Warren–Donnelly surface water allocation plan methods report

Supporting information for the Warren–Donnelly surface water allocation plan

Looking after all our water needs

Department of Water

April 2012

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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.

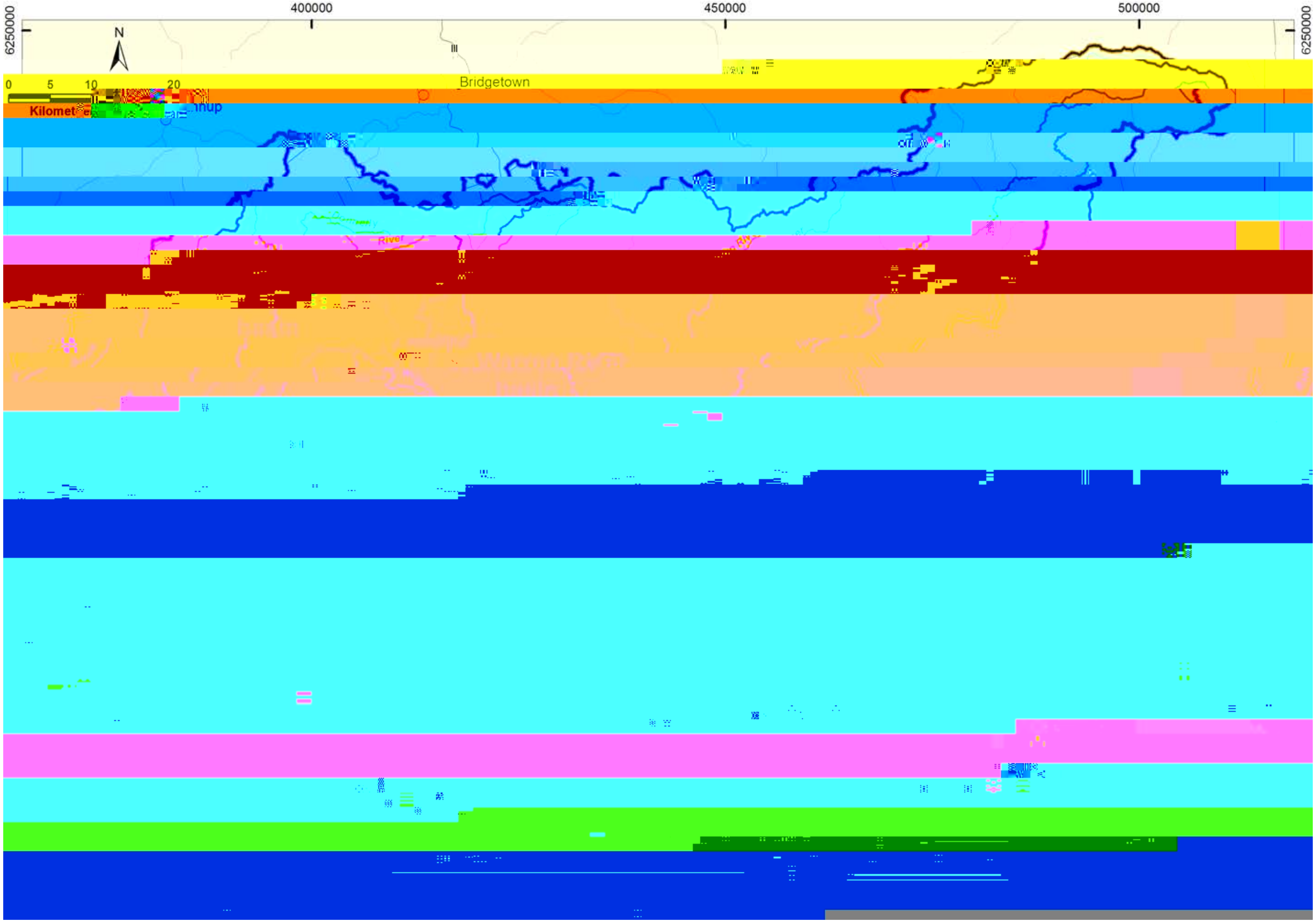


Figure 1   Warren–Donnelly surface water allocation plan area and proclaimed areas

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.

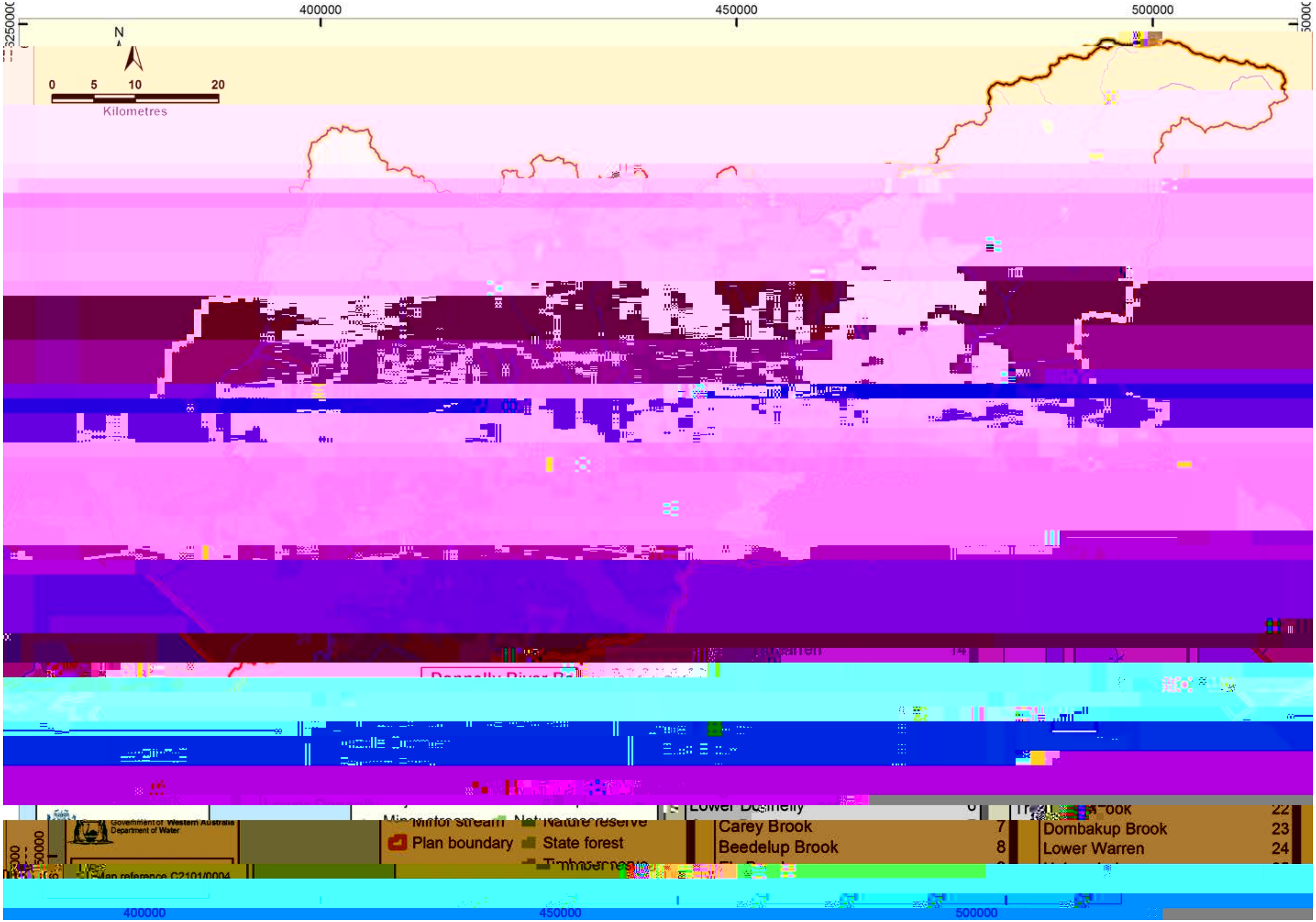


Figure 2 Warren–Donnelly surface water resources (subareas)

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>.

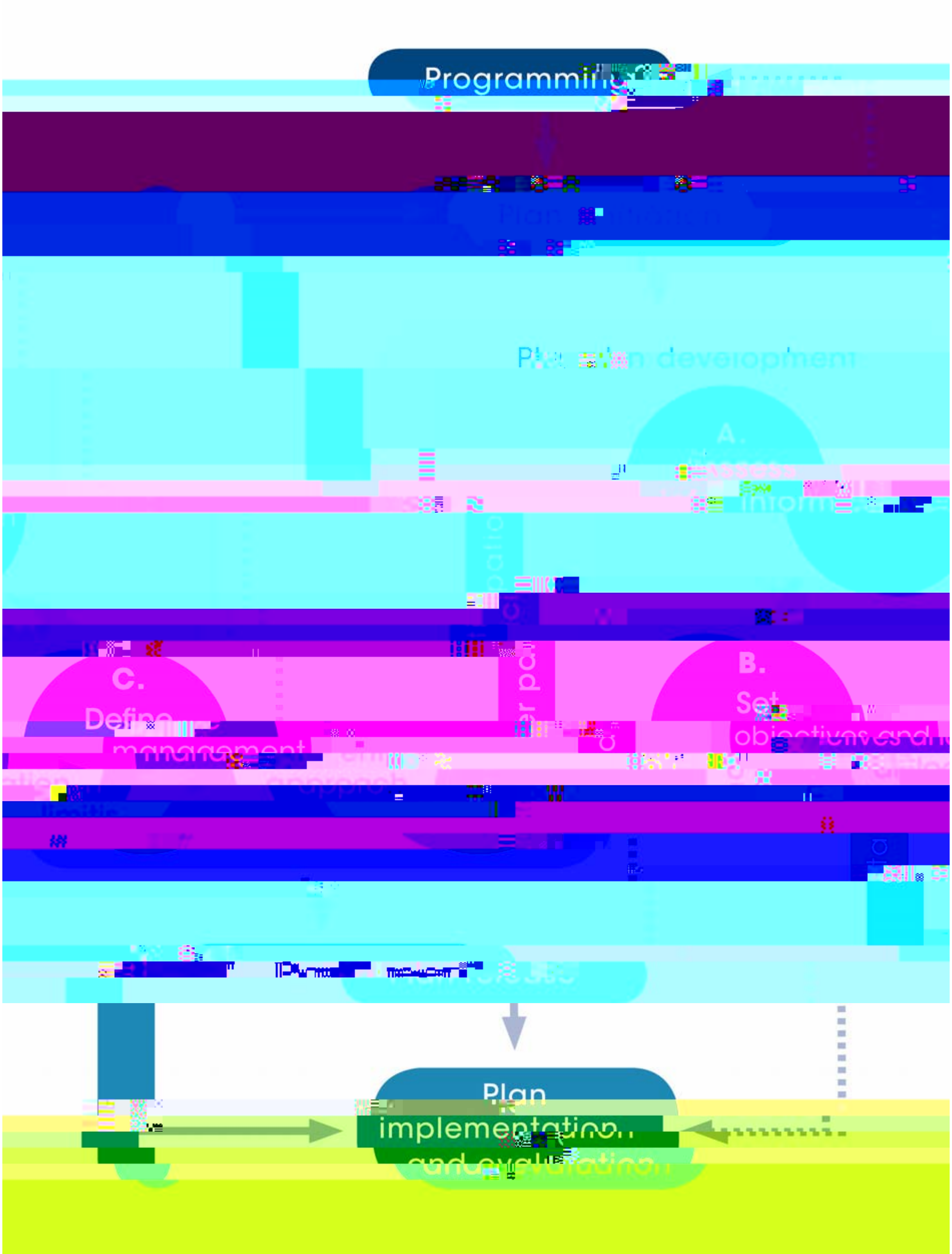
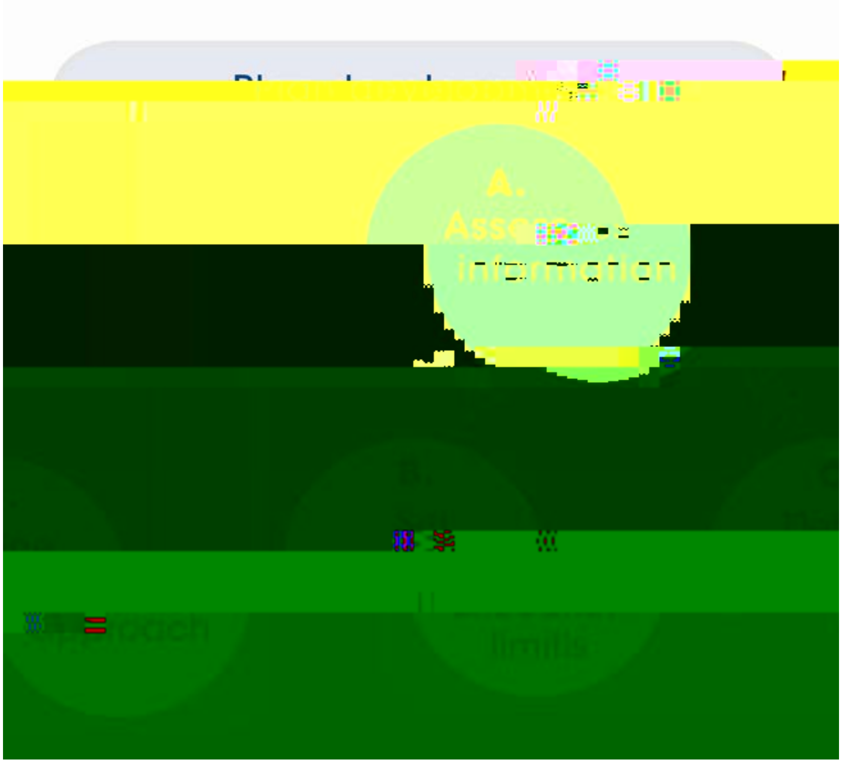


Figure 3 Water allocation planning process

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

2.3

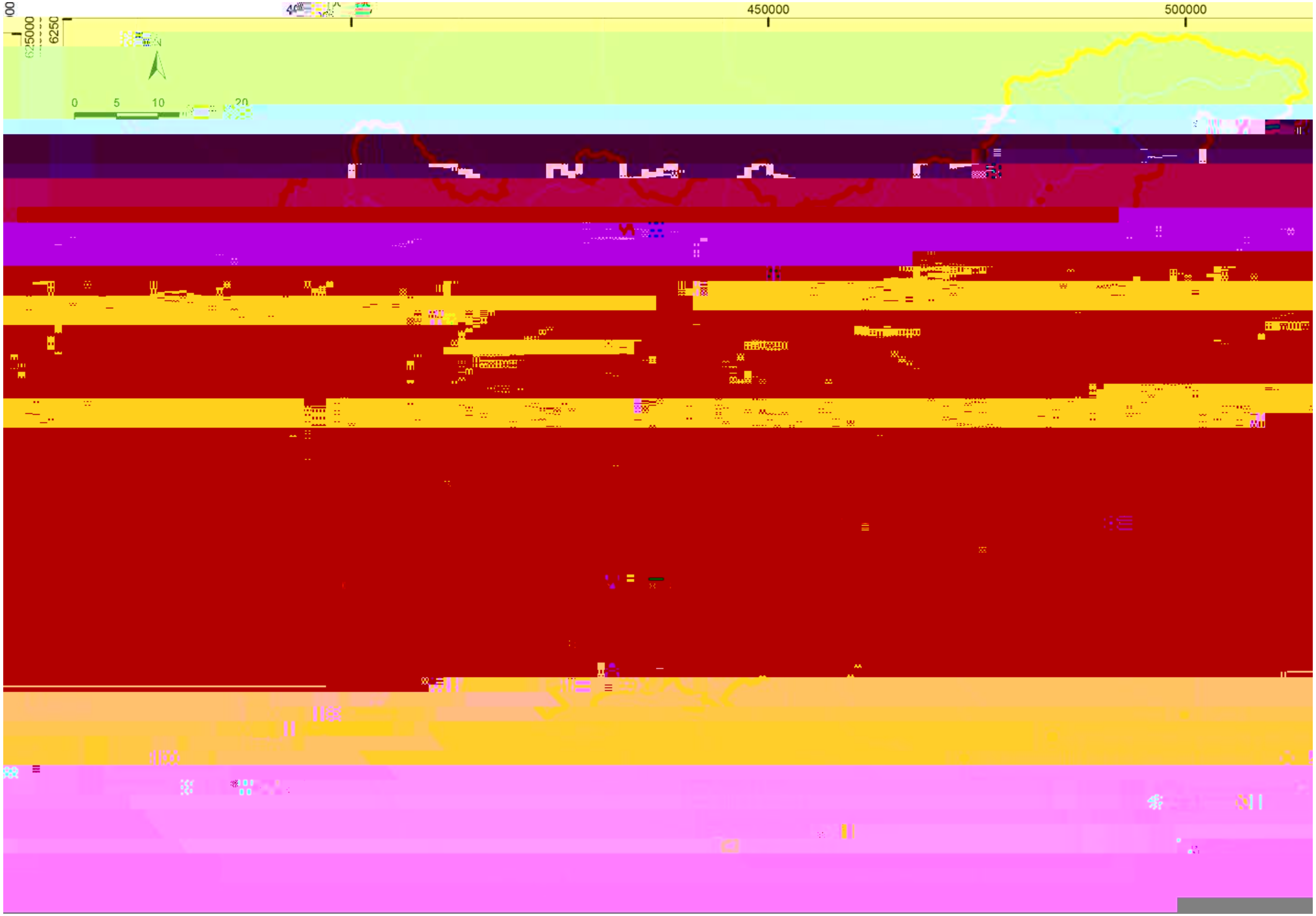


Figure 6   Stream gauging stations and mean annual rainfall across the Warren–Donnelly area

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

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

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

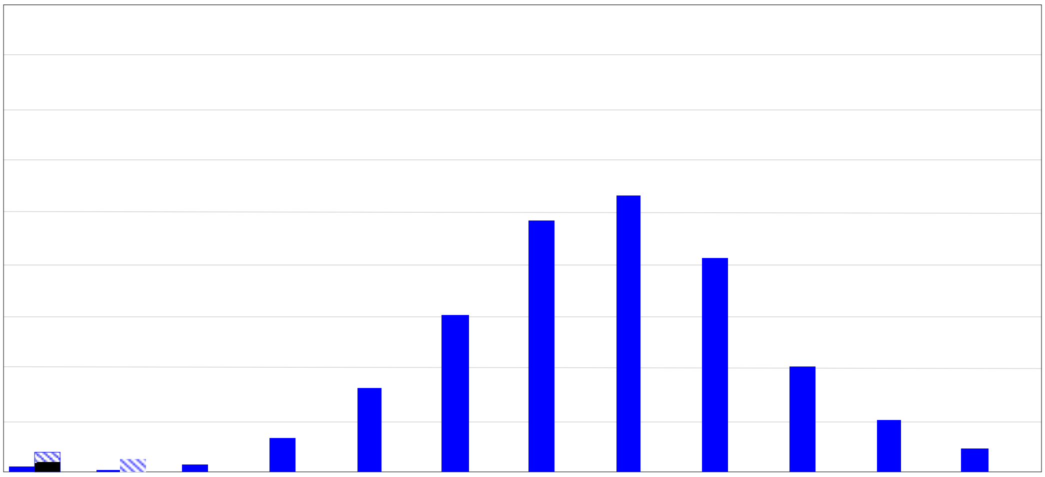
	Annual flow in the Upper Lefroy subarea GL					
Year	**Uncleared, no dams (A)**	**Cleared, no dams (B)**	**Cleared, with dams (C)**	**Increase in flow post-clearing (B – A)**	**Reduction in cleared flows from dams (B-C)**	
					Volume	**%**
1975	10.0	16.3	13.3	6.2	3.0	18
1976	9.1	15.0	10.3	5.9	4.7	31
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.

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).



of the change in flow regimes from clearing, farm dams and other effects of development.

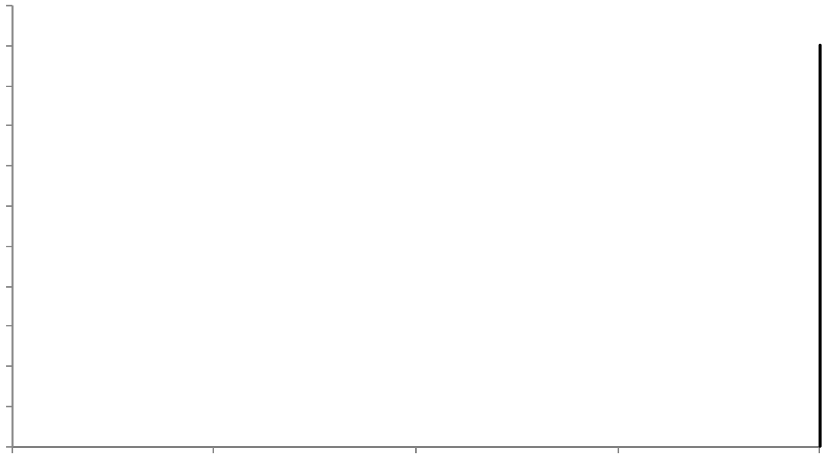
Clearing and development for agriculture is concentrated in the middle and upper parts of the Lefroy Brook catchment. The Cascades reach was selected as the representative reach for the study, as it is in good ecological condition and contains a gauging station with a good flow record. The study found 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*

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.



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

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^{2i}**	**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).*

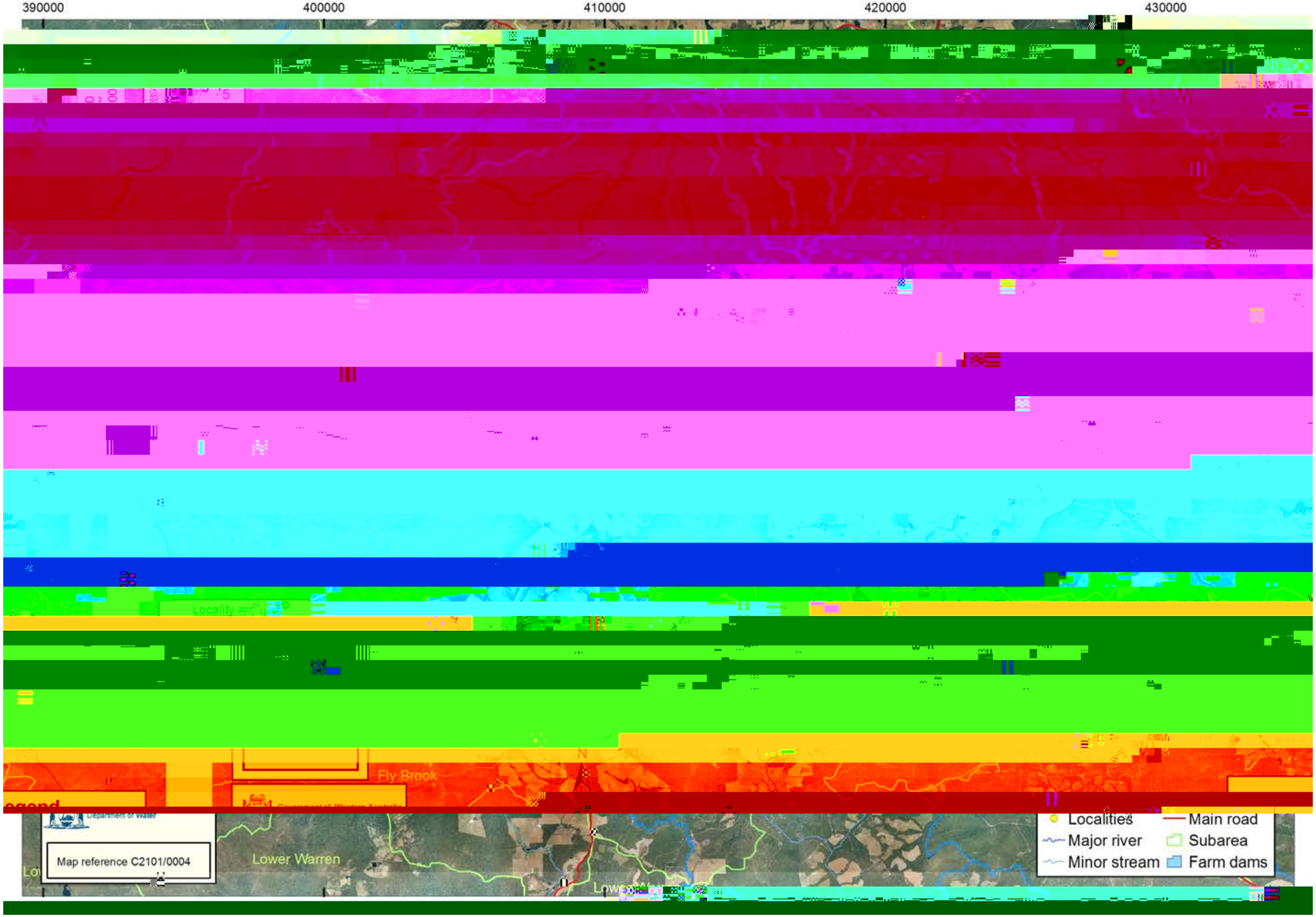


Figure 13 Farm dams of the Lefroy Brook, East Brook, Four Mile Brook and Upper Lefroy subareas

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).

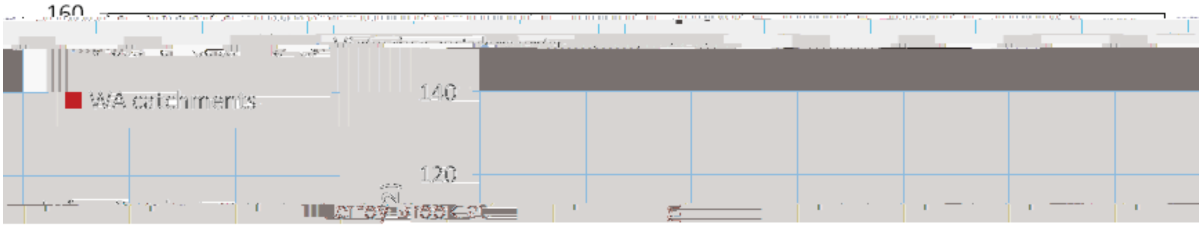


Figure 14 Comparison of farm dam density between Western Australian and Victorian catchments (SKM 2008c)

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 ithe .52Vsg247(daor6lx92 70.89c

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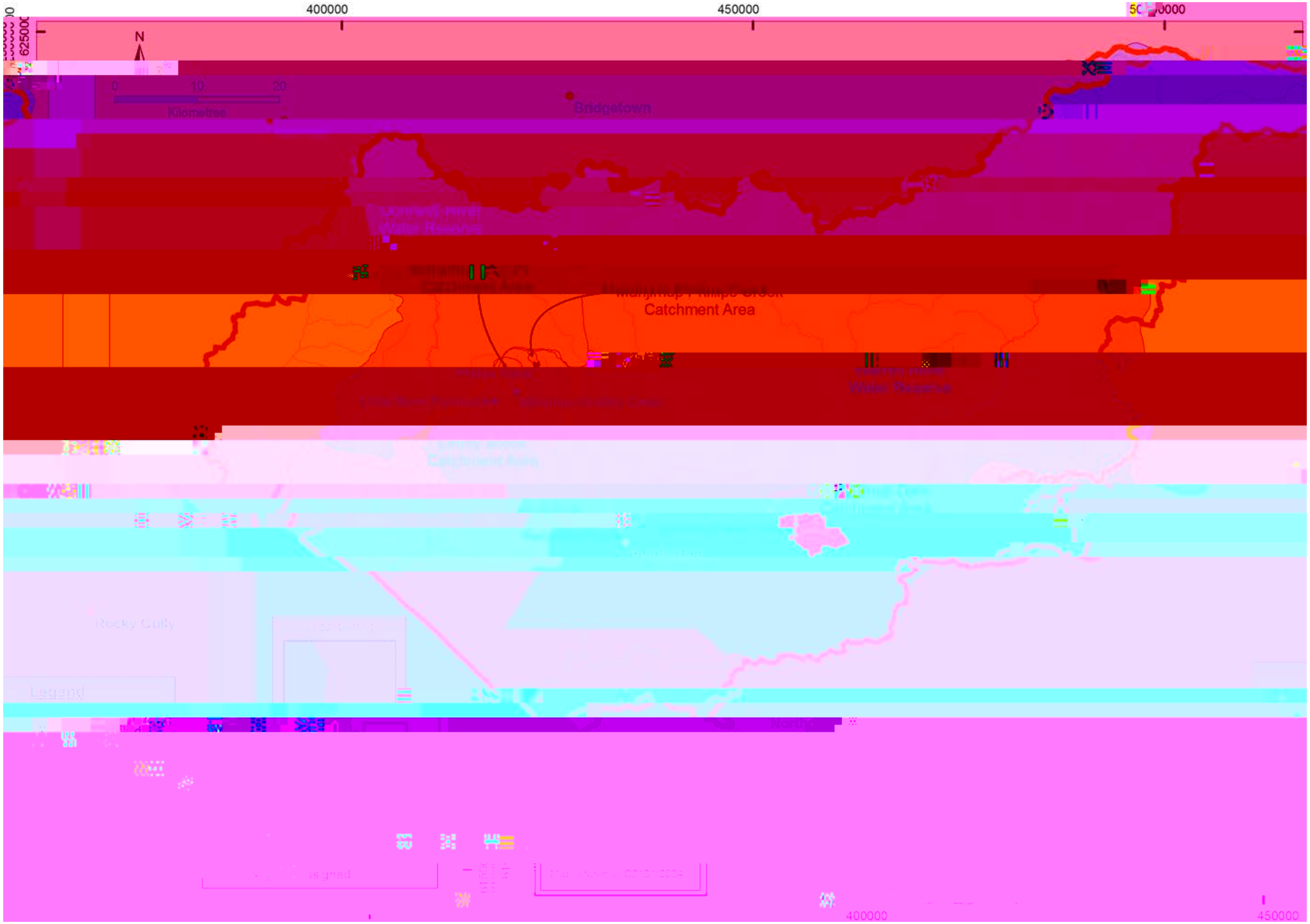


Figure 15 Public drinking water source areas in the Warren–Donnelly area

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

4.5 Current water use

The volume of water currently abstracted from the rivers in the Warren–Donnelly area is a combination of water capt

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	damw7a4r

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

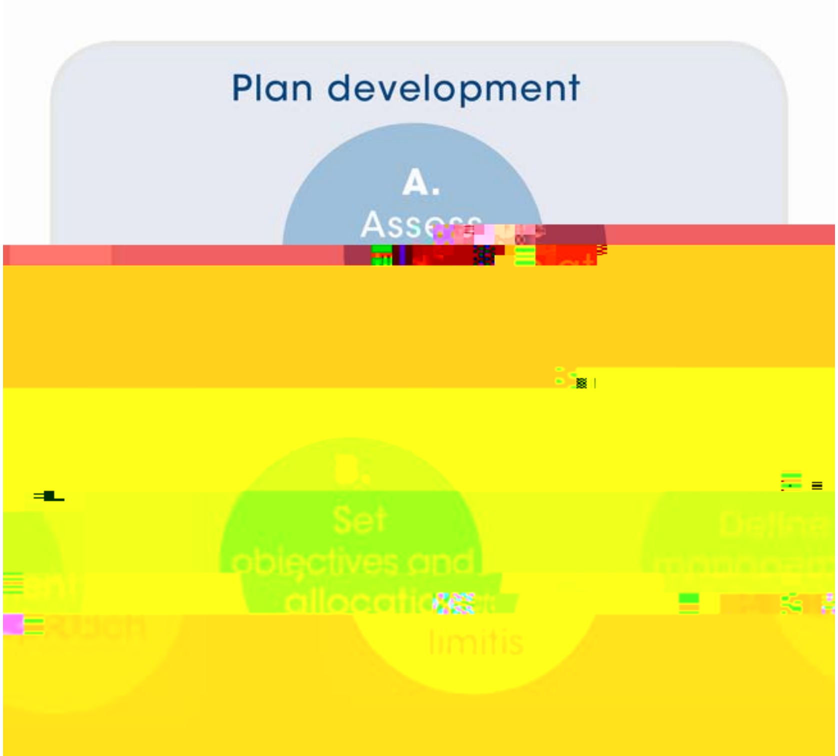
Water yields and demands in south-west Western Australia (CSIRO 2009) includes future water demand scenarios for high, medium and low demand scenarios to 2030. Modelling predicts self-ext

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

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		

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.

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

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

limits in the /0.0

minimum ESY in Figure 19). If, for example, the average ESY in Lefroy Brook was 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

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 12 Donnelly River basin yield calculations and allocation limits.

Subarea				**Ecologically sustainable yield**								
	Catchment category	**Risk**	**Minimum annual flow ML/yr**	**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. is calcu.2.0328 0 0 [(compmm2iR s3D1rb8r0e1T32 e

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

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[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

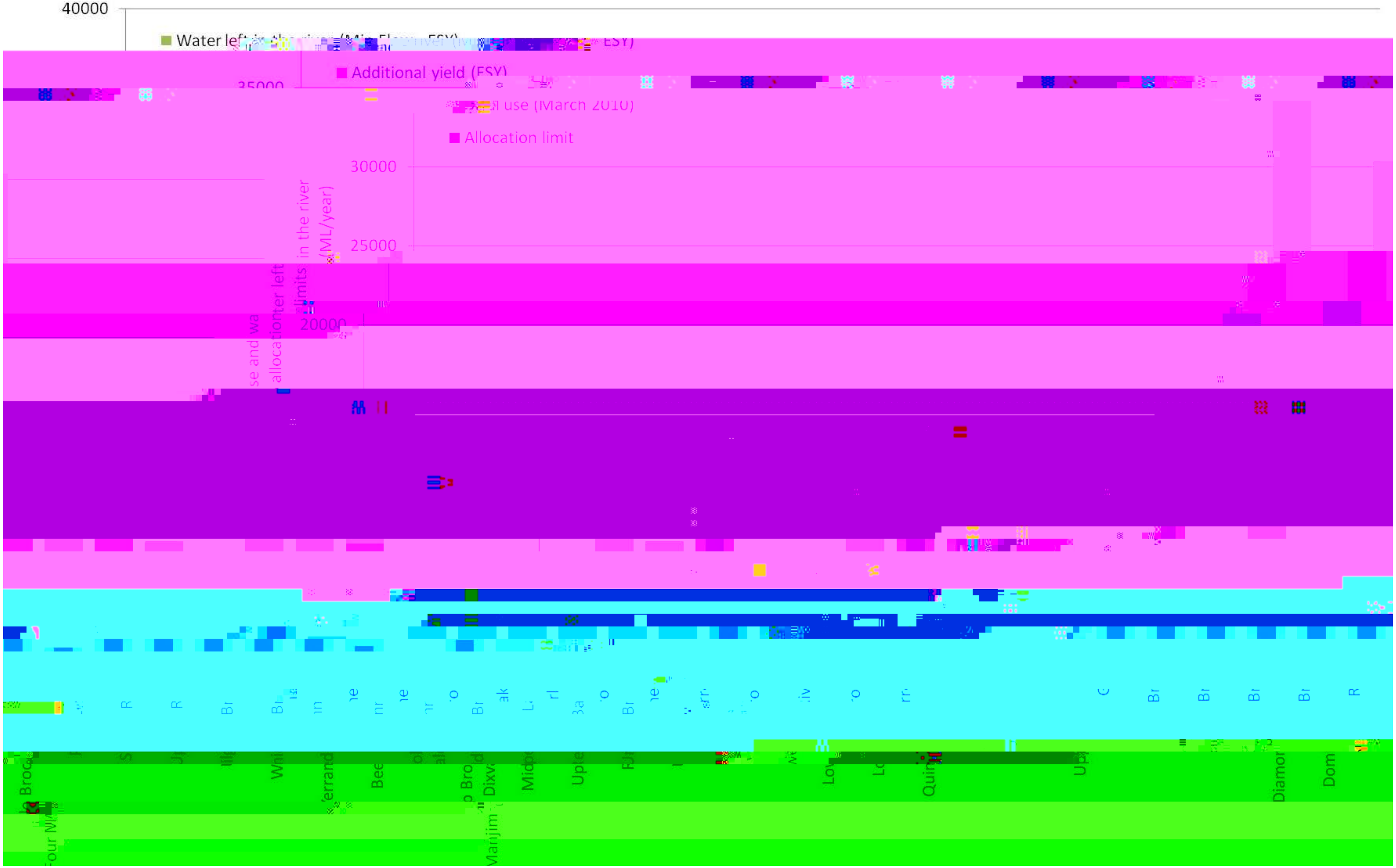


Figure 22 Allocation limits compared to total use, additional yield and water left in the river in the minimum flow year

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.

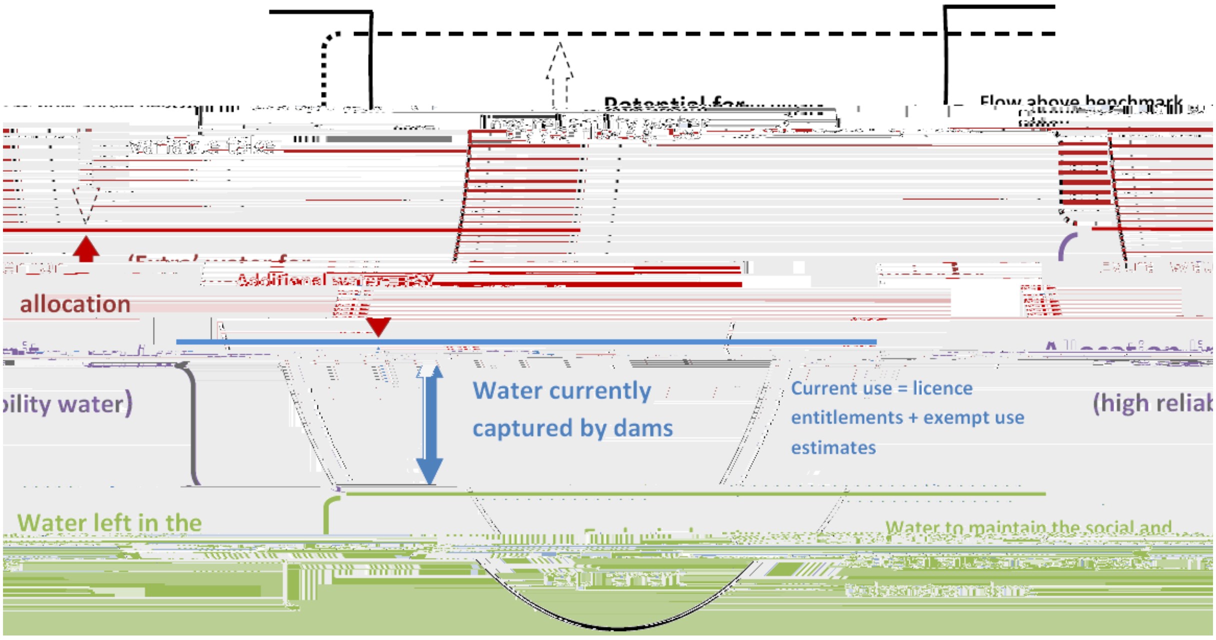


Figure 23 Conceptual model of river cross section and allocation limits in irrigated agriculture catchments

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.

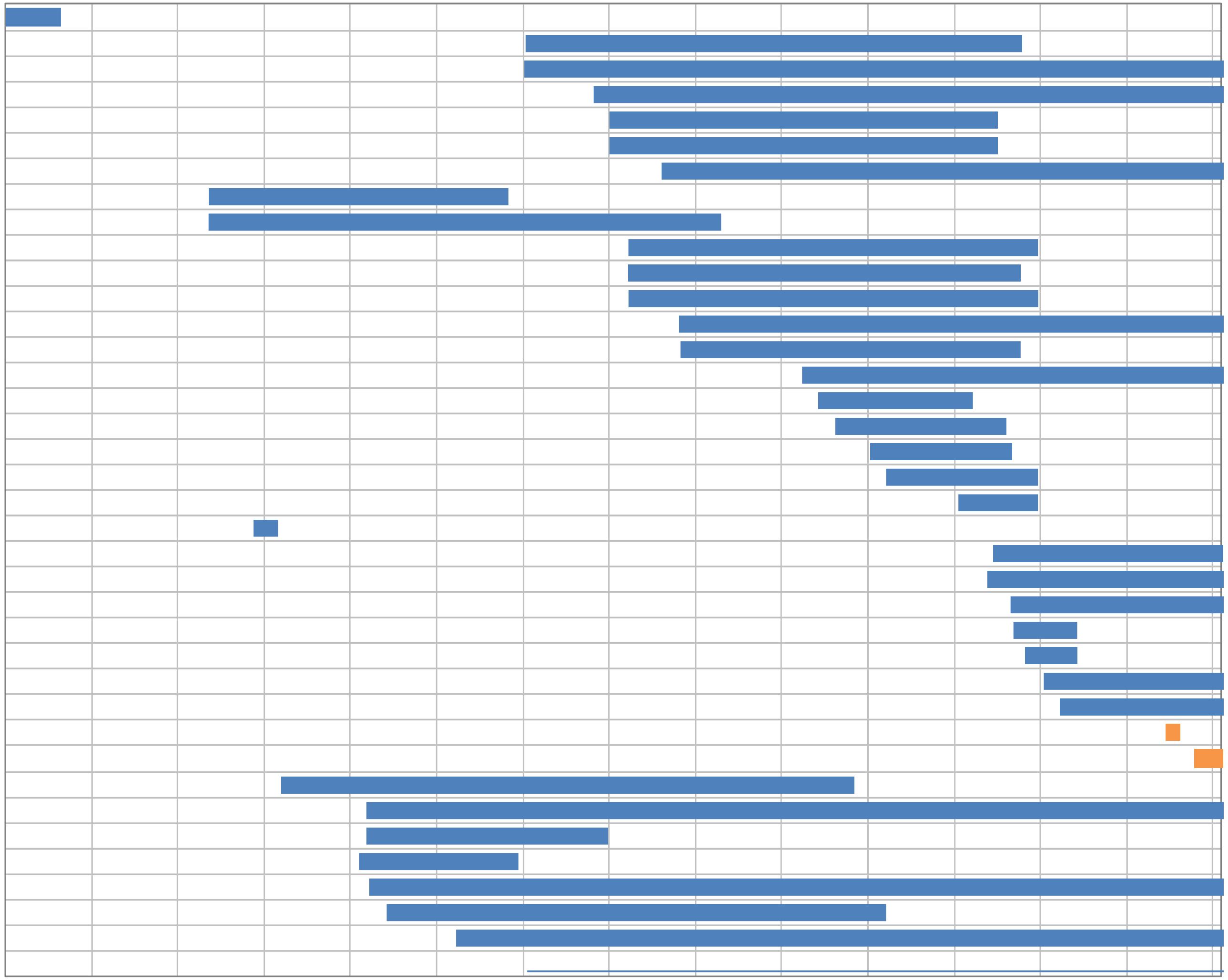
By using the lowest flow year as the benchmark and allowing some water to remain in the rivers, we are also allowing for some underuse of the available dam storage. Not all farm dams are used to their full extent (e.g. ‘sleeper licences’ or aesthetic dams). Allocating all of the river water in the lowest 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 lo



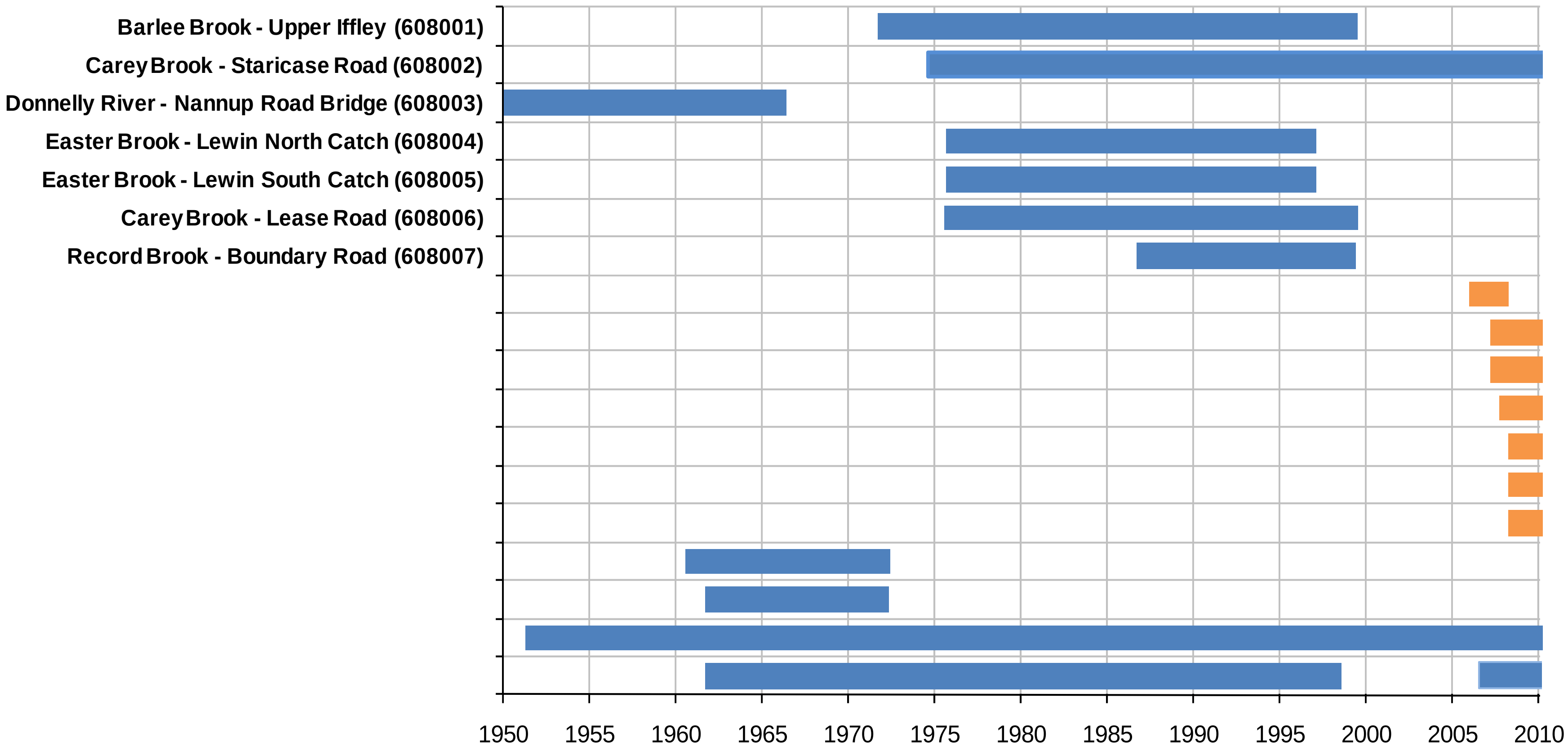

Barlee Brook - Upper Iffley (608001)
Carey Brook - Staricase Road (608002)
Donnelly River - Nannup Road Bridge (608003)
Easter Brook - Lewin North Catch (608004)
Easter Brook - Lewin South Catch (608005)
Carey Brook - Lease Road (608006)
Record Brook - Boundary Road (608007)
1950
1955
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010

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

Year	Annual flow in the Warren River basin subareas for 1975 to 2010 ML/yr[1]			
	Tone River	**Perup River**	**Yerraminnup River**	**Wilgarup River**

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

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	5154o97			

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

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

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:

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

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):

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

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

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

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}that 5003 Tm (Fc)-5.00256.42 495.5603 Tm/a,of m

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Watercourse	A watercourse means: a) any river, creek, stream or brook in which water flows

References

Sinclair Knight Merz 2007, *Impacts of farm dams in seven catchments in Western Australia*, Sinclair Knight Merz, Armadale, Victoria.

——2008a, *Approach for determining sustainable diversion limits for south west Western Australia*, report for the Department of Water, Perth.

——2008b, *Estimation of sustainable diversion limits for south west Western Australian catchments*, report for the Department of Water, Perth.

——2008c, *Impacts of farm dams on streamflow, impacts of farm dams in Lefroy Brook upstream of Channybearup*, report for the Department of Water, Perth.

South West Development Commission 2006,ining sustainablise1eepo 7e 08.5603 Tm (, Sinclair Kn

Donohue, R, Green, A, Moulden, B & Bennett, K 2010, *Ecological water requirements of Wilyabrup Brook*, Department of Water, Environmental water report series, in prep., Perth.

Donohue, R, Green, A, Storey, A & Lynas, J 2010, *Ecological water requirements of Chapman Brook*, Department of Water, Environmental water report series, in prep., Perth.

Pen L 1999, *Managing our rivers: A guide to the nature and management of the streams of the south-west Western Australia*, Water and Rivers Commission, Perth.

Smith MG, Dixon, RNM, Boniecka, LH, Berti, ML, Sparks, T, Bari, MA& Platt, J 2006, *Salinity situation statement: Warren River,* Department of Water, Water resource technical series no. WRT 32, Perth.

Smith RA 2003, *Hydrogeology of the Muir–Unicup catchments, Western Australia*, Salinity and land use impacts series report SLUI 22, Water and Rivers Commission, Perth.

RECYCLED CONTENT

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