5.2 Merbein and Red Cliffs

Both Merbein and Red Cliffs have experienced very slow urban growth in recent years, and it is understood that there is sufficient residential land available in both townships through infilling to cater for development in the foreseeable future.

5.3 Irrigation development

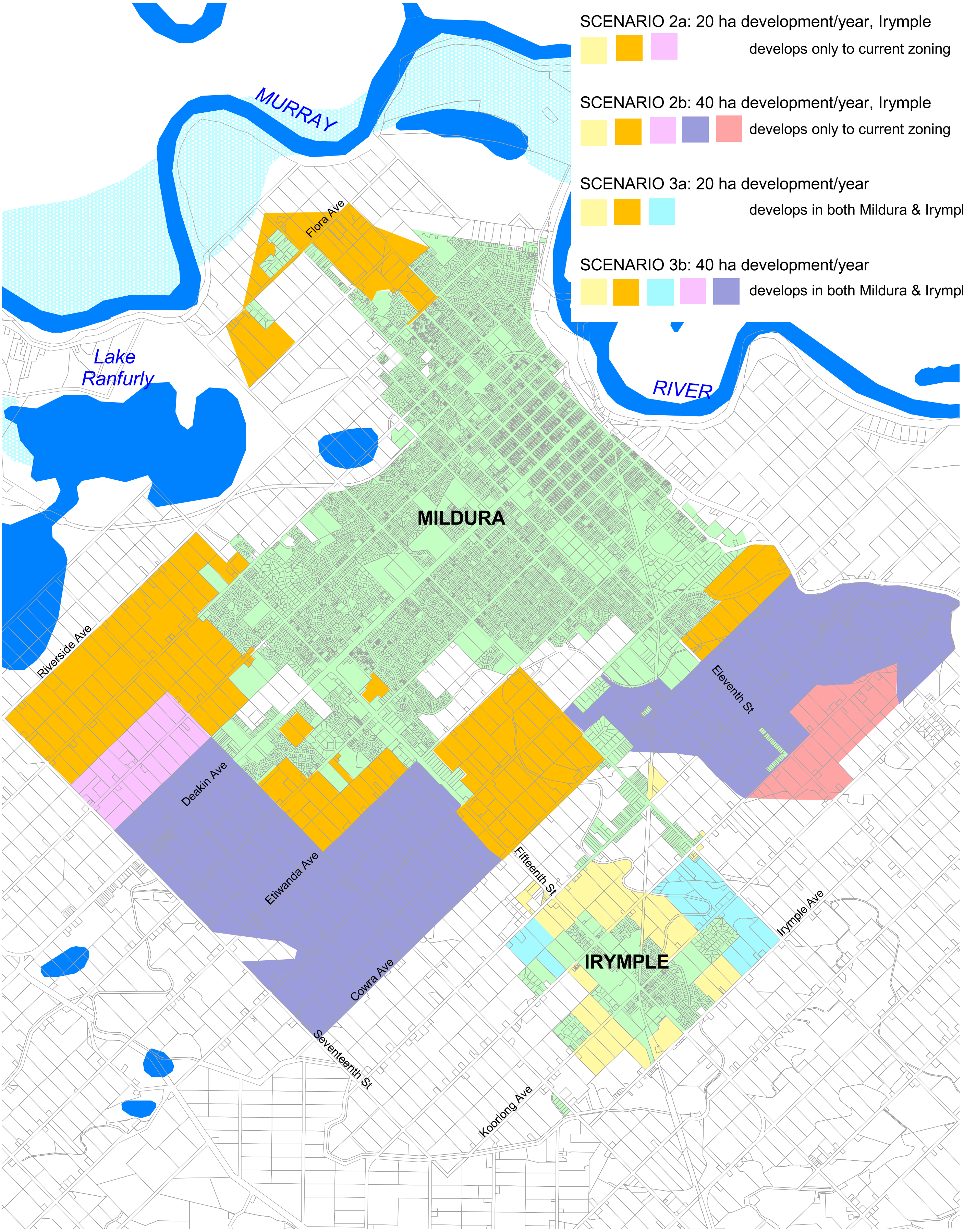
As noted in Section 4.4, future urban growth around Mildura and Irymple will result in take up of land currently used for irrigated agriculture. There is some scope for minor expansion of the Merbein Irrigation District along the western boundary of the Study Area, and it is assumed that this will be taken up within the next ten years. There is understood to be relatively little scope for expansion of the irrigated area in the Red Cliffs District. It is assumed that expansion of the FMIT Irrigation District will be predominantly by in-fill development.

Parts of the Study Area that could potentially be taken up for irrigation development by 2050 are shown on Figure 5-3. Areas in each irrigation areas that will potentially require drainage to 2050 are summarised in Table 5-2.

■ Table 5-2 Existing and 2050 Irrigated and Drained Areas

Area	Existing Development				2050 Development			
	Irrigated Area (ha)	Irrigated Areas (ha) Served by			Irrigated Area (ha)	Irrigated Areas (ha) Served by		
		Irrigation Authority Drains	Private Drains	Undrained		Irrigation Authority Drains	Private Drains	Undrained
Merbein Irrigation District	2914	2718	196	0	3727	3531	196	0
Mildura Irrigation District	6281	5592	689	0	7884	6924	960	0
Red Cliffs Irrigation District	3826	2644	1182	0	5342	3695	1647	0
Merbein area, outside Irrigation District	1087	0	861	226	1087	0	861	226
Mildura area, outside Irrigation District	574	0	539	35	559	0	539	20
TOTAL	**14682**	**10954**	**3467**	**261**	**18599**	**14150**	**4203**	**246**

FIGURE 5.1 - DEVELOPMENT SCENARIOS



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LEGEND

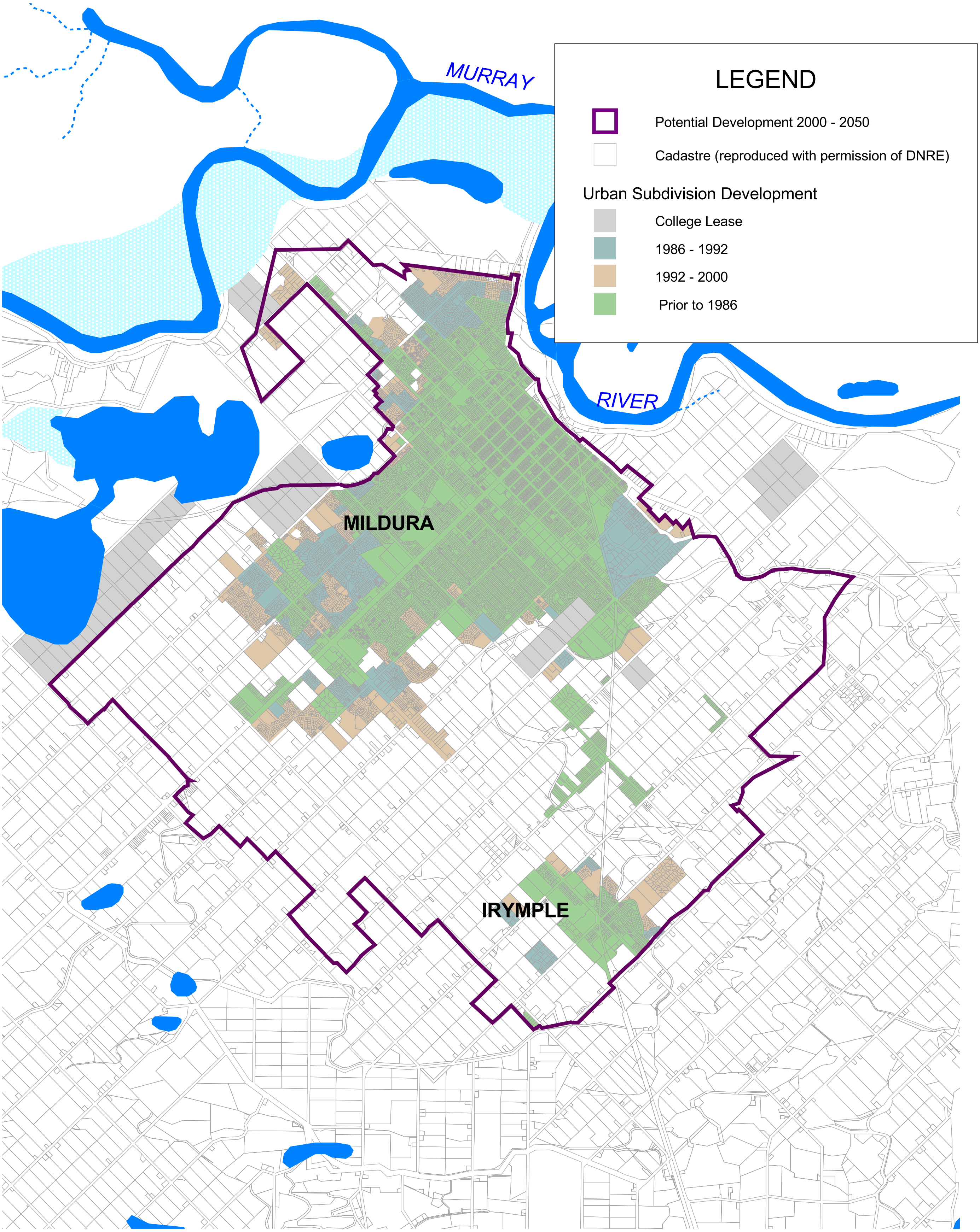
Cadastre (reproduced with permission of DNRE)

Urban Development

N

1 0 1 2 Kilometres

FIGURE 5.2 - ADOPTED 2050 SCENARIO



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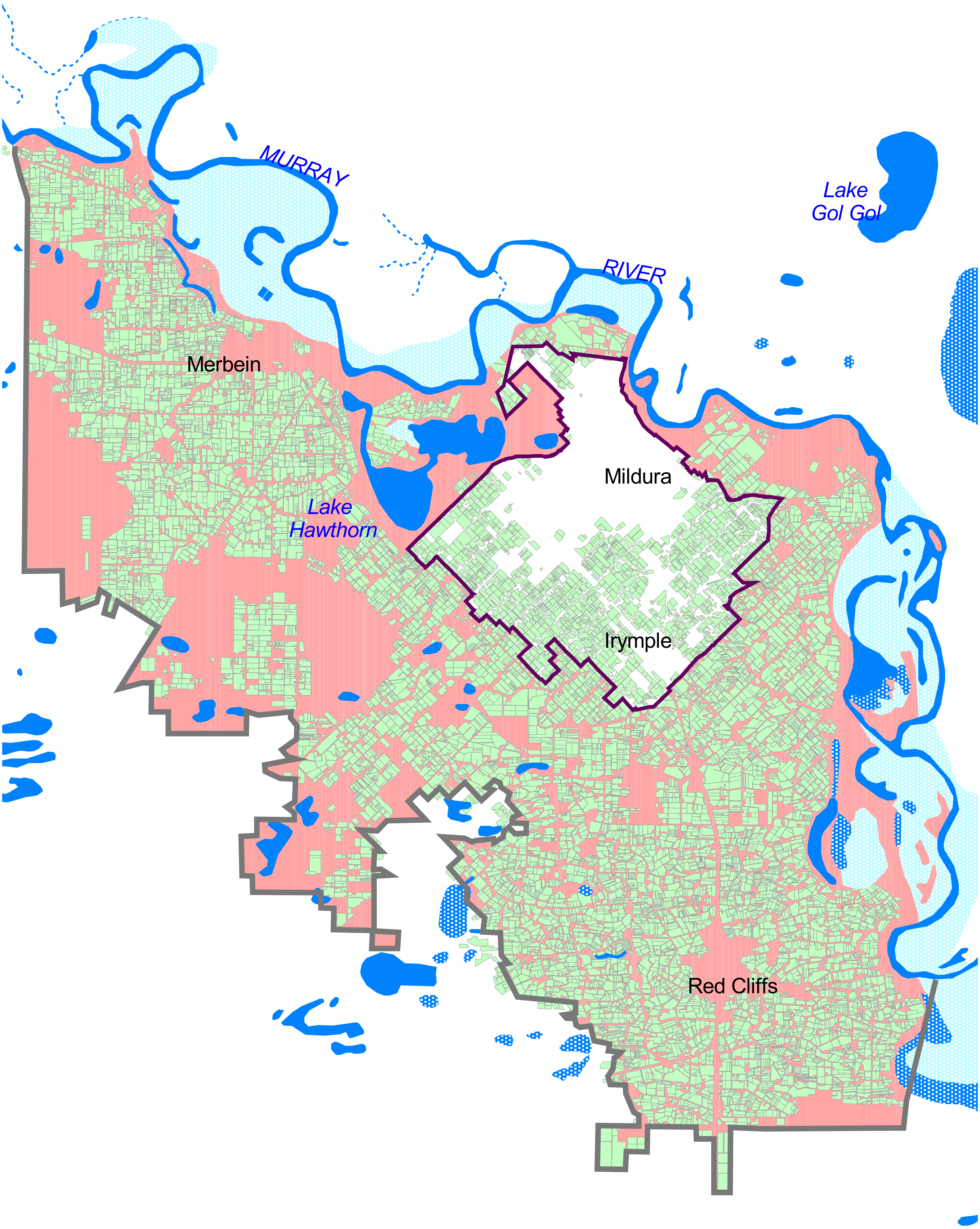
AUSLIG

FIGURE 5.3 - IRRIGATION DEVELOPMENT



LEGEND

- Study Area
- Future Urban Development 2050
- Existing Irrigation
- Potential Future Irrigation

N

2 0 2 4 Kilometres

SINCLAIR KNIGHT MERZ

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6. Standard of Service

6.1 Urban drainage

6.1.1 Design Standards

Mildura Rural City Council currently applies the following drainage standards to new urban development:

- peak flows resulting from a 5 year average recurrence interval (ARI) storm event should be contained within the piped drainage systems;
- the floor levels of all habitable buildings should be at least 300 mm above peak flood levels resulting from a 100 year ARI storm event.

These standards are generally in accordance with current practice for residential development in other urban areas in Australia. A higher piped standard, generally the 10 year ARI event, is usually applied to commercial and industrial development, where nuisance flooding is likely to have greater impact. The standards generally provide some scope for reducing the piped drainage standard to say the 2 or 3 year ARI event in some residential areas, in situations where the consequences of nuisance flooding are low. Many areas of new urban development in around Mildura/Irymple will be in landlocked catchments, with street systems depressed below residential allotments. The consequences of flooding in excess of the capacity of the piped systems would be relatively severe in these areas, and a 2 or 3 year ARI piped design standard would not be appropriate.

It is recommended that the following drainage design standards for future urban development be adopted for the current Project:

- minor drainage system standard: peak flows should be contained within the piped drainage system as follows:
  - residential development – 5 year ARI storm event; and
  - industrial and commercial development – 10 year ARI storm event;
- major drainage system standard: floor levels of all habitable buildings should be at least 300 mm above peak flood levels resulting from the 100 year ARI storm event.

The risks associated with adoption of lower standards of service for both major and minor drainage systems are summarised in Table 6-1. Adoption of lesser standards for new development will generally result in a standard of service that is less than normal industry practice, and this could potentially leave Council open to a legal challenge for provision of substandard drainage.

■ **Table 6-1 Drainage Service Standard Risk Factors**

Risk associated with lower standard of service	Likelihood	Consequence
Urban Drainage		
Minor (piped) drainage system		
Increased frequency of nuisance flooding and associated property access difficulties	Very high	Moderate
Major (overland) drainage system		
Increased frequency of above floor flooding and associated flood damage costs	Very high	High
Increased flooding of streets	Very high	High
Increased flood safety risk	Very high	High
Subsurface Irrigation Drainage		
Increased groundwater accessions	Very high	Low
Loss of production due to waterlogging	Moderate	High
Property access difficulties	Low	Moderate
Rural Surface Drainage		
Reduced road access	Very high	Moderate
Safety of traffic and pedestrians	High	Moderate
Above floor flooding of upstream buildings	Low	High
Flooding of upstream land	Very high	Moderate

6.1.2 Current Standard of Service

The standard of service provided by the existing drainage network, with existing development, has been assessed in two ways, depending on whether catchments are predominantly serviced by basins, or gravity outfalls.

<u>Drainage Basins</u>

For subcatchments with significant basins, viz. generally landlocked catchments, the standard of service has been assessed by comparing the estimated existing 100 year ARI 72 hour runoff volume, with the total estimated existing basin volume. Only basins included on Council's register have been included in the analysis. Where basin volumes are not known, these calculations are very approximate only, as basin volumes have then generally been estimated from plan areas provided by Council, assuming a depth of 2 metres, and side slopes of 1 (vertical) to 3 (horizontal). The analysis take no account of any pumped or gravity discharge capacity, which is generally negligible. Results are summarised for some of the more significant catchments in Table 6-2.

■ **Table 6-2 Standard of Service provided by existing Drainage Basins**

Catchment	Total Basin Volume (ML)	Existing 100 year ARI 72 hour runoff volume (ML)
T (Irymple)	61	104
Z2 (incl Centennial Gardens)	37	71

The results show that both the Irymple (catchment T) and Z2 catchments (which includes Centennial Gardens) are capable of catering for only around half the runoff volume from a 100 year ARI storm event.

Gravity Outfalls

For catchments draining by gravity, standard of service has been assessed by comparing estimated existing outfall drain capacity, with estimated peak 5-year flow under, existing development conditions. This information is presented in Appendix B.

The analysis shows that most piped drainage systems servicing existing developed areas of Mildura have capacity to accommodate less than 50% of the 5 year ARI design flow, which will generally be less than a 2 year ARI event. The two largest catchments, Etiwanda and San Mateo (I and L), have an estimated combined outfall capacity of around 520 ML/d, compared to a combined 5 year ARI design peak flow of around 1,900 ML/d.

6.2 Irrigation sub surface drainage

6.2.1 Design Standards

Sunraysia Rural Water currently applies the following drainage design standards to new irrigation development:

- sprinkler irrigation – 0.19 L/s/ha; and
- drip irrigation – 0.14 L/s/ha.

(New furrow irrigation development is rare, and the Authority consequently has no drainage design standard for this type of development.)

Original design standards were based on draining 25% of the irrigation supply rate, on the basis of the farmer receiving water once every 28 days and applying 150 mm over the entire area. There was no allowance for stormwater (Andrew Sinn, SRWA, pers comm). Whilst this bears little resemblance to current day practices, these design rates equate reasonably closely to 25% of current day supply rates as follows:

Drip	40 mm per week peak (0.66 L/s/ha)
Low level sprinklers	55 mm per week peak (0.91 L/s/ha)

Risk factors and associated consequences associated with adoption of lesser standards are summarised in Table 6-1.

It has occasionally been suggested that subsurface drainage might not be required in the Sunraysia District. We would strongly recommend the continuation of the current practice of installing subsurface drainage systems, to prevent exacerbation of risk factors listed in Table 6-1.

Subsurface drains, particularly off-farm, are often very deep, and pipe supply costs would then generally be a relatively small proportion of total drainage system construction costs. The construction cost savings to be gained by adoption of a lesser design standard would therefore generally be relatively small.

The design life of subsurface drains is understood (Andrew Sinn, pers comm) to be of the order of 100 years. Subsurface drainage system were first installed in the area in the 1930's, so in theory most drains have at least 30 years remaining design life and many much longer, provided they are adequately maintained. Root intrusion is the predominant cause of any damage. Consideration of a lesser design standard for most of the Study Area is then largely irrelevant when looking at a Year 2050 scenario, as the majority of the drainage systems will not require replacement over this period.

Most of the Study Area is underlain by relatively impermeable Blanchetown Clays, resulting in a perched watertable at around the level of the subsurface drains. There are however understood to be "windows" within these Clays, covering perhaps 15% of the Study Area, providing direct connection to the Parilla Sands aquifer. Depending on location and topography, a reduction in subsurface drainage service standard could then potentially result in some additional accessions to the Parilla Sands, which would then in turn result in displacement of an equivalent volume of highly saline groundwater to the Murray River.

Watertable levels within the Parilla Sands aquifer have been relatively stable in recent years, and are shown in Figure 6-1.

6.2.2 Current Standard of Service

Current standard of subsurface drainage standard has been assessed by comparing estimated existing outfall drain capacity, with SRWA's current design standards for sprinkler and drip irrigation. This information is presented in Appendix B.

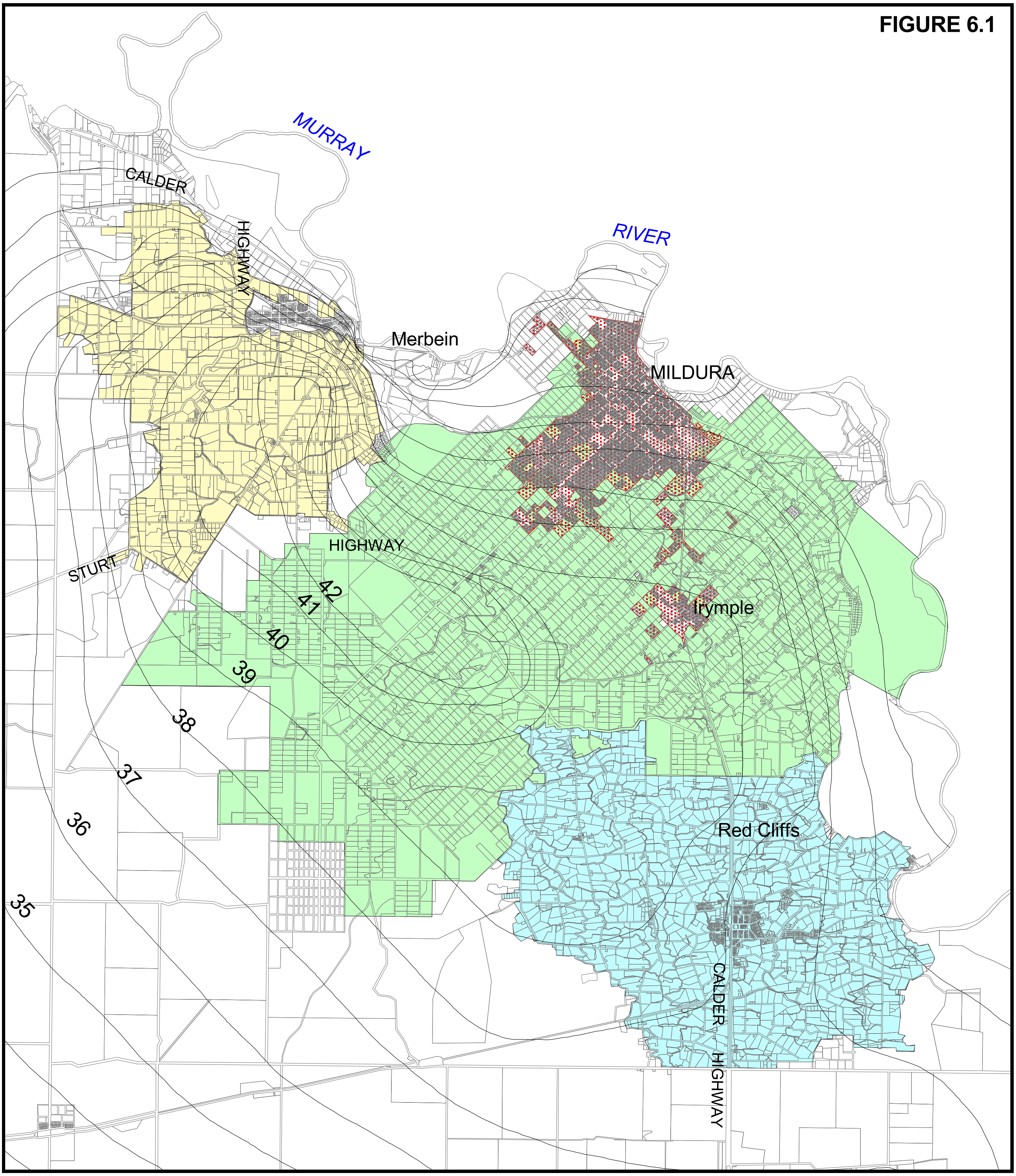
From available information, the existing subsurface drains easily cater for SRWA's design standard for sprinkler irrigation.

6.3 Rural surface drainage

Mildura Rural City Council currently requires culverts for cross drainage of rural roads to be designed to cater for peak flows from either the 5 or 10 year average recurrence interval storm event, depending on the importance of the road. Current practice in Australia (ref 10) is for culverts for cross drainage of major highways and railways to be designed to cater for peak flows from either then 50 or 100 year average recurrence interval storm event. These standards are generally considered adequate, and it is recommended that they continue to be applied. It should be remembered however that there is a scarcity of defined rural watercourses and surface drains within the municipality. Many of the drainage problem areas identified in the Current Situation Report (ref 1) are along rural roads, and are likely to be a result of either lack of culverts or inadequate culvert capacity.

There may be situations in landlocked catchments, where installation of culverts under roads will only serve transfer a flooding problem from an upstream to a downstream landholder. Council may then need to consider additional options for mitigating the impact on the downstream landholder.

Other risk factors are summarised in Table 6-1.



SINCLAIR KNIGHT MERZ

Refer to Sinclair Knight Merz document WCMA\wc01738\gis\arcview\c01738t002.apr; Irrigation Districts (Layout)

Sunraysia Drainage Strategy and Urban Stormwater Management Plan

WATER TABLE ELEVATION (metres AHD)

Water Table Elevation
Existing Development (pre 2000)
Irrigation Districts
Merbein
Mildura (FMIT)
Red Cliffs

0 1 2 3 4 5 Kilometres

7. Current and Future Drainage Volumes, and Salt and Nutrient Loads

7.1 Export rates

7.1.1 Flows

Rural Irrigation

Trend analyses of subsurface drainage flows in the Study Area have been undertaken as part of a current investigation of the Mildura Merbein Salt Interception Scheme for Goulburn-Murray Water. These have shown that if the effects of rainfall and supply diversion are removed, the average subsurface drainage rate in 1998 was around 1.4 ML per irrigated hectare per year. This rate decreased by around 0.05 ML/ha/yr over the period of analysis (two different drainage systems analysed with periods of record respectively from 1975 to 1998, and 1988 to 1988), due presumably to improvements in irrigation practices, including conversion from furrow to sprinkler and drip irrigation.

In considering future drainage volumes, it is recommended that realistic maximum and minimum rates be adopted as follows:

- maximum practical rate, based on no reduction in the 1998 drainage rate, of 1.4 ML/ha/yr;

- minimum practical rate based on our experience that it is difficult to achieve a drainage rate of less than 10% of applied water, which for grapes represents something of the order of 0.7 ML/ha/yr. This is predominantly due to salinity leaching requirements. If the trends noted in the Goulburn Murray Water study continue, this minimum value would be reached in around 15 years. Furrow irrigation still represents around 50% of total irrigation in Mildura and Red Cliffs, and more than 70% in Merbein. It is expected that only around 20% of the irrigated area in Merbein and Red Cliffs will be under furrow irrigation in 10 years time (Andrew Sinn, pers comm). It is assumed that this rate will apply to the 2050 scenario.

Urban

A number of year 2050 urban development scenarios have been presented in Chapter 5. Each of these will result in changes to drainage volumes and salt loads.

Urban expansion will occur largely by take up of land that is currently used for irrigated agriculture. Drainage rates for irrigated land will often exceed annual runoff volumes for urban land. A typical irrigation area drainage rate of 1.4 ML/ha/yr represents a runoff depth of 140 mm. It would generally be expected that somewhere around 30% of rainfall on a typical urban area would runoff. In Mildura, where the average annual rainfall is around 300 mm, this represents an annual rainfall depth of only 90 mm. If it is assumed that urban expansion will result from take up of land that was previously 80% irrigated, then the nett change in runoff volume that will result from this is estimated as follows:

- assuming maximum drainage rate of 1.4 ML/ha/yr: nett decrease of 0.2 ML/urbanised ha/yr (viz. 80% of 1.4, minus 0.9);

- assuming minimum drainage rate of 0.7 ML/ha/yr: nett increase of 0.3 ML/urbanised ha/yr. This would result in a total increase of 750 ML/yr under the adopted 2050 scenario, of an additional 2500 ha of urban development in Mildura/Irymple.

7.1.2 Salt Loads

Rural Irrigation

The salinity of rural subsurface drainage has been assumed to be 2,000 EC units, based on recent investigations undertaken for Goulburn-Murray Water. This equates to around 1.2 t/ML. Trend analyses have indicated that the average salinity of subsurface drainage has remained virtually constant over the past ten to twenty years, despite significant decreases in flow rates. It has therefore been assumed that a subsurface drainage salinity of 2,000 EC units will apply to the 2050 scenario.

Urban

The salinity of urban runoff is highly variable. Data for Mildura indicates a typical figure of around 500 EC units, but values ranging from less than 100 to 2500 EC units have been recorded (based on data provided by the CMA, samples from December 1999 to March 2001 indicate an average salinity of approximately 500 EC units). The nett change in salinity export due to urbanisation, on the basis of an average urban runoff salinity of 500 EC units (0.3 t/ML), is therefore estimated as follows:

- maximum drainage rate: nett decrease of 1.1 t/urbanised ha/yr (viz. 1.4 ML/ha @ 1.2 t/ML @ 80%, less 0.9 ML/ha @ 0.3 t/ML);

- minimum drainage rate: nett decrease of 0.4 t/urbanised ha/yr, total decrease of 1,000 t/yr under the adopted 2050 scenario.

7.1.3 Nutrients

Adopted nitrogen export rates have been based on figures quoted in the Mallee Water Quality Management Plan, as follows:

- urban areas 5 mg/L
- horticultural areas 1 mg/L

Phosphorus export rates quoted in this reference are 10% of nitrogen rates for both land use types.

7.2 Current and Future Loads

Estimated current and future drainage volumes, and salt and nutrient loads are summarised in Table 7-1. These are based on the export rates presented in Section 7.1, and the adopted 2050 development scenario presented in Section 5.

An irrigated area of 158 ha in the Merbein District is currently drained by disposal to drainage shafts, which connect directly into the Parilla Sands aquifer. As noted previously, this results in direct displacement of highly saline groundwater to the Murray River. It is estimated that this is currently resulting in discharge of around 5,400 t/year of salt to the Murray River (ref 9). Because this is a consequence of a drainage practice, and is not related to the land or subsurface drainage rate, this figure is not included in the figures presented in Table 7-1. It is understood that there may also be some disposal of drainage waters to shafts in the Red Cliffs District.

It should be noted that design standards for all drainage systems are based on peak flows, which will generally only occur for very short durations. Average annual drainage volumes are therefore largely independent of adopted design standards.

- **Table 7-1 Current and 2050 Drainage Volumes, and Salt and Nutrient Loads**

Source	Existing				2050			
	Area (ha)	Volume (ML/yr)	Salt Load (t/yr)	N load (t/yr)	Area (ha)	Volume (ML/yr)	Salt Load (t/yr)	N load (t/yr)
Urban	2,039	2,202	661	11	4,682	,201	1,260	21
Irrigation	15,489	21,685	26,022	21	19,425	13,598	16,318	14
TOTAL	**17,528**	**23,887**	**26,683**	**32**	**24,107**	**17,799**	**17,578**	**35**

8. References

1. Mildura Rural City Council (2001), “Sunraysia Drainage Strategy 2000, Stage 1, Current Situation Report, April 2001, Final Report”.

2. Sunrise 21 (1996), “A Sewerage and Stormwater Assessment of Potential Urban Areas adjoining Mildura, Irymple, Mildura South, Nichols Point, Merbein, Red Cliffs, Wentworth, Dareton, Buronga, Gol Gol, Robinvale”, a support document for the Regional Landuse Strategy, June 1996.

3. Sunrise (1999), “Sunraysia Land Information System, Horticulture of the Lower Murray Darling, Irrigated Crops Report”, November 1999.

4. Lower Murray Water (2001). “Sewage Catchment Areas, Mildura and Irymple”, Draft, June 2000.

5. Lower Murray Water (2001), “Sewerage Catchment Areas, Red Cliffs and Merbein”, Draft, July 2001.

6. Mildura Rural City Council (2001), “Mildura Planning Scheme”, March 2001.

7. Kinhill (1998), “Final stormwater strategy report”. Produced for Mildura Rural City Council, April 1998.

8. Mallee Catchment Management Authority (2000), “Water Quality Management Plan, Investigation Report”, August 2000.

9. Sunrise (1997), “Merbein Integrated Development Scheme Feasibility Study and Coast Benefit Analysis”, PJ Hallowes and Associates, in association with Gutteridge Haskins and Davey.

10. Institution of Engineers, Australia (1998), “Australian Rainfall and Runoff, A Guide to Flood Estimation”.

Appendix A Irrigation Drainage Trend Analysis

A.1 Introduction

An analysis of trends in subsurface drainage flows in the Study Area has been undertaken as part of a current investigation for Goulburn-Murray Water into the operation of the Lake Ranfurly, Lake Hawthorn, and Mildura Merbein Groundwater Interception Scheme system, and this is summarised in the following sections. The analysis was based on three separate drainage systems. This information is presented with the kind permission of Goulburn-Murray Water.

A.2 Lake Hawthorn Irrigation Drainage Inflows

Drainage inflows from both the FMIT and Mildura Merbein areas have decreased over recent years. This reduction is likely to be due to changes in irrigation practices, rainfall and the volume of water delivered to the area.

One of the requirements of the investigation was to be able to simulate the Schemes' behaviour with the climatic and River flow conditions that occurred over the period 1975 to 2000, but:

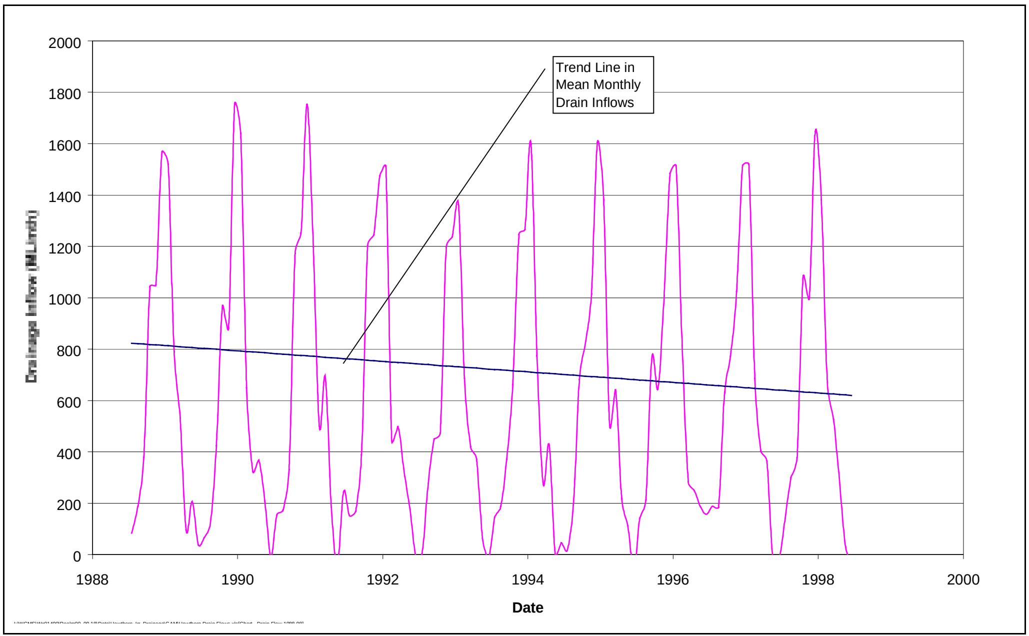
- with the irrigation drainage inflows that would have corresponded to the irrigation management efficiencies that had been achieved as at a particular date; and
- the stormwater inflows that would be expected with the level of urban development as at a specified date.

In regard to the irrigation drainage inflows, which, by visual inspection, trended downwards over the period of record, the reduction in volume due to improved irrigation efficiencies was determined using a statistical model known as the Generalised Additive Model (GAM).

The GAM was fitted to the monthly historical drainage inflows to Lake Hawthorn. The historical inflows were estimated as a function of rainfall, season, historical diversion volumes into FMIT, and time. GAM determines the strength of the influence (statistical significance) of the function variables on the changes in the drainage inflows. Any trend versus time that remains after rainfall, season, and FMIT diversions have been accounted for is taken to indicate the effect of improved irrigation efficiency.

The GAM analysis for the Lake Hawthorn drainage inflows showed a statistically significant time trend in the inflows over the period July 1988 to June 1998 with a reduction of 250 ML/yr in annual drainage volumes, over an irrigated catchment area of 5,300 ha. This represents a reduction of 0.05 ML/irrigated hectare/year, to a 1998 value of 1.4 ML/ha/yr. Figure A-1 displays the fit of the GAM model with the time trend shown as a straight sloping line. As GAM accounts for the influence of changes in rainfall, diversion volume and season, the time trend determined reflects the impacts on drainage volumes of improved irrigation efficiency.

- **Figure A-1 Lake Hawthorn Monthly Drainage Inflows with GAM Trend Line**



The form of the function fitted to historical inflows is as follows:

*Drainage Inflow (ML/mth) = 198 + 0.098 * Diversion Volume (ML/mth) + 4.4 * Rainfall(mm/mth) – 121* Sin (month number/12 * 2π) + 128* Cos (month number/12 * 2π) – 20.5 * Time*

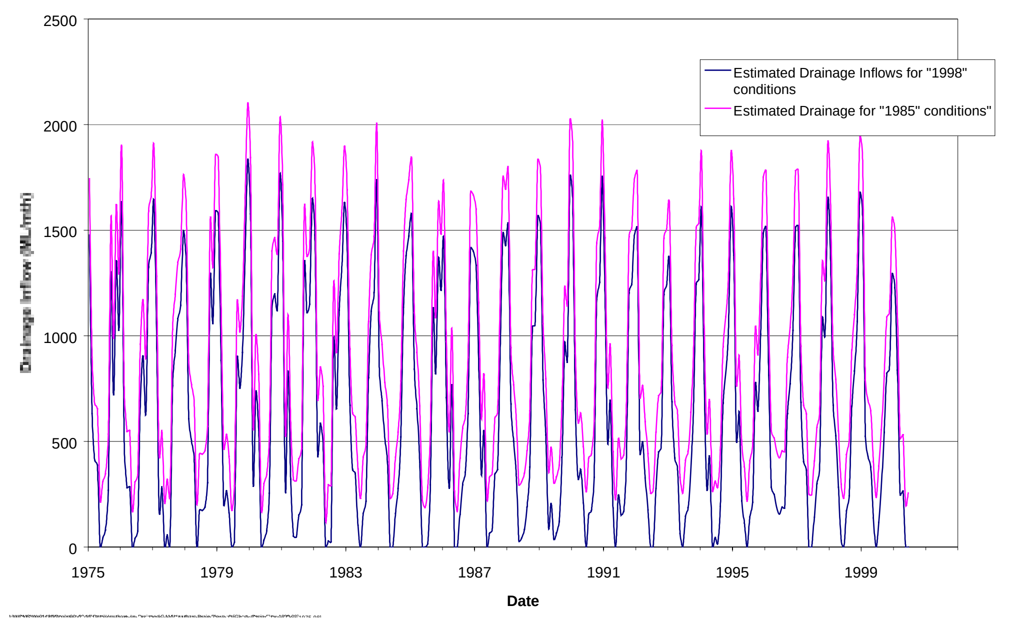
where: month number - 1 to 12 (January being 1 and December being 12)
time – year number with the year 1988 equal to zero. Note years prior to 1988 have a negative time value e.g. time is –3 for the year 1985

The above equation can be used to estimate drainage inflow for a given irrigation efficiency by setting the time variable is set to a constant value equivalent to the year of the required irrigation efficiency.

For the "present day" drainage inflow, the time variable was set to the year 1998. Similarly, the time variable was set to the year 1985 for estimation of the "1985" drainage inflows.

Figure A-2 shows the estimated time-series of drainage inflows for "present day" and '1985" irrigation management practices.

■ **Figure A-2 Estimated Lake Hawthorn Drainage Inflows for "Present Day' and "1985" Conditions for the period 1975-2000**



The estimated monthly drainage inflows were uniformly distributed across a month to obtain daily inflows.

For the scenario modelling for this investigation, a constant salinity of 2000 EC was adopted for the drainage inflows to Lake Hawthorn.

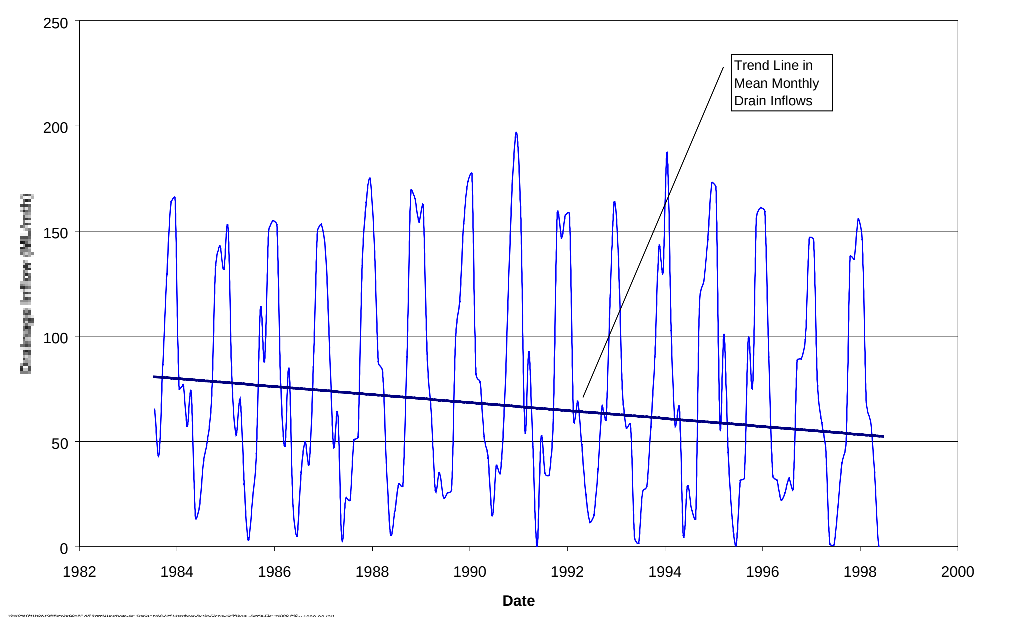
A.3 Merbein West and North West Irrigation Drainage Inflows

As for the Lake Hawthorn drainage inflows, the recorded flows from the Merbein West and North West drains have reduced over recent years. A GAM model was fitted to the recorded drain flows to assess the significance of this downward trend due to improved irrigation practices.

Monthly recorded drains for the Merbein West Drain (414701) and Merbein North West Drain (414706) were used in the GAM models. As for the Lake Hawthorn, the monthly inflows were estimated as a function of rainfall, season, historical diversion volumes into the Merbein District, and time.

The GAM analysis for the Merbein West Drain showed a statistically significant time trend in the inflows over the period July 1982 to June 1998 with a reduction of 22 ML/a in annual drainage volumes over an irrigated catchment area of 480 ha. This represents a reduction of 0.05 ML/irrigated hectare/year, to a 1998 value of 1.4 ML/ha/yr, and these rates are the same as for the Lake Hawthorn catchment. Figure A-3 displays the fit of the GAM model with the time trend shown as a straight sloping line for the Merbein West Drain.

■ Figure A-3 Merbein West Drain (414701) Monthly Drain Flows with GAM Trend Line



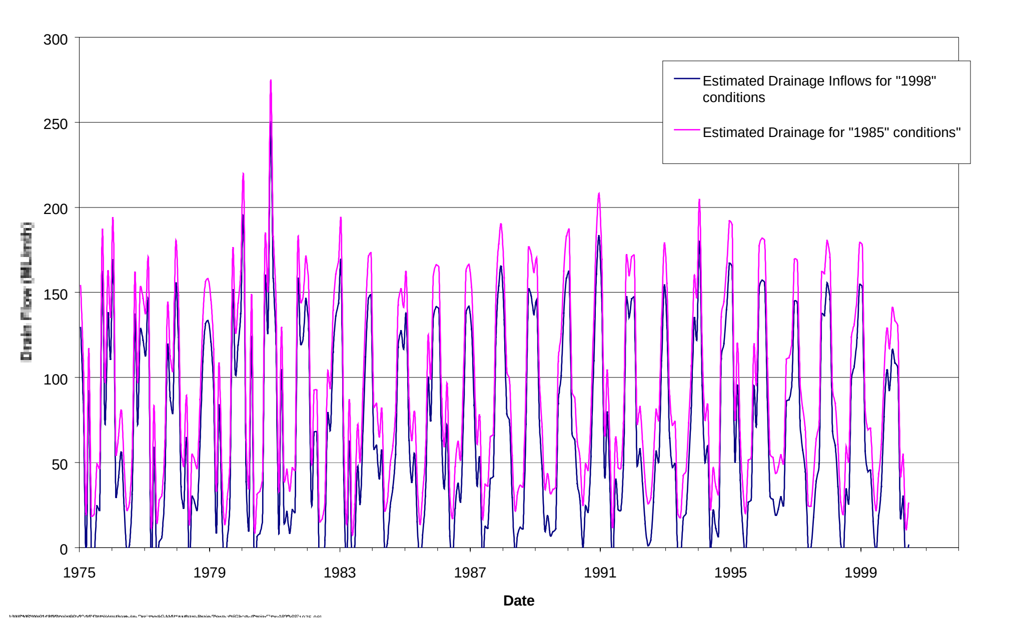
The form of the function fitted to historical inflows is as follows:

*Drainage Inflow (ML/mth) = 4.4 + 0.026 * Diversion Volume(ML/mth) + 0.68 * Rainfall(mm/mth) – 19.7* Sin (month number/12 * 2π) + – 1.9 * Time*

where: month number - 1 to 12 (January being 1 and December being 12)
time – year number with the year 1988 equal to zero. Note years prior to 1988 have a negative time value e.g. time is –3 for the year 1985

As for the Lake Hawthorn inflows, the above equation can be used to estimate drainage inflow for a given irrigation efficiency by setting the time variable is set to a constant value equivalent to the year of the required irrigation efficiency. Figure shows the estimated time-series of Merbein West drain flows for “present day” and ‘1985” irrigation management practices.

■ **Figure A-4 Estimated Merbein West Drain Monthly Flow for "Present Day' and "1985" Conditions for the period 1975-2000**



The estimated monthly drainage inflows were uniformly distributed across a month to obtain daily inflows.

Due to the periodic flushing of Lambert Swamp into the Merbein North West Drain, the fit of GAM model to recorded data proved difficult. The North West Drain flows for various irrigation management practices were estimated by factored the drain flows for the North West Drain by the ratio of catchment areas, i.e. 2.47 (1111 ha/450 ha).

For the scenario modelling for this investigation, a constant salinity of 2000 EC was adopted for the drainage inflows from the Merbein West and North West Drains.

Appendix B Drainage Volumes

Drainage volumes, salt loads and nutrients are presented in Tables B-1 to B-3.

Catchment areas and irrigated fractions have generally been taken from information presented in the Current Situation Report (ref 1). Surface catchments for non-urban areas have been defined from contours provided by Sunrise 21.

Current annual subsurface drainage volumes have been calculated using an average 1998 drainage rate of 1.4 ML/ha/yr. This is based on the analyses presented in Appendix A, with due allowance for removal of impacts of rainfall and diversion rates. Year 2050 volumes have been calculated using an average drainage rate of 0.7 ML/ha/yr.

Annual urban runoff volumes have been calculated assuming 30% runoff from developed areas, and 3.75% runoff from undeveloped areas in partially developed catchments.

Storm volumes and peak flows were calculated using the rational method. Times of concentration for free draining catchments were calculated assuming an average velocity of 1.5 m/s in urban catchments, and 1 m/s in rural catchments, plus five minutes. Runoff coefficients were assumed to be 0.40 for developed areas, and 0.05 for undeveloped areas.

A salinity of 2000 EC has been applied to subsurface drainage flows, based on analyses undertaken as part of the same Goulburn Murray Water investigation. A salinity of 500 EC units has been assumed for calculation of salt loads from urban catchments.

Total nitrogen concentrations were assumed to be 1 mg/L for irrigation drainage, and 5 mg/L for urban drainage.

The areas of existing basins were calculated from asset maps provided by Council. If the volume of a basin was not known, it was assumed that the basin is two metres deep with 3 (horizontal) : 1 (vertical) side slopes.

Pipe capacities were determined from standard nomographs for concrete pipes. Pipe diameters, lengths and slopes were derived from mapping information provided by the various authorities. Hydraulic slope was assumed to be 50% of ground slope to account for losses other than pipe friction losses. If contours were not available in the piped area, a ground slope of 1% was assumed.

■ Table B-1 Surface Catchments

Catchment	Total Area (ha)	Current Developed Area (ha)	2050 Developed Area (ha)	Land locked or Free draining	Current peak flow (5 yr ARI) m^3/s free draining only	2050 peak flow (5 yr ARI) m^3/s free draining only	Current 100 yr 72 hour storm volume land locked only	2050 100 yr 72 hour storm volume land locked only (ML)	Current Pipe outfall capacity - free draining only	Current basin volume - landlocked only	Current Annual runoff volume (ML/yr)	2050 Annual runoff volume (ML/yr)	Current Annual salt load (T/yr)	2050 Annual salt load (T/yr)	Current N (T/yr)	2050 N (T/yr)
Total	**6038**	**2039**	**4683**								**2202**	**4201**	**661**	**1260**	**11.0**	**21.0**
Merbein Township	145	145	181	FD							124.8	152.1	37.4	45.6	0.6	0.8
Redcliffs	285	285	428	FD							261.9	376.5	78.6	112.9	1.3	1.9
Mildura / Irymple																
A	64	58	64	FD	3.5	3.9					50.6	55.1	15.2	16.5	0.3	0.3
B	59	55	59	FD	3.6	3.8			0.82		47.8	50.8	14.3	15.2	0.2	0.3
D	20	15	20	FD	1.1	1.4			0.6		13.4	17.2	4.0	5.2	0.1	0.1
E	2	2	2	FD	0.2	0.2					1.7	1.7	0.5	0.5	0.0	0.0
F	73	61	73	FD	3.8	4.4			12		53.8	62.8	16.1	18.8	0.3	0.3
G	17	12	17	FD	1.0	1.4			0.22		10.9	14.6	3.3	4.4	0.1	0.1
H	9	4	9	FD	0.4	0.8					4.0	7.7	1.2	2.3	0.0	0.0
I	119	119	119	FD	6.8	6.8			2.2		102.4	102.4	30.7	30.7	0.5	0.5
J	170	107	153	FD	5.7	7.7			2.5		98.9	133.5	29.7	40.1	0.5	0.7
K	87	83	87	FD	5.4	5.6			1.7		71.9	74.9	21.6	22.5	0.4	0.4
L	503	357	402.4	FD	15.0	16.6			4		323.0	357.2	96.9	107.2	1.6	1.8
M	536		160.8	FD	2.6	8.1					57.7	178.8	17.3	53.6	0.3	0.9
N	155			FD	0.9	0.9					16.7	16.7	5.0	5.0	0.1	0.1
O	316	6	189.6	LL			23.7	108.8			38.5	176.8	11.6	53.0	0.2	0.9
P	86			FD	0.6	0.6					9.3	9.3	2.8	2.8	0.0	0.0
Q1	65	12	65	LL			9.9	34.4			16.0	55.9	4.8	16.8	0.1	0.3
Q2	420	62	420	LL			56.6	222.6		213	91.9	361.5	27.6	108.4	0.5	1.8
Q3	457		457	LL			30.3	242.2			49.2	393.3	14.8	118.0	0.2	2.0
Q4	36		36	LL			2.4	19.1			3.9	31.0	1.2	9.3	0.0	0.2
R	128		32	LL			8.5	23.3			13.8	37.9	4.1	11.4	0.1	0.2
S	33		3.3	LL			2.2	3.7			3.6	6.0	1.1	1.8	0.0	0.0
T	522	150	522	LL			104.1	276.6		61	169.1	449.3	50.7	134.8	0.8	2.2
U	142	10	35.5	LL			14.0	25.9			22.8	42.0	6.8	12.6	0.1	0.2
V	50		25	LL			3.3	14.9			5.4	24.2	1.6	7.3	0.0	0.1
W	25		25	LL			1.7	13.2			2.7	21.5	0.8	6.5	0.0	0.1
X	98	91	98	FD	5.0	5.3			4		79.1	84.3	23.7	25.3	0.4	0.4
Y	194	172	194	FD	8.3	9.2			2.7		150.4	167.0	45.1	50.1	0.8	0.8
(Y)	32	32	32	FD	2.4	2.4					27.5	27.5	8.3	8.3	0.1	0.1
Z1	147	77	147	FD	3.7	6.3					73.8	126.5	22.1	38.0	0.4	0.6
Z2	203	124	203	LL			70.9	107.6		4.9	115.2	174.7	34.6	52.4	0.6	0.9
AA	424		424	FD	2.0	15.6					45.6	364.9	13.7	109.5	0.2	1.8
AB	416			FD	2.7	2.7					44.8	44.8	13.4	13.4	0.2	0.2

■ Table B-2 Rural Surface Catchments (newly defined)

Catchment	Total Area (ha)	Current Developed Area (ha)	Land locked or Free draining	Current peak flow (5 yr ARI) m^3/s free draining only	Current 100 yr 72 hour storm volume land locked only	Current Annual runoff volume (ML/yr)
Adjusted Mildura / Irymple						
N (new)	431		FD	1.48		46.3
P (new)	292		FD	0.95		31.4
R (new)	142		LL		9.4	15.3
U (new)	85	10	LL		10.3	16.7
W (new)	670		LL		44.4	72.1
AB (new)	184		FD	0.75		19.8
Merbein (undeveloped)	7943					
2	182		FD	0.69		19.6
3	1235		FD	2.99		132.9
22	356		FD	1.22		38.3
28	976		LL		64.6	105.0
73	178		FD	0.69		19.2
74	26		FD	0.17		2.8
75	4990		FD	6.62		536.8
Red Cliffs (undeveloped)	12093					
33	113		LL		7.5	12.2
34	353		FD	1.21		38.0
38	240		LL		15.9	25.8
39	421		LL		27.9	45.3
40	444		FD	1.40		47.8
42	420		LL		27.8	45.1
43	3477		LL		230.3	374.1
44	315		LL		20.8	33.9
45	121		LL		8.0	13.0
46	663		LL		43.9	71.3
47	104		FD	0.38		11.2
48	45		FD	0.19		4.9
49	283		FD	0.97		30.4
50	395		LL		26.2	42.5
51	189		FD	0.69		20.3
52	396		FD	0.98		42.6
53	761		LL		50.4	81.9
54	100		FD	0.43		10.8
55	156		LL		10.3	16.7
56	294		LL		19.5	31.7
57	87		FD	0.43		9.3
58	157		LL		10.4	16.9
59	161		FD	0.69		17.3
60	386		LL		25.5	41.5
61	251		LL		16.6	27.0
62	256		LL		17.0	27.5
63	593		LL		39.3	63.8
64	133		LL		8.8	14.3
65	99		FD	0.49		10.6
66	37		FD	0.17		4.0
67	291		LL		19.3	31.3
68	7		LL		0.4	0.7
69	166		LL		11.0	17.9
70	48		LL		3.2	5.2
71	20		FD	0.15		2.1
72	113		LL		7.5	12.2

■ Table B-3 Subsurface Catchments

Catchment	Total Area	Area to be lost to urban development by 2050	Current Irrigated Area	Area that will never be irrigated	2050 Potential irrigation area	Current piped outfall capacity	Current required capacity (based on 0.20 l/s/ha)	2050 required capacity (based on 0.20 l/s/ha)	Current Annual Drainage Volume	2050 Annual dainage Volume	Current Annual Salt Load	2050 Annual Salt load	Current N
	Ha	Ha	Ha	Ha	Ha	l/s	l/s	l/s	ML/yr	ML/yr	t/yr	t/yr	(T/yr)
Total	**22694**	**2484**	**15489**	**1372**	**19406**	**2080**	**3098**	**3881**	**21685**	**13584**	**26022**	**16301.165**	**21.7**
SRWA													
SRWA (Merbein)													
North West	645	0	504	1	644		101	129	706	451	847	541	0.71
West	599	0	482	4	595		96	119	675	416	810	500	0.67
East	1063	0	795	18	1045	250	159	209	1113	732	1336	878	1.11
South East	317	0	244		317	130	49	63	342	222	410	266	0.34
Cabarita	108	0	39	9	99		8	20	55	69	66	83	0.05
South West	833	0	654	1	832		131	166	916	582	1099	699	0.92
Lamberts Swamp													
SRWA (Redcliffs)													
1	1512	0	1088	15	1497	580	218	299	1523	1048	1828	1258	1.52
2	101	0	69		101		14	20	97	71	116	85	0.10
3	228	0	173	1	227		35	45	242	159	291	190	0.24
4	325	0	227	5	320		45	64	318	224	381	268	0.32
5	66	0	50		66		10	13	70	46	84	55	0.07
6	95	0	65		95		13	19	91	67	109	80	0.09
7	56	0	42		56		8	11	59	39	71	47	0.06
8	169	0	122	3	166		24	33	171	116	205	140	0.17
9	21	0	16		21		3	4	22	15	27	18	0.02
10	1283	0	866	34	1249		173	250	1212	875	1455	1049	1.21
11	16	0	4		16		1	3	6	11	7	13	0.01
12	17	0	12		17		2	3	17	12	20	14	0.02
13	138	0	95	11	127		19	25	133	89	160	107	0.13
14	166	0	119	8	158		24	32	167	111	200	133	0.17
15	296	0	229		296		46	59	321	207	385	249	0.32
16	19	0	16		19		3	4	22	13	27	16	0.02
17	475	0	330	12	463		66	93	462	324	554	389	0.46
17A	113	0	81		113		16	23	113	79	136	95	0.11
17B	88	0	64	4	84		13	17	90	59	108	71	0.09
17E	34	0	27		34		5	7	38	24	45	29	0.04
17G	102	0	59		102		12	20	83	71	99	86	0.08
18	115	0	72		115		14	23	101	81	121	97	0.10

Catchment	Total Area	Area to be lost to urban development by 2050	Current Irrigated Area	Area that will never be irrigated	2050 Potential irrigation area	Current piped outfall capacity	Current required capacity (based on 0.20 l/s/ha)	2050 required capacity (based on 0.20 l/s/ha)	Current Annual Drainage Volume	2050 Annual dainage Volume	Current Annual Salt Load	2050 Annual Salt load	Current N
	Ha	Ha	Ha	Ha	Ha	l/s	l/s	l/s	ML/yr	ML/yr	t/yr	t/yr	(T/yr)
Private Irrigators													
Private Irrigators (Yelta)													
1	32		29		29		6	6	41	20	49	24	0.04
2	101		81		81		16	16	113	57	136	68	0.11
3	37		33		33		7	7	46	23	55	28	0.05
4	24		21		21		4	4	29	15	35	18	0.03
5	267		195	1	195		39	39	273	137	328	164	0.27
Private Drainage (Merbein)													
A (outside district)	127		82		82		16	16	115	57	138	69	0.11
B (outside district)	70		31		31		6	6	43	22	52	26	0.04
C (outside district)	143		62		62		12	12	87	43	104	52	0.09
D (inside district)	91		48		48		10	10	67	34	81	40	0.07
E (outside district)	67		45		45		9	9	63	32	76	38	0.06
F (inside district)	56		40		40		8	8	56	28	67	34	0.06
G (inside district)	-		108		108		22	22	151	76	181	91	0.15
H (outside district)	508		508		508		102	102	711	356	853	427	0.71
Mildura / Redcliffs (Private)													
Old Mildura	151	15.1	151		136		30	27	211	95	254	114	0.21
Bruces Bend	117		117		117		23	23	164	82	197	98	0.16
Other Private Diverters	306		306		306		61	61	428	214	514	257	0.43
Private Drainage (Redcliffs))			309		309		62	62	433	216	519	260	0.43
Private Systems			369		369		74	74	517	258	620	310	0.52
“ “			129		129		26	26	181	90	217	108	0.18
Irrigation First Mildura Irrigation Trust													
6 – North	865	454	494	31	380	270	99	76	692	266	830	319	0.69
7 – North East	1076	215.2	707	9	851		141	170	990	596	1188	715	0.99
8B	135	0	84		135	80	17	27	118	95	141	113	0.12
8A	269	0	176	61	208	150	35	42	246	146	296	175	0.25
9	229	0	169	9	220		34	44	237	154	284	184	0.24
12	402	0	284	3	399		57	80	398	280	477	335	0.40
1A	195	0	128	38	157		26	31	179	110	215	132	0.18
1B	800	0	340	307	493		68	99	476	345	571	414	0.48
1C	492	0	249	65	427		50	85	349	299	418	359	0.35
2A	1060	0	426	137	923		85	185	596	646	716	775	0.60
2B	579	0	146	339	240		29	48	204	168	245	201	0.20
2C	109	0	55	23	86		11	17	77	60	92	72	0.08
3A	236	0	178	9	227		36	45	249	159	299	190	0.25
3B	393	0	287	4	389		57	78	402	272	482	327	0.40
4A	105	13	13	3	89	20	3	18	18	63	22	75	0.02
4B	300	32	32	44	224		6	45	45	156	54	188	0.04
5	3975	1735.5	2286	119	2121	600	457	424	3200	1485	3840	1782	3.20
16	270	0	120	16	254		24	51	168	178	202	213	0.17
17	107	0	107	27	80		21	16	150	56	180	67	0.15