure the accuracy of this data, the department accepts no responsibility for any inaccuracies and persons relying on this data do so at their own risk.

Sources

The Department of Water acknowledges the following datasets and their custodians in the production of this map:

Road Centrelines – Landgate – 2012

State Roads – Landgate – 1999

Western Australian Towns – Landgate – 2011

Spatial Cadastral Database (SCDB) – Landgate – 2012

Donnelly 50cm Orthomosaic – Landgate – 2004

Manjimup 50cm Orthomosaic – Landgate – 2004

WA Coastline, WRC (Poly) – DoW – 2006

Farm Dams – DoW – 2011

Hydrography, Linear (Hierarchy) – DoW – 2007

Hydrographic Catchments – Basins – DoW – 2012

Surface Water Allocation Subareas – DoW – 2012

WIN Surface Water Sites – DoW – 2012

Public Drinking Water Source Areas – DoW – 2012

RIWI Act, Surface Water Areas and Irrigation Districts – DoW – 2007

Isohyets 1975-2003 – BoM – 2008

Glossary

Abstraction	The permanent or temporary withdrawal of water from any source of supply, so that it is no longer part of the resources of the locality.
Allocation limit	Annual volume of water set aside for consumptive use from a water resource.
Allocation limit component	A portion of the allocation limit, defined by the department for administrative and water accounting purposes
Biodiversity	Biological diversity or the variety of organisms, including species themselves, genetic diversity and the assemblages they form (communities and ecosystems). Sometimes includes the variety of ecological processes within those communities and ecosystems.
Catchment	The area of land from which rainfall runoff contributes to a single watercourse, wetland or aquifer.
Climate change	A change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods.
Consumptive use	The use of water for private benefit consumptive purposes including irrigation, industry, urban and stock and domestic use.
Dam	An embankment constructed to store or regulate surface water flow. A dam can be constructed in or outside a watercourse.
Discharge	The water that moves from the groundwater to the ground surface or above, such as a spring. This includes water that seeps onto the ground surface, evaporation from unsaturated soil, and water extracted from groundwater by plants (e.g. evapotranspiration) or engineering works (e.g. groundwater pumping).
Ecologically sustainable yield	The amount of water that can be abstracted or extracted over time from a water resource while maintaining the ecological values (including assets, functions and processes).
Ecological values	The natural ecological processes occurring within water-dependent ecosystems and the biodiversity of these systems.

Ecological water requirement	The water regime needed to maintain the ecological values (including assets, functions and processes) of water-dependent ecosystems at a low level of risk.
Ecosystem	A community or assemblage of communities of organisms, interacting with one another, and the specific environment in which they live and with which they also interact, e.g. lake, to include all the biological, chemical and physical resources and the interrelationships and dependencies that occur between those resources.
Environment	Living things, their physical, biological and social surroundings, and interactions between all of these.
Evaporation	Loss of water from the water surface or from the soil surface by vaporisation due to solar radiation.
Flow	Streamflow in terms of m^3/a, m^3/d or ML/yr. May also be referred to as discharge.
Groundwater	Water which occupies the pores and crevices of rock or soil beneath the land surface.
Inflows	Surface water runoff; deep drainage to groundwater (groundwater recharge); and transfers into the water system (both surface and groundwater), for a defined area.
Licence	A formal permit which entitles the licence holder to 'take' water from a watercourse, wetland or underground source.
Off-stream storage	Storages (such as farm dams, turkey's nest dams) that are not on defined waterways or watercourses and primarily store water either extracted from rivers or aquifers, or from flood water emanating from rivers or from local catchment runoff.
On-stream storage	Storages (such as farm dams) that are built on or within a defined waterway or water course.
Over-allocated	Sum of water access entitlements is more than 100 per cent of sustainable yield.
Over allocation	Refers to situations where with full development of water access entitlements in a particular system, the total volume of water able to be extracted by entitlement holders at a given time exceeds the environmentally sustainable level of extraction for that system.

Reliability	The frequency with which water allocated under a water access entitlement is able to be supplied in full. Referred to in some states as ‘high security’ and ‘general security’.
Riparian right	The right of a riparian land owner to take water from a watercourse, that flows through their property, unlicensed and free of charge for the purpose of stock and domestic use, without sensibly diminishing the flow of water downstream.
Self supply	Water diverted from a source by a private individual, company or public body for their own individual requirements.
Salinity	The measure of total soluble salt or mineral constituents in water. Water resources are classified based on salinity in terms of total dissolved salts (TDS) or total soluble salts (TSS). Measurements are usually in milligrams per litre (mg/L) or parts per thousand (ppt).
Social value	A particular in-situ quality, attribute or use that is important for public benefit, welfare, state or health (physical and spiritual).
Spring	A spring is where water naturally rises to and flows over the surface of land.
Stock and domestic water use	Water that is used for ordinary domestic purposes associated with a dwelling, such as: water for cattle or stock other than those being raised under intensive conditions; water for up to 0.2 ha (if groundwater) or 2 ha (if surface water) of garden from which no produce is sold. This take is generally considered a basic right. Note: (Intensive conditions under the Act means ‘conditions in which the cattle or stock: a) are confined to an area smaller than that required for grazing under normal conditions and b) are usually fed by hand or by mechanical means.’)
Surface water	Water flowing or held in streams, rivers and other wetlands on the surface of the landscape.

Watercourse	A watercourse means: a) any river, creek, stream or brook in which water flows b) any collection of water (including a reservoir) into, through or out of which any thing coming within paragraph (a) flows c) any place where water flows that is prescribed by local by-laws to be a watercourse and includes the bed and banks of any thing referred to in paragraph a, b or c. (Definition from the *Rights in Water and Irrigation Act 1914*)
Water-dependent ecosystems	Those parts of the environment, the species composition and natural ecological processes, of which are determined by the permanent or temporary presence of water resources, including flowing or standing water and water within groundwater aquifers.
Water entitlement	The quantity of water that a person is entitled to take annually in accordance with the *Rights in Water and Irrigation Act 1914* or a licence.
Water regime	A description of the variation of flow rate or water level over time. It may also include a description of water quality.
Water reserve	An area proclaimed under the *Metropolitan Water Supply, Sewerage and Drainage Act 1909* or *Country Areas Water Supply Act 1947* to allow the protection and use of water on or under the land for public water supplies.
Waterways	All streams, creeks, stormwater drains, rivers, estuaries, coastal lagoons, inlets and harbours.
Wetland	Wetlands are areas that are permanently, seasonally or intermittently waterlogged or inundated.
Yield	The volume of water that may be drawn from a well or water supply system.

Volumes of water

One litre	1 litre	1 litre	(L)
One thousand litres	1000 litres	1 kilolitre	(kL)
One million litres	1 000 000 litres	1 megalitre	(ML)
One thousand million litres	1 000 000 000 litres	1 gigalitre	(GL)

Shortened forms

CSIRO	Commonwealth Scientific and Industrial Research Organisation
DEC	Department of Conservation and Environment
DLI	Department of Land Information
DoP	Department of Planning
DoW	Department of Water
EF	Environmental flow
ESY	Ecologically sustainable yield
EWR	Ecological water requirement
IPCC	Intergovernmental Panel on Climate Change
MAF	Mean annual flow
PADFLOW	Proportional abstraction of daily flow
REG6	Regional model 6
REG75	Regional model 1975
REU	Resource Economics Unit
SDL	Sustainable diversion limits
SKM	Sinclair Knight Merz
SWDC	South West Development Commission
UoM	University of Melbourne
WRC	Water and Rivers Commission

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RECYCLED CONTENT

Department of **Water**
168 St Georges Terrace, Perth, Western Australia
PO Box K822 Perth Western Australia 6842
Phone: 08 6364 7600
Fax: 08 6364 7601
www.water.wa.gov.au

5330 50 0412