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

Warren-Donnelly surface water allocation limits report

Supporting information for the Warren-Donnelly surface water allocation plan

Looking after all our water needs

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1 Introduction

During 2009 and 2010, the Department of Water prepared the *Warren-Donnelly surface water allocation plan: for public comment* (DoW 2010) (Warren-Donnelly plan). This allocation limits report describes how the department developed the surface water allocation limits in the Warren-Donnelly plan.

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

In the Warren-Donnelly area, irrigated agriculture is the primary user of surface water. Rivers also support water-dependent ecological values that are under pressure from loss of habitat in some areas and from a drying climate. Irrigated agriculture in the area is a self-supply industry which depends almost entirely on river water stored in on-stream (gully wall) dams which intercept catchment runoff.

1.1 What is an allocation limit?

An allocation limit is the annual volume of water set aside for consumptive use from a water resource. Allocation limits are the main tool the department uses to manage abstraction. Water is allocated within the allocation limit through the department's licensing process, complemented by other mechanisms (monitoring, investigations, and compliance) with the aim of minimising the impacts of water abstraction on the environment and other users.

1.2 Allocation units

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).

In this document, 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 1 Area covered by the Warren-Donnelly surface water allocation plan

Figure 2 Warren-Donnelly surface water resources and proclaimed areas

1.3 Previous allocation limits

Surface water use in the Warren and Donnelly river basins has been managed through licences since the 1960s. Until 2008, the department estimated the yield of rivers in the south-west as a per cent of mean annual flow, which was calculated based on land clearing and rainfall data using regional models REG6 and REG75. The REG6 model used the minimum of the 10th percentile annual flow and 60 per cent of the mean annual flow. REG75 used 18 per cent of the mean annual flow (30 per cent of 60 per cent). The REG75 model replaced the REG6 model and incorporated the lower average rainfall period of 1975-2003 (DoW 2007b).

The department recognised that because of variability in streamflow between years, mean annual flow was not a reliable basis for allocation. Ecological studies also showed that allocation based on REG75 may not sufficiently meet environmental needs. So in 2007, the department initiated a project to determine streamflow diversion limits for south-west rivers (from Geraldton to Esperance) that would maintain an acceptable reliability of supply to water users and protect river ecology in most years. The sustainable diversion limits (SDL) project was completed in April 2008 (SKM 2008a & b). The sustainable diversion limit volumes from this project indicated that some areas in the Warren-Donnelly area may be fully or over-allocated.

In May 2008, the department announced the sustainable diversion limit volumes as recommended allocation limits in the Warren-Donnelly area. In effect, the department capped water use at current licensed entitlements where entitlements were higher than the sustainable diversion limit volumes. This reduced the risk of further allocations affecting water supply to existing water users and the health of river ecosystems and brought forward the need to review the allocation limits more formally through an allocation planning process.

The sustainable diversion limit methodology is based largely on hydrology. Since then more specific ecological water studies have been completed across the south-west. The methodology used to calculate streamflow yields for new allocation limits incorporates the new ecological information. The new allocation limit decisions also take into account new farm dam studies, the impact of further allocations on existing water users, and salinity.

This report sets out how the department has developed new allocation limits. The allocation limits in the 2010 Warren-Donnelly plan replace the allocation limits announced in 2008.

1.4 Reviewing the allocation limits

The aim of reviewing and updating the Warren-Donnelly allocation limits is to:

- maximise the availability of water for consumptive use within sustainable limits
- maintain the reliability of supply of water to existing water users

- prevent over-allocation and over-use
- avoid unacceptable impacts on water-dependent ecosystems.

The department used the best scientific information available at the time (including information from studies that were completed after the 2008 allocation limits were announced). To protect water supply to existing licence-holders and the environment, the department has accounted for any uncertainty in the accuracy of information and risks of over-allocation (discussed in Section 5).

2 Surface water hydrology

This section provides a summary of the hydrology in the Warren and Donnelly river basins and the implications for sustainable yields and the supply of water.

A more detailed study on the surface water hydrology of Lefroy Brook, downstream of Pemberton townsite (DoW 2008) and the *Salinity Situation Statement: Warren River* (Smith et al. 2006) are available on our website (<www.water.wa.gov.au>). More detailed studies on the surface water hydrology of Barlee and Carey brooks in the Donnelly River basin are currently in preparation, along with a detailed hydrologic investigation into the Warren and Donnelly river basins.

2.1 Catchment description

The Donnelly River basin covers an area of 1728 km^2. The catchment is mostly forested with some clearing for irrigated agriculture in the north-east, around the Manjimup area (Figure 1).

The Donnelly River has two large tributaries, Barlee Brook and Carey Brook, which have catchment areas of 392 km^2 and 135 km^2 respectively. The majority of the Barlee Brook catchment is covered by national park or conservation areas, with only a small cleared area in the middle of the catchment. Most of the Carey Brook catchment is covered by the Beedelup National Park with the exception of small cleared areas in the east and in parts of Beedelup Brook (Figure 1).

The Warren River basin covers an area of 4370 km^2. The catchment is predominantly forested with clearing for agriculture predominantly in the Tone River catchment. Extensive plantation development has occurred in the catchment since the 1990s. The towns of Manjimup and Pemberton are located within the Warren River basin.

The Warren River has seven main tributaries (Figure 1). The Tone River becomes the Warren River after the confluence with Perup River. Much of the clearing in the basin, and associated salinity problems, are upstream of this confluence. Wilgarup River, Quininnup, Smith, Lefroy and Dombakup brooks are located in the lower portion of the basin.

The Lefroy Brook catchment covers an area of 358 km^2 in the western part of the Warren River basin. About 40 per cent of the Lefroy Brook catchment has been cleared for agriculture, most occurring in the Upper Lefroy resource. Lefroy Brook flows through Pemberton before joining the Warren River.

2.2 Climate and rainfall

The Warren-Donnelly area has a temperate climate with distinctly dry, hot summers and wet cool winters. Mean annual rainfall generally reduces with distance from the coast, 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 (Figure 4).

There has been a 6 per cent decline in mean annual rainfall for the period 1975 to 2008, compared to the long-term average (Figure 3). The mean annual rainfall for the period 1997 to 2008 is similar to the mean annual rainfall for the period 1975 to 2008 in the Manjimup area and has increased slightly (2 per cent) at Pemberton (Figure 3).

Rainfall in the region is highly seasonal with about 70 per cent of annual rainfall occurring between May and September. Rainfall peaks in July. Since 1975, the seasonal distribution of rainfall has changed, with less rainfall in autumn and early winter (April to June) and more rainfall in spring (September to October).

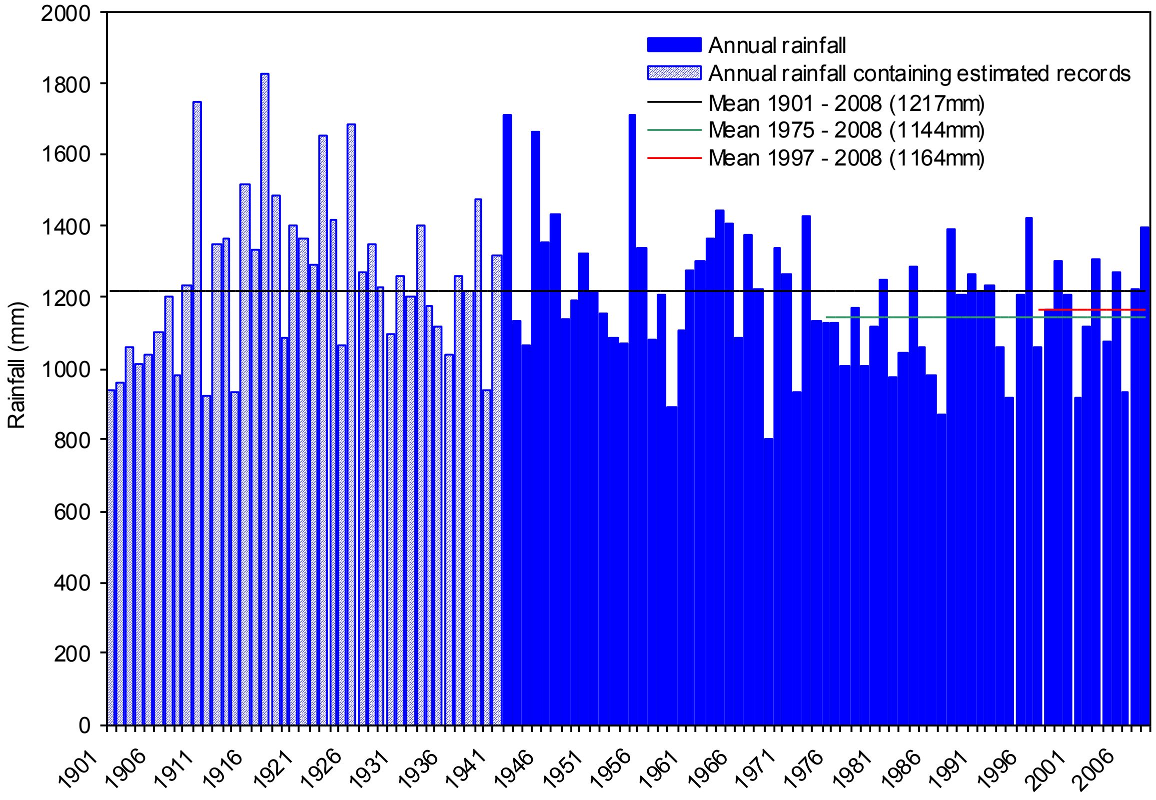


Figure 3 Annual rainfall at Pemberton rainfall gauging station (009592)

Figure 4 Stream gauging stations and mean annual rainfall across the Warren-Donnelly area

2.3 Variation in flow

In rivers in the upper parts of the Warren and Donnelly river basins, flow typically only ceases in February or March of most years. In the lower, wetter parts of the basins, the rivers tend to flow all year, although in dry periods these rivers can also stop flowing. For example, at the Strickland gauging station on the Donnelly River (608151) (Figure 4), flows tend to continue through the dry summer months. However, the river has stopped flowing around March and April in some summers after 1975 (1988, 1995, 2002, 2003, 2004, 2005 and 2006). The cause of the drying is possibly due to a decrease in the saturated area due to the reduced rainfall in the post-1975 period.

As with the rainfall, flow is highly seasonal. Flows tend to peak in August, compared with the peak rainfall month of July. With the declining trend in annual flow, monthly streamflow has decreased for all months. There is also an apparent shift in the seasonal pattern of flow, with relatively less flow in winter (June to August) and relatively more flow later into the year (Figure 5).

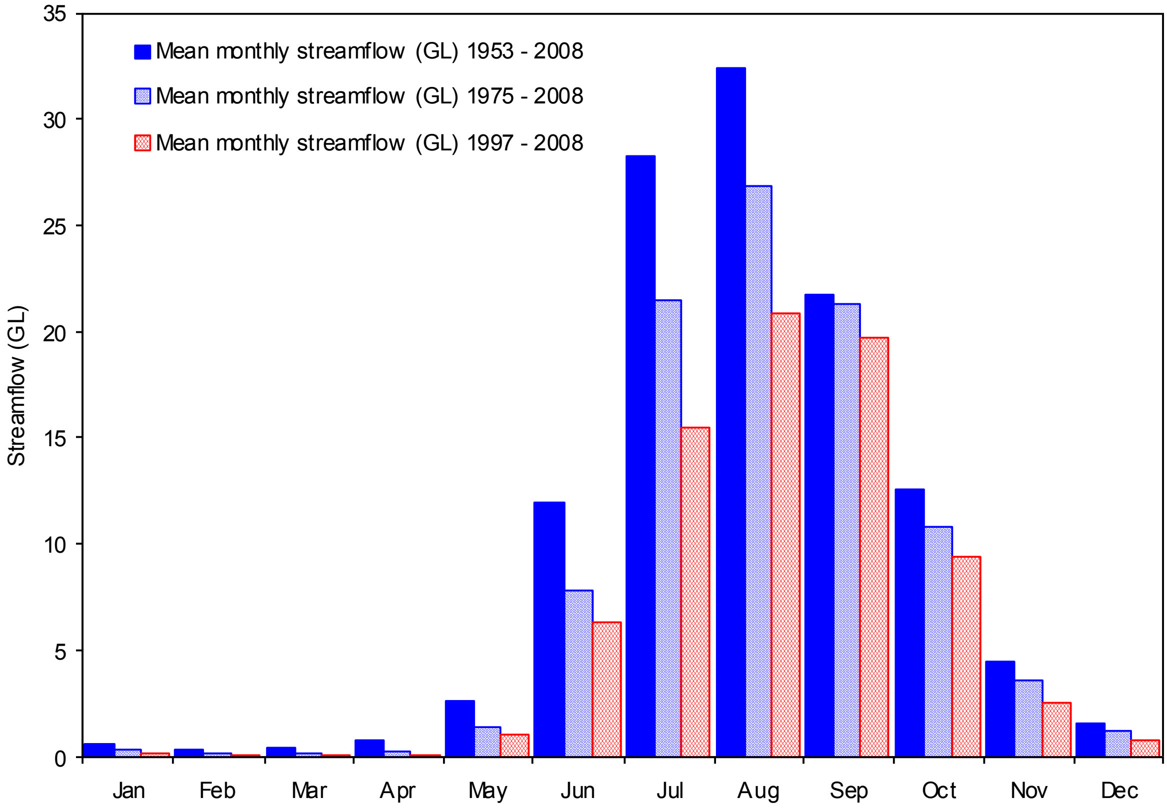


Figure 5 Variation in mean monthly streamflow for the Donnelly River at Strickland gauging station (608151)

Only some of the catchments have stream gauges, so annual flows for each surface water resource (river) were estimated based on existing gauged catchments. Streamflows for non-gauged catchments was scaled, by catchment area, from gauging stations in catchments which were relatively close and which were hydrologically similar.

Flow in the rivers also varies between years (Tables 1 and 2). For example, annual flow in the Wilgarup River has varied between a low of 4.6 GL in 2001 to a high of 64 GL in 1998. In the same period, annual flow in the Upper Lefroy resource has varied between 3 GL and 25 GL. This variation is important when deciding which year or series of years to base allocation limits on. An average flow year is likely to be very different from a low flow year and allocation limits based on an average flow year would not be achievable during a low flow year. In order to provide an allocation limit that has the greatest reliability, low flow years have been used. The lowest flow year for the various Warren and Donnelly river basin resources is shown in Tables 1 and 2, respectively.

Table 1 Annual flow in the Warren River basin resources for 1975 to 2007

	Annual flow in the Warren River basin resources for 1975 to 2007 ML/yr														
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
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

Annual flow in the Warren River basin resources for 1975 to 2007
ML/yr

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
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
Min	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	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	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

Note: Minimum annual flows are shown in bold

Table 2 Annual flow in the Donnelly River basin resources for 1975 to 2007

Annual flow in the Donnelly River basin resources for 1975 to 2007 ML/yr									
Year	**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
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

Annual flow in the Donnelly River basin resources for 1975 to 2007 ML/yr									
Year	Upper Donnelly	Manjimup Brook/ Yanmah-Dixvale	Middle Donnelly	Record Brook	Barlee	Lower Donnelly	Carey Brook	Beedelup Brook	Fly Brook
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
Min	9 282	5 269	2 896	1 175	34 263	30 376	9 260	6 278	7 160
Mean	39 314	22 318	12 267	3 441	73 913	81 451	18 099	12 271	17 359
Max	83 353	47 318	26 009	6 182	124 864	151 190	28 931	19 614	30 302

Note: Minimum annual flows are shown in bold

3 Water resource development and use

To set surface water allocation limits we need to understand the characteristics of water resource development in the area, how surface water is abstracted and used and how this use affects water-dependent ecosystems and social values of the area. In the Warren-Donnelly area, river flow is intercepted by large and small 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.

3.1 On-stream dams for 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, pears and avocados, and vegetables such as potatoes, onions, cauliflower, broccoli and lettuce. The farm dams are typically gully wall dams that are constructed on-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. Overall, the period of highest water demand for irrigated agriculture is from about January to April, which is the driest part of the year.

As at December 2009, there are 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 store 25.6 GL of the flow in the Warren River basin and 7.8 GL of the flow in the Donnelly River basin (Table 3). The size of commercial 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 up to 1.5 GL.

Some resources, 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 6). The Upper Lefroy resource has the highest storage density in the Warren-Donnelly area. For every square kilometre of the Upper Lefroy resource there is 65 ML of surface water storage capacity in on-stream farm dams (licensed entitlements, see Table 3).

Table 3 Mean annual flow, licensed entitlements and storage density for each resource

Resource	Mean annual flow[1] ML	Licensed entitlements[2] ML	Overall storage density[3] ML stored per km^2	Storage density using cleared area upstream of use only ML/km^2
		Warren River basin		
Tone River	51 357	50	0	0
Perup River	11 405	478	1	1
Yerraminnup River	5 323	12	0	0
Wilgarup River	25 881	5 637	12	12
Upper Warren	42 623	1 172	3	4
Quinninup Brook	20 302	368	3	3
Smith Brook	14 601	3 139	30	30
Diamond Tree Gully	4 767	253	9	11
Upper Lefroy	13 609	5 967	65	76
East Brook	12 576	2 477	33	46
Lefroy Brook	12 312	1 546	20	26
Four Mile Brook / Big Brook	20 852	3 244	28	38
Treen Brook	14 015	799	13	13
Dombakup Brook	38 574	120	1	2
Lower Warren	20 015	312	1	1
Unicup Lakes	13 609	0	0	0
Warren River total	**321 819**	**25 574**		
		Donnelly River basin		
Upper Donnelly	39 314	370	1	4
Manjimup Brook / Yanmah-Dixvale	22 318	4 728	26	32
Middle Donnelly	12 267	1 115	11	12
Record Brook	3 441	0	0	0
Barlee	73 913	0	0	0
Lower Donnelly	81 451	13	0	0
Carey Brook	18 099	0	0	0
Beedelup Brook	12 271	739	14	14
Fly Brook	17 359	795	12	12
Donnelly River total	**280 432**	**7 760**		

Notes

1. Mean annual flow 1975 to 2007
2. Licensed entitlements as at 24 March 2010. Licensed entitlement volume generally based on dam storage volume.
3. Storage density calculations based on licensed entitlement volumes (does not include estimates of existing stock and domestic use) (see Section 5.2)

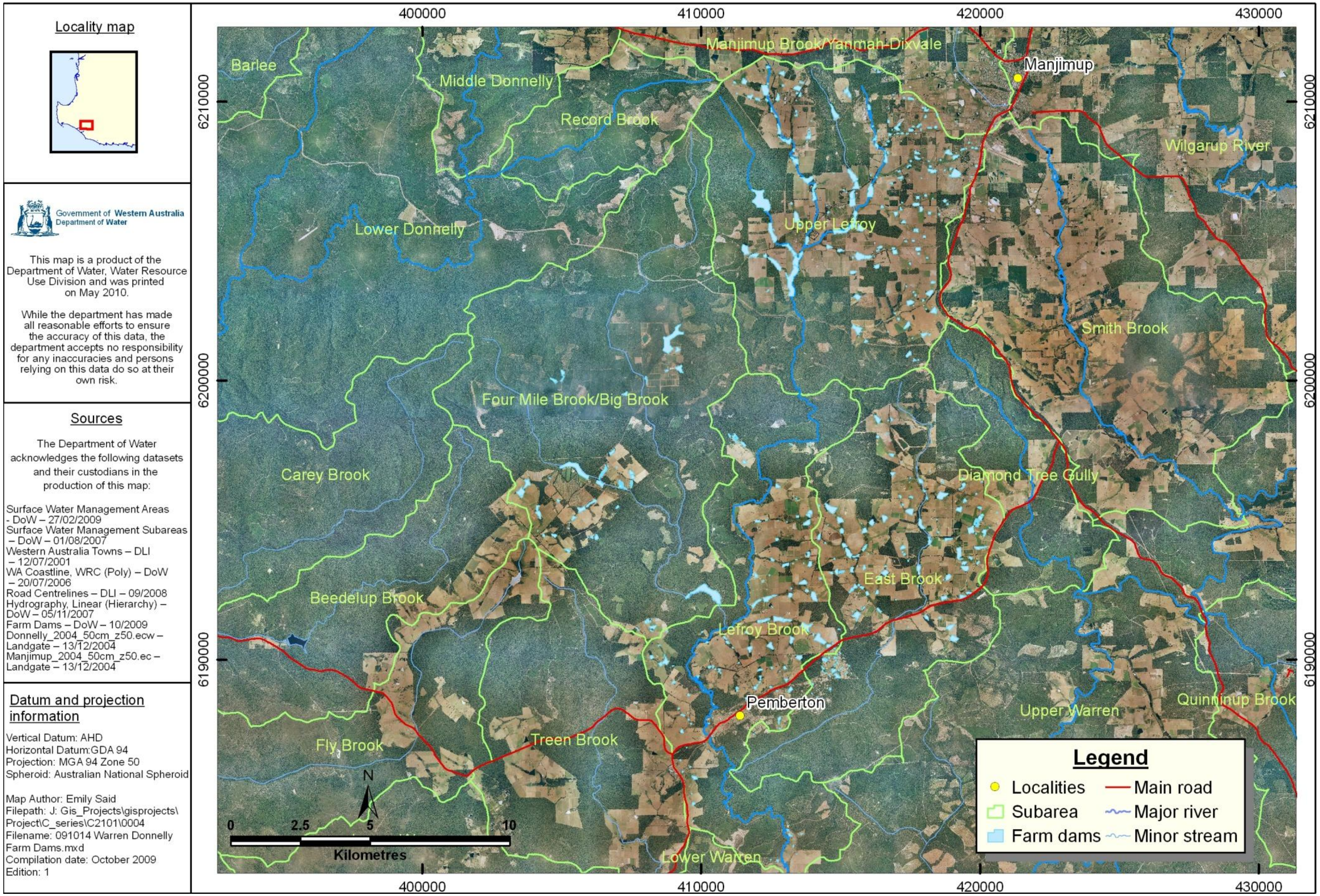


Figure 6 Farm dams of the Lefroy Brook, East Brook, Four Mile Brook and the Upper Lefroy resources

Between 50 and 70 per cent of water in irrigation dams is used to water crops. The remaining water in the dams is needed as a buffer against evaporation, variation in the length of the irrigation season and to cover longer periods of drought (known as ‘drought proofing’, also see Section 3.2.2). Some of the extra water is also required to keep the dam walls moist to maintain structural integrity.

Once a dam is full, inflows spill downstream, usually via spillways at the edge of dam walls. Most of the irrigation dams have under wall scour valves that are used to release unused, poor quality water at the end of the irrigation season. Some irrigators leave scour valves open until late winter to minimise overspill and the risk of damage to the earthen dam walls or spillways. The valves are closed as flows begin to recede so that the dams will fill before the start of the irrigation season. In some areas the scour valves are left closed all winter.

Few dams have any other means to divert low flows or control the volume of river water intercepted every year. Given the way dams are typically operated, the volume of water intercepted in each resource every year is basically equivalent to the total maximum storage of the dams (SKM 2007).

3.2 Implications of on-stream dams for allocating surface water

Existing and new dams affect the magnitude and seasonal pattern of river flow. The most important considerations in determining sustainable yields and setting allocation limits are:

- the impact of increased water entitlements on the reliability of water supply to existing users
- the impact of existing and new entitlements on river ecosystems.

3.2.1 Impacts of catchment clearing and farm dams on river flow

The department modelled the impacts of farm dams and catchment clearing on river flows in the Upper Lefroy resource in the Warren River basin using flow data from the Channybearup site (closed gauging station 607002). The department used a combination of a farm dam model (SKM 2008C) and the ‘forest cover flow change’ land-use change model to estimate the combined effects of dams and catchment clearing.

The impact of clearing and the interception of runoff by farm dams on annual flow in the Upper Lefroy, the most developed of the resources, is shown in Table 4. In the Upper Lefroy, modelling found that the decreases in annual flow caused by interception by dams are generally less than the increases in flow from clearing (Table 4). For example, modelling suggests that flows in the Upper Lefroy increased by an average of 6.4 GL/yr following clearing, but decreased by an average of 3.6 GL/yr (or 22 per cent) by farm dams. Note however, that in the driest year (1987), the reduction in flow by dams (4.0 GL) exceeds the increases following clearing (3.4 GL).

Table 4 Comparison of annual flow in the Upper Lefroy resource as a result of clearing of native vegetation and construction of farm dams

	Annual flow in the Upper Lefroy resource GL					
Year[1]	Uncleared, no dams (A)	Cleared, no dams (B)	Cleared, with dams (C)	Increase in flow post-clearing (B – A)	Reduction in post-clearing flows by 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

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

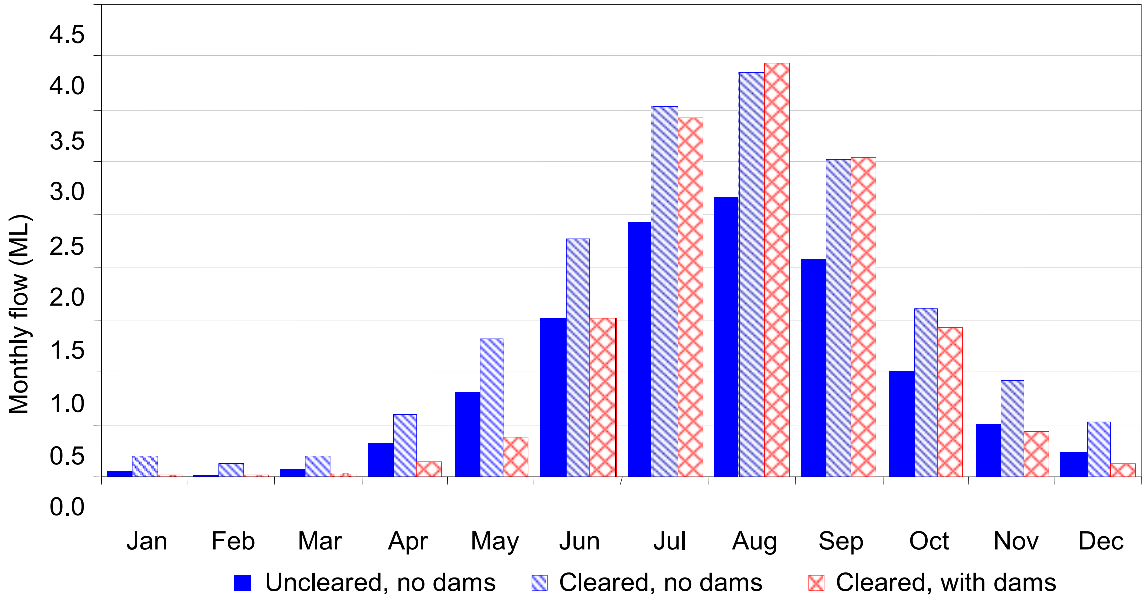


Figure 7 Changes to seasonal patterns of flow from catchment clearing and on-stream farm dams in the Upper Lefroy resource

The effect of clearing and farm dams on seasonal flows is shown in Figure 7. Modelling shows that flows increased following clearing for all months (compare 'Cleared, no dams' scenario with 'Uncleared, no dams' scenario in Figure 7). Interception by dams post-clearing has decreased flows in the drier months from November and as the dams are filling in late autumn and early winter (compare 'Cleared, with dams' scenario with 'Cleared, no dams' scenario in Figure 7). Later winter flows are unaffected by interception as dams are full and spilling.

Modelling of flows in seven river systems studied in the south west indicates that flows are affected more in dry years (SKM 2007). For example, modelling suggests farm dams in the Upper Lefroy have reduced winter flows post clearing by 45 per cent in the lowest flow year for the period 1975 to 2005, compared to an average reduction of 10 per cent. The impact of new dams on existing irrigators and river ecosystems will be more severe in low flow years.

3.2.2 Reliability of water supply

Currently, dams consistently fill by the end of the winter period (even in years of very low rainfall). For example, in years of low rainfall, at least 3 GL of water continues to flow through the dam network in Upper Lefroy (Table 1), the most highly developed of the Warren-Donnelly resources.

New dams are likely to cause existing dams to fill a little later in the season but as long as the dams are full by the start of the irrigation season reliability of supply is unaffected.

As the number of dams and the volume of water stored in dams increases relative to winter flow rates, there is an increasing risk that dams will not fill by the start of the season, decreasing the reliability of water supply. The greatest risk of this happening is during low flow years (see the figures for 1987 in Table 4). The risk to the reliability of water supply to existing licence-holders also increases with a drying climate.

3.2.3 Impact of dams on river ecosystems

No studies have isolated the ecological impact of change in flow regimes caused by clearing and farm dams from other effects of catchment development. Degradation in the ecological health of rivers has been linked to a variety of factors, including clearing of native vegetation, loss of riparian and in-stream habitat, poor water quality, as well as the construction of on-stream farm dams and changes in the natural flow regime caused by water abstraction.

Interception of river flow by farm dams has changed the magnitude and seasonality of flows (Section 3.2.1). On-stream dams are also a physical barrier to the upstream movement of aquatic species, especially native fish (Cape to Capes 2008). However, as post-dam winter flows are at least equal to the natural, pre-cleared condition flows (Table 4 and Figure 7) observed degradations to river ecosystems may not be directly related to construction of on-stream dams.

3.2.4 Other impacts on river ecosystems

The loss of riverine habitat is a significant factor in the observed loss of the biodiversity of river systems (Pen 1999). Catchment clearing, de-snagging and the presence of livestock in riparian areas, have severely decreased the amount, 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.

These problems are outside the scope of allocation planning, but are manageable through actions such as re-vegetation, exclusion of livestock from river channels and riparian areas, low-flow bypasses and fish ladders on the larger dams (Cape to Capes 2008).

The aim of allocation planning is to ensure the total amount of water available for consumptive use is within ecologically sustainable limits. This will ensure that any catchment management activities such as revegetation, habitat restoration and exclusion of livestock from rivers have maximum benefit.

3.3 Public water supply

Large 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 8). 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 8, are:

- Lefroy Brook Catchment Area
- Manjimup Dam Catchment Area
- Manjimup 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. 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 8). Manjimup water supply comes from Phillips Creek Dam and Manjimup/Scabby Creek Dam, which are located higher in the catchment. Town water supply for Quinninup comes from the Quinninup (Karri Lake) Dam.

Figure 8 Public drinking water source areas in the Warren-Donnelly area

3.4 Stock and domestic water use

In the Warren-Donnelly area, most stock and domestic water use is taken from farm dams. Water taken for non-intensive stock and for domestic purposes is exempt from licensing. Water from farm dams used only for household purposes and non-intensive stock watering is not licensed.

Analysis of farm dam mapping indicates that the largest dam volumes associated solely with stock and domestic purposes are between 5 ML and 8 ML. Currently, in the Upper Lefroy, Four Mile Brook/Big Brook, Lefroy Brook and East Brook resources, there is collectively about 400 storages of 8 ML or less, that are classified as stock and domestic dams. Individually these dams have a very small effect on flows due to their small size.

3.5 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 5), where plantations are helping to reduce salinity.

Table 5 Plantations in the Warren-Donnelly area

Resource	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**

Resource	Area km^2	Area of cleared land km^2	Area of plantations km^2	Proportion of cleared land with plantations %
		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 doesn't license the water used by plantations. However, the department does provide advice to local government on the potential impacts of plantation development applications and considers plantation development in deciding how much water is available.

The flows modelled to determine sustainable yields for resources in the Warren-Donnelly area account for the impacts of existing mature plantation forests on surface water availability. This is because flow records incorporate any impacts of existing resource development on river flow.

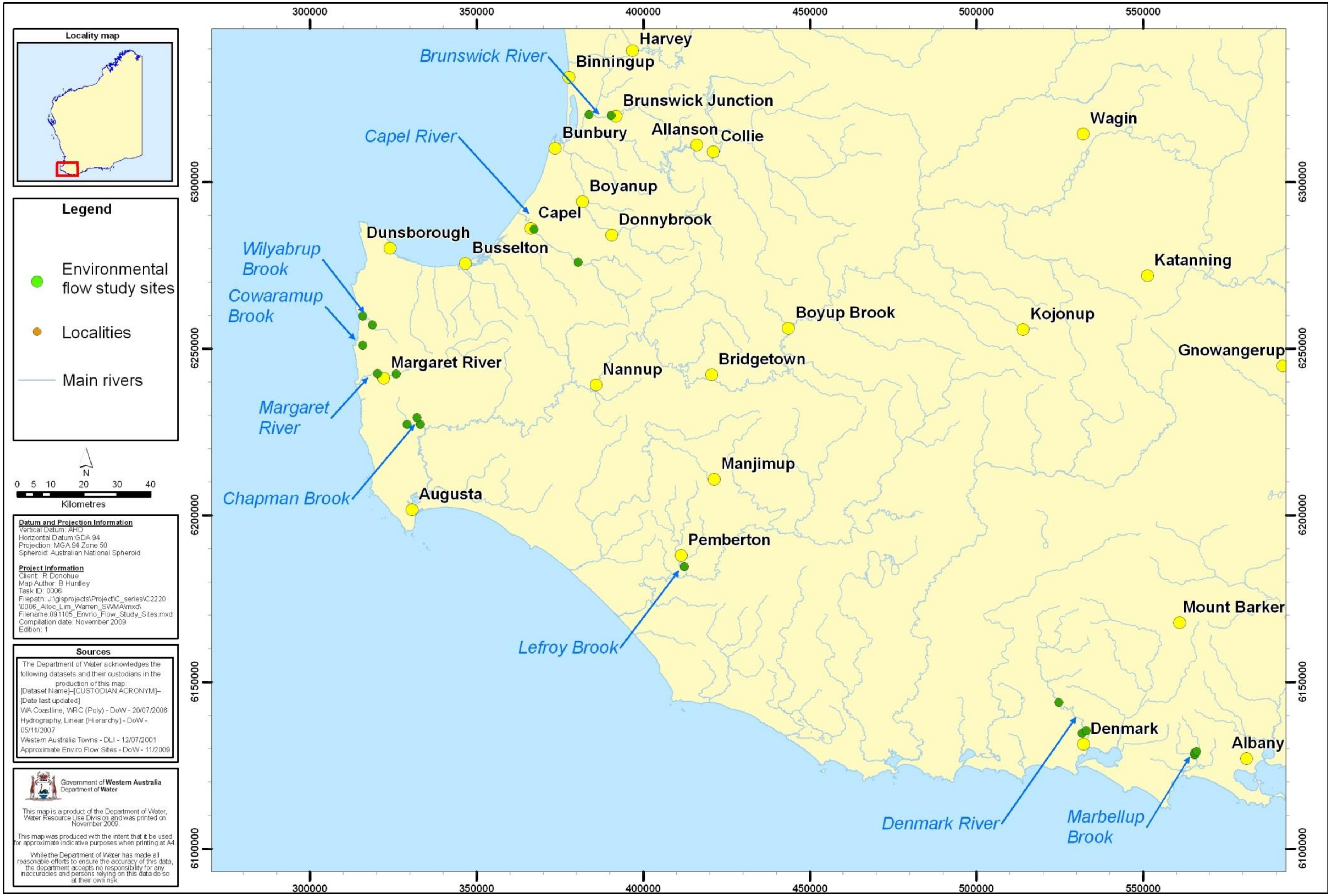
4 Determining ecologically sustainable yields

The ecologically sustainable yield (ESY) of a river is the volume of water that can be taken for consumptive uses while maintaining environmental flows that are important for river ecosystems and water-dependent social values. The ESY of rivers are estimated from the results of environmental flow studies, which identify the flow regimes needed to maintain current ecological values at a low level of risk.

4.1 Ecologically sustainable yields from environmental flow studies

A methodology was developed to estimate a river's ESY from environmental flow studies carried out in the South West region between 2006 and 2008. These studies involved 14 sites located in 7 river systems (Figure 9) (Donohue et. al. 2009a, 2009b, 2009c, 2009d, 2010a, 2010b; Close et. al. 2008a, 2008b). Important ecological parameters in the studies include flow regimes required to maintain ecological characteristics at a low level of risk, such as summer low flows, fish passage, bankfull and flood flows, defined habitat type, seasonal inundation of habitat pools, or channel morphology. Historical flow data for the period of 1975 to 2003 was used (or 2005 for Margaret River, Marbellup Brook and Denmark River) (Figure 9).

Figure 10 shows the daily environmental flow (and the corresponding ESY) for Lefroy Brook for 2000. Environmental flow and ESY have been generated for every year at every study site (Figure 9) over the 29-year period between 1975 and 2003 (and at some sites up to 2005). These results have then been used to calculate annual flow and ESY (as shown in Figure 11 for Lefroy Brook).



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 9 Location of environmental flow study sites across the South West

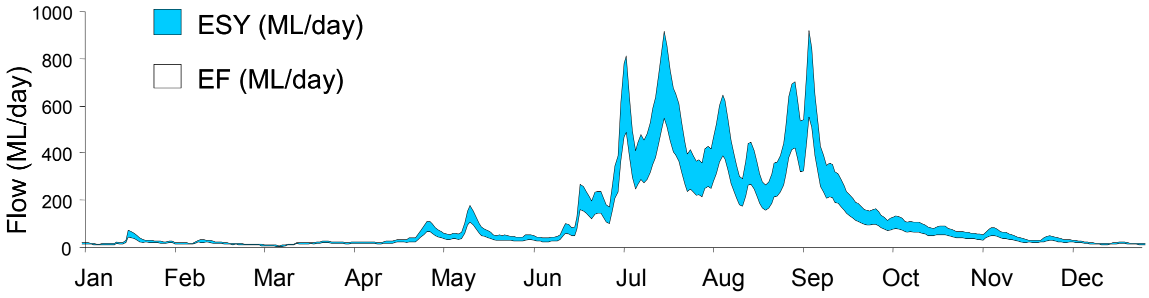


Figure 10Environmental flow and ecologically sustainable yield for Lefroy Brook for 2000

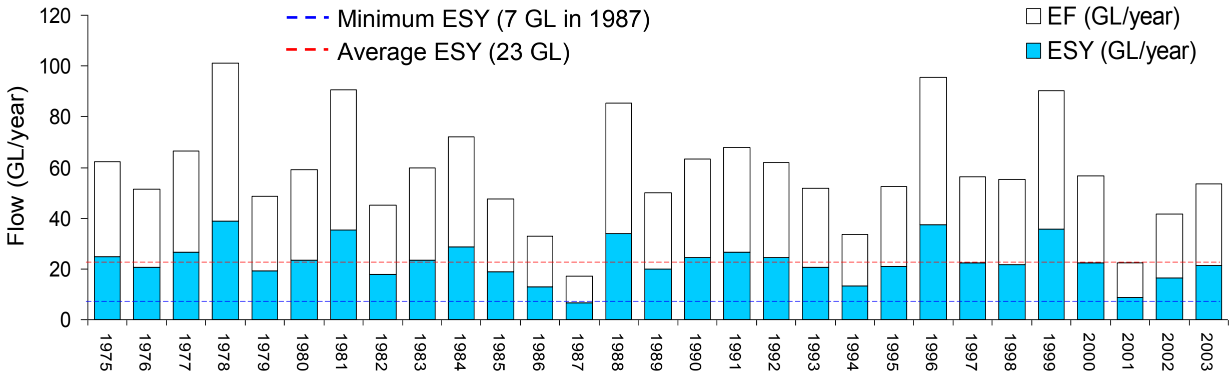


Figure 11Annual environmental flow and ecological sustainable yields for Lefroy Brook for 1975 to 2003

4.2 Determining an ecologically sustainable yield for each Warren-Donnelly surface water resource

Of the 14 south-west environmental flow study sites, only one (Lefroy Brook) is within the Warren-Donnelly area. This site is located in the lower reaches of the Lefroy River in the Warren River basin and includes flow contributions from the Upper Lefroy, Four Mile Brook/Big Brook, Lefroy Brook and East Brook resources.

To determine the ESY for each of the Warren-Donnelly resources, the department considered the relationship between annual flows and ESY for each of the 14 study sites.

Table 6 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
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

Note: Minimum annual flow and minimum ESY are in bold.

4.2.1 Minimum ecologically sustainable yield

Environmental flows and ESY are related to the volume of annual flow, with high flow years providing a high ESY, and low-flow years a low ESY. To ensure security for existing users and that environmental flows are met in low flow years, the ESY corresponding to the year with the minimum annual flow within the data period (minimum ESY) for each of the 14 sites was selected as the appropriate ESY.

As on-stream dams have limited capacity to modify annual capture of water, the use of the historic minimum annual flow and corresponding minimum ESY for allocation limit decisions minimises the risk of total allocations exceeding the ecologically sustainable yield of rivers in the area.

4.2.2 Developing a regionalisation model using the relationship between minimum annual flow and minimum ecologically sustainable yield

To determine ESY for each of the Warren-Donnelly resources, a regionalisation model was developed by correlating minimum annual flow and minimum ecologically sustainable yields for each of the 14 study sites (Figure 12).

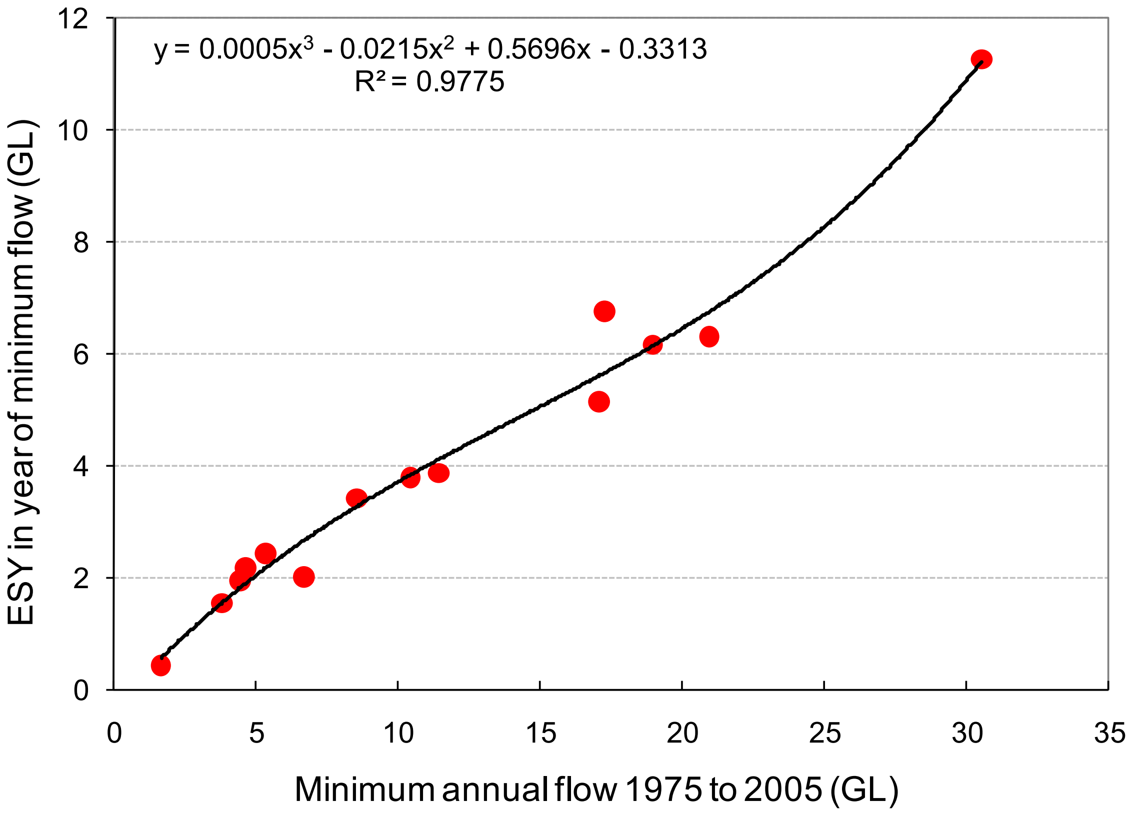


Figure 12 Relationship between minimum annual flow and minimum ecologically sustainable yield

This relationship was modelled as a third-order polynomial. Figure 12 shows that the minimum ESY is related to minimum annual flow, according to the following equation:

$$ESY_{min} = 0.0005\ Q_{min}^{3} - 0.0215\ Q_{min}^{2} + 0.5696\ Q_{min} - 0.3313$$

Where: ESY_{min} = ecologically sustainable yield (ML) in the year of minimum annual flow (1975 to 2007)
Q_{min} = minimum flow (in ML/yr) at the outlet of the study site catchment

4.2.3 Estimating ecologically sustainable yields using the regionalisation model

The relationship derived from the environmental flow studies (in Figure 12 above) was used to estimate the minimum ESY for each of the 25 surface water resources in the plan area. To do this, we used the minimum annual flow for each resource from the available flow data period of 1975 to 2007 (see Section 2.3 and Table 1 for annual flows for each resource and how they were calculated). See Section 5.6, Table 12 for the calculated minimum ESY for each resource.

For the Yerraminnup River in the Warren River basin, the minimum annual flow was in 2006. This is after the 1975–2005 period used to determine the regionalisation formula (Table 6 and Figure 12). The year 2006 was also a very low flow year for many of the other resources.

5 Allocation limit decisions

This chapter describes how the department set allocation limits for the Warren-Donnelly plan using:

- calculated ecologically sustainable yields (Section 4)
- assessment of the impact of existing farm dams on ecologically sustainable yields
- information on existing and future water use
- information on existing land use
- an assessment of risk:
    - environmental risk based on the combination of estimation error in ecologically sustainable yields and the current level of irrigation development
    - risk to salinity objectives for the Warren River basin.

5.1 Ecologically sustainable yields and existing level of dam development

The current streamflows already reflect the changes resulting from the current level of development, that is, changes to flows caused by catchment clearing, water abstraction and interception by on-stream farm dams.

Modelling shows that on-stream farm dams have not greatly affected winter flows (Figure 7), except in low flow years (especially in highly developed catchments such as Upper Lefroy).

Because current streamflows reflect the current level of development, the minimum ecologically sustainable yields calculated for the Warren-Donnelly surface water resources are therefore considered to be additional water that can be taken while still maintaining important ecological processes at a low level of risk.

The minimum ecologically sustainable yields calculated by applying the regionalisation formula for each surface water resource are shown in Table 12 (column A). This minimum was not calculated for the Unicup Lakes resource because it is mainly internally draining and does not have well-defined drainage channels suitable for water supply development. The lake system rarely discharges into the Tone River (Smith 2003).

5.2 Existing and future water use

Estimates were needed for existing and future water use, including licensed water use and water use exempt from licensing. Departmental figures for existing use were used to calculate the allocation limit. These figures are a combination of licensed entitlements and estimates of small scale stock and domestic water use, which is exempt from licensing. Estimates of future water use are used to determine how much water is available for new licences.

5.2.1 Existing licensed use

The department used licensed entitlements at March 2010 (Table 3) to estimate existing licensed use.

5.2.2 Existing water use exempt from licensing

To set allocation limits the department needs to account for water uses exempt from licensing. These 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.

From farm dam mapping completed in the Upper Lefroy, Four Mile Brook/Big Brook, East Brook and Lefroy Brook resources, the department identified farm dams with a storage capacity of less than 8 ML. These are the dams likely to be for stock and domestic use only and unlicensed.

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 7).

Table 7 Water stored in dams < 8 ML as a percentage of total water stored in farm dams

Resource	Proportion of 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: Percentage was calculated from water only stored in farm dams and does not include public water supply dams

To estimate existing exempt water use the department assumed that it is 9 per cent of private licensed entitlements (total licensed entitlements minus public water supply entitlements). Where we have more accurate figures (i.e. for the four resources in Table 7 with farm dam mapping), we have used this percentage instead (Table 8).

Table 8 Estimated existing exempt water use for Warren-Donnelly surface water resources

Resource	Proportion of private licensed entitlements[1] %	Estimated existing 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. Private licensed entitlements = total licensed entitlements – public water supply entitlements
2. Estimated existing exempt use = private licensed entitlements x assumed percentage

5.2.3 Future water use exempt from licensing

The department has assumed that exempt water use as a percentage of private licensed entitlements for farm dams will remain the same as use increases.

5.2.4 Future public water supply reserves

The department has reserved water for future public water supply needs in Record Brook (500 ML), Upper Warren (500 ML) and Four Mile Brook/Big Brook (50 ML).

5.3 Categorising surface water resources based on water resource development

To assist us in deciding what the appropriate allocation limit is for each surface water resource and to consider the risks mentioned above, we categorised all resources according to land and water supply development and grouped them. The categories and the general allocation objective for each category are shown in Table 9.

Table 9 Allocation categories and the general allocation objective for each category

Category	Allocation objective
1. Irrigated agriculture	Provide for current irrigation demand and other uses while allowing for sustainable growth within a manageable risk to river ecology.
2. Future public water supply	Provide for future public water supply only.
3. Predominantly forest or conservation areas	Maintain existing land management arrangements to protect environmental values.
4. Warren River salinity improvement	Provide additional small volumes of water to allow for some development, while supporting the potential of the Warren River basin as a long-term water supply.

Depending on the allocation objective, the values and priorities for water use vary, which can alter the acceptable level of risk. Where economic values are a higher priority, the acceptable level of risk to environmental values may be higher and more water may be made available for consumptive purposes. Where the environmental values are a higher priority, the acceptable level of risk may be lower and less water may be made available.

The methods used to set allocation limits for each category are detailed in the following sections. The surface water resources within each category are shown in Table 10.

Table 10 Surface water resources in each category

Category	Resource
1. Irrigated agriculture	Smith Brook Upper Lefroy East Brook Wilgarup River Upper Donnelly Manjimup Brook/ Yanmah-Dixvale Middle Donnelly Perup River Yerraminnup River Diamond Tree Gully Lefroy Brook Four Mile Brook/ Big Brook Dombakup Brook
2. Future public water supply	Record Brook
3. Predominantly forest or conservation areas	Barlee Brook Lower Donnelly Carey Brook Beedelup Brook Fly Brook Unicup Lakes
4. Warren River salinity improvement	Upper Warren Quinninup Brook Treen Brook Lower Warren Tone River

5.4 Reducing risk for existing water users and the environment

All ecologically sustainable yield estimates have a degree of uncertainty. It is important that this uncertainty and the risk of over-allocation is considered in allocation decisions. To define the uncertainty, the department estimated the potential error of the minimum ecologically sustainable yield estimates in terms of plus or minus a percentage error. The department assessed that the minimum ecologically sustainable yields were accurate within a range of ±20 to 60 per cent of the true value for the 14 study sites, with a median of ±40 per cent.

The department then considered how the risk of over-allocation might vary in each surface water resource. The risk and consequences of over-allocation are greater in highly developed resources, where a large volume of water is captured by on-stream dams. This means that in resources where there is more water taken by on-stream dams, there is a higher risk of over-allocation.

To reduce the uncertainty in the estimates the department selected the negative error percentages (0, –20, –40 and –60 per cent error) to define ecologically sustainable yield. To also reduce the risk of over-allocation in relation to the current level of development, the negative error percentages were related to storage density categories to develop risk management factors (see Table 11).

These factors were applied to the minimum ecologically sustainable yields for all surface water resources to derive the additional yield (Table 12, column C).

Table 11 Risk management factor used to set allocation limits

Storage density using area upstream of use only ML/km^2	Influence on risk of over-allocation	Per cent error	Risk management factor
≤ 15	Negligible	0	1.0
> 15 ≤ 30	Low	–20	0.8
> 30 ≤ 75	Moderate	–40	0.6
> 75	High	–60	0.4

5.5 Setting allocation limits

The allocation limit was set by determining the final additional yield for each resource (Table 12, column E) and adding existing use (column F).

The following sections explain how we determined the additional yield for each resource according to the allocation categories in Table 9.

5.5.1 Category 1: Irrigated agriculture

For these resources the objective is to provide for existing and future irrigation demand while allowing for sustainable growth within a manageable risk to river ecology.

The final additional yield (Table 12, column E) was set equal to the additional yield (column C).

However, it is often impractical to abstract water from forested areas in these resources (e.g. Upper Donnelly resource) due to land tenure or access. The department has included the yield from the forested areas in the allocation limit as water could be available for consumptive use if innovative methods are developed to enable transfer of water to the irrigation site.

5.5.2 Category 2: Future public water supply

The only surface water resource that falls into this category is Record Brook. Currently there are no licensed entitlements in Record Brook. The department has reserved 500 ML/yr for future public water supply. Since public water supply is a high priority use, the final additional yield (Table 12, column E) for Record Brook has been set at 500 ML/yr, higher than the minimum ecologically sustainable yield.

If the reserve is no longer required then the allocation limit will be reviewed.

5.5.3 Category 3: Predominantly forest or conservation areas

The surface water resources that are predominantly or completely forested or conservation area (category 3) are Barlee, Lower Donnelly, Carey Brook, Beedelup Brook, Fly Brook and Unicup Lakes. Water from these areas is inaccessible for consumptive uses. The allocation objective for these resources is to maintain existing land management arrangements and protect environmental values.

The final additional yield was reduced to zero (Table 12, column E) for these resources.

5.5.4 Category 4: Warren River salinity improvement

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 (Mayer et al. 2005), particularly in the Tone, Perup and Yerraminnup rivers. The department's salinity recovery program is working with stakeholders in the upper Warren catchment 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 in the forested south-western part of the catchment at Barker Road Crossing gauging station (607220) (Figure 4).

The taking of water from fresh tributaries in the Warren River basin has the potential to increase the salinity concentration downstream.

We applied a salinity risk management factor of 0.6 (moderate) (Table 12, column D) to the fresh, low water use resources, to provide additional small volumes of water to allow for some development, while supporting the potential of the Warren River basin as a long-term water supply.

The surface water resources that currently have low water use, average annual salinities at a potable level and contribute to flows above the Barker Road Crossing gauging station are Upper Warren, Quinninup Brook, Treen Brook and Lower Warren (category 4). The reduced, final additional yields for these resources are shown in Table 12, column E.

The final additional yield from the Tone River was reduced to zero (Table 12, column E) for two reasons:

- this allocation unit has low demand for surface water due to the high salinity of the Tone River
- to account for future water interception by plantations for salinity management.

To offset the effect on stream salinity of allocating the final additional yields (Table 12), it is predicted that the proposed level of plantations in the Tone River catchment would have to be increased by up to 10 per cent to meet long-term salinity objectives.

5.6 Additional yield calculations and allocation limit decisions

Table 12 presents the information used for each resource to calculate the final additional yields available for future use (allocations) and the allocation limits, from the steps outlined in the previous sections of this chapter.

Table 12 Yield calculations and allocation limits.

Resource	Minimum ESY ML/yr	Storage density risk management factor	Additional yield ML/yr	Salinity risk management factor Category 4 only	Final additional yield[1] ML/yr Category 4 only	Existing use[2] ML/yr	Allocation Limit ML/yr
	(A)	(B)	(C = A x B)	(D)	(E = C x D)	F	(G = E + F)
			Warren River Basin				
Tone River	2 913	1.0	2 913	NA	0[3]	55	55
Perup River	1 050	1.0	1 050	NA	1 050	521	1 571
Yerraminnup River	111	1.0	111	NA	111	13	124
Wilgarup River	1 882	1.0	1 882	NA	1 882	6 144	8 027
Upper Warren	5 151	1.0	5 151	0.6	3 090	1 277	4 368
Quinninup Brook	1 702	1.0	1 702	0.6	1 021	401	1 422
Smith Brook	1 567	0.6	940	NA	940	3 422	4 362
Diamond Tree Gully	407	1.0	407	NA	407	276	682
Upper Lefroy	1 375	0.4	550	NA	550	6 425	6 975
East Brook	1 462	0.6	877	NA	877	2 750	3 627
Lefroy Brook	1 450	0.8	1 160	NA	1 160	1 744	2 905
Four Mile Brook / Big Brook	3 111	0.6	1 866	NA	1 866	3 428	5 294
Treen Brook	2 832	1.0	2 832	0.6	1 699	871	2 570
Dombakup Brook	3 652	1.0	3 652	NA	3 652	131	3 783
Lower Warren	2 708	1.0	2 708	0.6	1 625	340	1 965
Unicup Lakes[3]	-	-	-	NA	NA	NA	0
Warren River total			**27 802**		**19 932**	**27 798**	**47 730**

Resource	Minimum ESY ML/yr	Storage density risk management factor	Additional yield ML/yr	Salinity risk management factor Category 4 only	Final additional yield[1] ML/yr Category 4 only	Existing use[2] ML/yr	Allocation Limit ML/yr
				Donnelly River Basin			
Upper Donnelly	3 503	1.0	3 503	NA	3 503	403	3 906
Manjimup Brook/ Yanmah-Dixvale	2 146	0.6	1 288	NA	1 288	5 154	6 441
Middle Donnelly	1 150	1.0	1 150	NA	1 150	1 215	2 366
Record Brook	309	1.0	309	NA	500	0	500
Barlee	14 057	1.0	14 057	NA	0	0	0
Lower Donnelly	11 147	1.0	11 147	NA	0	14	14
Carey Brook	3 497	1.0	3 497	NA	0	0	0
Beedelup Brook	2 521	1.0	2 521	NA	0	806	806
Fly Brook	2 828	1.0	2 828	NA	0	867	867
Donnelly River total			**40 299**		**6 441**	**8 458**	**14 900**

Notes

1. See sections 5.5.1 to 5.5.4 for final additional yield decisions
2. Assumes existing use is equivalent to total licensed entitlements as at 24 March 2010 plus estimates of existing exempt water use.
3. The ESY wasn't calculated for the Unicup Lakes resource (see Section 5.1).

6 Allocation limits and components for the Warren-Donnelly resources

The updated allocation limits for each surface water resource are shown in Table 13. We have divided the allocation limits into components to ensure that we account for existing and potential exempt, unlicensed water use and potential future public water supply. We used the information in Section 5.2 to help us determine the volume set aside for these components. Table 13 also indicates whether water is still available for licensing.

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

Resource	Allocation limit ML/yr	Allocation limit components ML/yr				Status of water availability for licensing[1] (as at June 2010)
		Licensable		Unlicensable	Reserved water	
		General licensing	Public water supply	Unlicensed use	Public water supply	
Warren River and tributaries surface water area						
Tone River	55	50	0	5	0	No water available
Perup River	1 571	1 434	0	138	0	Water available
Yerraminnup River	124	113	0	11	0	Water available
Wilgarup River	8 027	7 350	0	677	0	Limited water available
Upper Warren	4 368	3 484	0	384	500	Water available
Quinninup Brook	1 422	1 267	30	125	0	Water available
Smith Brook	4 362	3 745	0	617	0	Limited water available
Diamond Tree Gully	682	623	0	59	0	Water available
Upper Lefroy	6 975	5 581	894	500	0	No water available
East Brook	3 627	3 258	0	370	0	No water available
Lefroy Brook	2 905	2 108	450	347	0	Water available
Four Mile Brook/ Big Brook	5 294	4 505	450	290	50	Water available
Treen Brook	2 570	2 345	0	225	0	Water available
Dombakup Brook	3 783	3 443	0	339	0	Water available
Lower Warren	1 965	1 790	0	174	0	Water available
Unicup Lakes[2]	0	0	0	0	0	No water available
Warren totals	**47 730**	**41 096**	**1824**	**4260**	**550**	

Resource	Allocation limit ML/yr	Allocation limit components ML/yr				Status of water availability for licensing[1] (as at June 2010)
		Licensable		Unlicensable	Reserved water	
		General licensing	Public water supply	Unlicensed use	Public water supply	
Donnelly River System surface water area						
Upper Donnelly	3906	3 558	0	349	0	Water available
Manjimup Brook/ Yanmah-Dixvale	6441	5 900	0	541	0	Limited water available
Middle Donnelly	2366	2 162	0	204	0	Water available
Record Brook	500	0	0	0	500	No water available
Barlee	0	0	0	0	0	No water available
Lower Donnelly	14	13	0	1	0	No water available
Carey Brook	0	0	0	0	0	No water available
Beedelup Brook	806	739	0	67	0	No water available
Fly Brook	867	795	0	72	0	No water available
Donnelly totals	**14900**	**13166**	**0**	**1233**	**500**	

[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.

[2] 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). The allocation limit was set at current use (0) to help protect the environment.

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 run-off 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/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/a. 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)

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Looking after all our water needs

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