Australian Government

BIOREGIONAL ASSESSMENTS

PROVIDING SCIENTIFIC WATER RESOURCE INFORMATION ASSOCIATED WITH COAL SEAM GAS AND LARGE COAL MINES

Observations analysis, statistical analysis and interpolation for the Gippsland Basin bioregion

Product 2.1 - 2.2 from the Gippsland Basin Bioregional Assessment

2018

The Bioregional Assessment Programme

The Bioregional Assessment Programme is a transparent and accessible programme of baseline assessments that increase the available science for decision making associated with coal seam gas and large coal mines. A bioregional assessment is a scientific analysis of the ecology, hydrology, geology and hydrogeology of a bioregion with explicit assessment of the potential direct, indirect and cumulative impacts of coal seam gas and large coal mining development on water resources. This Programme draws on the best available scientific information and knowledge from many sources, including government, industry and regional communities, to produce bioregional assessments that are independent, scientifically robust, and relevant and meaningful at a regional scale.

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Cover photograph

Lake Victoria, Victoria, 2013
Credit: Hashim Carey

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2.1 Observations analysis and 2.2 statistical analysis and interpolation

2.1.1 Geology

Summary

A review of available surface and subsurface datasets in the onshore and offshore Gippsland Basin was conducted to build a regional geological model.

The Gippsland Basin geological model represents an interpretation of the underground geometries and lithologies. The interpretation is based on bores, wells, outcrop and geophysical data and accounts for the uncertainties and resolution inherent in these data. The well data helps to define the limits between the different geological units as well as the lithology. Geophysical data (mostly seismic reflection data) were used to extrapolate the data calibrated at the wells. Geophysical data (mostly potential fields) was also used to constrain basin architecture away from wells and seismic surveys. The uncertainty in these data increases as the distance between wells geophysical surveys increases.

As the density of both wells and geophysical data varies throughout the Gippsland Basin, isopach maps (i.e. thickness maps) were used to define the basin-scale architecture of the sequences.

The Gippsland Basin geological model can be updated and refined with additional or new datasets and can be populated with hydraulic properties derived from stratigraphic facies.

2.1.2 Surface water hydrology and water quality

Summary

The Gippsland Basin covers seven catchments. The Gippsland Basin bioregion contains 197 streamflow gauges. The Victorian water monitoring scheme classifies streamflow data into 57 quality codes. In this analysis, these quality codes were grouped into six broad water quality codes based on the national water quality coding scheme, to enable consistency and comparison between states and territories. Based on an analysis of all daily streamflow gauge data: 72% of all records were good; 8% fair; 6% poor; 4% unknown; and 10% missing. The quality of individual streamflow data varied significantly whilst results suggest that streamflow monitoring in the South Gippsland Basin was of a higher quality than the monitoring in all other basins. Water chemistry and quality was not considered in this analysis.

2.1.2.1 Hydrogeology and groundwater quality

The hydrogeology and groundwater quality discussion forms the basis of the conceptualisation of the numerical groundwater model that was built for the region. Hydrogeological data was sourced from various Victorian Government agencies and was combined and integrated to form a dataset fit for modelling purposes.

Groundwater level and bore depths information was sourced for various aquifers in the Gippsland region including the alluvial aquifers, the fractured rock aquifers and the deep water bearing units. This information is important for understanding groundwater processes and groundwater model calibration. Hydraulic parameters provide critical input into the numerical groundwater model – the identification of uncertainties in the hydraulic parameter fields is essential as they can contribute significantly to the overall uncertainty associated with the modelling of impacts.

The gap analysis provides an overall assessment of data availability required to construct three-dimensional representation of aquifers of various depths.

2.1.3 Surface water - groundwater interactions

Summary

Fifty stream gauges in unregulated catchments and 34 groundwater observation bores along main stems of some major rivers were selected for analysis of surface water – groundwater interaction in the Gippsland region. The 50 stream gauges cover the majority of main stems of major rivers in the region. The majority of these gauges have long-term record with a large number of high-quality daily streamflow. Forty-five of the 50 gauges record greater than 80% daily streamflow data classified as 'Good' or 'Fair' as defined by the national streamflow quality code. The 34 selected observation bores also have long-term record with high-quality groundwater level readings. Thirty have more than 100 readings with typical monitoring frequency ranging from monthly to quarterly. However, these selected bores only represent a small proportion of main stems of the major rivers in the region. There is no adequate water chemistry data from the gauges and bores for surface water – groundwater interaction analysis.

2.1.4 Geography

Summary

This section covers data characteristics, including accuracy, for all datasets used in the Geography section of companion product 1.1 for the Gippsland Basin bioregion.

For physical geography, brief assessments are provided from the relevant literature for the: (i) digital elevation model (DEM) data, (ii) surface watercourses and basin/catchment boundary data, (iii) soil classes and (iv) land use.For human geography, concise descriptions are provided of the land use management.

For historical climate analysis, brief descriptions are provided for: (i) precipitation (P), (ii) maximum and minimum air temperature (Tmax and Tmin, respectively), (iii) vapour pressure (VP), (iv) net radiation (Rn), and (v) potential evapotranspiration(PET) and (vi) flooding.

Estimates of the errors attributed to the spatial assignment of key climate inputs are presented. The relative error was presented as the percentage deviation of the interpolated mean annual climate data to measured daily climate observations. For rainfall, the median relative error was 6% whereas for Tmin the median relative error was approximately 9% and for Tmax the median relative error was approximately 3%. The error associated with interpolated rainfall reflects the significant variation in topography which ranges in elevation from sea level to 1,600mAHD. Similarly, the minimum air temperature is also influenced by topography, hence the high median relative error, whereas the maximum air temperature is modelled more accurately. For potential evaporation, the median relative error was 2.5%, for solar radiation it was 2.1%.

2.1.4.1 Methods

For physical geography, the main datasets used are: (i) digital elevation model (DEM) data, (ii) surface watercourses and basin or catchment boundary data, (iii) soil classes and (iv) land use. Each is briefly outlined in the following section.

2.1.4.2 Observed data

This section describes the nature, source, construct and the spatial and/or temporal resolution of all relevant geographic datasets that have been used in the Gippsland Basin bioregional assessment, and in particular the development of the groundwater model.

2.1.4.2.1 Digital Elevation Model data

The Digital Elevation Model (DEM) was obtained from the 1 second (~30 m resolution grid cell) Shuttle Radar Topography Mission (SRTM). This national elevation data set was developed by the National Elevation Data Framework (NEDF) partners comprising Geoscience Australia (GA), the Bureau of Meteorology (BoM), the Commonwealth Scientific and Industrial Research Organisation (CSIRO) and the Australian National University (ANU) (Gallant et al., 2011). The SRTM global elevation data was collected by the Space Shuttle Endeavour during 11 days in February 2000. The data was acquired by interferometric synthetic aperture radar based on interference patterns between radar signals collected by two antennas. The shuttle was oriented to point the antennas at 45° to the ground to optimise the effect of topography on the interference patterns. Obscured regions such as zones of large topographic variation were evaluated by collecting overlapping swathes from different orbits. The elevation of ground surface in metres above Australian Height Datum (mAHD) based on the 1 second DEM is shown in Figure 1. Derived map surfaces of aspect and slope based on the DEM are shown in Figure 2 and Figure 3 respectively.

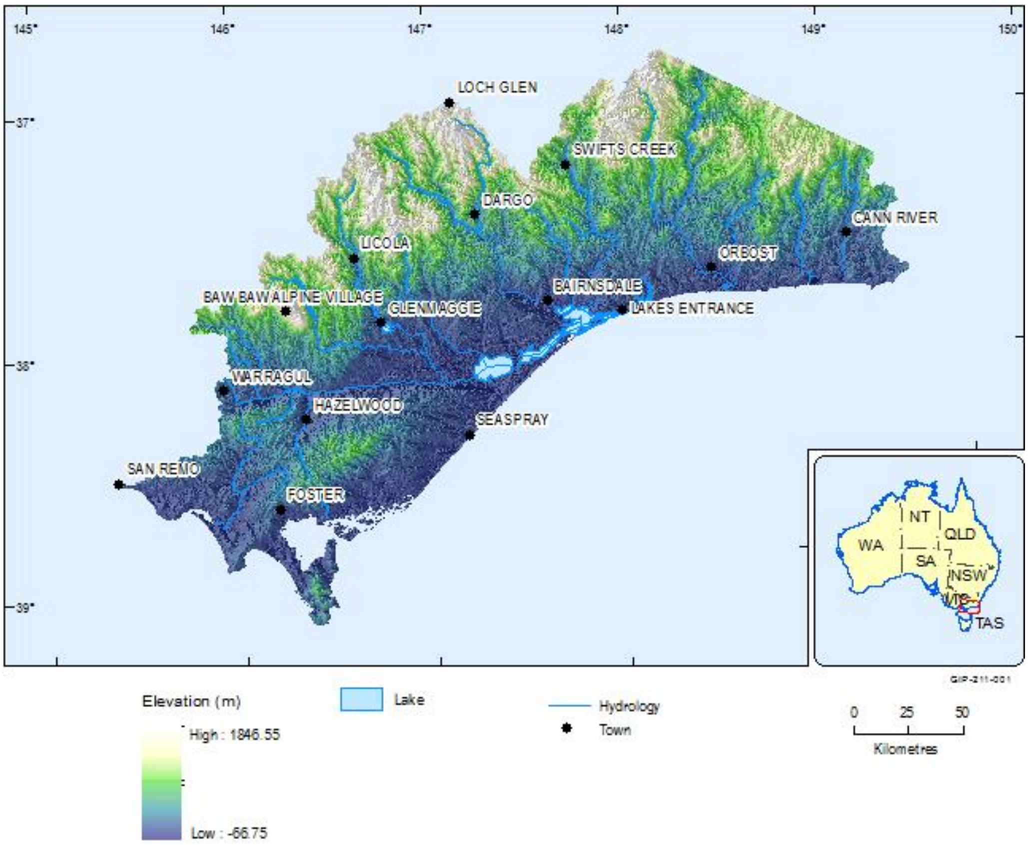


Figure 1 Elevation of ground surface (mAHD) based on the 1 second digital elevation model (Gallant et al., 2011)

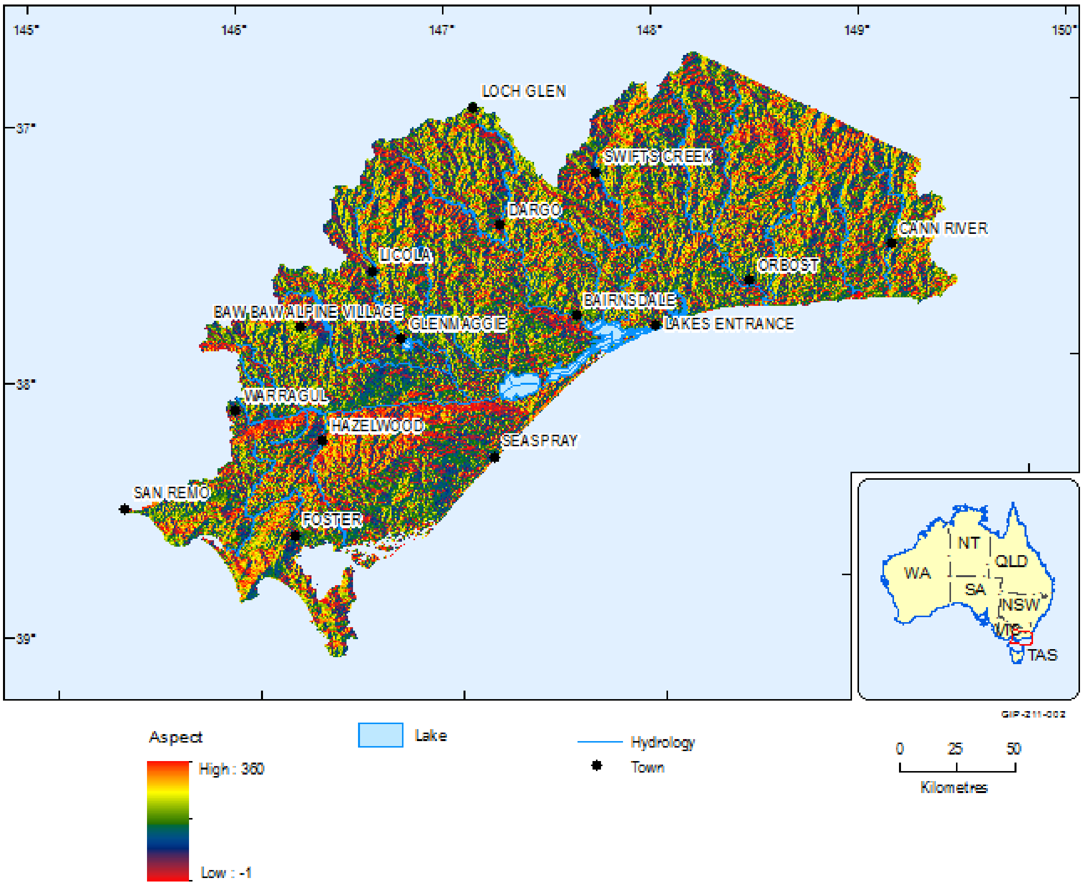


Figure 2 Aspect derived from the 1 second digital elevation model. Aspect is reported as the angle in degrees from north

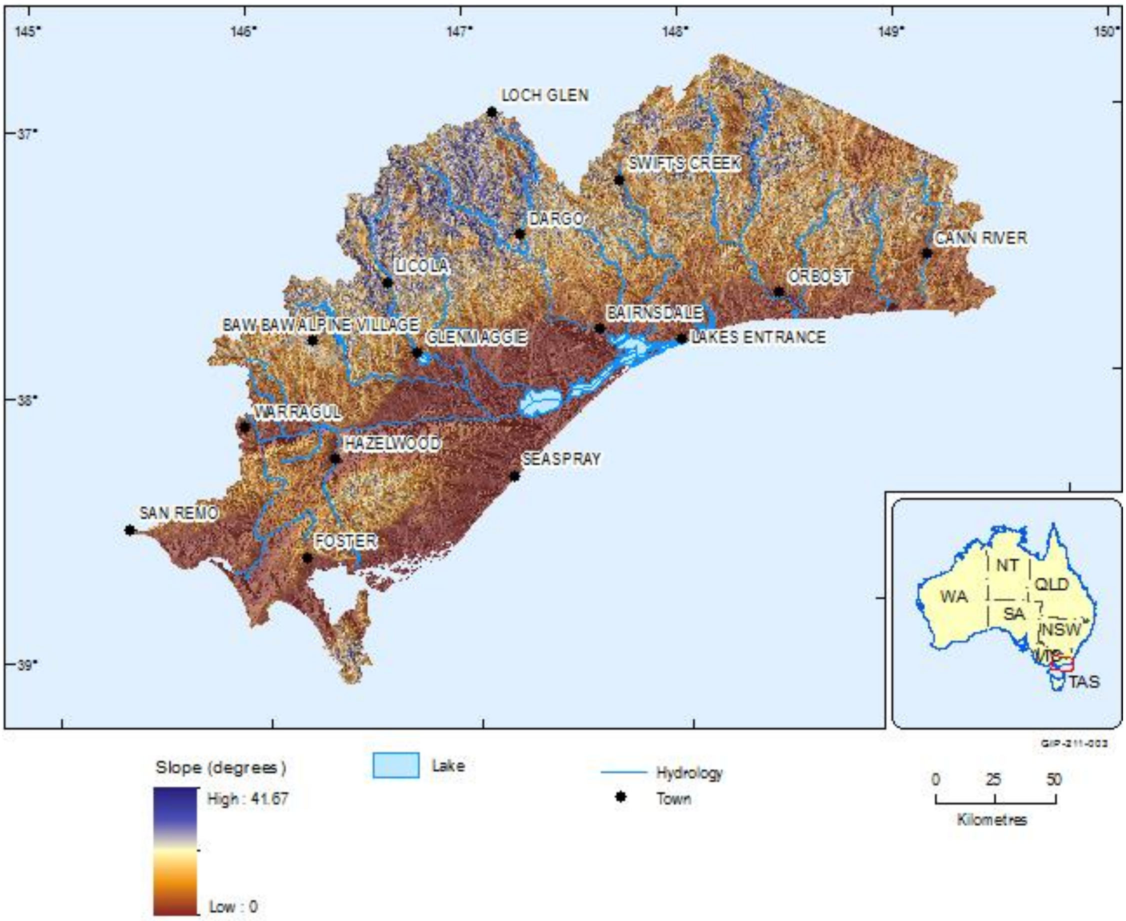


Figure 3 Slope derived from the 1 second digital elevation model

2.1.4.2.2 Surface water courses and catchment boundaries

The spatial map of surface water courses was sourced from the Victorian Department of Sustainability and Environment Spatial Information Infrastructure group, Vicmap Hydro data layer (www.land.vic.gov.au/vicmapdata). Vicmap Hydro is a topologically structured digital data set depicting Victoria’s natural and man-made water resources including selected water-related structures and coastal navigational features. This data layer contains line features delineating hydrological features including watercourses (ie channels, rivers and streams) and connectors. The drainage pattern covering Victoria is made up of point, line and polygon area features in a seamless and topologically structured data set. The line work and points were derived from the Vicmap Digital Topographic (VDT) map base which evolved from Victoria's printed 1:25,000 Topographic Map Series program. As such, data within the Vicmap Hydro spatial map has primarily been captured to 1:25 000 scale topographic specifications.

2.1.4.2.3 Spatial soil data layer and attribution

The spatial soil data layer was derived by merging broad scale Land Classification Survey data and 1:25,000 soil attribute coverage (Smith, 2002). Numerous Land Classification/Landform studies have been undertaken within the Gippsland Basin region (Sibley, 1966; Nicholson, 1974; Sargeant, 1975; Rowe, 1977; Nicholson, 1978; Schoknecht, 1982; Aldrick et al., 1988; Aldrick et al., 1992; Rees, 1996; Sargeant and Imhof, 2000) and have been mapped at varying scales ranging from 1:50

000 to 1:250 000 scale. Public land was typically mapped at 1:250 000 scale, freehold land was mapped at 1:100 000 scale whereas irrigated regions were mapped at 1:50 000 scale.

The spatial landform data attribution was based on information related to parent material, depositional processes, topography and climate. Soil pit studies were subsequently used to develop relationships between landform attributes, soil texture and soil profile information. Based on these relationships and the spatial landform data attribution a spatial soil map was generated for the study area. The merged spatial soil layer was attributed using the Factual Key of Northcote (1979) at the Principal Profile Form (PPF) level to classify different soil types. Within the study area, 169 different soil types were identified and spatially assigned. The spatially-assigned key primary level soil classifications are presented in Figure 4. The primary levels refer to Dr (texture contrast soils, red clay B horizons), Dy (texture contrast soils, yellow-grey clay B horizons), Gn (sodosol, gradational not calcareous throughout), NS (no soil representing water bodies), Oo (organsols), Uc (uniform coarse textured), Uf (uniform fine textured, not cracking), and Um (uniform medium textured).

The soil attribution through depth for each soil type was based on published data sources (McKenzie et al., 2000), field observations and pseudo-transfer functions (vanGenuchten et al., 1991) and includes soil water characteristics, bulk densities, hydraulic properties and impedance properties specified for each soil layer modelled. Additionally, each soil required specification of erodability, erosion and soil evaporation attributes.

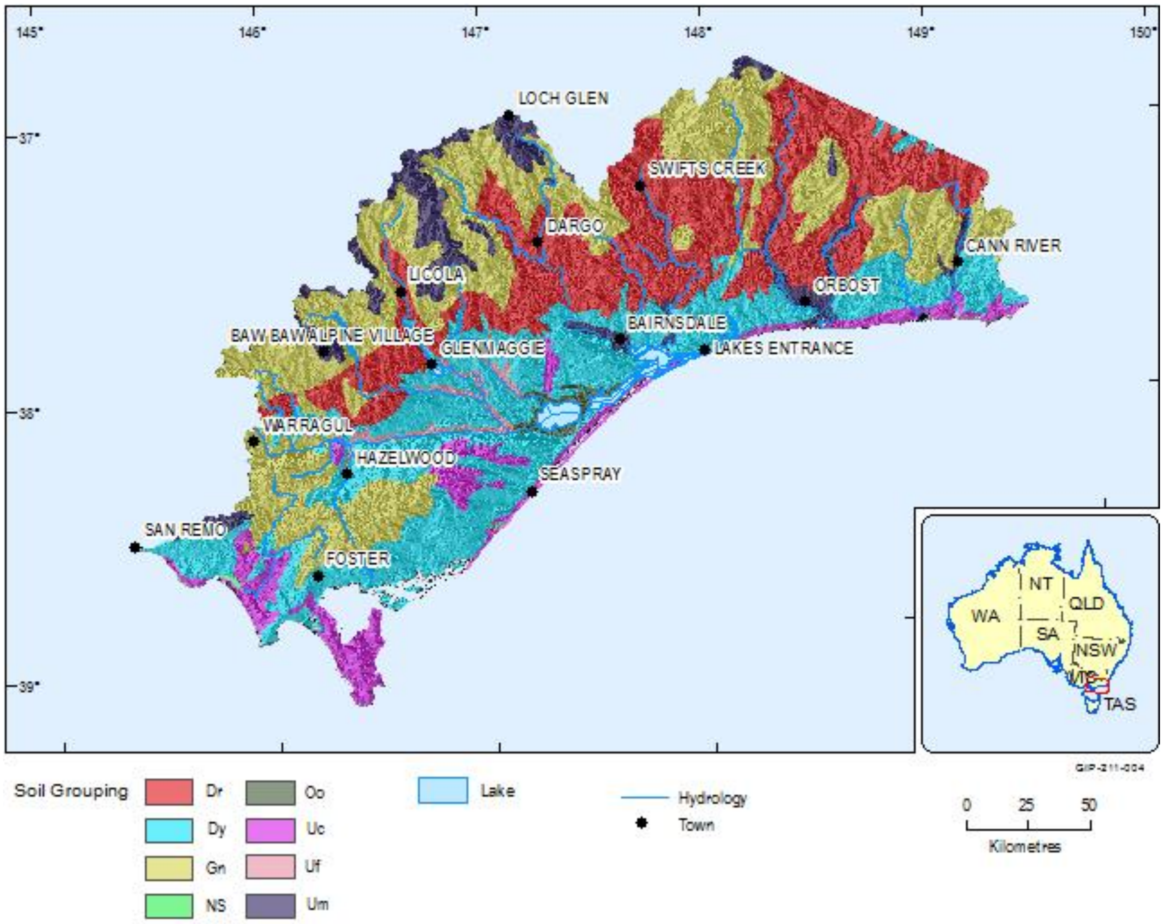


Figure 4 Spatial pattern of the key soil classifications in the Gippsland region

2.1.4.2.4 Land use data

The land use spatial data layer for this study was sourced from the Catchment Scale Land Use Mapping for Australia update March 2010 (CLUM Update 03/10) dataset compiled by the Australian Bureau of Agricultural and Resource Economics (ABARE) and the Bureau of Rural Sciences (BRS). Land use data was classified based on the Australia Land Use and Management (ALUM) classification Version 6 (BRS, 2006) (http://adl.brs.gov.au).

The land use spatial data layer is a 50 m raster dataset and was collated as part of the Australian Collaborative Land Use and Management Program (ACLUMP). The March 2010 version used in this study represents the land use as mapped in 1997. Where land use data was not assigned, attribution was based on the land use specified in the corresponding Australian Bureau of Statistics mesh block with modifications based on: (1) the 1:250 000 scale topographic data for built up areas published by Geoscience Australia (GA) in 2006; (2) land tenure data compiled by the Bureau of Rural Sciences (BRS) in 2007; and (3) native and plantation forest data compiled by BRS in 2007.

The ALUM taxa describe land cover against which management strategies need to be specified. A total of 49 land use classifications were adopted in this study (Figure **5**). In the case of cropping enterprises, crop rotations and cropping history was incorporated into the management scripts used in the catchment modelling.

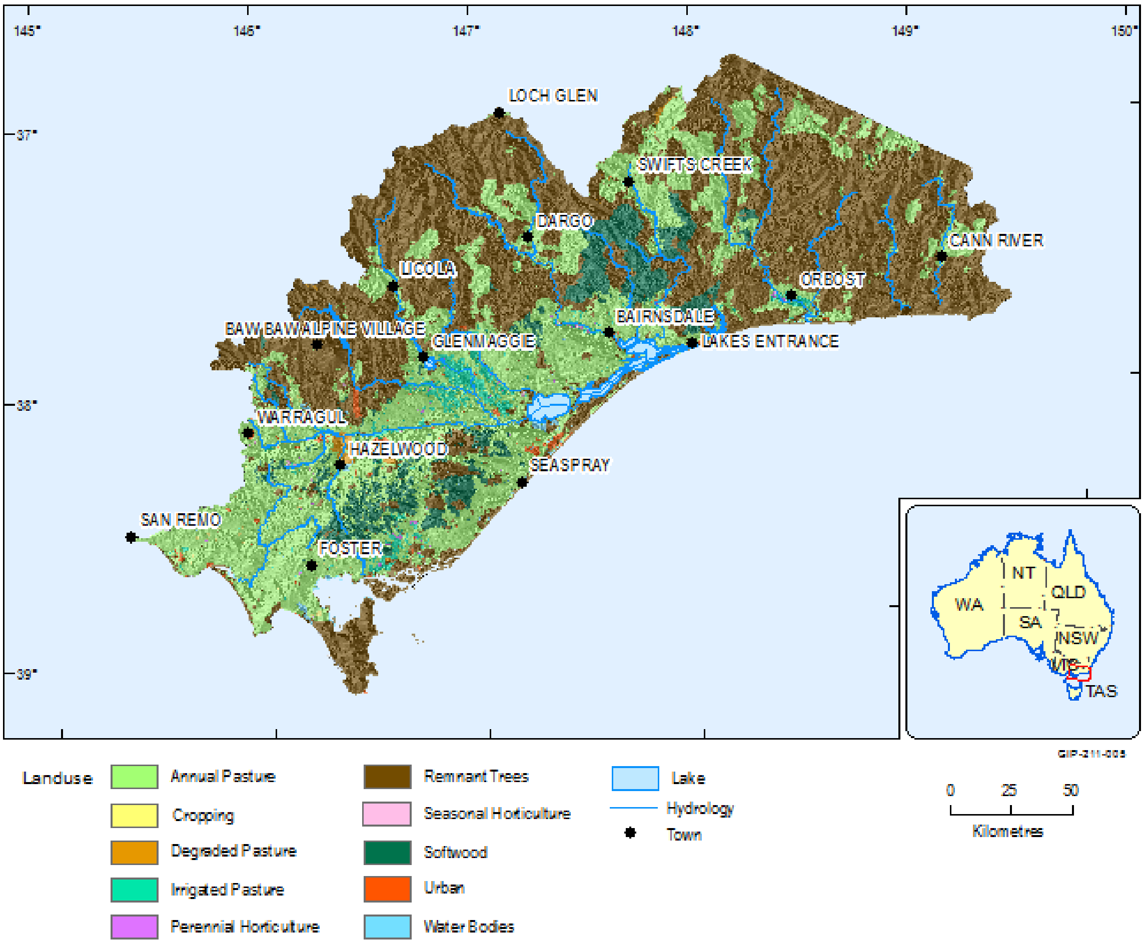


Figure 5 Land use classified into broad grouping

2.1.4.2.5 Climate data

For this study, daily meteorological data was obtained from the Bureau of Meteorology/Queensland Department of Science, Information Technology, Innovation and the Arts (https://www.longpaddock.qld.gov.au/silo/) for each of the 199 climate stations located within the study area from 1957 to 2013.

For a given climate station, daily meteorological data was a combination of site-specific measurements and rectified data to infill any gaps in the record using interpolation methods discussed in Jeffery et al., (2001). To account for sparsely located climate stations within the study area, daily rainfall, temperature, evaporation and solar radiation data were scaled to each solution point within the study area. This was based on interpolated mean annual spatial layers created using the ANUClim software (Hutchinson, 2001). This approach combines a DEM and temporal climatic data to generate a smoothed surface for each key climate attribute.

Using this approach daily meteorological data assigned to each solution point within the study area is a function of the data from the 199 climate stations, landscape position and topography. Figure 6 shows the area influenced by each climate station. Figure 7, Figure 8, Figure 9, Figure 10 and Figure 11 show respectively, the smoothed surfaces for the mean annual rainfall, average daily minimum temperature, average daily maximum temperature, average daily radiation and mean average potential evaporation from 1957 to 2012.

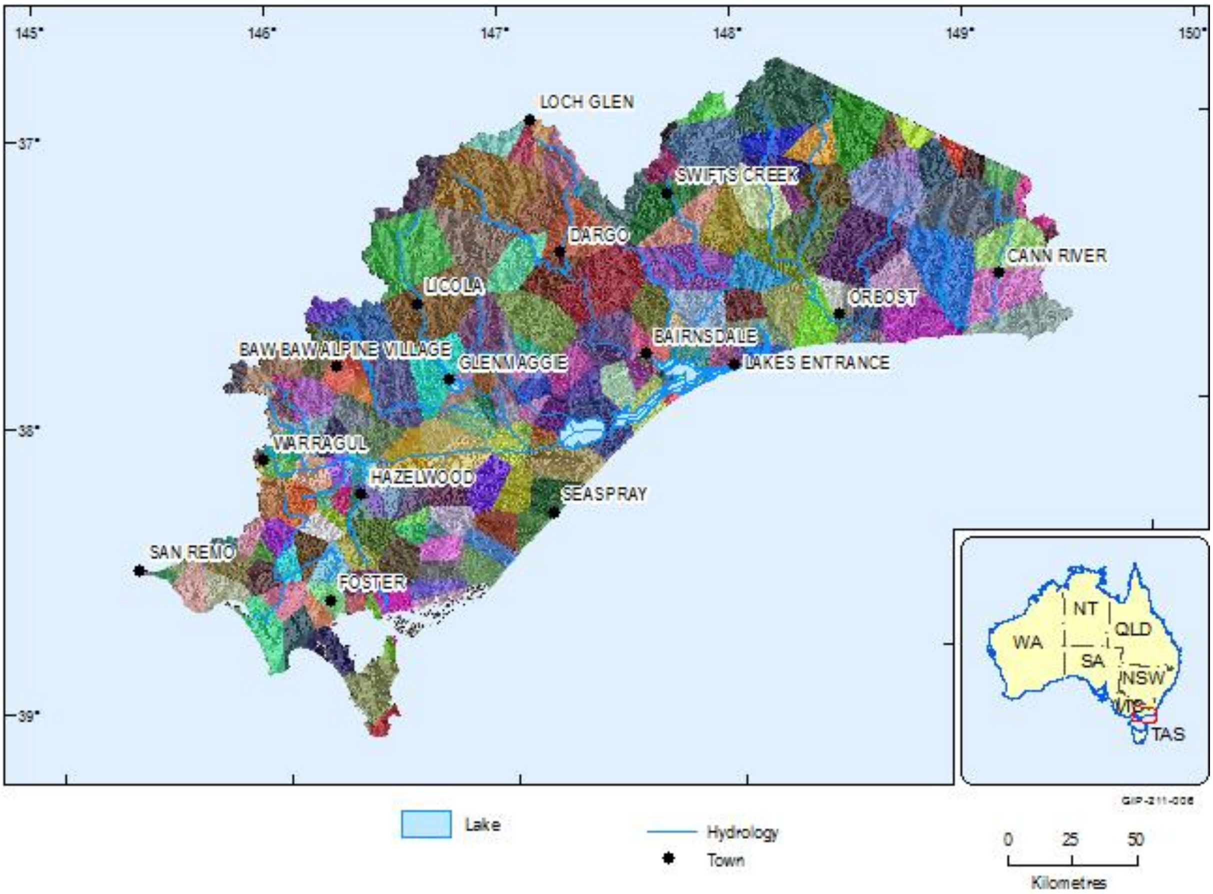


Figure 6 Zones of influence attributed to climate stations within the study area

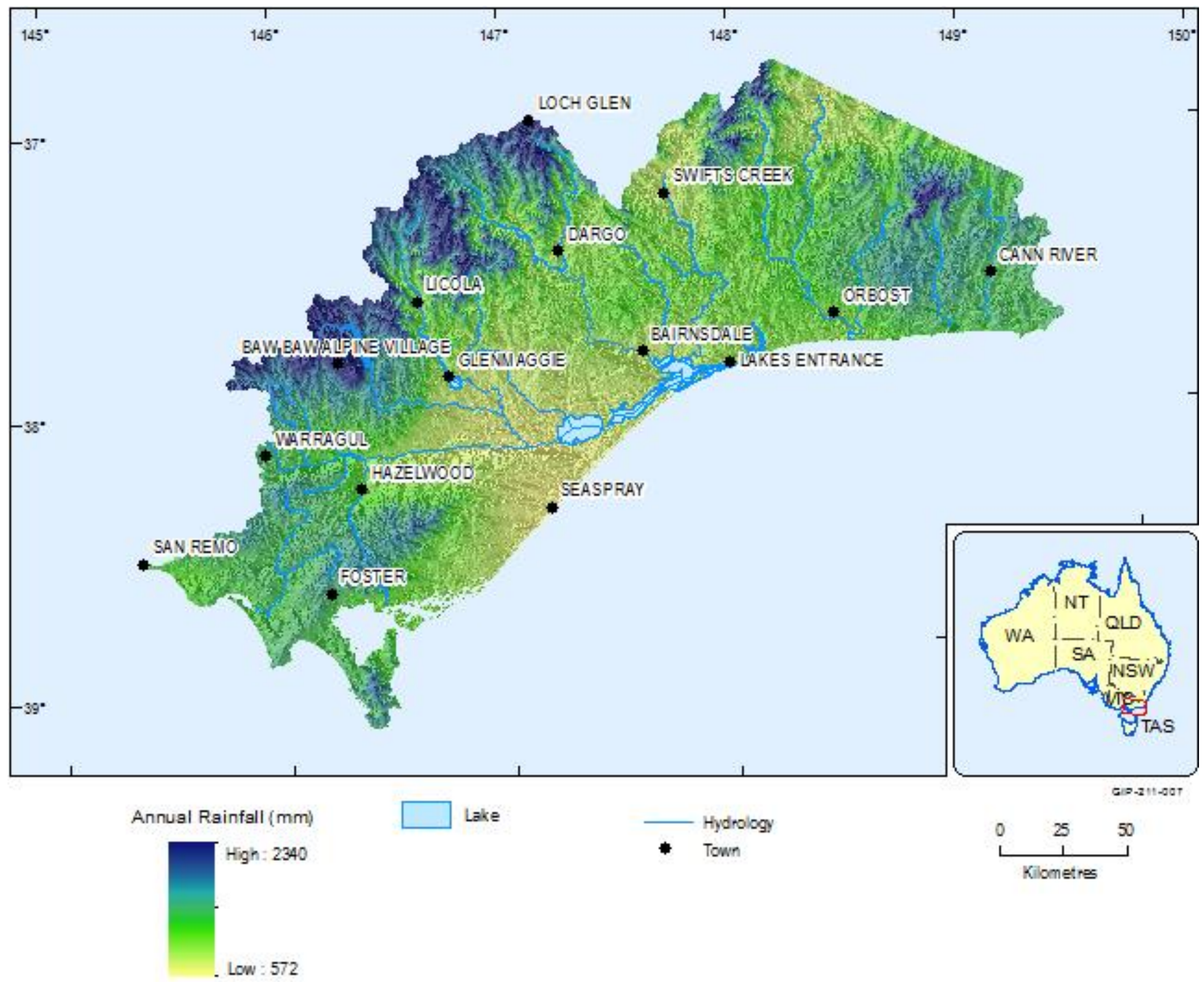


Figure 7 Interpolated mean annual rainfall (mm/yr) for the period 1957–2012

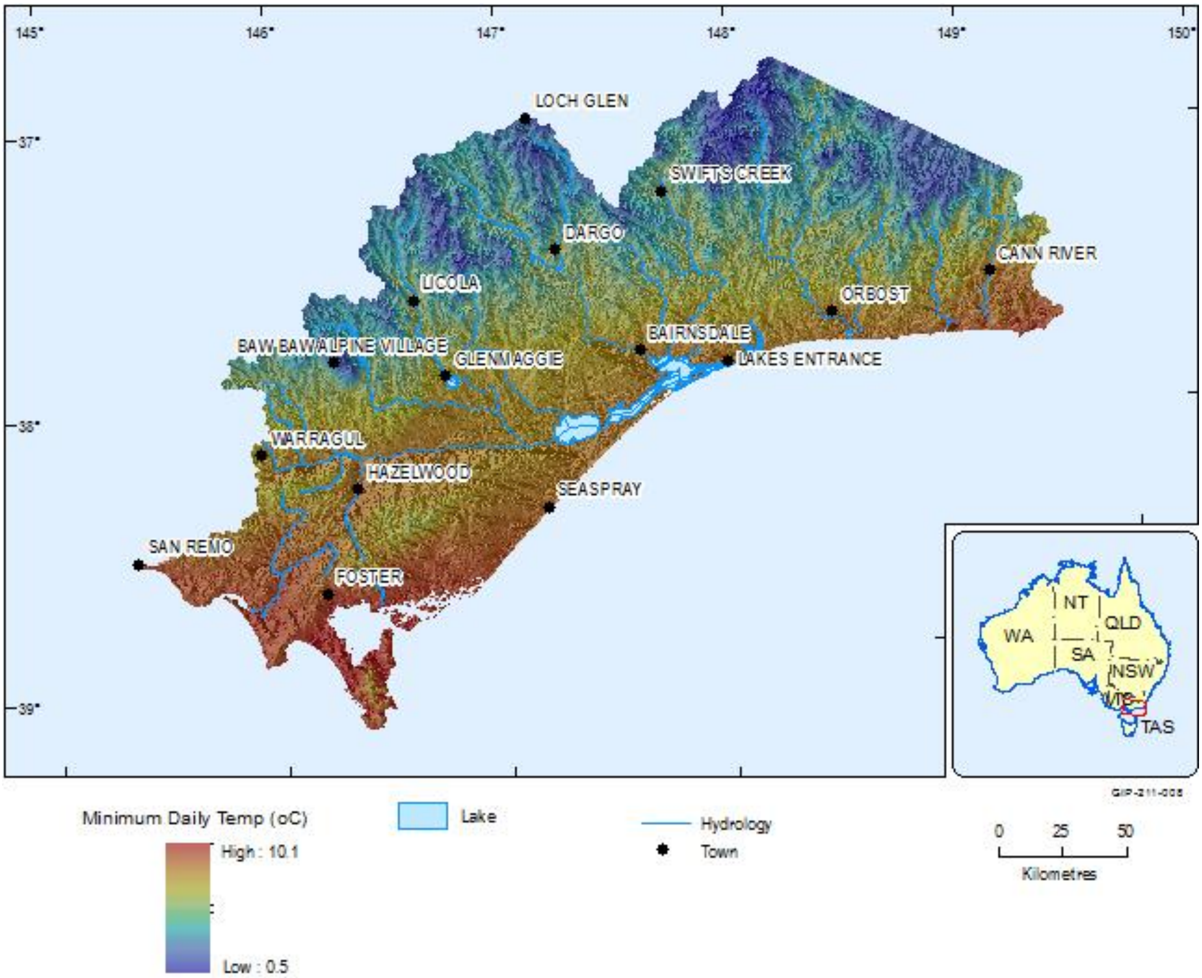


Figure 8 Interpolated average daily minimum temperature (ºC) for the period 1957–2012

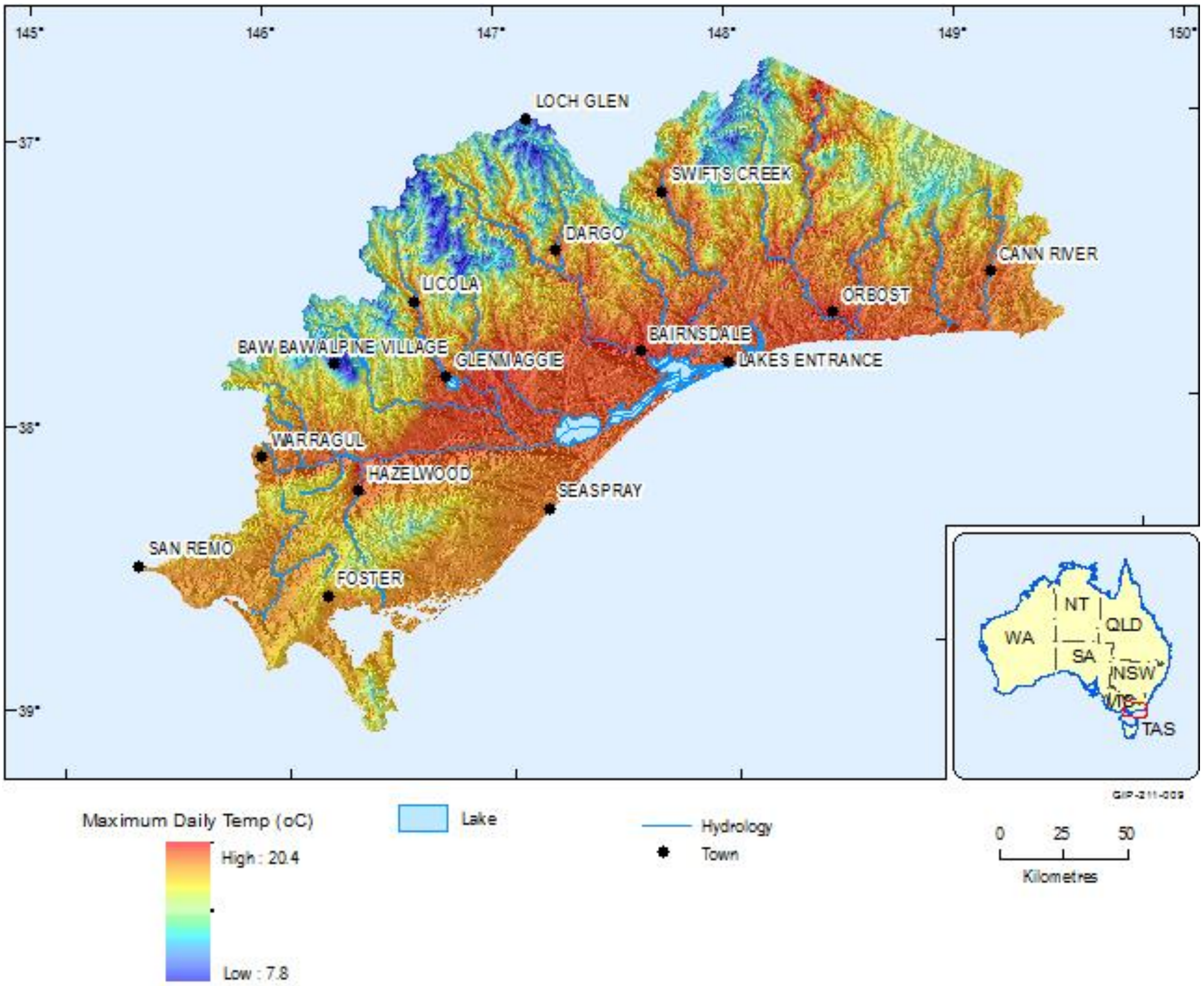


Figure 9 Interpolated average daily maximum temperature (ºC) for the period 1957–2012

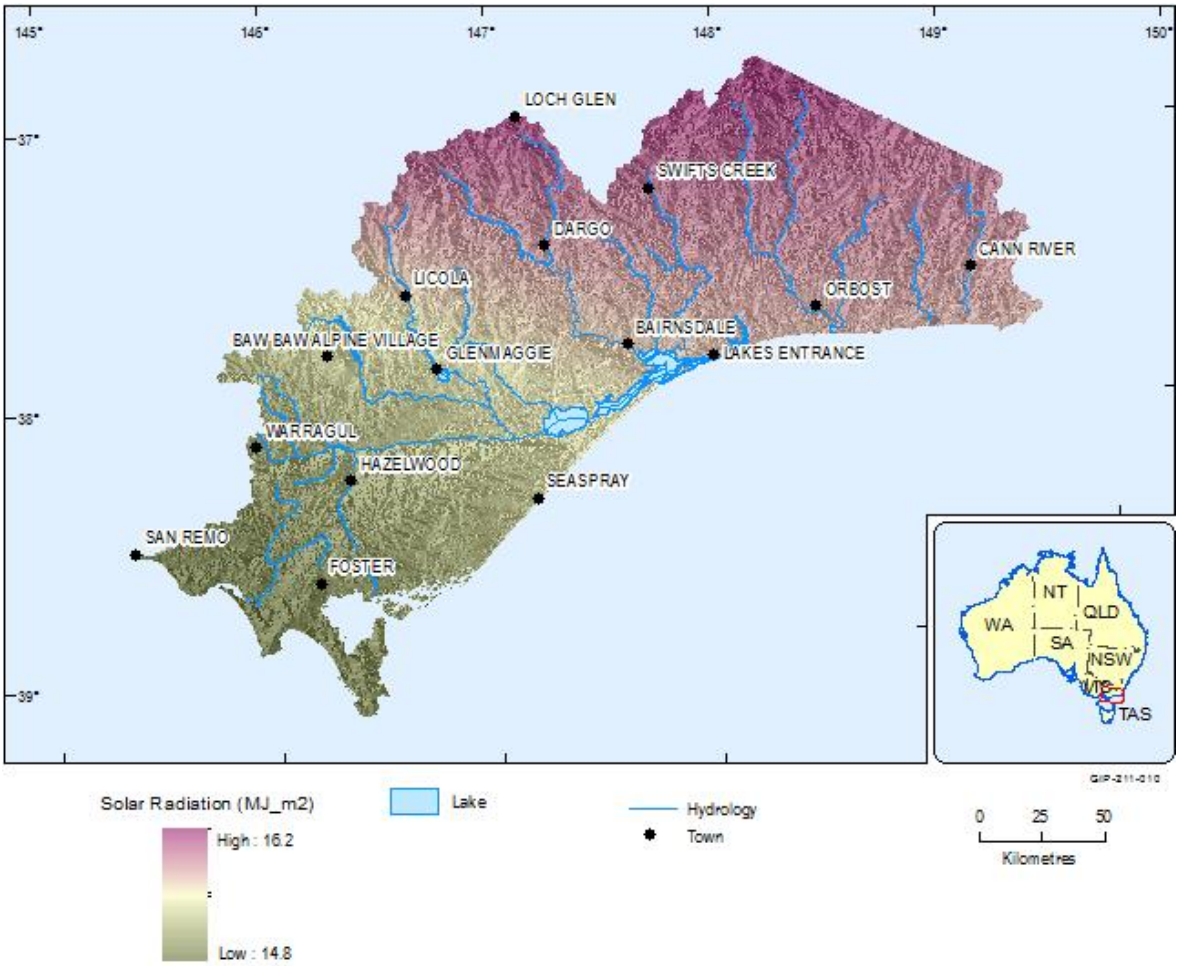


Figure 10 Interpolated average daily solar radiation (MJ/m2) for the period 1957–2012

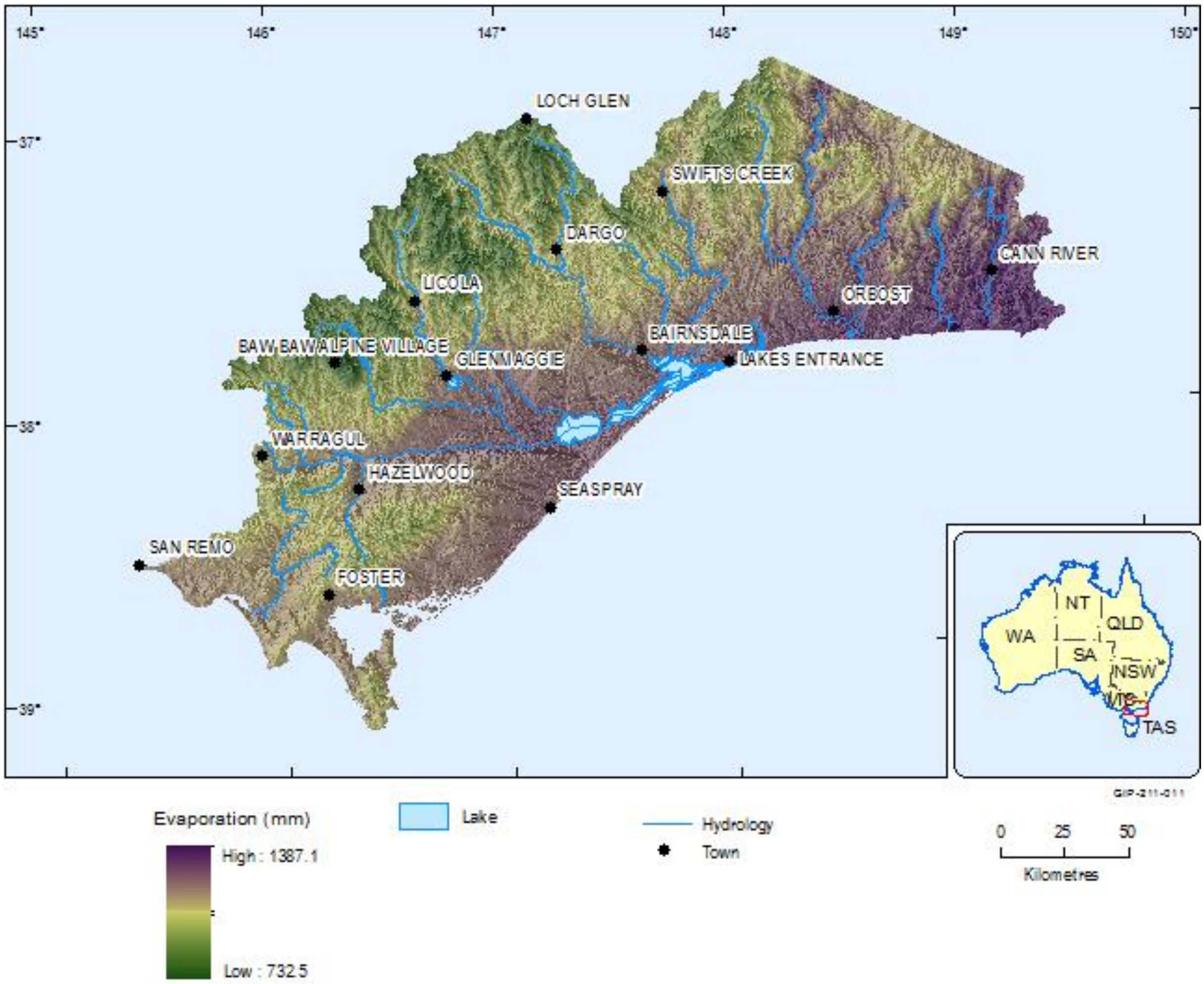


Figure 11 Potential mean annual evaporation (mm/yr)

2.1.4.2.6 Flood data

Flood data was sourced from the Victorian Flood Database and included information regarding location and extent of a 1-in-100 year event and historical flood events. The database contains flood extent, contour and spot height features derived from various flood studies, reports, plans and imagery. It includes both modelled and observed data and comprises 3 main data groups, containing a total of 26 separate layers, with data groups as follows:

- Modelled Flood Extents: Extent_{n}y_ARI, where n = 5, 10, 20, 30, 50, 100, 200, 500, 1000 year intervals
- Modelled Flood Contours: Contour_{n}y_ARI, where n = 5, 10, 20, 30, 50, 100 and 200 year intervals
- Other flood data: Floodway, historic_extent, historic_height, historic_contour, flow direction, levee, levee spot height and running distance.

The mapped scale of input data ranges from 1:1 000 to 1:10 000. Figure 26 shows the location and extent of recent major floods and Table 10 presents the magnitude of each flooding event in the past 100 years (including area directly affected and duration). The extent of the 1-in-100 year flooding event only covers 4.8% of the total area of the Gippsland region. In the last 100 years, flooding events mainly occurred in small areas around the lower reaches of the Mitchell, Thomson, Latrobe and Snowy rivers. The area directly affected by flooding was generally less than 1% of the Gippsland region. The largest flood event occurred in June 2012 and covered 1.4% of the Gippsland region. Given the areas affected by historic flooding events were relatively small, it is believed that the impact of flooding on groundwater recharge is insignificant at the regional scale, but likely to be significant at the local scale.

2.1.4.3 Statistical analysis and interpolation

The observed datasets were interpolated to form derived datasets. A brief review of the accuracy of each data set is presented below.

2.1.4.3.1 DEM

As reported in Gallant et al., (2011), a comparison of SRTM with reference data (Rodriguez et al., 2006) showed that 90 of tested heights were within 6 m of the reference heights. In much of the clear flat areas of Australia the height errors are less than 3 m, although there are some areas where the errors are much larger.

2.1.4.3.2 Surface water courses and catchment boundaries

The accuracy of the Vicmap Hydro spatial data layer in terms of the degree to which features and attribute values of spatial objects agree with the information on the source material ranges between a 1% to 5% error (DSE, 2012).

The planimetric accuracy attainable is defined as the sum of errors from three sources: the positional accuracy of the source material, errors due to the conversion process and errors due to the manipulation process. For topographic base derived data, it is estimated this represents an error of 8.3 m on the ground for 1:25 000 data. A conservative estimate of 10 m for the standard deviation is therefore assigned to represent the data quality of the Vicmap Hydro spatial data layer. An alternate and equal way of expressing this error is that not more than 10% of well-defined points will be in error by more than 16 m. The worst-case error for the data is +/- 30 m. The vertical positional accuracy of points based on contour elevation is less than or equal to half the value of the contour interval.

2.1.4.3.3 Soil map

The derived spatial soil map is considered to be highly reliable. It is not appropriate to derive statistical analysis based on comparing the soil map attributes at those locations where soil pit data exists due to the following reasons:

- Sparse site specific soil pit data may not be representative of a soil unit and should therefore not be the sole data set used to define the spatial boundaries of a soil type. Soil maps based on soil pit data are typically derived for irrigated regions or small-scale investigations where soil cores are sampled at a high spatial intensity.
- Soil structure is a function of environmental conditions and depositional processes which are not accounted for were soil pit data to be extrapolated across a landscape with no consideration of landscape processes.
- The majority of the study area was attributed by an individual soil scientist such that the mapped units are considered consistent.
- The scale of the spatial soil map is consistent with the scale of the catchment modelling.

2.1.4.3.4 Land use

Catchment scale mapping is produced by combining land tenure and other types of land use information, fine-scale satellite data and information collected in the field. These data sets were combined and gridded at 50 m. It is acknowledged that the scale of the source data may vary significantly. The Victorian Government has recently invested in the Victorian Land Use Information System (VLUIS) to create regular and consistent land use data over time. This dataset describes land tenure, land use and land cover for each cadastral land parcel. The land use classification used is the Australian Valuation Property Classification Code (AVPCC) 2010. A comparison of the CLUM and 2008/09 VLUIS data sets for a limited number of similar land classifications in a region of the Gippsland Basin resulted in a greater than 85% correlation. A more rigorous analysis of reliability is not possible as VLUIS does not adopt the Australian Land Use Mapping (ALUM) classification categories which was used in the catchment modelling.

2.1.4.3.5 Climate data

The catchment-scale water balance modelling was based on discretising the study area into 865,611 landscape units of varying size based on land use, climate, topography and sub-catchment boundaries. Within each landscape unit a solution point was assigned a time varying climate dataset based on climate station records. To account for sparsely located climate stations within the study area, daily rainfall, temperature, evaporation and solar radiation data were scaled to each solution point within the study area according to interpolated mean annual spatial layers created using the ANUClim software (Hutchinson, 2001). This approach combines a DEM and temporal climatic data to generate a smoothed climate surface. As such, daily meteorological data assigned to each solution point within the study area was a function of the data from the 199 climate stations, landscape position and topography.

To assess the accuracy of the input climate data the error associated with the spatial interpolation of the key meteorological inputs of rainfall, Tmax, Tmin, potential evaporation and radiation was evaluated. The error was calculated by comparing the climate station daily recorded information to the interpolated mean annual estimate derived using the ANUClim software (Hutchinson, 2001) for the same climate station location. That is, a comparison of the mean annual 1976–2005 rainfall, Tmax, Tmin, potential evaporation and radiation for each climate station was assessed to estimate the error associated with the spatial assignment of climate data to each solution point.

The comparative histograms derived from the SILO climate station data and the interpolated ANUClim for mean annual rainfall, Tmin, Tmax, potential evaporation and radiation are shown in Figure 12 to Figure 16; also shown are the corresponding probability of exceedance curves (Dataset 12).

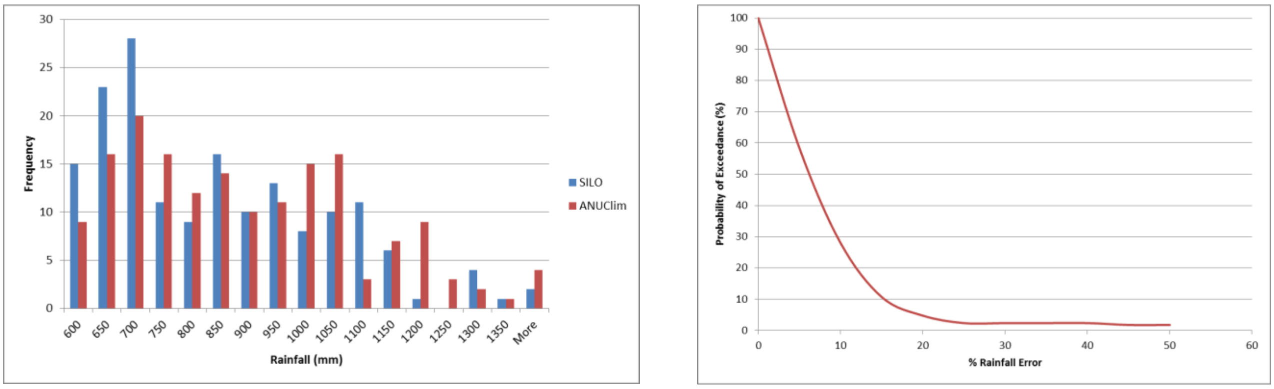


Figure 12 Comparative histograms derived from the SILO climate station data and the interpolated ANUClim for mean annual (left) and corresponding probability of exceedance curve of the percent variation (right) (Dataset 12)

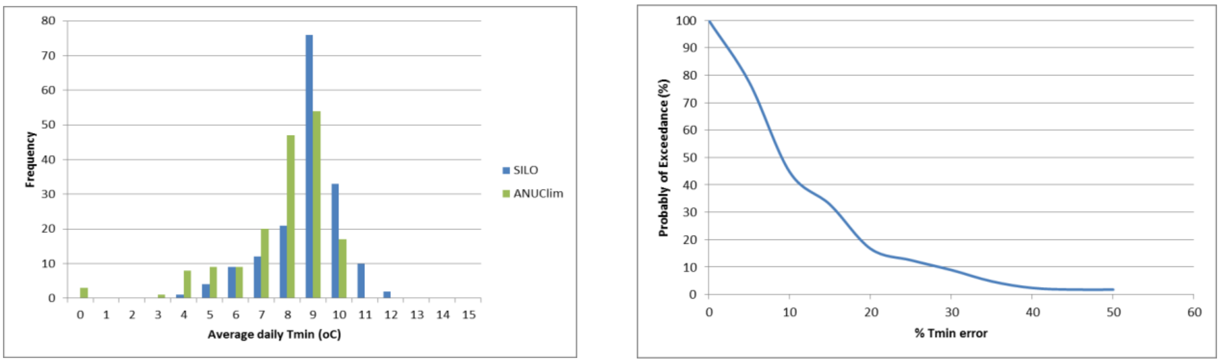


Figure 13 Comparative histograms derived from the SILO climate station data and the interpolated ANUClim for average daily minimum temperature (left) and corresponding probability of exceedance curve of the percent variation (right) (Dataset 12)

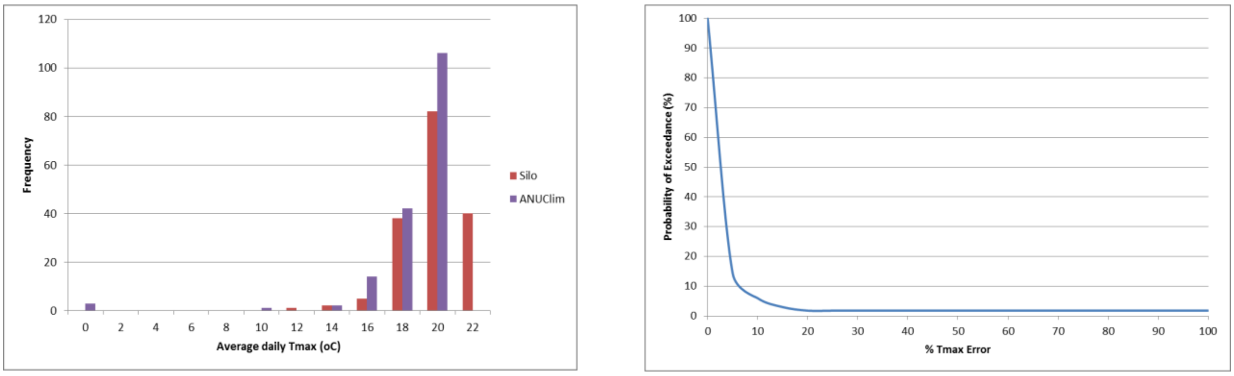


Figure 14 Comparative histograms derived from the SILO climate station data and the interpolated ANUClim for average daily maximum temperature (left) and corresponding probability of exceedance curve of the % variation (right) (Dataset 12)

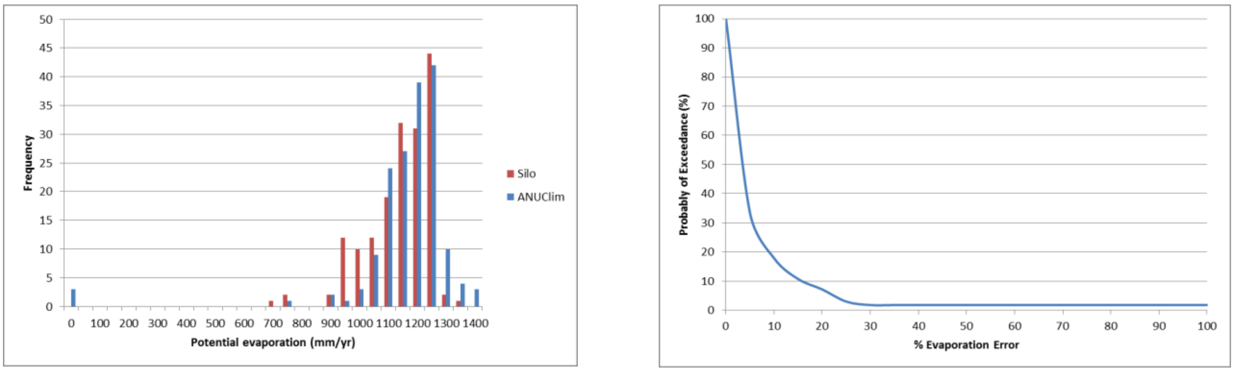
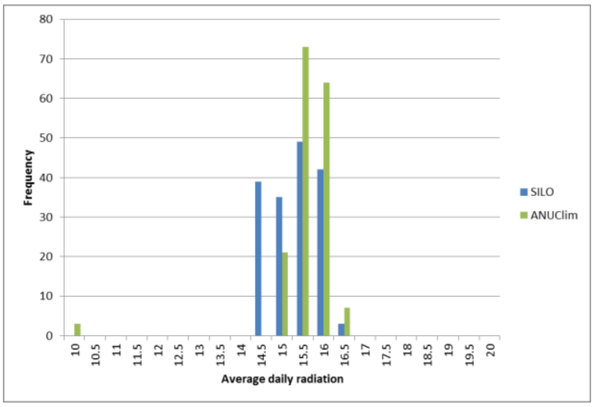


Figure 15 Comparative histograms derived from the SILO climate station data and the interpolated ANUClim for average potential evaporation (left) and corresponding probability of exceedance curve of the percent variation (right) (Dataset 12)



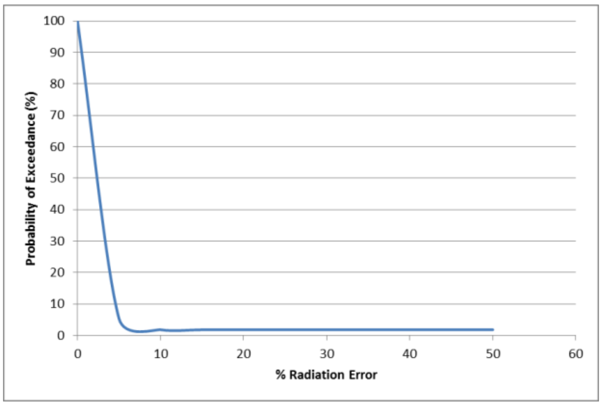


Figure 16 Comparative histograms derived from the SILO climate station data and the interpolated ANUClim for average daily solar radiation (left) and corresponding probability of exceedance curve of the percent variation (right) (Dataset 12)

Analysis of the climate data as reported in Table 1 suggests that the median variation between the observed climate station and interpolated ANUClim annual average rainfall, Tmin, Tmax, potential evaporation and radiation estimates are 6.0%, 8.8%, 2.9%, 2.5% and 2.1% respectively. The corresponding 90 percentile values are 1.3%, 2.2%, 0.9%, 0.5% and 0.7% respectively whereas the 10 percentile values are 13.8%, 25.6%, 5.6%, 14.6% and 4.7% respectively.

Table 1 Percentiles based on the percentage deviation of interpolated mean annual estimated derived using ANUClim to observed climate station data (Dataset 12)

Percentile	Rainfall	Tmin	Tmax	Potential Evaporation	Radiation
100	0.05	0.06	0.04	0.04	0.02
95	0.52	1.42	0.35	0.23	0.51
90	1.34	2.22	0.94	0.50	0.67
80	2.39	4.26	1.74	0.88	1.09
70	3.35	6.03	2.03	1.35	1.49
60	4.81	7.68	2.65	1.66	1.62
50	6.05	8.82	2.90	2.48	2.07
40	7.50	11.10	3.26	3.63	3.36
30	9.36	15.52	3.84	5.72	4.01
20	11.20	18.02	4.29	8.20	4.35
10	13.78	25.64	5.68	14.64	4.74
5	18.18	32.06	7.21	19.18	4.97

2.1.4.3.6 Flood mapping

The positional accuracy of the Victorian Flood database is reported to vary from 10 cm to 100 m. Reliability and date fields as specified in the data files indicate the source and relative reliability of each map product. The attribute accuracy is considered mostly reliable, especially data sourced from recent flood studies.

2.1.4.4 Gaps

The characterisation of input data errors reported in Section 2.1.4.3 suggest knowledge gaps related to (1) enhancement of the digital elevation model for integration into the Vicmap Hydro spatial map; (2) up to date land use mapping; (3) soil map attribution (as opposed to soil map units); and (4) spatial interpolation of Bureau of Meteorology climate station daily observations.

It is acknowledged that the Vicmap Hydro layer currently is subject to cartographic generalisation of data (DSE, 2012). This is due to the conversion and manipulation processes which have contributed to the degradation of positional accuracy. Improvements in cartographic clarity and the derivation of topology and directional flow of stream mapping would enhance the accuracy of the water course spatial data layer. Such an enhancement would also assist in the creation of the next generation digital elevation model for Victoria.

Land use mapping is essential for water balance modelling. The catchment scale modelling associated with the current study assigns various farming system models to land management units based on land use mapping data. Each farming system model is then used to derive a daily time varying water balance at each land management unit across a landscape. Components of the water balance are then used as inputs into both surface water and groundwater modelling. Significant errors in estimates of recharge can be associated with incorrect land use mapping and management scripts assigned to irrigated regions.

Erroneous soil map attribution can result in up to 50% variation in water balance components depending on soil texture (Beverly, 2012). The soil map attribution relates to the parameterisation of a soil profile through depth and includes information for each texture classification within the soil profile such as water holding capacity, porosity, bulk density and vertical hydraulic conductivities. Whereas soil mapping defines the spatial extent of soil units, often soil unit attribution is not reported.

The network of Bureau of Meteorology climate stations is somewhat limited and would benefit from the install additional stations in regions of high climatic and topographic variability. Each station would benefit from being equipped to record solar radiation as currently solar radiation is only recorded at limited sites. Of equal importance is the deployment of tools enabling the spatial interpolation of point scale daily climate data. Whereas the gridded interpolated daily climate data (SILO Data Drill made by the Australian Bureau of Meteorology http://www.derm.qld.gov.au/services_resources) offers a solution to this problem, the 5 km x 5 km scale of gridded data is often too coarse for the catchment scale modelling approach used in the current study.

2.1.5 Geology

Summary

A review of available surface and subsurface datasets in the onshore and offshore Gippsland Basin was conducted to build a regional geological model.

The Gippsland Basin geological model represents an interpretation of the underground geometries and lithologies. The interpretation is based on boreholes, wells, outcrop and geophysical data and accounts for the uncertainties and resolution inherent in these data. The well data helps to define the limits between the different geological units as well as the lithology. Geophysical data (mostly seismic reflection data) were used to extrapolate the data calibrated at the wells. Geophysical data (mostly potential fields) was also used to constrain basin architecture away from wells and seismic surveys. The uncertainty in these data increases as the distance between wells geophysical surveys increases.

As the density of both wells and geophysical data varies throughout the Gippsland Basin, isopach maps (i.e. thickness maps) were used to define the basin-scale architecture of the sequences.

The Gippsland Basin geological model can be updated and refined with additional or new datasets and can be populated with hydraulic properties derived from stratigraphic facies.

2.1.5.1 Methods

The main geological data sets used are: (1) the Victorian Aquifer Framework data, (2) the Latrobe Valley Coal model, (3) Gippsland Off-shore velocity model and (4) petroleum wells. Each is discussed in the following sections.

2.1.5.2 Observed data

This section described the nature, source, construct and the spatial and/or temporal resolution of all relevant geographic datasets.

There are four datasets that were utilised for the geological modelling task: petroleum wells dataset (GSV, 2014; Constantine 2001), Victorian Aquifer Framework (GHD, 2012), Latrobe Valley Coal Model (GHD, 2011) and geophysical datasets (McLean & Blackburn, 2013). The petroleum wells dataset consists of stratigraphic and lithological data compiled from well completion reports. The Victorian Aquifer Framework consists of hydrostratigraphic units extrapolated from the Victorian Groundwater database (GHD, 2012). The geophysical datasets comprise of a DEM model, Bathymetry, Bouguer Gravity and published interpretations of seismic reflection data. The 1:25 000 scale Structural Framework of the Onshore Gippsland geological map (Constantine et al., 1995) has also been used as a guide to determine the extent of the Strzelecki Group. The 1:250 000 Warragul and Sale geological maps (Vandenberg, 1997) have been used for other geological limits and the major structural trends (see Section 1.1.3 of companion product 1.1 for the Gippsland Basin bioregion). Figure 17 presents the major stratigraphic units of the sedimentary aquifers in the Gippsland Basin. The Strzelecki Group sits within the Cretaceous period not shown in Figure 17, and forms the bedrock aquifer system.

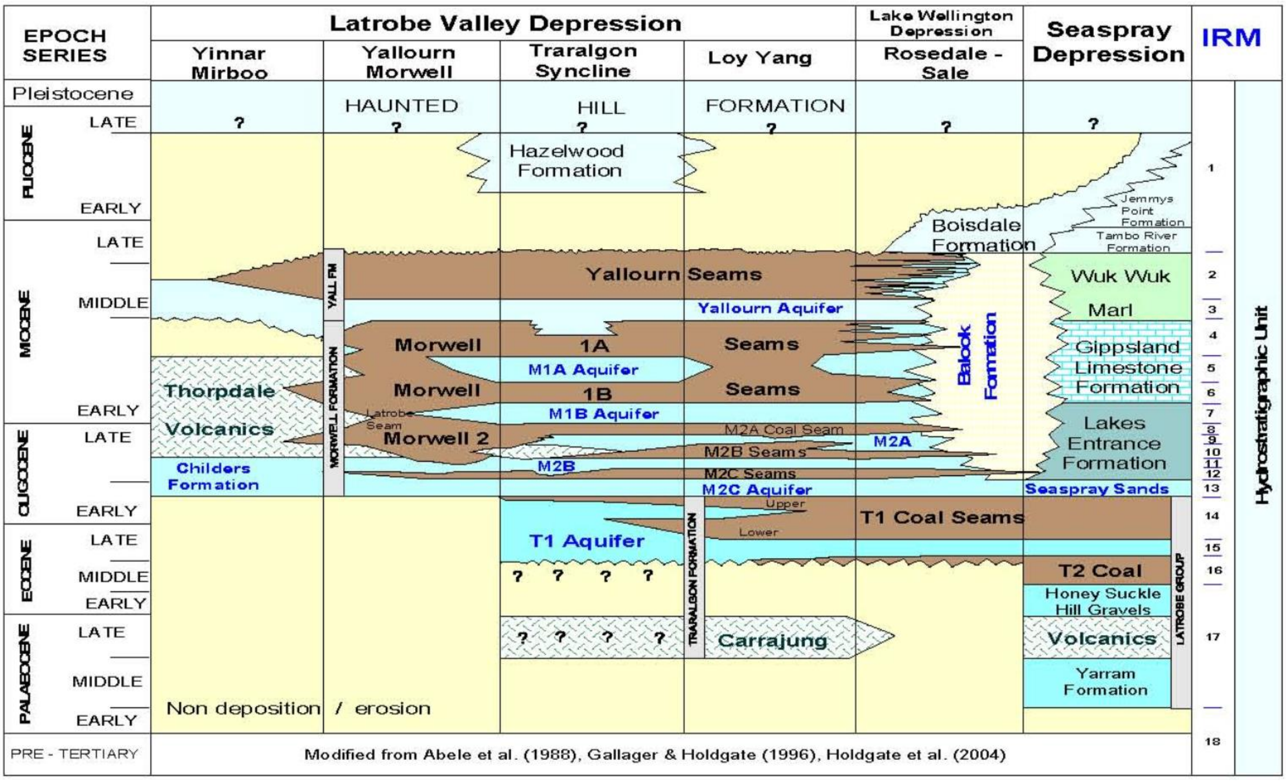


Figure 17 Stratigraphic units of the Gippsland study area (source; Schaeffer 2008), Dataset 1

2.1.5.2.1 Deep wells dataset

Well data provide information on the stratigraphy and the structure of the Gippsland Basin from geophysical logs, core and cutting analyses and test data. The Gippsland Basin is a mature petroleum province and an extensive deep well database with well completion reports from 1931 to 2013 by the Geological Survey of Victoria (GSV, 2014). Table 2 presents a list of 73 petroleum wells that have been drilled predominantly within the onshore and near shore sections of the Gippsland Basin. The list is presented in alphabetical order of the well name, not by formation. Further information on the wells can be found in the Victorian Petroleum Wells database or the Geoscience Australia Petroleum Wells database at://dbforms.ga.gov.au/www/npm.well.search.

Table 2 Selected petroleum wells used for stratigraphic interpretation

Well name	Date	Company	X coordinate (MGA54)	Y coordinate (MGA 54)	Total depth (m)
AVON-1	1990	Mosaic Oil NL	512128	5788952	934
AVON-1	1990	Mosaic Oil NL	512128	5788952	934
BALEEN-1	1981	Hudbay Oil (Australia) Ltd	626147	5792252	1030
BAUDIN-1	1999	Lakes Oil N.L.	576812	5809375	426
BELLBIRD-1	1963	ARCO International Oil and Gas Company	501088	5770580	763
BURONG-1	1985	Hartogen Energy Ltd	517395	5759852	1259

CARRS CREEK-1	1963	ARCO International Oil and Gas Company	523169	5761978	1679
COLLIERS HILL-1	1970	Woodside Petroleum Development Pty. Ltd.	525651	5772246	1711
CROSS ROADS-1	1971	Halliday Enterprises Pty Ltd	514243	5758004	1039
CUTTLEFISH-1	1999	Amity Oil NL	592364	5794425	1226
DARRIMAN-1	1955	Frome Lakes	500697	5744381	1497
DEADMAN HILL-1	2002	Lakes Oil N.L.	515940	5772428	839
DUCK BAY-1	1964	ARCO Ltd.	557961	5800239	1287
DUTSON DOWNS-1	1966	Woodside Petroleum Development Pty. Ltd.	531711	5772182	1862
EAST REEVE-1	1972	Halliday Enterprises Pty Ltd	548118	5783425	1622
EAST SEACOMBE-1	1980	Beach Petroleum NL	546812	5784974	1362
FAIRHOPE-1	1985	Ampol Exploration Ltd	551788	5803797	569
GALLOWAY-1	2006	Nexus Energy N.L.	549307	5784519	2315
GANGELL-1	2001	Lakes Oil N.L.	517317	5759405	2350
GANNET-1	1970	ENDEAVOUR	599954	5804208	1460
GOLDEN BEACH WEST-1	1965	Woodside Petroleum Development Pty. Ltd.	531155	5766790	2290
GOLDEN BEACH-1A	1967	B.O.C. of Australia	536914	5765607	2937
GOON NURE-1	1931	Amalgamated Oil Syndicate	549052	5796136	893
HEDLEY-1	1957	Woodside Petroleum Development Pty. Ltd.	460085	5722213	1223
HOLLANDS LANDING-1	1940	AGSO	540425	5788170	1220
INVESTIGATOR-1	1999	Lakes Oil N.L.	553976	5803731	697
KEYSTONE-1	1972	Halliday Enterprises Pty Ltd	513733	5758005	1960
LAKE REEVE-1	1965	Woodside Petroleum Development Pty. Ltd.	522307	5757974	2022
LOY YANG-1A	1994	Capital Energy NL	461493	5766123	1736
MACALISTER-1	1988	Crusader Ltd	512130	5755414	1453
MCCREESH-1	1998	Roma Petroleum NL	509260	5752833	1803
MERRIMAN-1	1963	ARCO International Oil and Gas Company	515578	5755832	1830
NORTH SEASPRAY-1	1962	ARCO Ltd.	517775	5761807	1524

NORTH SEASPRAY-2	1965	ARCO Ltd.	517943	5760913	1633
NORTH SEASPRAY-3	2000	Lakes Oil N.L.	517987	5761908	1170
NORTHRIGHT-1	2001	Eagle Bay Resources N.L.	689037	5799642	391
NUNTIN-2	1939	Commonwealth Government	518351	5791054	1085
PATRICIA-1	1987	Lasmo Energy Australia Ltd	627058	5789884	900
PATTIES PIES-1	2003	Lakes Oil N.L.	559436	5810660	441
PAYNESVILLE-1	1985	Ampol Exploration Ltd	559230	5803603	708
PELICAN POINT-1	1932	Valve Oil Wells	554178	5792837	704
ROMAWI-1	1938	Dept. of Nat. Res. & Environment - Govt. of Victoria	552761	5797704	989
ROSEDALE-1	1960	APM Development Pty Ltd	482123	5780238	1787
SALT LAKE-1	1970	Woodside Petroleum Development Pty. Ltd.	507675	5744636	1644
SEACOMBE SOUTH-1	1970	Woodside Petroleum Development Pty. Ltd.	542630	5778546	1186
SEASPRAY-1	1964	ARCO International Oil and Gas Company	514125	5758085	1694
SIGNAL HILL-1	1933	Sale Oil Development Co	527318	5767729	699
SOUTH LONGFORD-1	1964	ARCO International Oil and Gas Company	507656	5772425	747
SPERM WHALE HEAD-1	1939	Valve Oil Wells	561947	5797898	948
SPOON BAY-1	1970	Woodside Petroleum Development Pty. Ltd.	540972	5785123	1400
ST MARGARET ISLAND-1	1966	Woodside Petroleum Development Pty. Ltd.	485585	5723656	1422
STRINGY BARK-1	1990	Crusader Ltd	491437	5736950	1047
SUNDAY ISLAND-1	1966	Woodside Petroleum Development Pty. Ltd.	471251	5716127	1830
SWEEP-1	1978	Esso Australia	643725	5786718	900
TANJIL-PT.ADDIS-1	1939	Tanjil Point Addis Co	509431	5771869	485
TANJIL-PT.ADDIS-2	1939	Tanjil Point Addis Co	514772	5766744	841
TILDESLEY EAST-3	1986	Arena Petroleum	614646	5818306	300
TRIFON-1	2000	Lakes Oil N.L.	516865	5760571	2570
TRIFON-2	2004	Lakes Oil N.L.	517016	5760587	1267

WAHOO-1	1969	Esso Australia	653413	5789770	746
WELLINGTON PARK-1	1962	Woodside (Lakes Entrance) Oil Company No Liability	532832	5778804	3661
WELLINGTON PARK-2	1970	Woodside Petroleum Development Pty. Ltd.	530663	5779256	1258
WEST SEACOMBE-1	1972	Halliday Enterprises Pty Ltd	537066	5779217	1767
WOMBAT-1	2004	Lakes Oil N.L.	514009	5755039	1990
WOMBAT-2	2004	Lakes Oil N.L.	512512	5753661	1550
WONGA BINDA-1	1988	Crusader Ltd	503644	5744336	1394
WOODSIDE SOUTH-1	1965	Woodside Petroleum Development Pty. Ltd.	491984	5730785	1774
WOODSIDE-1	1955	Woodside Petroleum Development Pty. Ltd.	494285	5728444	1831
WOODSIDE-2	1957	Woodside Petroleum Development Pty. Ltd.	490830	5724681	2701
WOODSIDE-4	1957	Woodside Petroleum Development Pty. Ltd.	486195	5720143	821
WRIXONDALE-1	1985	Beach Petroleum NL	543724	5794768	987
YORK-1	2002	Lakes Oil Ltd	487941	5729699	1200

Dataset 2

Figure 18 shows the varied distribution of deep wells within the Gippsland Basin. The highest concentration of wells are in the offshore near the Central Deep where both historical and current oil and gas production occurs. Onshore wells have been drilled proximal to Ninety Mile Beach from Yarram to Lakes Entrance. Although there has been considerable exploration drilling in the onshore, no oil or gas is produced in the onshore Gippsland Basin. In the west of the Gippsland Basin, the concentration of deep wells are considerably lower. The greatest uncertainty of the basin structure is to the east. The northern Gippsland Basin is lacking deep wells due to outcropping Paleozoic Basement indicating a lack of hydrocarbon resources. The depths of wells in the deep well dataset vary between 300 m measured depth (MD) (Tildesley East-3) and 3,661 m MD relative to the kelly bushing (KB) (Wellington Park-1).

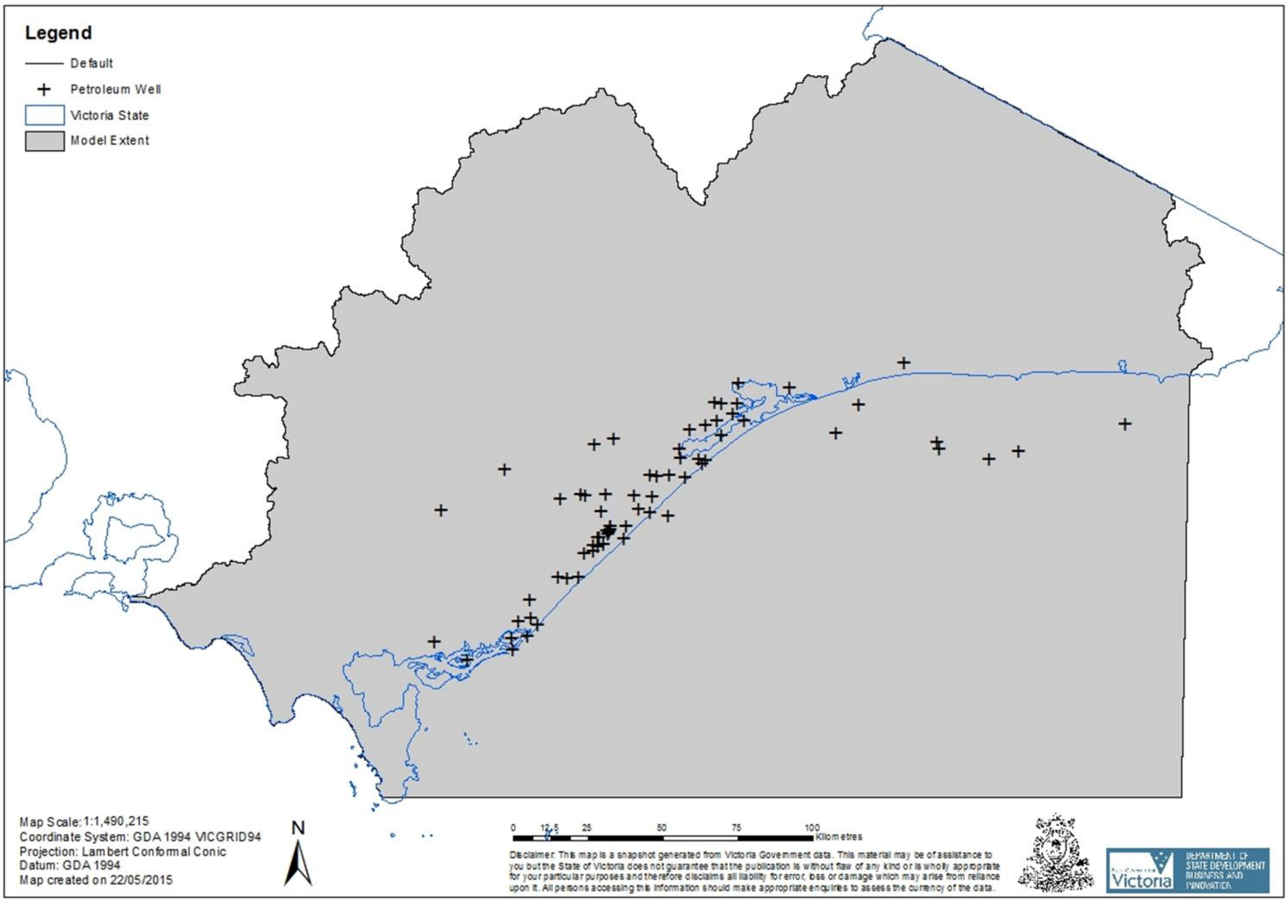


Figure 18 Location of petroleum wells used (Dataset 3)

Major lithological variations were identified among various formations. These variations were typical of an environment of deposition ranging from fluvial to a deltaic environment to coal swamps, beach barrier sands, shallow marine and cold water carbonates.

Within the Seaspray Group, beach barrier sands to coal and beach barrier sands to cold water carbonates represent the highest level of lateral variation. The correlation between Traralgon coals onshore and offshore remains ambiguous given the well spacing and lack of seismic bridging over the onshore offshore transition. It is highly probable that although coals are continuous offshore, there is a degree of discontinuity and pinching out of individual seams onshore.

2.1.5.2.2 Gravity interpretation

Isostatic corrected Bouguer Gravity (Figure 19) was used to interpret the depth to Palaeozoic Basement within the west Gippsland region. Gravity was used due to the low density of petroleum wells, poor seismic data and lack of differentiation between Strzelecki Group and Palaeozoic Basement within the Victorian Aquifer Framework (GHD, 2009).

The Gravity images used for interpretation were processed by Intrepid Geophysics and the Geological Survey of Victoria. Further details of the processing are reported in Fitzgerald et al., (2009).

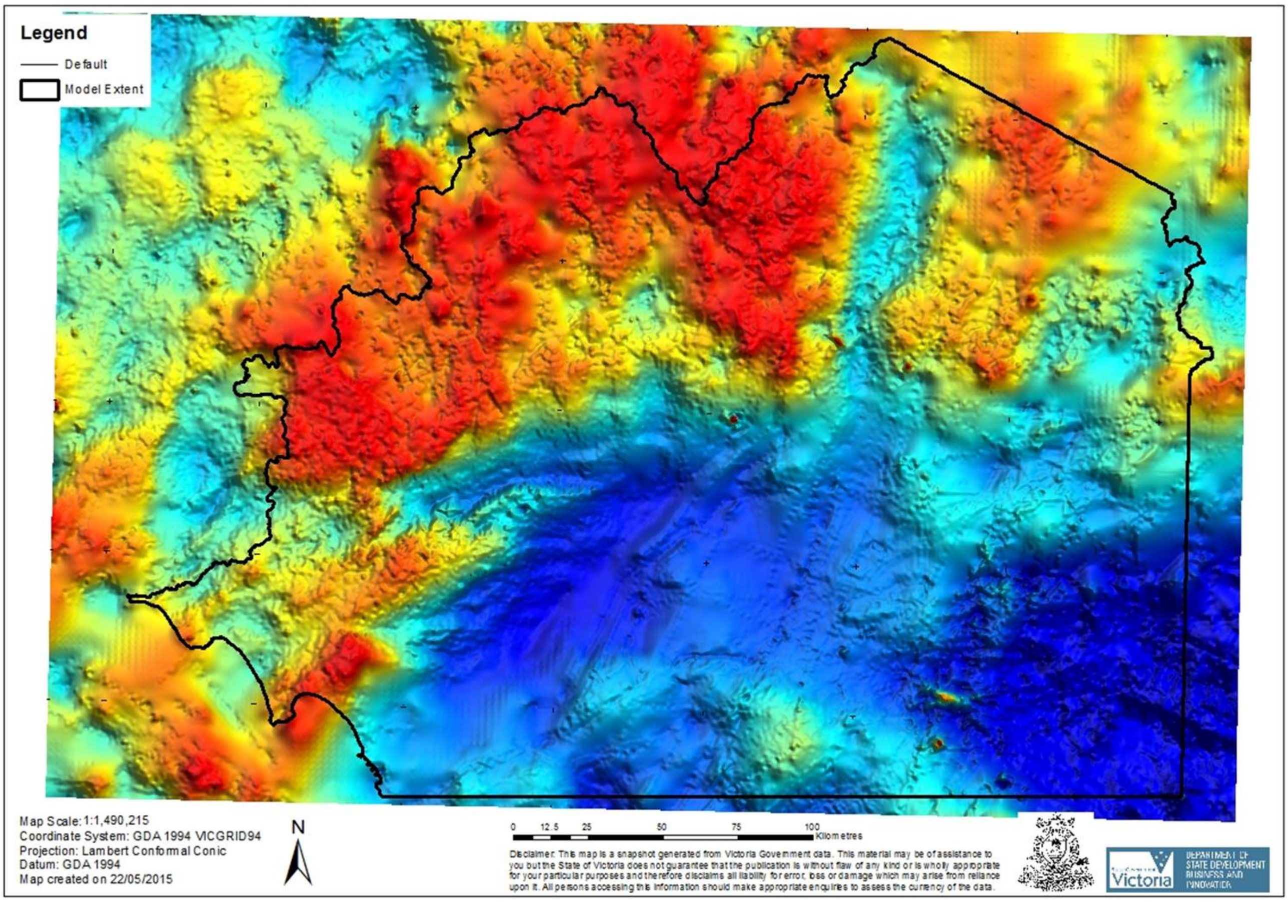


Figure 19 Isostatically corrected Bouguer Gravity image for the Gippsland Basin (Fitzgerald et al., 2009). (Dataset 4)

2.1.5.2.3 Seismic stratigraphy

A regional velocity model built by Mclean and Blackburn (2013) was used to convert seismic interpreted stratigraphic surfaces to depth based on the approach reported by Keetley et al. (2010) and Blevin et al. (2013). Notably, the stratigraphic surfaces are confined to the offshore portions of the Gippsland Basin. The mapped accuracy of the seismic interpreted stratigraphic surfaces are highest closest to wells and decreases away from wells and seismic lines. This has produced greater accuracy in the central deep of the Gippsland Basin and lower accuracy within 5 km of the coastline.

2.1.5.2.4 Victorian Aquifer Framework

The Victorian Aquifer Framework (VAF, GHD 2012) provides the basis for grouping detailed geology into logical aquifer units allowing a consistent conceptualisation of the state's aquifers and aquitards. The tiered system of geological units, hydrogeological units and aquifers as reported in the VAF has simplified complex geological sequences from a groundwater perspective while preserving the detail of the constituent units.

2.1.5.2.5 Latrobe Valley Coal Model

The Latrobe Valley Coal resource model has been developed utilising the past 40 years of stratigraphic drilling (GHD, 2011). The coal resource model specifies individual coal sequences as GIS surfaces, such M1A, M1B, T0, T1, T2, etc.

2.1.5.2.6 Digital Elevation Model

The surface topography represents a DEM model built from 1 second Shuttle Radar Topography Mission (SRTM) data (Geoscience Australia, 2008). The data was resampled to 100 m spatial resolution.

2.1.5.3 Statistical analysis and interpolation

Observed datasets (Section 2.1.6.1) were selected and processed to form derived datasets. These datasets were analysed and interpolated to propose a basin-scale three-dimensional geological model using Petrosys software.

2.1.5.3.1 Method

The method used to define the subsurface structural and stratigraphic architecture of the Gippsland Basin comprised:

1. Selection and processing of spatial and point data to form derived datasets:
    a. Reviewed all spatial data sets (VAF, seismic, coal model) and define stratigraphic sequence of differing units
    b. Merge spatial data sets to form a single coverage for each geological unit across the region. Where data anomalies occurred, point data (petroleum wells) were used to assess which surface required adjustment
    c. Incorporate Palaeozoic basement surface layer beneath Strzelecki geology.
2. Error check layer surfaces:
    a. Subtract geology tops from bottoms to determine residuals
    b. Either correct or remove areas where residuals were less than zero
    c. Map geology thickness for each unit across region for assessment.

2.1.5.3.2 Data selection and processing

The spatial distribution and density of the geological data in the Gippsland Basin is limited onshore in the west and good offshore in the east. Stratigraphic information provided by the petroleum well dataset was processed to constrain and inform the geological surfaces where no spatial information existed. Well completion reports from the 71 selected deep wells were analysed to determine each formation top depth, a listed in Table 3. The markers of the formation top depths in the wells are called ‘well picks’. The error in the formation top positions is a function of the well stratigraphic interpretation.

Table 3 Petroleum well database 'well picks'

Well name	Formation top	Pick depth (m TVD ss)	Well name	Formation top	Pick depth (m TVD ss)
AVON-1	La Trobe Group	735	ROMAWI-1	La Trobe Group	802
AVON-1	Lakes Entrance	610	ROMAWI-1	Lakes Entrance	597
AVON-1	Strzelecki Group	890	ROMAWI-1	Strzelecki Group	963
BALEEN-1	Lakes Entrance	512	ROSEDALE-1	La Trobe Group	52
BALEEN-1	Strzelecki Group	707	ROSEDALE-1	Strzelecki Group	714.8
BAUDIN-1	La Trobe Group	368	SALT LAKE-1	La Trobe Group	777.2
BAUDIN-1	Lakes Entrance	304	SALT LAKE-1	Lakes Entrance	675.1
BELLBIRD-1	La Trobe Group	6.1	SALT LAKE-1	Strzelecki Group	1588
BELLBIRD-1	Strzelecki Group	295.7	SEACOMBE SOUTH-1	Lakes Entrance	1009
BURONG-1	La Trobe Group	655	SEASPRAY-1	La Trobe Group	812.3
BURONG-1	Lakes Entrance	552	SEASPRAY-1	Lakes Entrance	655.3
BURONG-1	Strzelecki Group	1251.2	SEASPRAY-1	Strzelecki Group	1384.4
CARRS CREEK-1	Lakes Entrance	584	SIGNAL HILL-1	La Trobe Group	682.8
CARRS CREEK-1	Strzelecki Group	1618	SIGNAL HILL-1	Lakes Entrance	555.4
COLLIERS HILL-1	Lakes Entrance	451	SOUTH LONGFORD-1	Strzelecki Group	204
CROSS ROADS-1	La Trobe Group	815.3	SOUTH LONGFORD-1		0
CROSS ROADS-1	Lakes Entrance	655.3	SPERM WHALE HEAD-1	La Trobe Group	816.9
CUTTLEFISH-1	Lakes Entrance	792	SPERM WHALE HEAD-1	Lakes Entrance	664.5
CUTTLEFISH-1	Strzelecki Group	998	SPERM WHALE HEAD-1	Strzelecki Group	903.4
DARRIMAN-1	Lakes Entrance	452	SPOON BAY-1	La Trobe Group	1027.8
DARRIMAN-1	Strzelecki Group	1290	SPOON BAY-1	Lakes Entrance	976.884

DEADMAN HILL-1	La Trobe Group	101	SPOON BAY-1	Strzelecki Group	1305.153
DEADMAN HILL-1	Lakes Entrance	82	ST MARGARET ISLAND-1	La Trobe Group	604.1
DUCK BAY-1	La Trobe Group	696	ST MARGARET ISLAND-1	Lakes Entrance	548.6
DUCK BAY-1	Lakes Entrance	579	ST MARGARET ISLAND-1	Strzelecki Group	926.3
DUCK BAY-1	Strzelecki Group	818.1	STRINGY BARK-1	La Trobe Group	373.5
DUTSON DOWNS-1	Lakes Entrance	578.5	STRINGY BARK-1	Lakes Entrance	319.5
DUTSON DOWNS-1	Strzelecki Group	1829	STRINGY BARK-1	Strzelecki Group	1018
EAST REEVE-1	Lakes Entrance	989	SUNDAY ISLAND-1	La Trobe Group	399
EAST REEVE-1	Strzelecki Group	1410	SUNDAY ISLAND-1	Lakes Entrance	295.6
EAST SEACOMBE-1	La Trobe Group	1094	SUNDAY ISLAND-1	Strzelecki Group	506
EAST SEACOMBE-1	Lakes Entrance	1076	SWEEP-1	La Trobe Group	842
FAIRHOPE-1	La Trobe Group	533	SWEEP-1	Lakes Entrance	615
FAIRHOPE-1	Lakes Entrance	496	TANJIL-PT.ADDIS-1	La Trobe Group	367.9
GALLOWAY-1	Lakes Entrance	965	TANJIL-PT.ADDIS-1	Strzelecki Group	420
GANGELL-1	La Trobe Group	683	TANJIL-PT.ADDIS-2	La Trobe Group	397
GANGELL-1	Lakes Entrance	642	TANJIL-PT.ADDIS-2	Lakes Entrance	343.5
GANGELL-1	Strzelecki Group	1251	TANJIL-PT.ADDIS-2	Strzelecki Group	804.7
GANNET-1	La Trobe Group	440	TILDESLEY EAST-3	Lakes Entrance	159
GANNET-1	Strzelecki Group	825.6	TRIFON-1	La Trobe Group	689
GOLDEN BEACH WEST-1	Lakes Entrance	585	TRIFON-1	Lakes Entrance	620
GOLDEN BEACH-1A	Lakes Entrance	556	TRIFON-1	Strzelecki Group	1236
GOON NURE-1	La Trobe Group	786.5	TRIFON-2	La Trobe Group	688
GOON NURE-1	Lakes Entrance	756.9	TRIFON-2	Lakes Entrance	563

GOON NURE-1	Strzelecki Group	892	TRIFON-2	Strzelecki Group	1236
HEDLEY-1	Strzelecki Group	63	WAHOO-1	Lakes Entrance	369
HOLLANDS LANDING-1	Lakes Entrance	731	WAHOO-1	Strzelecki Group	591
INVESTIGATOR-1	La Trobe Group	584	WELLINGTON PARK-1	La Trobe Group	727
INVESTIGATOR-1	Lakes Entrance	529	WELLINGTON PARK-1	Lakes Entrance	655
KEYSTONE-1	La Trobe Group	826.3	WELLINGTON PARK-1	Strzelecki Group	1158
KEYSTONE-1	Lakes Entrance	645.6	WELLINGTON PARK-2	La Trobe Group	718.1
KEYSTONE-1	Strzelecki Group	1398.7	WELLINGTON PARK-2	Lakes Entrance	613.9
LAKE REEVE-1	Lakes Entrance	749	WELLINGTON PARK-2	Strzelecki Group	1092.7
LAKE REEVE-1	Strzelecki Group	1604	WEST SEACOMBE-1	La Trobe Group	813
LOY YANG-1A	Strzelecki Group	148	WEST SEACOMBE-1	Lakes Entrance	615.7
MACALISTER-1	La Trobe Group	792.5	WEST SEACOMBE-1	Strzelecki Group	1378.6
MACALISTER-1	Lakes Entrance	675.5	WOMBAT-1	La Trobe Group	694
MACALISTER-1	Strzelecki Group	1384	WOMBAT-1	Lakes Entrance	589
MCCREESH-1	La Trobe Group	792.5	WOMBAT-1	Strzelecki Group	1767
MCCREESH-1	Lakes Entrance	694	WOMBAT-2	La Trobe Group	776
MCCREESH-1	Strzelecki Group	1380	WOMBAT-2	Lakes Entrance	614
MERRIMAN-1	Lakes Entrance	625	WONGA BINDA-1	La Trobe Group	605.5
NORTH SEASPRAY-1	La Trobe Group	585.83	WONGA BINDA-1	Lakes Entrance	530.5
NORTH SEASPRAY-1	Lakes Entrance	518.2	WONGA BINDA-1	Strzelecki Group	1344
NORTH SEASPRAY-1	Strzelecki Group	1104.29	WOODSIDE SOUTH-1	La Trobe Group	592.3
NORTH SEASPRAY-2	La Trobe Group	646	WOODSIDE SOUTH-1	Lakes Entrance	511.5

NORTH SEASPRAY-2	Lakes Entrance	515	WOODSIDE SOUTH-1	Strzelecki Group	991.5
NORTH SEASPRAY-2	Strzelecki Group	1219	WOODSIDE-1	La Trobe Group	777.3
NORTH SEASPRAY-3	La Trobe Group	575	WOODSIDE-1	Lakes Entrance	701
NORTH SEASPRAY-3	Lakes Entrance	511	WOODSIDE-1	Strzelecki Group	1191.8
NORTH SEASPRAY-3	Strzelecki Group	1087	WOODSIDE-2	La Trobe Group	759
NORTHRIGHT-1	Lakes Entrance	250	WOODSIDE-2	Lakes Entrance	682.7
NORTHRIGHT-1	Strzelecki Group	337	WOODSIDE-2	Strzelecki Group	1158
NUNTIN-2	La Trobe Group	920.5	WOODSIDE-4	La Trobe Group	705.3
NUNTIN-2	Lakes Entrance	712.3	WOODSIDE-4	Lakes Entrance	610.8
PATRICIA-1	Lakes Entrance	655	WRIXONDALE-1	La Trobe Group	783.5
PATRICIA-1	Strzelecki Group	800	WRIXONDALE-1	Lakes Entrance	629
PATTIES PIES-1	La Trobe Group	297	WRIXONDALE-1	Strzelecki Group	948.5
PATTIES PIES-1	Lakes Entrance	250	YORK-1	La Trobe Group	532
PAYNESVILLE-1	La Trobe Group	569	YORK-1	Lakes Entrance	468.5
PAYNESVILLE-1	Lakes Entrance	529.5	YORK-1	Strzelecki Group	954.5
PELICAN POINT-1	Lakes Entrance	703.8			

Dataset 2

Three representative regional formation tops were selected from the Petroleum well database. These were used to extend the existing representative regional formations from the onshore to the offshore.

Key regional geological formation tops in the Gippsland Basin included:

- Lakes Entrance Formation
- La Trobe Group
- Strzelecki Group.

The Boisdale Formation and Gippsland Limestone were not included as they were too shallow for data to be recorded in Petroleum Well Completion Reports.

2.1.6 Hydrogeology and groundwater quality

2.1.6.1 Methods

2.1.6.1.1 Aquifer assignment

Assigning a bore to a specific aquifer is based on the screened interval data and the aquifer geometry. In many cases, it is impossible to assign the screened interval of a bore to an aquifer, as there is insufficient information on stratigraphy and screened intervals. Although the Victorian groundwater database contains stratigraphic data for some groundwater bores in the Gippsland region, stratigraphic information is not available for many groundwater bores.

All available groundwater observation bores data was compiled and included in this analysis. The compiled dataset comprised 686 onshore bores as recorded in the Victorian state groundwater database and 136 bores managed by other institutions (namely around the coal mines). Following a stratigraphic assessment for the Gippsland region, and after a quality check of the data, bores were assigned to aquifers by associating their screen intervals and depth with aquifer geometry.

The following steps were followed during the aquifer assignment:

1. Assess the boundaries of aquifers as outlined in Section 1.1.4.1 of companion product 1.1 for the Gippsland region.
2. Determine the screen intervals of bores onshore. The screen interval information was extracted from the groundwater database in the Water Measurement Information System (WMIS) (DEPI, 2014). For the bores without screen interval information in the database, the bore depth information was extracted from the site information table in the WMIS. For these bores, it is assumed that the screens start from the bottoms of the bores.
3. Determine the screen interval of bores for the bores offshore. The screen interval and bore depth information was extracted from the data provided the Victorian Water Management Information System (WMIS).
4. Filter bores for a specific area using a shape file or coordinates.
5. Cross-check the final datasets against expert knowledge and spatial context of aquifers.

2.1.6.1.2 Water levels

Water levels for the Gippsland region were obtained from the WMIS dataset (onshore bores) and Exxon Mobil (offshore production wells). The water level in the WMIS database is presented in three forms – depth from top of casing (m), the depth of water below the ground surface (m) and reduced water level (mAHD). For a small number of bores, reduced water levels are not available as their elevations are missing from the database. For these bores, the bore elevations were determined from a high resolution digital elevation model. Water level information for the offshore production wells are presented in the form of reduced water level (mAHD) instead of pressure head equivalents.

2.1.6.1.3 Hydraulic parameters

There are over 150,000 groundwater bores with in the Victorian groundwater database, some of which have undergone pumping tests. Notably, hydraulic parameters are not available in the state groundwater databases although the databases do contain limited pumping test data such as the date and duration of the test, initial water level, pumping rate, and maximum drawdown. To improve the accessibility and present the information in a more useful form, DSE (2011) created a Victorian Pump Test Database (PTD) which reports aquifer parameters derived from pumping tests referenced to the pump bore used, and linked to the reporting document. The PTD forms the main source of hydraulic parameters for this project.

Other hydrogeological data sources (e.g. university theses, consultancy reports and government reports) were explored and hydrogeological records were incorporated into the dataset where appropriate. The key previous studies explored include:

- West Gippsland CMA Groundwater Model-Transient Model Development Report (GHD, 2012a)
- East Gippsland CMA Groundwater Model-Transient Model Development Report (GHD, 2012b)
- Scaling Point Based Aquifer Data for Developing Regional Groundwater Models: Application to the Gippsland Groundwater System (Schaeffer, 2008).

2.1.6.1.4 Groundwater quality

Groundwater quality was sampled in the Gippsland Basin bioregion to assist in the characterisation of the aquifers in the Gippsland Basin. Historical data and literature was used to inform the site selection and selection of analytes to be sampled for. Three rounds of sampling were undertaken between December 2014 and April 2015 from 29 bores. Samples were taken using low flow sampling techniques. Bores were sampled for major ions, methane, BTEX, TPH, hydrocarbons and nitrogen. Full results of the sampling are available from the Onshore natural gas water science studies website (http://onshoregas.vic.gov.au/science-studies/about-the-water-studies).

This report presents the groundwater salinity records (uS/cm) from the Victorian Measurement Information System (WMIS) to show the distribution and general quality of groundwaters in the Gippsland Basin and a summary of the groundwater quality from the groundwater sampling program.

2.1.6.2 Observed data

The groundwater observation data for the Gippsland region was primarily sourced from the Victorian groundwater databases in the WMIS (onshore bores). For the offshore bores, the observation data was obtained from Exxon Mobile. The datasets used in the analysis are listed in Table 4.

Groundwater licence data was primarily sourced from Southern Rural Water (the licensing authority for groundwater in the Gippsland Basin). The data includes license number, bore location and annual licensed volume. It is noted that a groundwater licence may be associated with more than one bore. As the annual allocation volume is only associated with licence, for those licences with more than one bore or service point, one representative service point was selected to represent the location of the licence. The service points under the same licence are generally close to each other. It is believed that this assumption would cause minimum error. The extraction volumes for stock and domestic bores was provided by DSE. Licensed volumes and extraction data associated with Latrobe Valley coal mines was sourced via annual coal mine water usage reports. Groundwater extractions associated with offshore oil and gas operations were compiled by the Victorian Department of State Development, Business and Innovation via Exxon Mobile. The data used in the EcoMarkets project (GHD, 2012a; 2012b) was also incorporated into this dataset.

As screen information is necessary to assign a bore to particular aquifers, bores are assigned to aquifers based on the screen interval and when a bore's screen information is not available, its depth is used to assign the bore to a particular aquifer.

The alluvium and fractured rock aquifer subgroups represent the most accessed aquifer with 487 and 46 bores respectively. Most bores are either screened in the alluvium or the outcrops of underlying bedrock aquifers. Figure 20 shows the spatial distribution of these extraction bores.

Table 4 Data tables from the various sources used for hydrogeology and water quality analysis in the Gippsland region

Observed data	Title	Dataset name	URI
Bore construction	Victorian Water Measurement Information System	Bore	*data.**water**.vic.gov.au/ monitoring.htm*
	Victorian Water Measurement Information System	Construction details	*data.**water**.vic.gov.au/ monitoring.htm*
	Victorian allocation of aquifer for screened unit of monitoring bores	Aquifers assignment	*data.**water**.vic.gov.au/ monitoring.htm*
Groundwater level	Victorian Water Measurement Information System	Groundwater level	*data.**water**.vic.gov.au/ monitoring.htm*
	Exxon Mobile	Digital data supply	
Hydraulic parameters	Various previous studies	Refer to Schaeffer 2008	
Allocation	Southern Rural Water/DEPI	Victorian Water Accounts	

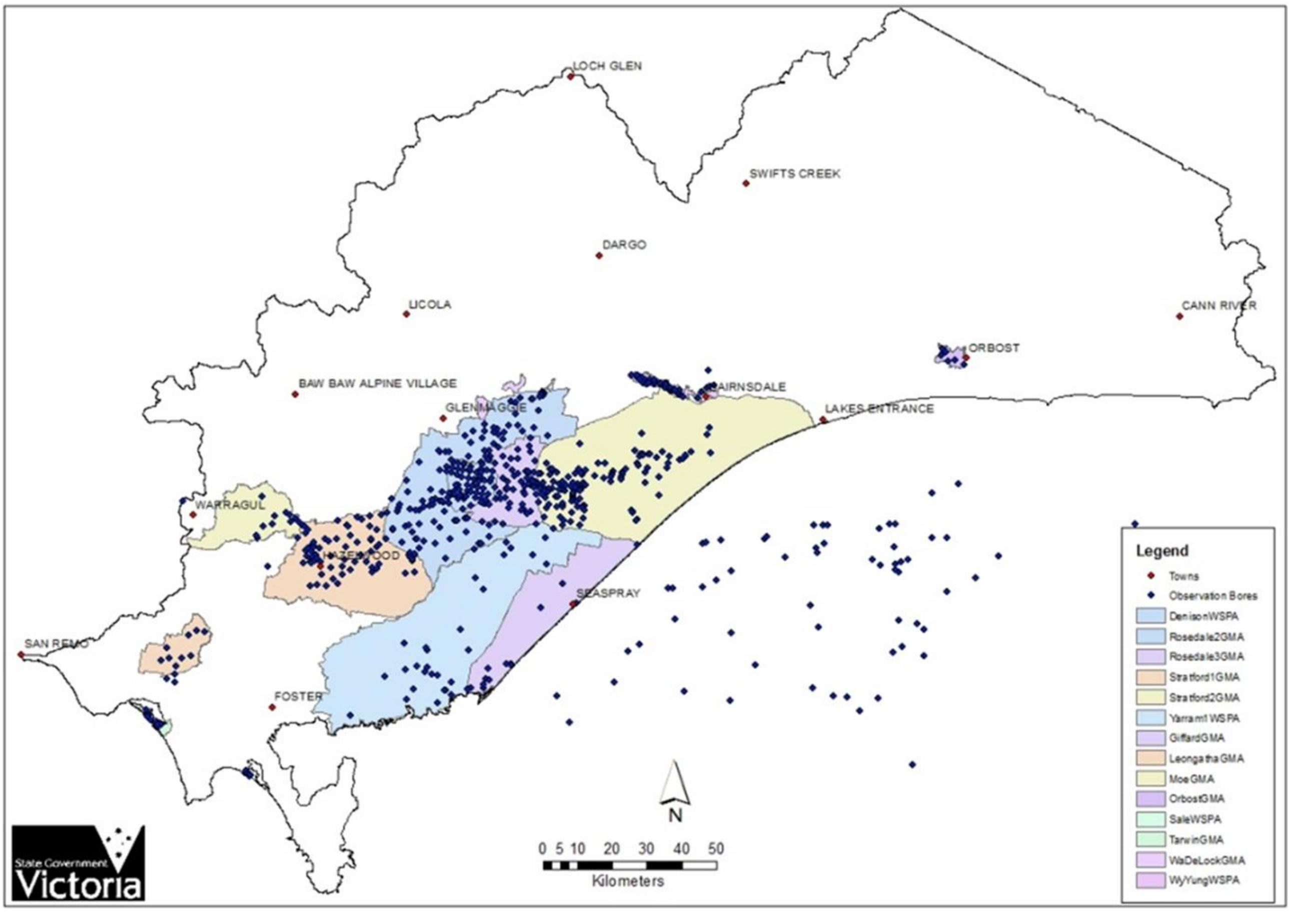


Figure 20 Location of observation bores in the Gippsland region by GMU

Table 5 Number of bores by aquifer system showing variability of aquifer depth in the Gippsland region

Aquifer system	Number of bores	Depth range* (m,BGL)	Modelled layer numbers[1]
Quaternary alluvium aquifer	487	1 – 335	1
Upper Tertiary aquifer	36	8 – 670	2 – 8
Mid-Tertiary aquifer	60	3 – 223	9 – 16
Lower Tertiary aquifer	174	3 – 680	17 – 22
Pre-Tertiary bedrock aquifer	46	1 – 1779	23 – 30

*The depth column presents the depth range of bores associated with a specific aquifer

[1]The modelled layer numbers column refers to the groundwater model layers associated with a specific aquifer

2.1.6.3 Statistical analysis and interpolation

2.1.6.3.1 Groundwater level

A summary of the measured water level data used in this analysis is provided in Table 6. More than a third of the 822 observation bores identified for this project are constructed in the Tertiary aquifers (model layers 2 to 22) and the majority are located within groundwater management units (GMUs). Those bores located within GMUs generally have longer and more frequent monitoring records. Records of groundwater level for bores constructed in located Quaternary alluvium aquifer (model layer 1) are also significant, with 75% of the total records. Conversely, the number of records for the observation bores constructed in Pre-Tertiary bedrock aquifer (model layers 23 to 30) are limited due to the relatively small number of bores and the shorter monitoring history. The bores offshore generally only have one indicative reading estimated from wellhead pressure test data provided by Exxon Mobile. Table 6 summarises the number of groundwater monitoring records in the Victorian state groundwater database, by aquifer system, for those bores located in the Gippsland region. An analysis of groundwater level trends for bores in the Gippsland region will be reported in the Groundwater numerical modelling report (companion product 2.6.2 for the Gippsland region).

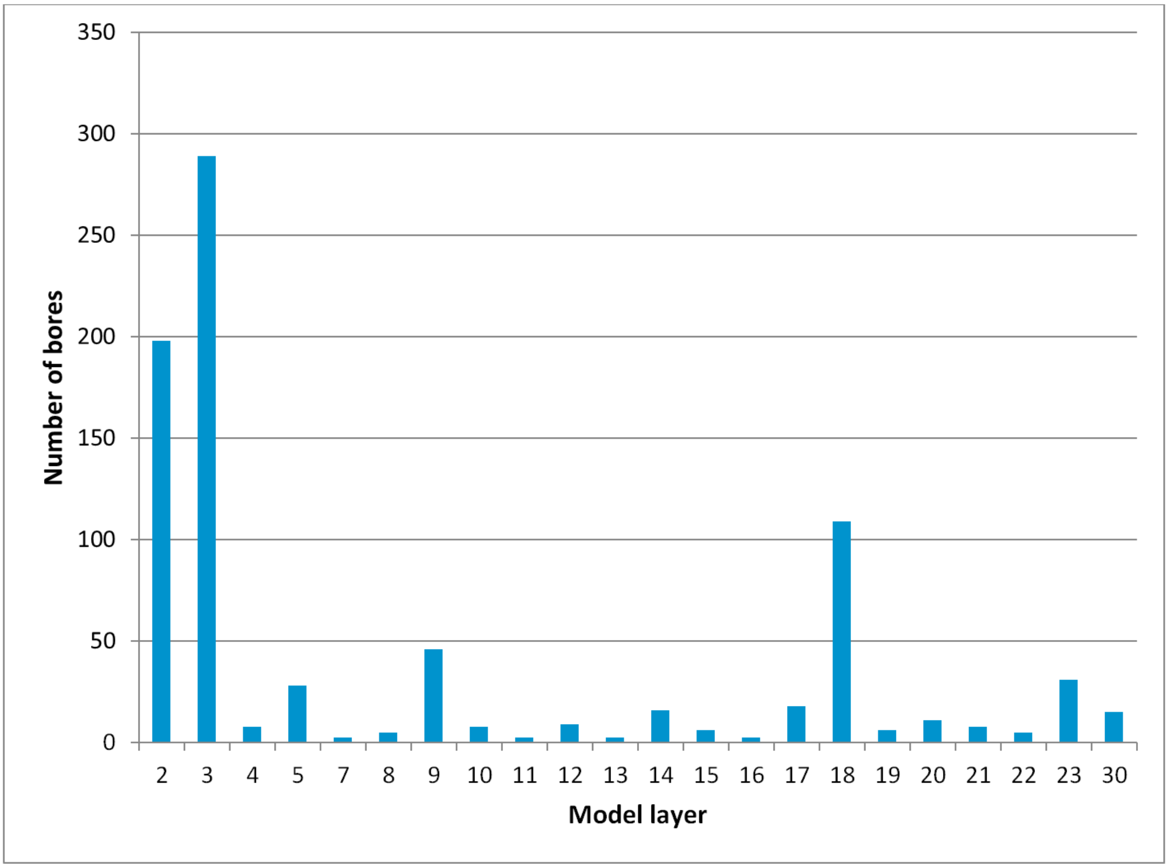


Figure 21 Summary of monitoring records for bores in the Gippsland region

Table 6 Summary of water level records for bores in the Gippsland region

Aquifer system	Number of bores	Average and range of groundwater depth (m,BGL)	Number of monitoring records
Quaternary alluvium aquifer	487	5 (2 to 61)	75,612
Upper Tertiary aquifer	36	10 (2 to 41)	6,096
Mid-Tertiary aquifer	60	13 (3 to 126)	6,970
Lower Tertiary aquifer	174	39 (3 to 188)	9,453
Pre-Tertiary bedrock aquifer	46	48 (4 to 796)	2,935

2.1.6.3.2 Hydraulic parameters

There are a limited number of pumping test records within the DSE pumping test database for the bores located in the Gippsland region. The majority of the pumping tests were conducted in the 1970s (e.g. Nahm 1977; Nahm & Reid, 1979a; 1979b; 1979c). Supplementary reports including commissioned studies (e.g. GHD, 2012a; 2012b) and university theses (e.g. Schaeffer, 2008) were also referenced to compile the hydraulic parameter's values for the aquifers of interest. Table 7 summarises the parameter ranges in the dominant aquifers within the Gippsland region. Ss refers to specific storage, Sy refers to specific yield and Kxy refers to horizontal hydraulic conductivity.

Table 7 Summary of hydraulic parameter's typical range reported for the main aquifers in the Gippsland region

Aquifer system	Ss (m^{-1})	Sy	Kxy (m/day)
Quaternary Alluvium Aquifer	1.0E-05 to 1.0E-04	0.04 to 0.15	2 to 50
Upper Tertiary Aquifer	1.0E-05 to 1.0E-03	0.05 to 0.2	1 to 30
Mid-Tertiary Aquifer	3.0E-06 to 5.0E-04	0.015 to 0.1	1.5 to 10
Lower Tertiary Aquifer	1.0E-06 to 4.7E-04	0.03 to 0.1	1 to 40
Pre-Tertiary Bedrock Aquifer	<3.0E-06 to 5.0E-03	0.005 to 0.02	0.02o 1

2.1.6.3.3 Groundwater quality

The observed groundwater quality data for the Gippsland region are sourced from the Victorian groundwater database in the WMIS. Of the 686 onshore observation bores, 128 bores have at least one salinity reading. Notably, the majority of these bores are constructed in the Quaternary and Tertiary aquifers within the central region of the Gippsland Basin. A summary of the groundwater salinity based on analysis of the groundwater bore salinity data for the main aquifers is presented in Table 8.

Groundwater quality is mapped by salinity for each of the major aquifer systems, and classed according to the SEPP Groundwaters of Victoria beneficial use classes. Most of the licensed extraction points are located in areas of low salinity (< 1000 mg/L).

Table 8 Summary of groundwater salinity for the main aquifers in the Gippsland region

Aquifer system	Number of bores	Total number of records	Median groundwater salinity (µS/cm)
Quaternary Alluvium Aquifer	65	781	1114
Upper Tertiary Aquifer	34	677	1355
Mid-Tertiary Aquifer	17	129	1000
Lower Tertiary Aquifer	8	11	708
Pre-Tertiary Bedrock Aquifer	4	69	1682

2.1.6.3.4 Licensed extraction volume

The data for licensed extraction bores is summarised in Table 9. The majority of the licensed bores are located in groundwater management areas and extractions are from the major tertiary aquifers. In addition to licensed extractions, there are a large number of stock and domestic bores. Each of these bores has a small estimated extraction volume (ranging from 1 to 2 ML/yr) such that the total volume of groundwater extraction from these bores is relatively small compared with the total extracted volume. The extracted volume attributed to licensed, stock and domestic, mine and offshore bores from 1970 to 2012 is shown in Figure 22. The corresponding extracted volume by aquifer system is shown in Figure 23.

Table 9 A summary of groundwater extraction data for the bores in the Gippsland region

Aquifer system	Number of licensed bores	Number of stock and domestic bores	Number of mine bores	Number of offshore bores	Mean annual volume* (ML)
Quaternary Alluvium Aquifer	894	4081	27	0	40,859
Upper Tertiary Aquifer	85	438	0	0	9,635
Mid-Tertiary Aquifer	142	520	11	0	8,604
Lower Tertiary Aquifer	104	234	78	22	116,282
Pre-Tertiary Bedrock Aquifer	133	812	0	0	7,930

* Mean annual volume calculated from 1970–2012 inclusive

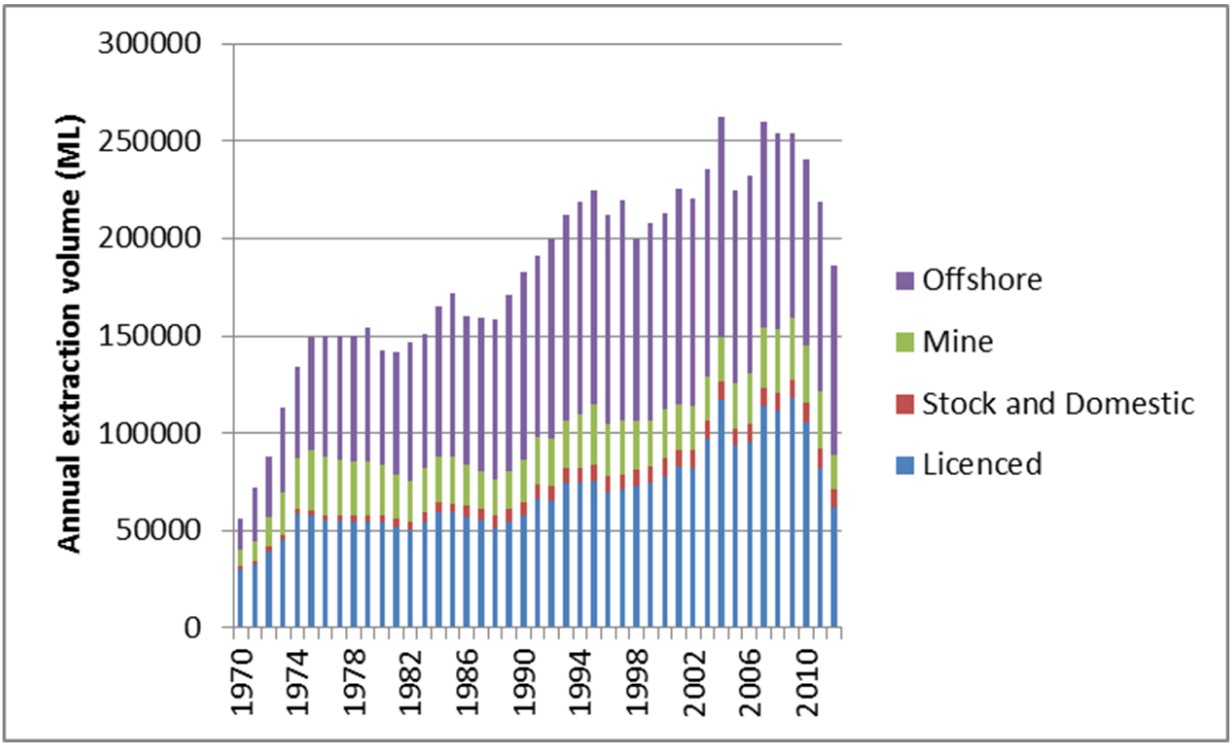


Figure 22 Annual extraction volume (ML) attributed to licensed, stock and domestic, mine and offshore bores for 1970–2012

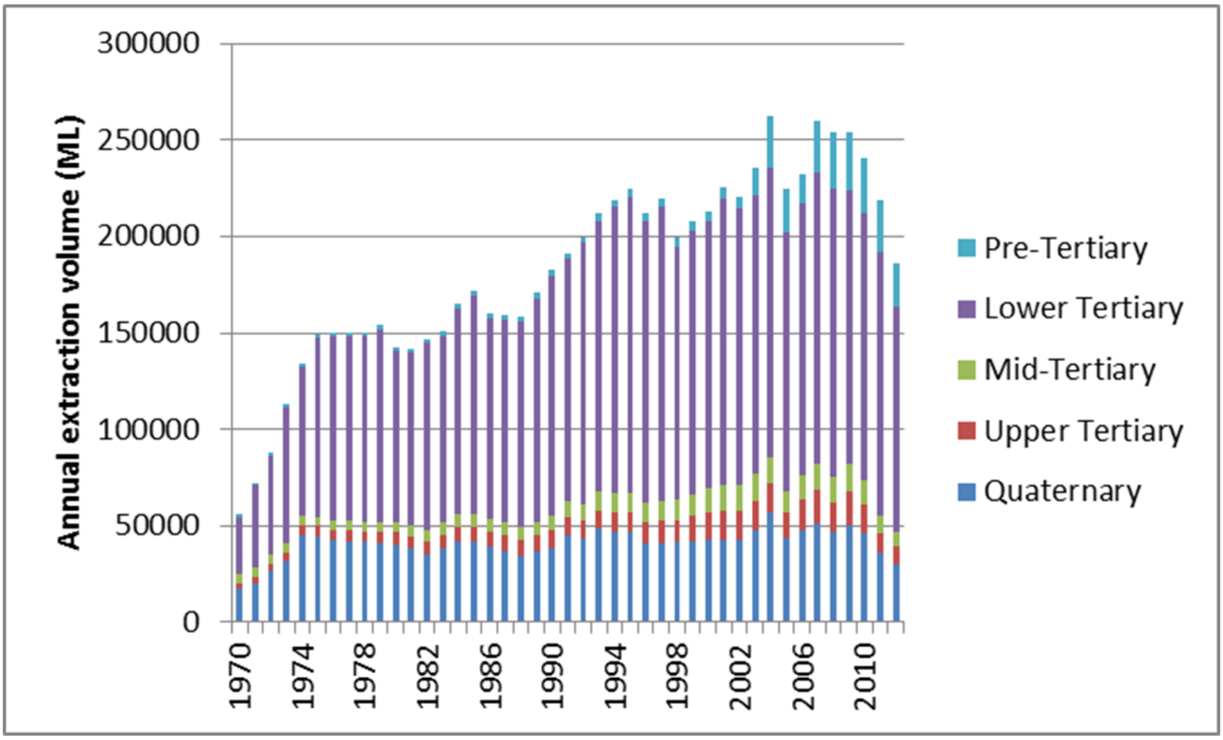


Figure 23 Annual extraction volume (ML) attributed to aquifer system for 1970–2012

2.1.6.4 Gaps

It is noteworthy that the groundwater observation bore network in the Gippsland Basin region is sufficient to monitor the key water resource aquifers. Adjacent to existing mines there is good coverage with shallow groundwater observation bores and regular reporting of groundwater dynamics. While there are many groundwater bores and a large number of groundwater observation bores, an on-going issue relates to future monitoring and maintenance. This aside, there are some distinct data and knowledge gaps that could potentially influence achieving realistic simulation and modelling based analysis. These include:

- There are limited deep groundwater observation bores, as 74% of all groundwater observation bores are less than 50 m deep and less than 17% are in the deep water-bearing units at depths greater than 150 m. As such, the existing groundwater monitoring network is likely to capture only a small component of the hydrodynamics of the Gippsland Basin subregion.
- Critical hydraulic information, including hydraulic properties and water chemistry, of key aquifers is currently missing. More information about hydraulic properties of key aquifer units needs to be obtained. In particular, information about the deep water-bearing units is required for the numerical model development to assess the impacts associated with coal seam gas development.
- There is a general lack of nested (multi-level) bore sites throughout the Gippsland Basin bioregion. While groundwater dynamics in shallow alluvial aquifers are relatively well understood, there is very limited knowledge on characteristics such as groundwater flow direction or inter-aquifer hydraulic head gradients throughout much of the bioregion.

- There are significant gaps in the groundwater databases. Of the observation bores identified in the Gippsland Basin bioregion, 62% has incomplete screen depth information.
- There is limited information associating a groundwater bore to a specific 'aquifer' layer where the screened interval of bores is assigned to a specific aquifer in the Victorian Aquifer Framework or equivalent.
- The hydraulic significance of faults is poorly understood due to the lack of nested (multi-level) groundwater monitoring sites. Only limited understanding exists about the role of faults as potential pathways or barriers for aquifer interconnectivity or groundwater flow to the surface. More research is required to identify the spatial extent and properties of faults.
- Uncertainty in recharge estimates impacts the robustness of model predictions. Numerous studies have identified significant variations in recharge. It is recommended that an evaluation of recharge estimates and their method of derivation be undertaken and documented.
- There remains incomplete time-varying groundwater pumping volume data. This information is critical in any assessment of groundwater response to proposed extractions. It is recommended that a database of time-varying extractions volumes (both measured and infilled) for all groundwater pumps be developed. A quality code should also be assigned to each record to identify the source of the measurement (actual, interpolated or infilled). In addition, the on-going installation of metering and monitoring of groundwater pumps is required in the future. This information would avoid variations in the estimated historical groundwater extraction volumes and unnecessary duplication in effort and resources undertaken by various modelling studies.
- There is limited groundwater quality data in the groundwater databases. Of the onshore groundwater observation bores, only 18% have at least one salinity record and less than 10% have other constituent information. For example, nutrient data is infrequently recorded and only available for 8% of all bores listed in the groundwater database.

2.1.7 Surface water hydrology and water quality

Summary

The Gippsland Basin bioregion contains 197 streamflow gauges. The Victorian water monitoring scheme classifies streamflow data into 57 quality codes. In this analysis, these quality codes were grouped into six broad water quality codes based on the national water quality coding scheme to enable consistency and comparison between states and territories. Based on an analysis of all daily streamflow gauge data, 72% of all records were good, 8% fair, 6% poor, 4% unknown and 10% missing. The quality of individual streamflow data varied significantly whilst results suggest that the streamflow monitoring program in the South Gippsland Basin was of a higher quality than the monitoring in all other basins. Water chemistry and quality was not considered in this analysis.

2.1.7.1 Methods

The Gippsland region includes the South Gippsland, Latrobe, Thomson, Macalister, Avon, Mitchell, Tambo and Nicholson, Snowy and East Gippsland river basins, as shown in Figure 24. The Latrobe, Thomson-Macalister, Avon, Tambo, Nicholson and Mitchell rivers flow into the Gippsland Lakes, while the Tarwin, Snowy and Cann rivers flow into small estuaries or to the sea. The Tarwin, Agnes and Tarra Rivers flow steeply from the southern face of the Strzelecki Ranges to the coast. The Gippsland Lakes form the largest estuarine lake system in Australia. Along with Ninety Mile Beach they are major features of the region. Dunes and wetlands are common around the lakes and along the coast. There are also some large dams such as Blue Rock, Thomsons Dam and Glenmaggie Dam, and extensive channel and drain networks in the Macalister Irrigation District (MID).

2.1.7.1.1 Latrobe River

The Latrobe Basin includes the Latrobe, Tanjil, Tyers, Moe, Morwell and Traralgon river systems. The Latrobe River rises at an elevation of approximately 750 m due west of Noojee. Its headwaters, together with the Ada, Loch and Toorongo rivers, drain the eastern and southern slopes of the Yarra Ranges, which form a southern extension of the Great Dividing Range. Approximately 70 km from its source, the Latrobe River emerges from the foothills onto its floodplain. The river flows through the Latrobe Valley and discharges into Lake Wellington, at the western end of the Gippsland Lakes. The Latrobe River is the highest contributor of freshwater inflows to the Gippsland Lakes contributing 44% of mean annual inflow. The Latrobe River system has been most affected by regulation and extraction, with a 33% reduction of inflows to Lake Wellington (Tilleard et al., 2009).

The Latrobe Valley houses two major water storages, Blue Rock Lake (capacity 208 GL) and Moondarra Reservoir (capacity 30 GL). Another much smaller storage, Lake Narracan, is situated on the main stem of the Latrobe River at Yallourn near Moe. Blue Rock and Lake Narracan are primarily used to supply Yallourn, Loy Yang A and Loy Yang B power stations.

The environmental condition of the Latrobe River varies from excellent in the headwaters to moderate and poor condition in the mid – lower reaches below the storages. Freshwater flows from the Latrobe Basin are critical for sustaining the health of the Ramsar-listed Gippsland Lakes, which underpin the region's tourism industry.

2.1.7.1.2 Mitchell River

The Mitchell River is identified as a heritage river and as one of two iconic rivers in Victoria. This is largely because of its size, being the largest unregulated river in Victoria, and because it supports a wide range of environmental and social values. Land use in the upper catchment includes sections of the Alpine National Park and the Mitchell River National Park.

The Mitchell River system originates on the southern slopes of the Great Dividing Range, with the Wonnangatta and Dargo rivers being the two major rivers in this area, and forming the Mitchell River downstream of their confluence. The Mitchell River discharges to Lake King within the Gippsland Lakes. Other surface water systems include the Humfray, Dargo, Wongungarra and Wonnangatta rivers, Wentworth Creek and the Gippsland Lakes.

The river system is highly valued by the community for urban and rural water supply, recreation and its contribution to the Gippsland Lakes. The Mitchell River provides about one third of the total flow to the Lakes system on average.

Geologically 70% of the catchment consists of fractured rock systems in Palaeozoic-aged metasediments and intrusive rocks. Small areas of alluvial valley sequences occur in the highland valleys together with layered systems within Tertiary-aged volcanics. The southern third of the catchment contains the regional aquifer systems of the Gippsland Basin sequence (SKM, 2012a).

2.1.7.1.3 Thomson/Macalister rivers

The Thomson River flows from the Dividing Range and joins the Latrobe River to the south of Sale. The Macalister River flows from the Alpine National Park in the Snowy Ranges and joins the Thomson River between Maffra and Sale. The Thomson and Macalister rivers then continue towards and contribute flows to the Ramsar-listed Gippsland Lakes. The Thomson River above Cowwarr Weir is listed as a Heritage River.

There are two major storages within the Thomson-Macalister system, namely Lake Glenmaggie situated on the Macalister River and the Thomson Reservoir on the upper reaches of the Thomson River. Lake Glenmaggie is the main source of supply for the Macalister Irrigation District, the largest irrigation area south of the Great Dividing Range. The Thomson Dam provides some of Melbourne's water supply system and the Macalister Irrigation District.

However, both the Thomson and Macalister rivers are amongst the most stressed rivers in Victoria. This is due to the altered flow regimes, through regulation and over allocation of water for irrigation and consumptive use. As such, river management is considered to have the greater impact on mitigating river stress than groundwater/baseflow management. The Thomson and Macalister rivers directly below the Thomson Dam and Lake Glenmaggie respectively have reduced annual flows and reversed seasonality as a result of the reservoirs, with high flows in January and February and low flows during the winter months. This altered flow regime has significant impacts on the breeding and migration cues for fish. The dams and weirs are also a barrier to fish movement. Poor water quality in the rivers is affecting water supplies for consumptive use and recreation, as well as the Gippsland Lakes.

2.1.7.1.4 Avon River

The Avon River rises on the slopes of Mount Wellington in the eastern highlands and flows south to Lake Wellington. A significant portion of the upper catchment is protected in the Avon Wilderness Area (295 km^2). The upper catchment is steep, heavily forested and largely inaccessible. The channel is stable and confined by bedrock. The upper reaches of the Avon River including Turton and Dolodrook rivers and Ben Cruachan Creek have been listed as Natural Catchment Areas.

The Lower Avon catchment below the Valencia Creek confluence flows through a topographically flat area which has been predominantly cleared for agriculture. The Avon River above Stratford and Freestone Creek have experienced dramatic widening since European settlement and now flow through wide mobile gravel beds. The Perry River joins the Avon approximately 1 km upstream from where the Avon discharges into Lake Wellington.

In the lower part of the Avon catchment, both surface water and groundwater are utilised for irrigation. The river has experienced low flows over the past decade and as a consequence, frequent irrigation restrictions have been imposed (Jones et al., 2009).

2.1.7.1.5 Snowy River

The Snowy River originates on the slopes of Mount Kosciuszko, draining the eastern slopes of the Snowy Mountains in New South Wales, before flowing through the Alpine National Park and the Snowy River National Park in Victoria and emptying into Bass Strait. The river flow was drastically reduced in the mid-20th century after the construction of four large dams (Guthega, Island Bend, Eucumbene, and Jindabyne) and many smaller diversion structures in its headwaters in New South Wales, as part of the Snowy Mountains Scheme.

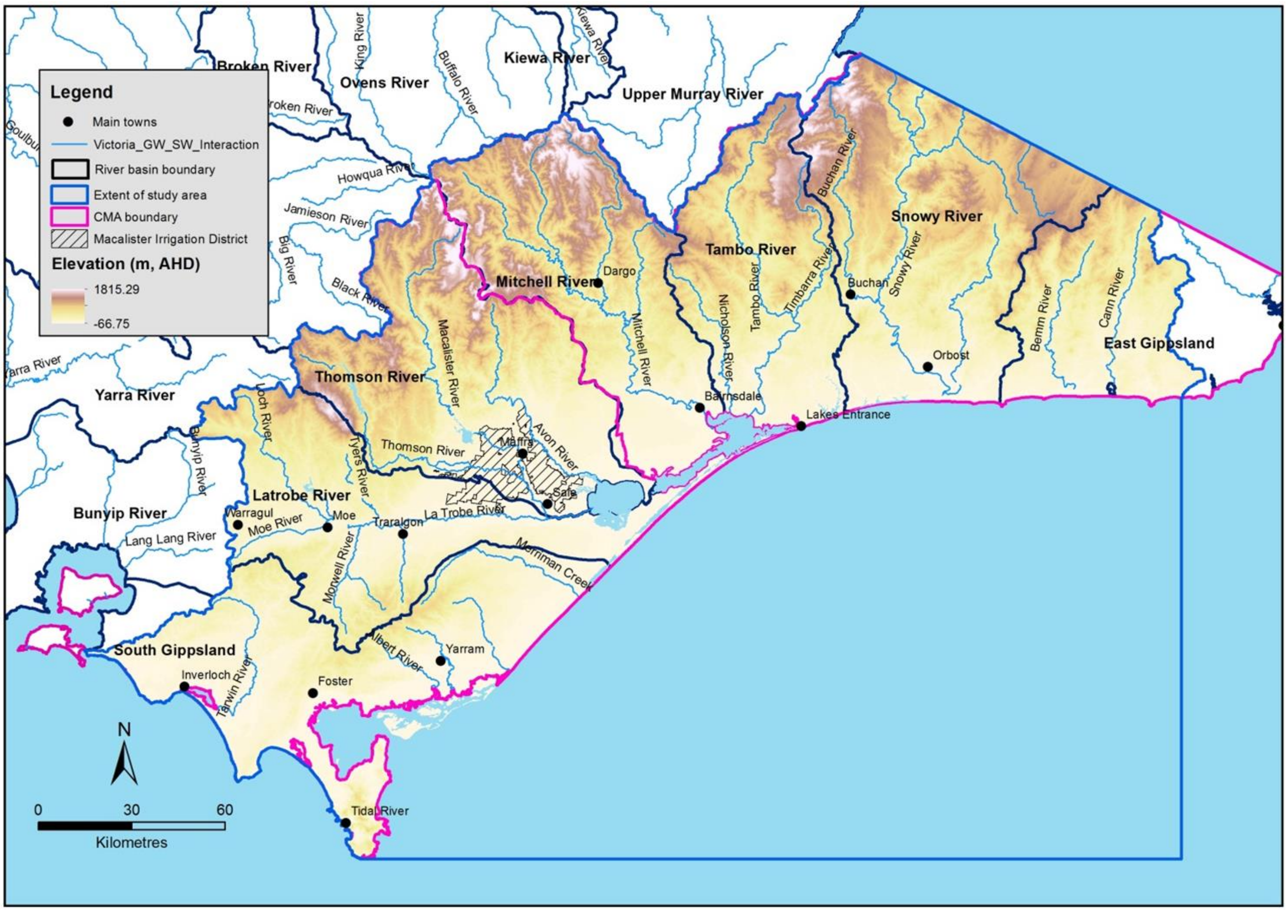


Figure 24 Major rivers of the Gippsland Basin

2.1.7.1.6 Flooding

Flooding contributes to episodic recharge and was considered in the Gippsland groundwater modelling study. For example, in early June 2012, much of Gippsland experienced heavy rainfall causing flooding across a number of municipalities, including Latrobe, Wellington and East Gippsland. Hydrograph analysis revealed that groundwater levels responded to this event.

For this study flood data was sourced from the Victorian Flood Database and included information regarding location and extent of a 1-in-100 year event (Figure 25) and historical flood events. Figure 26 shows the location and extent of recent major floods and Table 10 presents the magnitude of each flooding event in the past 100 years (including area directly affected and duration).

Although damage caused by some recent flooding events (e.g. June 2012) to towns and communities was widespread in the Gippsland region, the areas directly affected by flooding were relatively small compared with the total area of the region. The extent of the 1-in-100 year flooding event only covers 4.8% of the total area of the Gippsland region. In the last 100 years, flooding events mainly occurred in small areas around the lower reaches of the Mitchell, Thomson, Latrobe and Snowy rivers. The area directly affected by flooding was generally less than 1% of the Gippsland region. The largest flood event occurred in June 2012 and covered 1.4% of the Gippsland region. Given the areas affected by historic flooding events were relatively small, it is believed that the impact of flooding on groundwater recharge is insignificant at the regional scale, but likely to be significant at the local scale.

By examining groundwater hydrographs across the Gippsland region, noticeable impact of flooding on groundwater recharge is only evidenced in the shallow aquifer systems well connected to the lower reaches of Thomson, Mitchell and Latrobe rivers. It was found that recharge spikes in groundwater hydrographs of some shallow bores near the rivers are aligned to high river flow events.

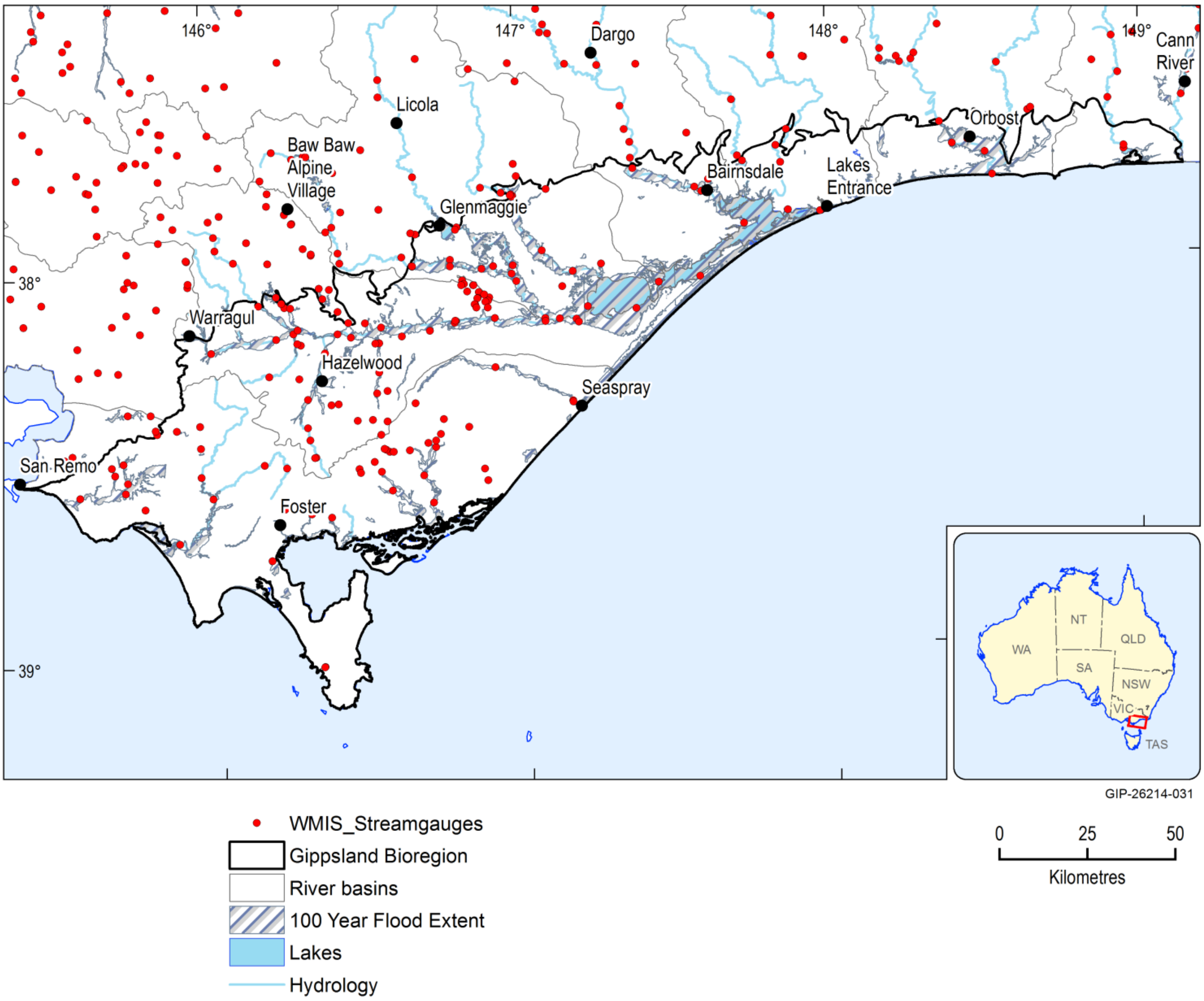


Figure 25 Location and extent of 1-in-100 year flooding events in the Gippsland area (sourced from the Victorian Flood Database)

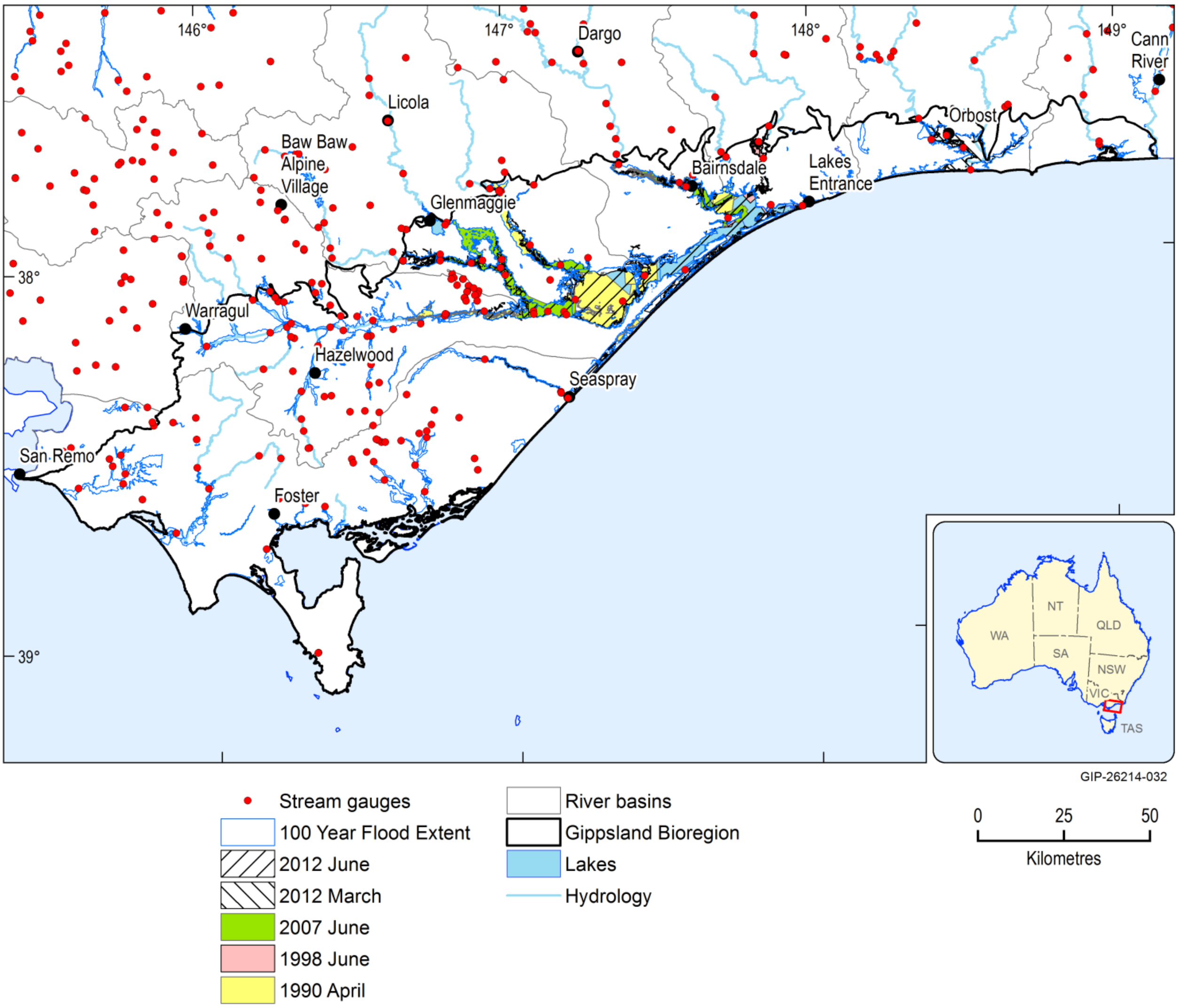


Figure 26 Location and extent of major recent flooding events (sourced from the Victorian Flood Database

Table 10 Extents of historical flood events (sourced from the Victorian Flood Database)

Date	Duration (days)	Area affected (ha)	% of total catchment area
Jan-1919	Not known	2,717	0.1
Jan-1920	Not known	1,129	0.0
Oct-1923	Not known	208	0.0
Jan-1934	Not known	7,527	0.2
Dec-1934	Not known	13,361	0.4
May-1968	1	544	0.0
Jun-1969	1	644	0.0
Feb-1971	Not known	1,666	0.0
Sep-1974	Not known	42	0.0

Date	Duration (days)	Area affected (ha)	% of total catchment area
Jan-1977	Not known	11,323	0.3
Jul-1977	3	20,248	0.5
Jan-1978	Not known	2,884	0.1
May-1978	5	14,947	0.4
Jun-1978	5	12,086	0.3
Jul-1978	1	3,709	0.1
Jan-1985	Not known	740	0.0
Dec-1985	1	6,427	0.2
Nov-1988	1	7,061	0.2
Apr-1990	27	32,563	0.9
Oct-1990	1	3,278	0.1
Oct-1991	1	169	0.0
Sep-1993	16	2,155	0.1
Jun-1998	3	6,364	0.2
Nov-1998	1	949	0.0
Jun-2007	4	23,308	0.6
Jul-2011	Not known	36	0.0
Mar-2012	8	9,023	0.2
Jun-2012	3	54,912	1.4
1-in-100 year extent	N/A	181,490	4.8

Source data: Victorian Flood Database

2.1.7.2 Observed data

There are 197 streamflow gauges in the Gippsland Basin. For this analysis, each streamflow gauge was assigned to the major river basin in which it was located. The nominated major river basins were the East Gippsland region, the Latrobe River, the Mitchell River, the Snowy River, the South Gippsland region, the Tambo River and the Thompson River. Site details for each streamflow gauge is summarised in Table 11 to Table 17 for each river basin. Daily computed daily streamflow data were obtained from the Victorian Water Measurement Information System (http://data.water.vic.gov.au/monitoring.htm). Associated with each daily flow estimate is a quality code which reflects the accuracy of the data. The quality of the daily interpolated streamflow data is dependent on the accuracy and robustness of the rating curve used to define the relationship between streamflow and gauge stage height.

Table 11 East Gippsland Basin streamflow site details

Site ID	Site name	Easting	Northing	Start date	Cease date
221001	GENOA RIVER @ ROCKTON	705825	5887218	26/05/1993	
221201	CANN RIVER (WEST BRANCH) @ WEERAGUA	694682	5861473	21/02/1957	
221202	GENOA RIVER @ WANGARABELL	721597	5858291	13/10/1927	30/06/1929
221203	BETKA RIVER @ MALLACOOTA	737895	5836091	26/01/1966	24/07/1972
221204	THURRA RIVER @ POINT HICKS	699200	5822200	17/05/1966	28/07/1978
221205	BEMM RIVER @ BEMM RIVER	671894	5821411	28/06/1966	5/06/1975
221206	CANN RIVER @ NOORINBEE	694397	5854712	31/05/1967	3/02/1971
221207	ERRINUNDRA RIVER @ ERRINUNDRA	669418	5853798	28/07/1971	
221208	WINGAN RIVER @ WINGAN INLET NATIONAL PARK	719710	5825780	14/12/1982	
221209	CANN RIVER (EAST BRANCH) @ WEERAGUA	695470	5863398	23/10/1972	
221210	GENOA RIVER @ THE GORGE	723046	5856007	22/08/1972	
221211	COMBIENBAR RIVER @ COMBIENBAR	675439	5854433	12/08/1974	
221212	BEMM RIVER @ PRINCES HIGHWAY	667855	5836059	30/04/1975	
221213	GOOLENGOOK RIVER @ D/S OF ARTE RIVER JUNCTION	663700	5846900	1/05/1978	18/12/1986
221214	CANN RIVER @ D/S OF CANN RIVER	688655	5836283	26/07/1979	
221216	GENOA RIVER @ D/S OF BIG FLAT CREEK JUNCTION	722309	5858210	23/05/1967	10/12/1970
221217	GENOA RIVER @ GIPSY POINT (WOOD'S JETTY)	736900	5848600	8/07/1992	3/11/1998
221218	BETKA RIVER @ MINERS TRACK	732688	5835801	16/01/1996	
221222	HENSLEIGH CREEK U/S COMBIENBAR	679158	5863650	18/05/2006	17/11/2010
221223	COMBIENBAR RIVER @ TIGER SNAKE CK	680158	5864336	18/05/2006	17/11/2010
221224	CANN RIVER U/S CANN RIVER OFFTAKE	690544	5843171	11/03/2009	
221225	BEMM RIVER U/S OF PUMPHOUSE	671929	5822377		
221800	RAINGAUGE (GENOA RIVER) @ THE GORGE	722715	5855916	22/08/1972	

Source data: Victorian flood database

Table 12 La Trobe Basin streamflow site details

Site ID	Site name	Easting	Northing	Start date	Cease date
226005	LATROBE RIVER @ THOMS BRIDGE	448418	5775480	24/05/1960	
226006	TYERS RIVER @ BOOLA	448568.9	5781803	16/04/1958	
226007	TYERS RIVER @ BROWNS	443476	5788600	17/08/1961	
226008	TYERS RIVER WEST BRANCH @ MORGANS MILL	439256	5800120	27/04/1960	
226012	TANJIL RIVER EAST BRANCH @ TANJIL BREN	429307.7	5812543	18/01/1961	11/08/1971
226016	WATERHOLE CREEK @ MORWELL	449045.2	5767997	22/08/1961	15/02/1982
226017	JACOBS CREEK @ O'TOOLES	446350	5788246	16/04/1962	
226021	NARRACAN CREEK @ MOE	435969	5775832	26/06/1996	
226023	TRARALGON CREEK @ TRARALGON	460064	5772541	18/09/1998	
226027	LA TROBE RIVER AT SWING BRIDGE	511200	5778084	7/05/2010	
226028	TYERS R @ PUMP HOUSE	451503	5778560	5/04/2007	
226033	LA TROBE RIVER @ SCARNES BRIDGE	460763	5777041	20/12/1996	
226039	BILLY CREEK @ U/S OF OFFTAKE WEIR	446116.2	5755156	2/03/1967	8/05/1968
226041	LAKE WELLINGTON @ BULL BAY	532876	5780415	25/02/1991	
226202	TYERS RIVER @ GOULD	444451.2	5785660	19/05/1926	28/02/1941
226204	LATROBE RIVER @ WILLOW GROVE	426308	5784017	17/10/1966	
226205	LATROBE RIVER @ NOOJEE	414035	5804037	1/05/1996	
226206	LATROBE RIVER @ APM MARYVALE	452119.2	5774427	2/01/1946	3/05/1977
226209	MOE RIVER @ DARNUM	412633	5770880	19/10/1960	
226216	TANJIL RIVER @ TANJIL SOUTH	433560	5783395	5/04/1955	
226217	LATROBE RIVER @ HAWTHORN BRIDGE	419490.7	5796548	2/06/1955	9/01/1989
226218	NARRACAN CREEK @ THORPDALE	428843	5763687	22/06/1955	
226219	TOORONGA RIVER @ NOOJEE	415838.9	5810012	1/10/1924	1/07/1933
226220	LOCH RIVER @ NOOJEE	412644	5808497	25/04/1978	
226222	LATROBE RIVER @ NEAR NOOJEE (US ADA R JUNCT.)	402650	5806658	10/05/1971	
226223	LATROBE RIVER @ NEERIM EAST	414328.5	5800194	16/03/1972	8/01/1979
226224	LATROBE RIVER @ ROSEDALE (ANABRANCH)	481555	5777709	1/12/1936	
226226	TANJIL RIVER @ TANJIL JUNCTION	429155	5796100	25/05/1960	
226227	LATROBE RIVER @ KILMANY SOUTH	492900	5778721	16/12/1976	
226228	LATROBE RIVER @ ROSEDALE (MAIN STREAM)	481748	5778351	1/12/1936	
226229	TANJIL RIVER @ D/S OF BLUE ROCK DAM	432764.2	5784647	11/05/1979	28/02/1982

Site ID	Site name	Easting	Northing	Start date	Cease date
226232	TANJIL RIVER @ MOE-WALHALLA ROAD BRIDGE	0	0	17/05/1990	5/06/1990
226233	TANJIL RIVER @ U/S OF SERPENTINE CREEK	435276.4	5783133	16/07/1992	12/12/2006
226235	TYERS RIVER @ TYERS JUNCTION	441506	5798197	20/08/2003	
226244	TYERS R EAST BRANCH @ CORRINGAL SCOUT CAMP	441496	5798505	27/10/2004	18/09/2008
226245	TYERS R WEST BRANCH U/S SOUTH FACE RD	436327	5807354	1/11/2004	24/02/2009
226246	TYERS R WEST BRANCH D/S SOUTH FACE RD	436123	5807237	28/10/2004	24/02/2009
226247	HOPE CK U/S SOUTHFACE ROAD BRIDGE	434283	5810028	26/03/2007	24/02/2009
226248	HOPE CK D/S SOUTHFACE ROAD BRIDGE	434267	5809990	26/03/2007	24/02/2009
226400	LATROBE RIVER @ YALLOURN	437171.9	5776866	1/11/1923	
226402	MOE DRAIN @ TRAFALGAR EAST	431070	5774351	7/06/1957	
226407	MORWELL RIVER @ BOOLARRA	439351	5748787	9/05/1972	
226408	MORWELL R @ YALLOURN	444702	5770110	21/04/2004	
226410	TRARALGON CREEK @ KOORNALLA	459050	5758231	9/07/1953	
226415	TRARALGON CREEK @ TRARALGON SOUTH (JONES RD)	459805	5764127	27/05/1976	
226602	AREA 2 SITE1 @ DOWDS MORASS NTH	515887	5777885	17/06/2003	24/09/2009
226603	AREA 4 SITE 2 @ DOWDS MORASS STH	516572	5776987	17/06/2003	
226605	LAKE VICTORIA AT MCLENNAN'S STRAIT	539492.4	5787708	17/11/2010	
226606	LAKE VICTORIA AT LOCH SPORT	551177	5789006	26/11/2010	
226607	MCMILLAN STRAIT AT PAYNESVILLE	564019	5803744	21/10/2010	
226608	LAKE KING AT METUNG	576509	5807128	17/11/2010	
226609	CUNNINGHAM ARM AT BULLOCK ISLAND	585591	5806582	19/10/2010	
226700	LOY YANG OUTFALL TO TRARALGON CREEK	0	0	17/12/1997	7/02/2000
226702	MORWELL GROSS POLLUTION TRAP D/S CIRCULAR PIPE	447900	5766700	1/06/1998	7/10/1998
226801	RAINGAUGE (REPRESENTATIVE BASIN) @ LATROBE NO. 2	399410	5810382	19/01/1982	17/08/1988
226802	RAINGAUGE (REPRESENTATIVE BASIN) @ LATROBE NO. 3	398477.4	5802788	19/01/1982	6/03/1986
226804	RAINGAUGE (SITE 3) @ WALHALLA ST - NEWBOROUGH	438000	5772500	6/12/1994	16/10/1995
226805	RAINGAUGE (SITE 4) @ MOE INDOOR RECREATION CENTRE	437018.3	5772948	7/12/1994	16/10/1995
226814	RAIN GAUGE @ MT TASSIE	461784	5750077	3/12/1998	
226815	RAIN GAUGE (TRARALGON CK) @ TRARALGON - EPA YARD	458982	5772514	25/05/1999	
226816	RAIN GAUGE @ MT HOOGHLY	453401	5750509	29/09/1999	15/05/2008
226817	RAIN GAUGE @ LE ROY QUARRY	457656	5750650	30/09/1999	31/10/2009

Site ID	Site name	Easting	Northing	Start date	Cease date
226818	RAIN GAUGE @ BALOOK	459952	5746341	10/06/1999	
226819	RAIN GAUGE @ CALIGNEE NORTH	462063	5758780	25/05/1999	
226825	RAINGAUGE @ MOE SOUTH	434231.7	5769649	6/10/2009	
226826	RAINGAUGE AT YARRAGON SOUTH	420511	5763367	21/10/2009	
226827	RAINGAUGE @ THORPDALE PEAK	431275	5760002	17/09/2009	
226828	RAINGAUGE @ JEERALANG SOUTH HALLAMS RD	451008.4	5752916	6/10/2009	16/11/2011
226829	RAINGAUGE AT JERRALANG, DOBBINS ROAD	450883.6	5754700	29/01/2013	

Source data: Victorian flood database

Table 13 Mitchell Basin streamflow site details

Site ID	Site name	Easting	Northing	Start date	Cease date
224200	MITCHELL RIVER @ BAIRNSDALE	552241	5813267		
224201	WONNANGATTA RIVER @ WATERFORD	514714	5850745	15/07/1976	
224203	MITCHELL RIVER @ GLENALADALE	533010	5820334	22/02/1991	
224205	DARGO RIVER @ DARGO (UPPER SITE)	524129.9	5861628	1/06/1953	26/06/1974
224206	WONNANGATTA RIVER @ CROOKED RIVER	507891	5859903	13/04/1977	
224207	WONGUNGARRA RIVER @ GUYS	508800	5862200	7/05/1953	10/01/1989
224208	MITCHELL RIVER @ HOWITT DAM SITE	532433.8	5827894	14/02/1969	22/12/1975
224209	COBBANNAH CREEK @ NEAR BAIRNSDALE	530900	5831600	15/05/1970	1/07/1987
224210	WONNANGATTA RIVER @ KINGSWELL BRIDGE (HAWKHURST)	510185.8	5859582	12/02/1970	25/03/1981
224213	DARGO RIVER @ LOWER DARGO ROAD	523752	5850152	24/05/1973	
224214	WENTWORTH RIVER @ TABBERABBERA	534808	5850099	4/07/1974	
224215	MITCHELL RIVER @ ANGUSVALE (TABBERABBERA)	529928	5838289	28/05/1975	30/09/2008
224216	CLIFTON CREEK @ WY YUNG	554294.5	5816640	28/01/1977	4/01/1979
224217	MITCHELL RIVER @ ROSEHILL	550366	5814542	2/04/2003	
224220	RAIN GAUGE (BOGGY CREEK) @ BULLUMWAAL	548565.5	5830013	26/02/1991	
224222	MITCHELL RIVER U/S GLENALADALE PUMPHOUSE	532443	5823351	18/12/2009	

Source data: Victorian flood database

Table 14 Snowy River Basin streamflow site details

Site ID	Site name	Easting	Northing	Start date	Cease date
222200	SNOWY RIVER @ JARRAHMOND	620071	5830901	30/06/1971	
222201	SNOWY RIVER @ ORBOST	627898	5825644	27/03/1997	
222202	BRODRIBB RIVER @ SARDINE CREEK	636752	5847240	16/06/1998	
222203	SNOWY RIVER @ MARLO JETTY	634504.8	5815385	25/06/1934	18/01/1998
222204	SNOWY RIVER @ BETE BELONG	623487.8	5824590	21/10/1938	26/07/1949
222205	SNOWY RIVER @ NEWMERELLA-LOCHEND ROAD	632611.9	5821910	1/03/1960	27/01/1983
222206	BUCHAN RIVER @ BUCHAN	603711	5849459	27/03/1926	
222207	BUCHAN RIVER @ MURRINDAL	609403	5848401	15/02/1951	21/11/1972
222209	SNOWY RIVER @ MCKILLOP BRIDGE	625612	5894902	5/04/1967	
222210	DEDDICK RIVER @ DEDDICK (CASEYS)	626577.7	5894694	5/04/1973	
222212	SNOWY RIVER @ BASIN CREEK NEAR BUCHAN	613458.7	5850738	4/05/1932	10/01/1934
222213	SUGGAN BUGGAN RIVER @ SUGGAN BUGGAN	618048	5909278	25/06/1974	
222214	ROCKY RIVER @ NEAR ORBOST	645109.5	5833373	8/12/1969	17/03/1978
222216	MURRINDAL RIVER @ BASIN ROAD (BUCHAN)	608500	5849900	4/02/1976	30/06/1987
222217	RODGER RIVER @ JACKSONS CROSSING	620346	5858744	3/06/1976	
222218	LITTLE RIVER @ WULGULMERANG	616400	5897200	21/04/1977	18/07/1984
222219	SNOWY RIVER @ D/S OF BASIN CREEK	612580	5848984	12/12/1978	
222221	BUCHAN RIVER @ EGW OFFTAKE	603874	5852271	14/05/2009	
222222	ROCKY RIVER U/S OT THE WEIR	645938	5834053	11/03/2009	
222400	MOYANGUL RIVER @ LOOKOUT NEAR TIN MINE	613203.5	5941898	14/03/1955	14/11/1963
222401	INGEEGOODBEE RIVER @ D/S OF TIN MINE HUTS	613098.4	5933947	19/05/1955	14/11/1963
222403	BUCHAN RIVER @ GLENMORE	600499.4	5879844	27/01/1955	22/07/1969
222404	MELLICK MUNJIE CREEK @ GILLINGALL	598595.5	5877355	5/07/1955	22/07/1969

Source data: Victorian flood database

Table 15 South Gippsland Basin streamflow site details

Site ID	Site name	Easting	Northing	Start date	Cease date
227001	MERRIMAN CREEK @ SEASPRAY	514294.7	5754491	29/09/1966	17/06/1971
227200	TARRA RIVER @ YARRAM	471649	5734286	18/02/1976	
227201	BRUTHEN CREEK @ WOODSIDE	488800	5735750	1/03/1946	30/09/1960
227202	TARWIN RIVER @ MEENIYAN	412165	5729150	22/06/1955	
227203	FRANKLIN RIVER @ HENWOODS BRIDGE	436475.8	5725294	3/12/1946	8/01/1985
227205	MERRIMAN CREEK @ CALIGNEE SOUTH	469833	5755048	13/12/1965	
227210	BRUTHEN CREEK @ CARRAJUNG LOWER	477651	5750309	7/08/1952	
227211	AGNES RIVER @ TOORA	445387	5722973	10/01/1957	
227213	JACK RIVER @ JACK RIVER	459739	5735728	1/12/1962	
227216	ALBERT RIVER @ HIAWATHA (BELOW FALLS)	453863.5	5735534	25/06/1964	23/02/1989
227217	LILLYPILLY CREEK @ STAIRCASE	442292	5680223	2/09/1965	15/01/1974
227219	BASS RIVER @ LOCH	388609	5753722	1/04/1966	
227220	GREIG CREEK @ MUMFORDS	473100	5743600	6/05/1968	2/12/1998
227221	BODMAN CREEK @ BRIDGES	476725.7	5746056	7/05/1968	20/10/1978
227222	SPRING CREEK @ BOWDENS	475282.4	5742353	20/05/1968	13/06/1975
227223	MACKS CREEK @ RICHARDS	467870.1	5741587	24/04/1968	15/06/1987
227224	WOMERAH CREEK @ TARR VALLEY ROAD	462201	5741377	29/04/1968	20/12/1982
227225	TARRA RIVER @ FISCHERS	461190	5741983	24/04/1968	
227226	TARWIN RIVER EAST BRANCH @ DUMBALK NORTH	426838	5738399	8/01/1969	
227227	WILKUR CREEK @ LEONGATHA	408948	5750056	31/07/1970	
227228	TARWIN RIVER EAST BRANCH @ MIRBOO	433155.3	5737489	30/04/1971	18/06/1987
227231	BASS RIVER @ GLEN FORBES SOUTH	370463	5741320	30/03/1973	
227232	LANCE CREEK U/S LANCE CREEK RESERVOIR	383783	5738738	31/03/2008	
227234	SPRING CREEK @ BEAUMONT	475276.8	5744202	3/04/1975	15/12/1982
227235	MIDDLE CREEK @ TALL TIMBERS	460742.6	5742295	27/04/1978	18/01/1989
227236	POWLETT RIVER @ D/S FOSTER CREEK JUNCTION	387508	5731353	18/05/1979	
227237	FRANKLIN RIVER @ TOORA	439771	5724088	7/04/1983	
227238	FOSTER CREEK @ DAM SITE	387050.1	5739747	8/06/1979	17/01/1989
227239	MERRIMAN CREEK @ STRADBROKE WEST	492658	5764652	18/11/1983	
227240	MERRIMAN CREEK @ PROSPECT ROAD SEASPRAY	514320	5754179	26/08/1983	
227242	MERRIMAN CREEK @ SEASPRAY TOWNSHIP	516203	5752529	6/03/1990	

Site ID	Site name	Easting	Northing	Start date	Cease date
227243	BRUTHEN CREEK @ D/S REEDY CREEK	484778	5747810	13/05/1992	
227244	DEEP CREEK @ FOSTER	432312	5725707	29/04/1993	
227245	LITTLE BASS RIVER @ POOWONG U/S LITTLE BASS RES.	39050	5753576	18/05/1999	
227246	COALITION CREEK	396827	5748087	8/06/2004	
227248	BELLVIEW CREEK U/S BELLVIEW RESERVOIR	396367	5749105	18/05/1999	
227249	RUBY CREEK @ ARAWATA	402379	5748848	23/07/2008	
227251	TARRA RIVER @ TARRA WEIR OFFTAKE	463301	5741305	27/10/2004	
227264	COALITION CREEK @ LEONGATHA (SPENCERS ROAD BRIDGE)	409001	5743754	21/10/2008	
227265	GOLDEN CREEK @ BLACK SWAMP ROAD	428266	5711026	15/02/2008	18/11/2008
227266	TARWIN RIVER @ KOONWARRA	408996	5735402	22/09/2008	
227270	FOSTER CREEK AT KORUMBURRA	394617.6	5745540	13/10/2011	

Source data: Victorian flood database

Table 16 Tambo Basin streamflow site details

Site ID	Site name	Easting	Northing	Start date	Cease date
223202	TAMBO RIVER @ SWIFTS CREEK	564619	5875047	8/03/1977	
223204	NICHOLSON RIVER @ DEPTFORD	561543	5839104	12/05/1961	
223205	TAMBO RIVER @ D/S OF RAMROD CREEK	576710	5830147	9/06/1965	
223206	TAMBO RIVER @ BINDI	571424.2	5896694	8/08/1957	19/12/1974
223207	TIMBARRA RIVER @ TIMBARRA	592900	5869900	9/09/1957	4/06/1973
223208	TAMBO RIVER @ BINDI (NEAR JUNCTION CREEK)	568710	5887104	21/03/1974	14/07/2003
223209	TAMBO RIVER @ BATTENS LANDING	574796.1	5820758	26/01/1977	
223210	NICHOLSON RIVER @ SARSFIELD	562646	5823050	21/09/1977	
223212	TIMBARRA RIVER @ D/S OF WILKINSON CREEK	594066	5855069	6/05/1982	
223213	TAMBO RIVER @ D/S OF DUGGAN CREEK	578509	5904321	16/09/1987	
223214	TAMBO RIVER @ U/S OF SMITH CREEK	582588	5909736	2/03/1989	
223215	HAUNTED STREAM @ HELLS GATE	573015	5851389	8/02/1990	
223216	TAMBO RIVER U/S SWIFTS CK OFFTAKE	563729	5877748	20/05/2009	
223217	NICHOLSON RIVER AT PUMP HOUSE	564088	5821594	20/01/2011	
223402	TIMBARRA RIVER @ NUNNIONG PLAINS	587028.3	5888209	22/06/1955	16/02/1960
223403	TAMBO RIVER @ NUNNIONG PLAINS	583943.9	5892463	21/06/1955	16/02/1960
223800	RAINGAUGE (TAMBO RIVER) @ MOUNT ELIZABETH	582300	5850700	15/01/1985	20/10/2004

Site ID	Site name	Easting	Northing	Start date	Cease date
223801	RAIN GAUGE (TAMBO RIVER) @ MT ELIZABETH HELIPAD	581909	5850809	20/10/2004	19/01/2011
223802	RAINGAUGE AT MOUNT ELIZABETH SOMMERVILLE TRACK	580733	5851999	19/01/2011	

Source data: Victorian flood database

Table 17 Thompson Basin streamflow site details

Site ID	Site name	Easting	Northing	Start date	Cease date
225019	NORTH CASCADE CREEK @ THOMSON VALLEY ROAD	441836.2	5815578	11/01/1962	6/06/1974
225105	THOMSON RIVER @ NEWLAND ROAD	427654.1	5819830	30/03/1954	1/05/1984
225114	THOMSON RIVER @ D/S WHITELAWS CREEK	436711	5825795	27/03/1987	
225200	THOMSON RIVER @ HEYFIELD	480693	5795763	17/01/1991	
225201	AVON RIVER @ STRATFORD	506676	5797653	1/11/1976	
225204	MACALISTER RIVER @ LAKE GLENMAGGIE (TAIL GAUGE)	482885	5805021	28/09/1966	
225207	THOMSON RIVER @ WALHALLA	449064.3	5798591	9/03/1950	22/05/1952
225209	MACALISTER RIVER @ LICOLA	466762	5835198	1/08/1952	
225210	THOMSON RIVER @ THE NARROWS	447551	5805990	9/04/1957	
225212	THOMSON RIVER @ WANDOCKA	489554	5792978	1/03/1977	
225213	ABERFELDY RIVER @ BEARDMORE	450135	5810238	27/06/1963	
225216	JORDAN RIVER @ ABERFELDY	439747.8	5829099	4/10/1971	18/07/1972
225217	BARKLY RIVER @ GLENCAIRN	461700	5842800	12/05/1966	4/01/1989
225218	FREESTONE CREEK @ BRIAGALONG	508366.4	5815233	14/07/1975	
225219	MACALISTER RIVER @ GLENCAIRN	461689	5847757	7/04/1967	
225221	MACALISTER RIVER @ STRINGYBARK CREEK	470738	5819709	18/03/1968	
225222	GLENMAGGIE CREEK @ SEATON (AUBREYS)	471117.4	5803310	10/03/1970	18/12/1975
225223	VALENCIA CREEK @ GILLIO ROAD	499321	5822633	26/03/1991	
225224	AVON RIVER @ THE CHANNEL	489868	5816150	12/07/1972	
225225	MACALISTER RIVER @ LAKE GLENMAGGIE (HEAD GAUGE)	482418.6	5804322	26/01/1925	
225228	THOMSON RIVER @ COWWARR TIMBER WEIR H.G.	469855.4	5794300	1/01/1958	
225230	GLENMAGGIE CREEK @ THE GORGE	469772	5803687	2/05/1975	
225231	THOMSON RIVER @ U/S OF COWWARR WEIR	467065	5796878	1/04/1976	
225232	THOMSON RIVER @ BUNDALAGUAH	499308	5789148	3/11/1976	
225233	PERRY RIVER @ PERRY BRIDGE	523288.7	5793398	24/12/1976	19/11/1982
225234	AVON RIVER @ CLYDEBANK (CHINN'S BRIDGE)	515238	5791515	29/06/2004	

Site ID	Site name	Easting	Northing	Start date	Cease date
225236	RAINBOW CREEK @ HEYFIELD	480686	5793911	30/04/1992	
225247	MACALISTER RIVER @ RIVERSLEA	498044.5	5791336	11/01/2001	
225248	BOGGY CREEK @ CORNWALLS ROAD	492831	5793650	29/08/2008	
225255	AVON RIVER U/S VALENCIA CK JUNCTION	498324	5813965	30/06/2004	
225256	MACALISTER R D/S MAFFRA (SMITHS BR.)	498377	5793730	26/10/2005	
225600	LAKE WELLINGTON @ SALE	519212	5781296	1/12/1973	1/07/1977
225703	THOMSON RIVER DIVERSION CHANNEL @ COWWARR WEIR	470010	5794250	5/02/2001	19/07/2007
225711	LAKE WELLINGTON DRAIN @ 5 MILES 32 CHAIN MEASURING WEIR	512208.2	5787288	12/11/1976	3/05/2001
225715	CENTRAL GIPPSLAND DRAIN 3 @ NAMBROK (RD 1066M)	488590	5786295	24/02/1980	15/04/2005
225716	CENTRAL GIPPSLAND 1/2 DRAIN 3 @ DROP STRUCTURE (RD500)	491500	5784700	24/02/1980	4/02/2004
225717	CENTRAL GIPPSLAND 2/3 DRAIN @ US OF DRAIN 3 (RD 500M)	491102	5783737	24/02/1980	15/04/2005
225721	CENTRAL GIPPSLAND DRAIN NO 3/3 U/S OUTFALL	487050	5788350	29/05/2000	13/02/2004
225722	CENTRAL GIPPSLAND DRAIN NO 3 D/S NO3 O/FALL	487100	5788300	29/05/2000	13/02/2004
225723	CENTRAL GIPPSLAND DRAIN NO 1/3 @ D/S 11/4/1 JUNCTION	488200	5784600	29/05/2000	13/02/2004
225724	CHANNEL O/FALL 11/4/1 U/S JUNCTION CG DR 1/3	488150	5784500	29/05/2000	15/04/2005
225725	CENTRAL GIPPSLAND DRAIN NO 3 D/S O/FALL 11/1	490400	5783500	26/05/2000	15/04/2005
225726	CENTRAL GIPPSLAND DRAIN NO 3 D/S RAILWAY LINE	491000	5781800	29/05/2000	15/04/2005
225727	CENTRAL GIPPSLAND DRAIN NO 2/3 @ SOLDIERS RD	490100	5785600	26/05/2000	13/02/2004
225737	CENTRAL GIPPSLAND DRAIN NO 8/2 @ DENISON ROAD	483978	5789779	28/05/2002	15/04/2005
225738	CENTRAL GIPPSLAND DRAIN NO 2 @ SALE-TOONGABBIE RD	487500	5782800	28/05/2002	15/04/2005
225739	CENTRAL GIPPSLAND DRAIN NO 2/2 @ DESSENTS	487311	5782836	28/05/2002	15/04/2005
225740	CENTRAL GIPPSLAND DRAIN NO 2 U/S TINAMBA-ROSEDALE RD	487800	5781900	16/05/2002	15/04/2005
225741	CENTRAL GIPPSLAND DRAIN NO 2 U/S NAMBROK ROAD	485335	5786592	16/05/2002	15/04/2005
225742	CENTRAL GIPPSLAND DRAIN NO 2 U/S SALE-COWWARR ROAD	484488	5788744	28/05/2002	15/04/2005
225743	CENTRAL GIPPSLAND DRAIN NO 6/2 U/S DENISON ROAD	483670	5788400	28/05/2002	15/04/2005
225747	NOBLES O/FALL @ VALENCIA CK	498563	5813297	24/02/2004	1/07/2005
225748	TINAMBA MAIN O/FALL @ MENBURN PARK	498214	5813767	25/02/2004	27/06/2005
225801	RAIN GAUGE (MACALISTER RIVER) @ MURDERERS HILL	460964	5810725	8/06/1970	
225802	RAIN GAUGE (MACALISTER RIVER) @ MOUNT TAMBORITHA	472550	5853466	1/04/1986	
225809	RAIN GAUGE (AVON RIVER) @ MOUNT WELLINGTON	487412	5850069	21/05/1997	
225810	RAIN GAUGE (AVON RIVER) @ REEVE KNOB	500533.2	5846182	21/05/1997	

Site ID	Site name	Easting	Northing	Start date	Cease date
225819	RAINGAUGE @ MT USEFUL	456353	5827872	27/05/2002	
225823	RAINGAUGE AT BLANKET HILL	472533.6	5811892	26/07/2010	
225824	RAINGAUGE (MACALISTER RV) AT SNOWY RANGE	0	0	22/02/2011	
225825	RAINGAUGE (MACALISTER RV) AT HIGH RIDGE	0	0		
225826	RAINGAUGE (MACALISTER RV) AT MOUNT SUNDAY	448995	5867264	6/04/2011	

Source data: Victorian flood database

2.1.7.3 Statistical analysis and interpolation

Daily streamflow data was classified into unified six-class quality codes for each gauge (Viney et.al., 2011). The six unified quality categories are good, fair, poor, unverified, non-conforming and missing (Table 18). The categories are defined as follows:

- Good: data are an accurate representation of streamflow
- Fair: data are a moderately accurate representation of streamflow
- Poor: data are a poor representation of streamflow and may be unsuitable for some quantitative applications
- Unverified: data quality is not known
- Non-conforming: data are unsuitable for most applications requiring quantitative analysis, but may contain useful qualitative information
- Missing: data are missing or unusable.

The national streamflow quality code assigned to each of the Victorian quality codes for streamflow data are summarised in Table 19.

Table 18 Proposed national streamflow quality code scheme

Code	Quality	Description
G	Good	Data is an accurate representation of streamflow.
F	Fair	Data is a moderately accurate representation of streamflow
P	Poor	Data is a poor representation of streamflow and may be unsuitable for some quantitative applications
N	Non-conforming	Data is unsuitable for most applications requiring quantitative analysis, but may contain useful qualitative information.
U	Unknown	Data quality is not known.
M	Missing	Data is missing or unusable.

Source data: Viney et al. (2011)

Table 19 National water quality code assigned to Victorian water monitoring codes

Victorian code	Description	Proposed national code
1	Good continuous records	G
2	Good quality edited data	G
3	Linear infill to first value in block (no data lost)	G
4	Temporary coded for currumbeene data	G
5	Drawdown - chart rating applies	G
6	Phased Rating Applicable-gradual changing of control and channel	G
8	Pool reading only	G
9	Pool dry - no data collected	G
10	Data transposed from recorder chart	G
11	Raw data used for operational purposes (not validataed)	U
13	Accurate derived data from multiple sources (level and flow)	G
14	Telemetry data not stored in archive	U
15	Minor editing	F
20	Edited to measurements	F
26	Daily read records (MW - Good periodic data)	F
30	Good Meas. - mult. point; 40 sec timing (Good acc. data - MW)	G
31	Good Meas. - Adeq. verts & obs; 40 sec timing (Good acc. data - MW)	G
32	Fair Measurement - Weighted mean gauge height; turbulent flow; flow angle extreme	F
35	Composite Measurement - Segments taken from several gaugings to create a composite	F
36	Measurement for sampling purposes. Rough estimate	P
42	Low velocity acoustic record affected by wind or gate opening	F
50	Medium editing >Q=15 (1996 on & MW) or HYMAN data import (pre1996)	P
60	Latrobe Valley Water Authority supplied data.	G
65	Other Authorities supplied data. Validation not supplied	U
75	Height correction applied	P
76	Reliable interpolation	P
77	Correlation with other station; same variable	P
82	Linear interpolation across gap in records. (<0.5 day)	P
100	Irregular data use with caution	U
101	Drawdown - normal rating does not apply.	U
104	Records estimated	P
146	Drawdown - no rating applies	F
148	Theoretical rating table applied	P
149	Raw data as received from Serco	U

Victorian code	Description	Proposed national code
150	Rating extrapolated due to insufficient gaugings (Unreliable data)	F
151	Data lost due to natural causes - NRE approved loss	M
152	Refer station file	U
153	Data not recorded. Probe out of water/below instrument threshold.	N
155	Data unreliable. Recording above instrument range.	N
156	Drawdown - normal rating does not apply	U
160	Backed-up by d/s influence. (Unreliable periodic data)	N
161	Debris Effecting Sensor.	N
165	Suspect or bad data supplied by other authority	P
170	Raw unedited data stored in archive (Unreliable. accumulated. data)	U
180	Equipment malfunction	M
190	Data unavailable station discontinued	M
200	Data available but not digitised	U
201	Data not recorded - no correlation available (Station not operational)	M
235	Poor Measurement - Not enough verticals or observations; not enough information	P
236	Suspect or Incomplete Measurement - Equipment suspect or giving problems causing measurement to be aborted.	M
237	Surface Velocities - Velocity measurements taken on surface only.	P
238	Control Leaking - Control leaking; either as noted on measurement or chart.	N
239	Backed up Flow Measurement - Measurement is affected by backup.	N
240	Not Coded Measurement - Measurement not coded as per HYDSYS System.	U
250	Rating table suspended	P
254	Rating table exceeded	P
255	No Data Exists	M

Source data: Viney et al. (2011) and DEPI (2014)

The proportion of basin streamflow data assigned to each national streamflow quality code is summarised in Table 20. This summary presents the aggregated results derived from all gauges within each major basin and does not reflect the variations observed for each individual gauges as reported in Table 21.

Table 20 Proportion of basin stream flow data assigned to each national streamflow quality code

Basin	Number of gauges	Good	Fair	Poor	Non-conforming	Unknown	Missing
East Gippsland	19	78.5	4.2	4.5	0.0	1.8	11.0
Latrobe	38	64.4	10.4	5.5	0.1	8.6	11.0
Mitchell	15	73.2	6.6	8.2	0.0	0.6	11.4
Snowy	19	68.7	12.4	6.1	0.1	2.8	9.9
South Gippsland	41	83.6	6.1	6.8	0.3	0.9	2.4
Tambo	15	67.1	6.1	3.2	0.1	0.5	23.0
Thomson	50	76.7	6.3	4.7	0.1	4.0	8.3
All above	197	72.9	7.8	5.6	0.1	3.7	9.9

Table 21 Proportion of stream flow data assigned to each national streamflow quality code

Gauge ID	Number of records	Good	Fair	Poor	Non-conforming	Unknown	Missing
East Gippsland Basin							
221001	7646	74.5	11.8	11.9	0.2	0.0	1.6
221201	20902	94.5	2.9	1.6	0.0	0.0	0.9
221202	19015	16.2	8.8	0.8	0.0	0.1	74.1
221203	2371	65.2	0.7	34.1	0.0	0.0	0.0
221204	6138	89.7	0.0	9.3	0.0	0.0	1.0
221205	3264	96.5	0.0	3.5	0.0	0.0	0.0
221206	1344	83.6	0.0	16.3	0.0	0.0	0.1
221207	16884	87.2	2.0	4.0	0.0	5.6	1.2
221208	12744	92.5	3.1	3.7	0.0	0.7	0.0
221209	15178	88.0	4.9	7.1	0.0	0.0	0.0
221210	15240	92.0	4.7	3.3	0.0	0.0	0.0
221211	14519	91.6	3.4	4.7	0.0	0.4	0.0
221212	14260	92.9	2.6	4.0	0.0	0.1	0.3
221213	3153	97.9	0.0	2.0	0.0	0.0	0.0
221214	3455	96.5	0.0	3.5	0.0	0.0	0.0
221216	1713	79.5	5.3	0.0	0.0	0.0	15.2
221218	6636	26.9	4.1	1.8	0.0	14.0	53.2
221224	1848	61.9	15.6	5.4	0.0	17.1	0.1
221225	1639	50.2	3.9	7.2	0.0	37.3	1.4
Latrobe Basin							
226005	19131	68.1	3.4	2.6	0.0	25.9	0.0

Gauge ID	Number of records	Good	Fair	Poor	Non-conforming	Unknown	Missing
226006	8590	35.9	0.0	0.8	0.0	0.0	63.3
226007	19270	64.3	1.3	6.1	0.0	12.7	15.6
226008	19712	33.5	2.5	0.7	0.0	1.1	62.2
226012	3848	95.9	0.0	0.3	0.0	0.0	3.9
226016	1755	98.9	0.0	0.0	0.0	0.0	1.1
226017	13852	34.4	1.7	5.6	0.0	0.5	57.8
226021	6552	41.9	21.2	11.0	0.0	25.9	0.0
226023	19583	65.7	19.2	4.3	0.3	0.1	10.4
226028	2092	90.8	3.8	0.0	0.0	4.8	0.6
226033	5988	86.8	7.6	4.2	0.0	1.3	0.0
226039	433	98.4	0.0	1.4	0.0	0.0	0.2
226202	514	90.9	0.0	8.9	0.0	0.0	0.2
226204	32738	38.9	45.6	8.4	0.0	7.2	0.0
226205	20909	79.2	6.1	2.9	0.0	11.0	0.7
226206	427	81.0	0.0	2.3	0.0	0.0	16.6
226209	23649	67.4	2.9	20.6	0.0	9.1	0.1
226216	21621	76.1	10.0	4.0	0.0	10.0	0.0
226217	12275	90.6	0.0	5.1	0.0	0.0	4.3
226218	21540	83.6	2.4	3.2	0.0	10.8	0.0
226219	6488	98.3	0.0	1.7	0.0	0.0	0.0
226220	20908	75.4	8.0	2.9	0.1	9.7	3.9
226222	15730	83.0	0.3	5.3	0.5	0.1	10.8
226223	1813	98.1	0.0	1.9	0.0	0.0	0.1
226224	28307	53.8	28.9	4.3	0.3	7.8	4.9
226226	19732	79.8	3.6	3.9	0.0	12.7	0.0
226227	13682	38.2	3.7	1.1	0.0	10.4	46.7
226228	28307	62.8	25.4	2.8	0.0	8.8	0.2
226229	1024	96.4	0.0	3.5	0.0	0.0	0.1
226233	5262	89.7	3.6	6.7	0.0	0.0	0.0
226235	4611	63.8	13.3	7.2	0.0	1.7	14.1
226400	2827	33.9	1.8	60.2	0.0	0.0	4.1
226402	20846	59.7	3.4	5.6	0.0	31.3	0.1
226407	20329	59.0	1.9	12.4	0.0	2.9	23.9
226408	10122	24.6	13.9	3.9	2.8	1.5	53.3
226410	18988	80.0	4.5	1.4	0.5	13.5	0.0

Gauge ID	Number of records	Good	Fair	Poor	Non-conforming	Unknown	Missing
226415	6173	92.4	5.2	1.2	0.0	1.2	0.0
226700	929	96.8	3.1	0.0	0.0	0.0	0.1
Mitchell River Basin							
224200	3995	23.0	9.8	57.1	0.0	0.0	10.1
224201	17701	60.6	2.4	36.1	0.0	0.9	0.0
224203	28047	74.6	20.3	4.9	0.0	0.3	0.0
224205	197	99.5	0.0	0.0	0.0	0.0	0.5
224206	19803	94.6	2.7	1.9	0.0	0.7	0.0
224207	10534	97.2	0.2	2.2	0.0	0.0	0.3
224208	378	84.7	0.0	15.1	0.0	0.0	0.3
224209	6256	99.6	0.0	0.4	0.0	0.0	0.0
224210	4059	96.9	0.0	3.0	0.0	0.0	0.0
224213	14979	93.0	3.6	3.1	0.1	0.2	0.0
224214	14527	94.7	0.8	3.3	0.0	0.8	0.5
224215	12179	35.5	1.4	0.8	0.0	0.0	62.3
224216	706	77.6	0.0	22.2	0.0	0.0	0.1
224217	13723	28.8	5.1	1.2	0.0	0.4	64.5
224222	1532	3.6	74.5	0.3	0.0	20.9	0.7
Snowy River Basin							
222200	33647	43.6	17.0	1.6	0.0	0.3	37.5
222202	33623	50.9	29.5	2.1	0.0	0.0	17.5
222206	24324	42.9	25.8	30.6	0.0	0.7	0.0
222207	5703	87.3	0.6	2.9	0.0	1.9	7.2
222209	18416	90.6	2.2	3.6	0.1	0.2	3.3
222210	18309	88.7	2.2	2.9	0.1	1.7	4.4
222212	5477	85.5	0.0	14.5	0.0	0.0	0.0
222213	20746	72.5	8.4	4.5	0.6	14.0	0.0
222214	3021	99.2	0.0	0.7	0.0	0.0	0.0
222216	4164	96.1	0.0	3.8	0.0	0.0	0.0
222217	13706	96.7	1.5	1.7	0.0	0.0	0.0
222218	2645	95.6	0.0	4.3	0.0	0.0	0.0
222219	12936	92.7	3.9	2.5	0.0	0.9	0.0
222221	1790	0.0	18.7	1.8	0.0	68.0	11.6
222222	1638	36.3	14.7	2.8	0.0	39.5	6.7
222400	1331	98.5	0.7	0.0	0.0	0.8	0.1

Gauge ID	Number of records	Good	Fair	Poor	Non-conforming	Unknown	Missing
222401	1331	99.5	0.2	0.0	0.0	0.2	0.1
222403	2421	92.6	5.4	0.0	0.0	1.9	0.0
222404	4145	91.7	2.6	0.0	0.0	2.6	3.1
South Gippsland Basin							
227001	1722	99.1	0.0	0.8	0.0	0.0	0.1
227200	17982	91.9	0.8	7.0	0.0	0.3	0.0
227201	2131	0.0	96.0	4.0	0.0	0.0	0.0
227202	21523	89.7	4.9	4.5	0.0	0.8	0.0
227203	5411	96.9	0.0	3.1	0.0	0.0	0.0
227205	14364	87.3	3.7	4.4	1.1	0.3	3.1
227210	22539	76.3	21.1	2.4	0.0	0.1	0.1
227211	22544	95.5	1.4	2.8	0.0	0.2	0.1
227213	19596	89.6	6.8	2.9	0.0	0.7	0.0
227216	4748	97.2	0.0	2.8	0.0	0.0	0.0
227217	375	99.7	0.0	0.0	0.0	0.0	0.3
227219	17587	95.8	1.1	2.5	0.0	0.5	0.1
227220	9520	92.4	0.0	4.9	0.0	0.0	2.7
227221	3261	85.9	0.0	9.2	0.0	0.0	4.9
227222	1612	86.5	0.0	13.5	0.0	0.0	0.1
227223	4569	95.6	0.0	4.4	0.0	0.0	0.0
227224	3016	95.8	0.0	4.2	0.0	0.0	0.0
227225	16834	95.0	2.3	1.6	0.0	1.0	0.2
227226	16076	97.3	1.2	1.5	0.0	0.0	0.0
227227	14823	86.2	11.5	1.6	0.0	0.7	0.0
227228	5893	97.6	0.0	2.3	0.0	0.0	0.0
227231	15012	96.7	1.2	2.0	0.0	0.1	0.0
227232	1071	95.1	0.0	4.9	0.0	0.0	0.1
227234	2813	98.4	0.0	1.6	0.0	0.0	0.0
227235	3919	100.0	0.0	0.0	0.0	0.0	0.0
227236	12772	93.7	1.6	4.6	0.0	0.1	0.0
227237	12772	95.4	1.3	3.1	0.0	0.2	0.0
227238	3511	98.1	0.0	1.8	0.0	0.0	0.0
227239	11148	1.5	0.1	72.4	0.0	11.4	14.6
227240	11231	62.2	9.6	21.7	5.5	1.0	0.0
227243	7463	52.1	25.5	3.9	0.0	0.0	18.5

Gauge ID	Number of records	Good	Fair	Poor	Non-conforming	Unknown	Missing
227244	7655	39.1	4.9	1.6	0.8	5.1	48.5
227245	2032	31.7	47.6	17.6	0.0	1.6	1.4
227246	1448	83.8	3.6	6.1	2.1	3.4	1.0
227248	2093	42.5	36.1	11.4	8.9	0.6	0.5
227249	2093	60.3	35.6	1.7	0.9	0.3	1.2
227251	3477	85.9	11.4	2.6	0.0	0.1	0.0
227264	2040	53.2	8.3	37.1	0.0	1.3	0.1
227265	245	24.9	75.1	0.0	0.0	0.0	0.0
227266	2063	41.1	14.5	35.7	0.0	8.2	0.5
227270	952	67.5	2.9	15.9	0.0	3.6	10.1
Tambo River Basin							
223202	24459	68.5	26.9	3.9	0.0	0.7	0.0
223204	19365	92.4	3.4	3.5	0.0	0.0	0.6
223205	17876	1.2	0.1	0.3	0.0	0.1	98.3
223206	6342	96.2	0.0	3.7	0.0	0.0	0.0
223207	9662	97.6	1.2	0.7	0.0	0.2	0.3
223208	10479	74.0	0.4	7.2	0.0	0.0	18.3
223209	13634	27.3	4.7	0.4	1.0	0.4	66.2
223210	13382	37.6	2.8	0.1	0.0	0.6	58.9
223212	11695	92.5	2.9	4.4	0.3	0.0	0.0
223213	9198	90.7	1.5	7.7	0.0	0.0	0.0
223214	9211	94.9	2.2	2.9	0.0	0.0	0.0
223215	8869	93.7	1.7	3.4	0.0	0.8	0.4
223216	1798	40.8	22.5	26.9	0.0	9.7	0.1
223402	1700	93.5	3.1	0.0	0.0	2.6	0.8
223403	1701	90.4	2.6	0.0	0.0	5.7	1.3
Thompson River Basin							
225019	2956	98.4	0.0	1.5	0.0	0.0	0.0
225105	11012	54.3	2.7	2.4	0.0	36.2	4.3
225114	6146	55.7	2.2	29.9	0.0	1.4	10.8
225200	8071	55.0	23.0	2.7	0.0	19.3	0.0
225201	13692	94.0	3.2	2.2	0.0	0.6	0.0
225204	19790	84.6	5.9	1.8	0.0	7.4	0.2
225207	454	59.5	0.0	0.0	0.0	2.9	37.7
225209	22482	93.9	3.9	0.5	0.0	0.4	1.3

Gauge ID	Number of records	Good	Fair	Poor	Non-conforming	Unknown	Missing
225210	17024	92.3	0.1	7.6	0.0	0.0	0.0
225212	18690	89.7	2.0	2.3	0.0	0.7	5.2
225213	18590	92.9	3.6	2.3	0.0	1.2	0.0
225216	2630	97.1	1.4	1.4	0.0	0.0	0.0
225217	5137	97.4	0.0	2.6	0.0	0.0	0.0
225218	17193	93.5	3.7	2.3	0.0	0.5	0.0
225219	17209	90.5	6.3	2.7	0.0	0.4	0.2
225221	16877	76.5	5.0	9.8	0.3	8.4	0.0
225222	2109	52.7	0.0	4.6	0.0	0.0	42.7
225223	15585	89.5	3.1	4.8	0.0	0.3	2.3
225224	15275	91.1	5.9	2.9	0.0	0.1	0.1
225228	4867	69.5	15.6	12.8	0.1	0.0	1.9
225230	13639	59.1	7.2	23.6	0.0	9.3	0.7
225231	13935	92.9	2.9	3.6	0.0	0.4	0.2
225232	13728	74.2	1.9	3.2	0.0	2.3	18.4
225233	2156	98.4	0.0	1.5	0.0	0.0	0.0
225234	13527	13.4	9.5	1.0	1.0	1.7	73.4
225236	8092	64.5	13.7	4.7	0.1	16.9	0.1
225247	4893	56.6	19.7	18.0	0.9	3.5	1.2
225248	4045	60.2	30.5	4.5	0.6	0.4	3.7
225255	3016	64.1	29.8	5.1	0.1	0.0	0.9
225703	2355	32.1	65.4	2.3	0.0	0.3	0.0
225711	8820	49.3	0.2	0.3	0.0	15.9	34.3
225715	5215	35.8	1.1	1.4	0.0	0.0	61.7
225716	4779	31.5	0.0	0.1	0.0	0.3	68.1
225717	5215	31.7	1.6	3.6	0.0	0.6	62.4
225721	1355	94.7	2.6	0.2	0.4	0.1	2.0
225722	1355	63.0	35.0	0.0	0.0	0.1	2.0
225723	1355	84.8	12.9	0.0	0.0	2.2	0.1
225724	1782	96.7	3.3	0.0	0.0	0.0	0.1
225725	1785	98.2	1.8	0.0	0.0	0.0	0.1
225726	1782	66.6	20.1	13.2	0.0	0.0	0.1
225727	1358	78.5	6.0	14.7	0.0	0.1	0.6
225737	1053	84.1	6.5	8.9	0.4	0.0	0.1
225738	1053	83.2	15.3	1.4	0.0	0.0	0.1

Gauge ID	Number of records	Good	Fair	Poor	Non-conforming	Unknown	Missing
225739	1053	66.2	28.2	5.5	0.0	0.0	0.1
225740	1065	67.0	31.5	1.3	0.0	0.0	0.1
225741	1054	87.8	9.7	2.5	0.0	0.0	0.1
225742	1053	97.3	1.8	0.8	0.0	0.0	0.1
225743	1053	73.6	17.5	8.8	0.0	0.0	0.1
225747	493	4.3	91.5	0.0	0.0	0.0	4.3
225748	488	50.2	48.2	1.4	0.0	0.0	0.2

2.1.7.4 Gaps

The Gippsland Basin has an extensive network of streamflow gauges. Information recorded in the Victorian Water Measurement Information System is easily accessible and well managed. Data and knowledge gaps that could potentially influence achieving realistic simulation and modelling-based analysis include:

- As summarised above, the quality of streamflow data is highly variable. Investment is further required to improve the reliability of monitored data.
- The flood inundation data also requires additional resources to improve data reliability. Currently there is limited spatial information and no inundation duration data attributed to each inundation event. Such information would greatly enhance the utility of the data and relevance/ability to integrate the data into a predictive modelling framework.
- Strategic investment in the installation of additional stream gauges to increase the monitoring of water quality information. To date there exists gaps in the spatial extent of the water quality network.
- Improved frequency in water quality sampling.
- Commitment for on-going maintenance and monitoring of priority stream gauges.

2.1.8 Surface water – groundwater interactions

Summary

Fifty stream gauges in unregulated catchments and 34 groundwater observation bores along main stems of some major rivers were selected for analysis of surface water – groundwater interaction in the Gippsland region. The 50 stream gauges cover majority of main stems of the major rivers in the region. Majority of these gauges have long-term record with a large number of high-quality daily streamflow. Forty-five of them have greater than 80% daily streamflow data classified as 'Good' or 'Fair' according to the national streamflow quality code. The 34 selected observation bores also have long-term record with high-quality groundwater level readings. Thirty of them have more than 100 readings with typical monitoring frequency ranging from monthly to quarterly. However, these selected bores only represent small proportion of main stems of the major rivers in the region. There is no adequate water chemistry data from the gauges and bores for surface water – groundwater interaction analysis.

2.1.8.1 Methods

There are no direct observations or measurements of the degree of interaction between surface water and groundwater in the Gippsland region. However, there is empirical evidence regarding surface water – groundwater interactions as provided by analysis of both the hydrographs of groundwater and stream, and the chemistry of groundwater and surface water. To investigate surface water – groundwater interactions in the region, relevant surface water and groundwater information along the main stems of the rivers in the following river basins was collected:

- Latrobe River
- Mitchell River
- Thomson/Macalister Rivers/Avon River
- Tambo River
- Snowy River
- East Gippsland
- South Gippsland.

The degree and direction of exchange between stream water and local groundwater in the Gippsland region is implied by comparing local groundwater levels to adjacent stream stage height. Previous studies (e.g. DSE, 2012, SKM, 2012a, 2012b; Hofmann, 2011) and the analysis of groundwater and surface water information have provided some level of quantification of surface water– groundwater interaction. Based on the outcomes from previous studies, DSE (2012) have classified surface water and groundwater interaction into four broad groups: neutral/losing, gaining, variable and unclassified.

Key inputs into this study included results from: (1) baseflow separation analysis for stream gauges on unregulated rivers undertaken by SKM (2012a; 2012b); and (2) the relative exchange between stream water and local groundwater using hydrogeochemistry and radon as a tracer as reported by Hofmann (2011).

2.1.8.2 Observed stream and bore water level data

There are two key observed datasets used for the analysis of the surface water – groundwater interaction in the Gippsland region. One is stream flow monitoring data at stream gauges in the region. A total of 197 river gauges were identified in the Gippsland region representing all of the major rivers. Daily gauge level data was sourced from the Water Measurement Information System (WMIS, http://data.water.vic.gov.au/monitoring.htm). The length of monitoring record and data quality vary significantly from one gauge to another. Details of this stream data are described in Section 2.1.7. Of these 197 stream gauges, 50 gauges in unregulated catchments were selected to investigate the surface water – groundwater along only main stems of the major rivers (including 33 currently active gauges). Locations of these gauges are shown in Figure 27 and the availability of flow data is summarised in Table 23.

Another key dataset is groundwater level data measured at observation bores. A total of 686 observation bores were identified in the Gippsland region (onshore). All water levels for these bores were sourced from the WMIS (http://data.water.vic.gov.au/monitoring.htm). The water levels in the WMIS database are presented in three form: depth from top of casing (m); the depth of water below the ground surface (m); and reduced water level (m, AHD). The nature, variation, spatial and temporal resolution of groundwater bore data is described in Section 2.1.6. Of the 686 bores, 34 observation bores were analysed (including 23 currently active observation bores) to evaluate the temporal surface water – groundwater interactions. The locations of these bores are shown in Figure 20 and associated water level data is summarised in Table 23. It is important to note that there is no suitable bore available for the analysis of surface water-groundwater interaction in the East Gippsland and Tambo River basins.

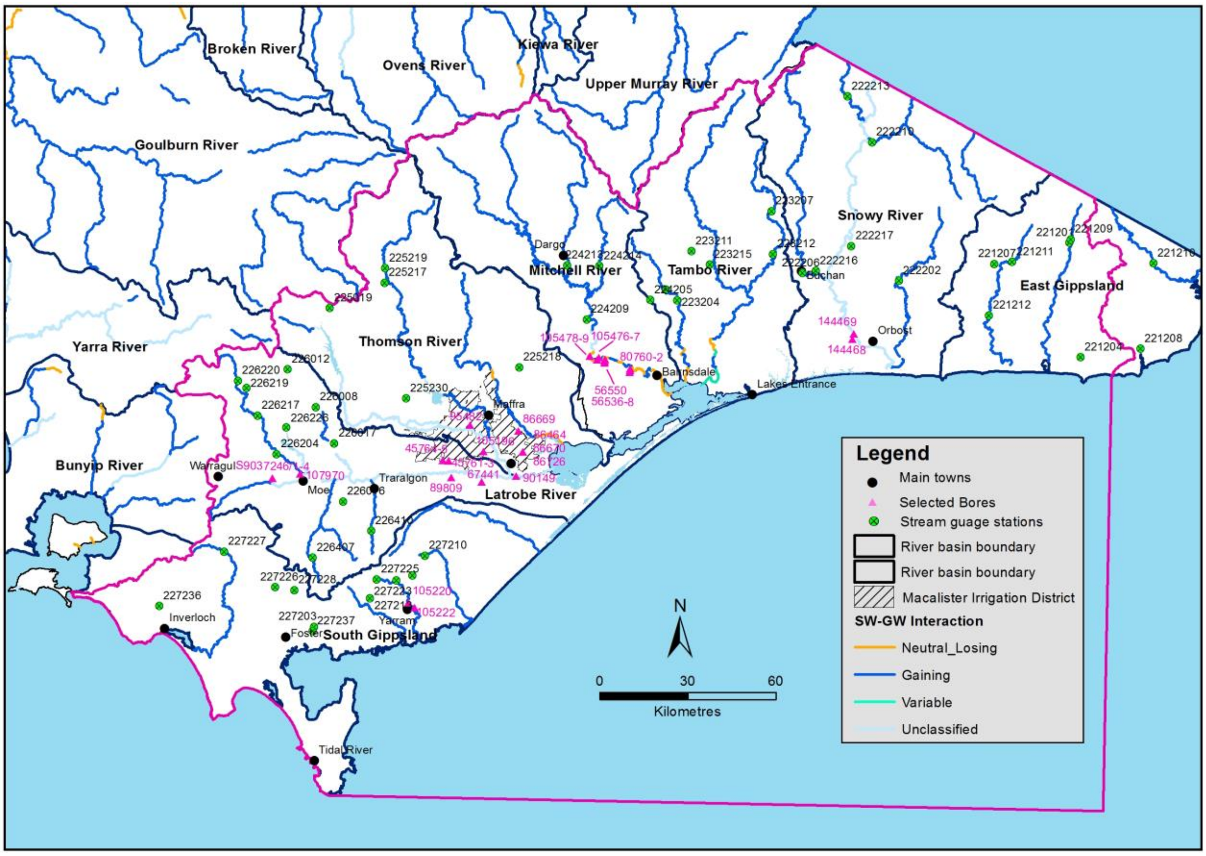


Figure 27 Location of selected stream gauges and surface-groundwater connectivity in the Gippsland region (surface water-groundwater interaction data sourced from DSE, 2012)

Table 22 Number of stream gauges selected for analysis of surface-groundwater interaction in each river basin in the Gippsland region

River basin	No. of gauge		No. of daily records
	Active	Ceased	
East Gippsland	7	1	6138 to 20902
Latrobe River	7	4	1755 to 32738
Mitchell River	2	2	197 to 14979
Snowy River	5	1	4164 to 33623
South Gippsland	7	4	4569 to 22539
Tambo River	3	2	6342 to 19365
Thomson River	2	3	2956 to 17209

Table 23 Number of bores selected for analysis of surface-groundwater interaction in each river basin in the Gippsland region

River basin	No. of bore		No. of record	RWL (m, AHD)
	Active	**Ceased**		
Latrobe River	8	5	34 to 400	-19.66 to 91.81
Mitchell River	8	3	99 to 330	6.03 to 33.35
Snowy River	1	1	120 to 130	2.82 to 4.98
South Gippsland (Tawin River)	1	1	65 to 122	2.43 to 22.65
Thomson River	2	0	198 to 221	13.48 to 25.9
Thomson River (Avon River)	3	1	174 to 232	0.32 to 17.99

2.1.8.3 Statistical analysis and interpolation

As Section 2.1.7.3 describes the statistical analysis of the daily streamflow information from all 197 stream gauges in the Gippsland region, this section only presents analysis based on the 50 gauges selected to assess surface water-groundwater interactions. The majority of these 50 gauges have long-term record with a large number of daily streamflow readings (Table 24 and Figure 28). Of the 50 gauges selected, 47 gauges have more than 3,000 daily measurements (Figure 28). These gauges generally have high quality streamflow data. As shown in Figure 29, 45 of these 50 gauges have greater than 80% daily streamflow data classified as 'Good' or 'Fair' according to the national streamflow quality code. However, there are only 41 gauges with accurate elevation and 16 gauges with accurate coordinates for their locations.

Water quality data from the 50 selected gauges is limited. There is no comprehensive major ions information available for any of these gauges. Most abundant water quality information is stream salinity measurements. There are 30 gauges with various numbers of EC and/or TSS measurements (Table 24).

The statistical analysis of the groundwater level and quality for all bores in the Gippsland region was presented Section 2.1.6.3. This section only presents the analysis of groundwater level and quality for the 34 selected observation bores. A summary of the measured water level and water quality data for the 34 bores used in this analysis is provided in Table 25. The majority of these 34 bores have more than 10 years of record with a large number of readings (Table 25 and Figure 30). Of the 34 bores selected, 30 bores have more than 100 readings (Figure 30). Typical monitoring frequency ranges from monthly to quarterly. As these bores are part of the state observation bore network, they generally have high quality water level data and other bore information (e.g. bore depth and screen interval).

Groundwater salinity is the main water quality information from these bores. Nineteen (19) of the 34 bores have at least one salinity reading (Table 25).

As only a few selected bores and stream gauges can be used for establishing a groundwater level–river relationship (an example shown in Figure 31), baseflow separation analysis (SKM, 2012b) were used to assess the degree of groundwater–stream connectivity in the Gippsland region

(Table 26). The analysis was based on the automated base flow separation and recession technique reported by Arnold et al., (1995) which uses a digital filter to match the slope of the base flow recession curve from stream flow records. Baseflow separation analysis suggests that groundwater contributes between 64% and 80% of streamflow in unregulated systems. As such, it is assumed that the groundwater is in good connection with rivers in these regions.

Table 24 Proportion of the streamflow data assigned to each national streamflow quality code

Site ID	River basin	Monitoring period		Accuracy of elevation	No. of flow records	% of each quality category						No. of EC records	No. of TSS records
		Start	**Stop**			Good	Fair	Poor	Non-conforming	Unknown	Missing		
221201	East Gippsland	21/02/1957	14/05/2014	Accurate	20,902	94.54	2.93	1.60	0.00	0.05	0.89	292	297
221204	East Gippsland	17/05/1966	6/03/1983	Accurate	6,138	89.72	0.00	9.25	0.00	0.00	1.03		
221207	East Gippsland	20/02/1968	12/05/2014	Accurate	16,884	87.22	2.01	4.00	0.00	5.60	1.17	292	294
221208	East Gippsland	22/06/1979	12/05/2014	Accurate	12,744	92.50	3.08	3.66	0.00	0.75	0.01	277	144
221209	East Gippsland	23/10/1972	13/05/2014	Accurate	15,178	87.97	4.93	7.09	0.00	0.00	0.01	7	
221210	East Gippsland	22/08/1972	13/05/2014	Accurate	15,240	91.98	4.69	3.33	0.00	0.00	0.01	293	299
221211	East Gippsland	12/08/1974	12/05/2014	Accurate	14,519	91.62	3.35	4.66	0.00	0.37	0.01	200	201
221212	East Gippsland	30/04/1975	14/05/2014	Accurate	14,260	92.95	2.62	4.04	0.00	0.13	0.27	292	296
222202	Snowy River	24/04/1922	13/05/2014	Accurate	33,623	50.86	29.46	2.11	0.00	0.02	17.54	292	295
222206	Snowy River	8/10/1947	12/05/2014	Estimated	24,324	42.93	25.78	30.60	0.00	0.66	0.03	243	249
222210	Snowy River	26/03/1964	11/05/2014	Accurate	18,309	88.73	2.18	2.91	0.10	1.71	4.37	106	99
222213	Snowy River	24/07/1957	11/05/2014	Accurate	20,746	72.46	8.37	4.51	0.63	14.03	0.00	106	98
222216	Snowy River	4/02/1976	29/06/1987	Accurate	4,164	96.13	0.00	3.84	0.00	0.00	0.02		
222217	Snowy River	3/06/1976	11/12/2013	Accurate	13,706	96.75	1.52	1.70	0.00	0.03	0.01	279	253
223204	Tambo River	12/05/1961	18/05/2014	Accurate	19,365	92.41	3.44	3.52	0.00	0.00	0.62	279	260
223206	Tambo River	8/08/1957	18/12/1974	Accurate	6,342	96.25	0.00	3.74	0.00	0.00	0.02		
223207	Tambo River	23/07/1957	4/01/1984	Accurate	9,662	97.57	1.18	0.71	0.00	0.23	0.31		
223212	Tambo River	6/05/1982	12/05/2014	Accurate	11,695	92.48	2.86	4.38	0.27	0.00	0.01	106	97
223215	Tambo River	8/02/1990	21/05/2014	Accurate	8,869	93.70	1.67	3.44	0.00	0.81	0.38	96	4
224205	Mitchell River	11/12/1973	25/06/1974	Accurate	197	99.49	0.00	0.00	0.00	0.00	0.51		
224209	Mitchell River	15/05/1970	30/06/1987	Accurate	6,256	99.57	0.00	0.42	0.00	0.00	0.02		

224213	Mitchell River	24/05/1973	27/05/2014	Accurate	14,979	93.02	3.61	3.10	0.08	0.19	0.01	291	297
224214	Mitchell River	13/08/1974	21/05/2014	Accurate	14,527	94.66	0.77	3.32	0.00	0.80	0.45		
225019	Thomson River	28/04/1966	31/05/1974	Accurate	2,956	98.44	0.00	1.52	0.00	0.00	0.03		
225217	Thomson River	12/12/1974	3/01/1989	Accurate	5,137	97.41	0.00	2.57	0.00	0.00	0.02	8	4
225218	Thomson River	12/04/1967	7/05/2014	Accurate	17,193	93.46	3.73	2.28	0.00	0.52	0.01	178	180
225219	Thomson River	7/04/1967	18/05/2014	Accurate	17,209	90.45	6.30	2.73	0.00	0.35	0.17	14	3
225230	Thomson River	2/05/1975	2/09/2012	Estimated	13,639	59.10	7.24	23.62	0.00	9.30	0.75	71	78
226008	Latrobe River	27/04/1960	15/04/2014	Accurate	19,712	33.47	2.49	0.75	0.00	1.07	62.22	43	55
226012	Latrobe River	27/01/1961	10/08/1971	Accurate	3,848	95.87	0.00	0.26	0.00	0.00	3.87		
226016	Latrobe River	24/03/1977	11/01/1982	Accurate	1,755	98.92	0.00	0.00	0.00	0.00	1.08		
226017	Latrobe River	12/05/1976	14/04/2014	Accurate	13,852	34.38	1.72	5.61	0.00	0.51	57.78	130	140
226204	Latrobe River	23/10/1924	10/06/2014	Estimated	32,738	38.87	45.56	8.40	0.00	7.17	0.00	243	250
226217	Latrobe River	2/06/1955	8/01/1989	Accurate	12,275	90.61	0.00	5.14	0.00	0.00	4.25		
226219	Latrobe River	15/10/1969	20/07/1987	Accurate	6,488	98.26	0.00	1.73	0.00	0.00	0.02		
226220	Latrobe River	6/03/1957	2/06/2014	Estimated	20,908	75.43	8.03	2.86	0.09	9.70	3.88	9	1
226226	Latrobe River	2/06/1960	10/06/2014	Estimated	19,732	79.81	3.60	3.89	0.04	12.66	0.01	274	148
226407	Latrobe River	6/10/1958	2/06/2014	Accurate	20,329	59.01	1.88	12.37	0.00	2.85	23.88		
226410	Latrobe River	31/05/1962	25/05/2014	Accurate	18,988	80.02	4.53	1.43	0.55	13.46	0.01		
227203	South Gippsland	17/03/1970	7/01/1985	Accurate	5,411	96.91	0.00	3.07	0.00	0.00	0.02		
227210	South Gippsland	7/08/1952	22/04/2014	Accurate	22,539	76.29	21.12	2.41	0.00	0.06	0.12		
227213	South Gippsland	1/10/1960	26/05/2014	Accurate	19,596	89.61	6.83	2.89	0.00	0.67	0.01		
227220	South Gippsland	8/11/1972	1/12/1998	Accurate	9,520	92.41	0.00	4.87	0.00	0.00	2.72		
227223	South Gippsland	11/12/1974	14/06/1987	Accurate	4,569	95.56	0.00	4.42	0.00	0.00	0.02		
227225	South Gippsland	24/04/1968	26/05/2014	Accurate	16,834	94.96	2.32	1.56	0.00	0.99	0.17	169	135
227226	South Gippsland	23/04/1970	27/04/2014	Estimated	16,076	97.28	1.19	1.52	0.00	0.01	0.01	7	
227227	South Gippsland	25/10/1973	25/05/2014	Estimated	14,823	86.24	11.53	1.57	0.00	0.65	0.01	106	98
227228	South Gippsland	30/04/1971	17/06/1987	Accurate	5,893	97.64	0.00	2.34	0.00	0.00	0.02		

227236	South Gippsland	18/05/1979	5/05/2014	Estimated	12,772	93.69	1.55	4.63	0.00	0.13	0.01	80	87
227237	South Gippsland	8/06/1979	26/05/2014	Estimated	12,772	95.37	1.32	3.12	0.00	0.19	0.01	280	256

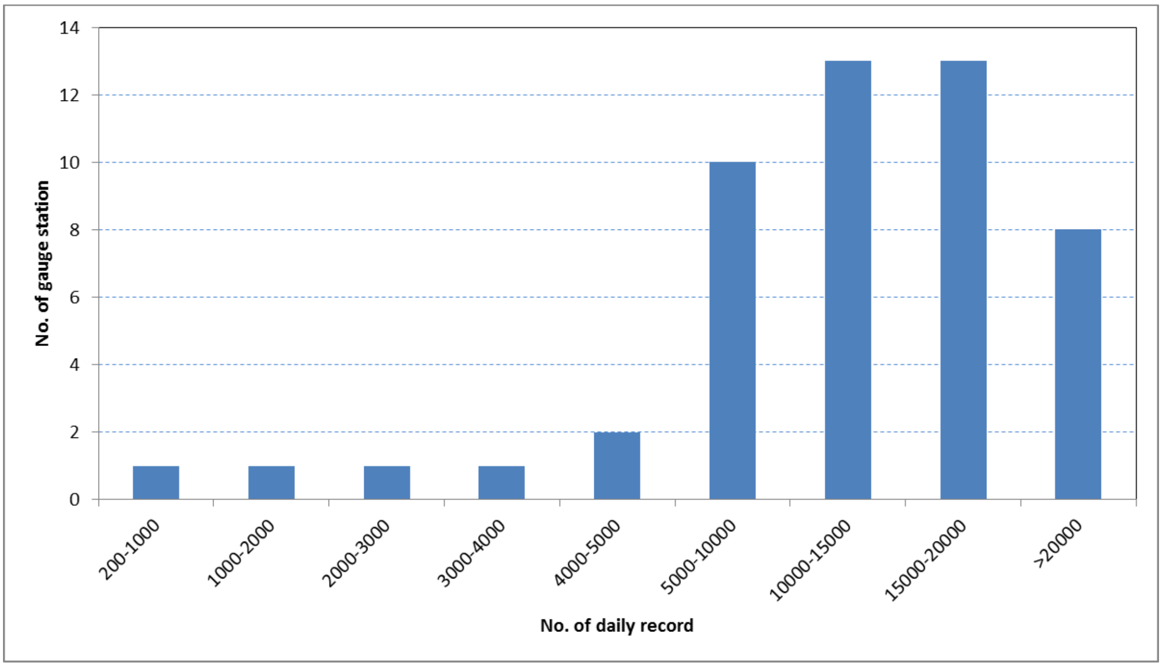


Figure 28 Summary of monitoring records for the 50 selected gauges in the Gippsland

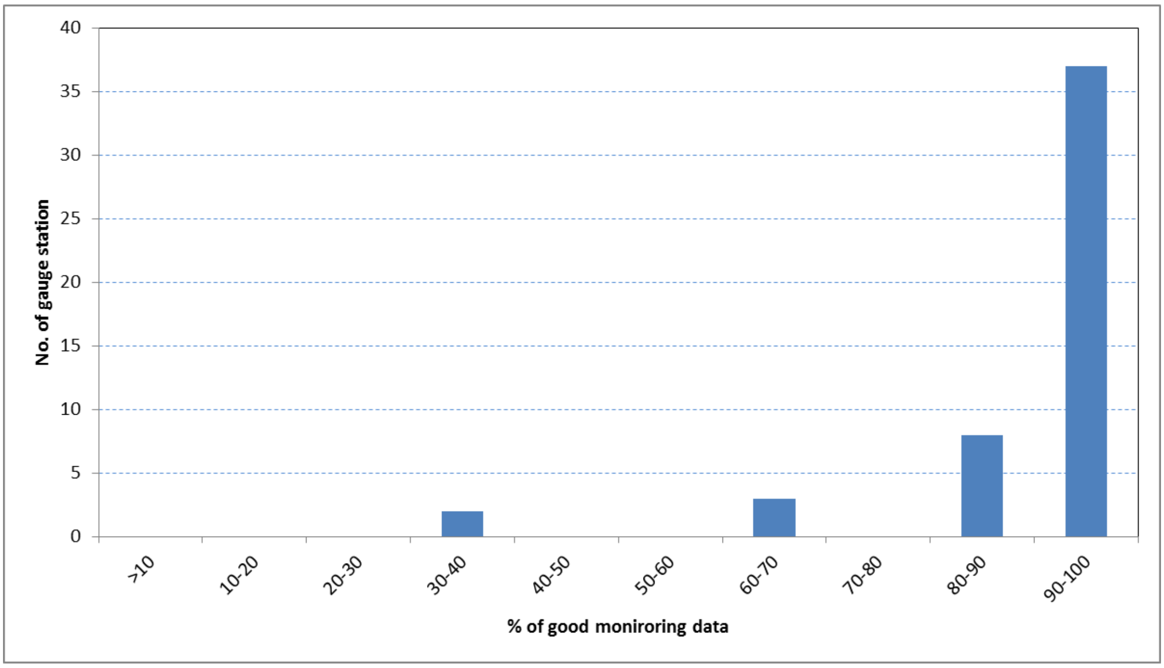


Figure 29 Data quality of monitoring records for the 50 selected gauges for surface water-groundwater interaction analysis in the Gippsland

Table 25 Summary of selected bores for surface-groundwater interaction analysis

Bore ID	Monitoring period		No. of water level records	Mean RWL (m, AHD)	Mean BGL (m)	No. of EC records	Mean EC (µS/cm)	River basin	Aquifer monitored
	Start	Stop							
45761	4/10/1991	23/01/2011	170	18.00	1.81	9	4088	Latrobe R	Alluvium
45762	4/09/1991	20/04/2011	174	17.96	1.83	27	8589	Latrobe R	Alluvium
45763	4/09/1991	23/01/2011	171	17.89	1.93	19	7355	Latrobe R	Alluvium
45764	4/09/1991	23/01/2011	167	18.44	2.17	9	7553	Latrobe R	Alluvium
45765	4/09/1991	18/09/2003	144	18.58	2.05	25	6812	Latrobe R	Alluvium
56536	3/09/1970	7/02/2011	297	21.12	4.24			Mitchell R	Alluvium
56537	3/09/1970	18/11/2010	304	20.81	4.68	1	1000	Mitchell R	Alluvium
56538	16/09/1970	7/02/2011	306	20.51	3.33	1	268	Mitchell R	Alluvium
56550	14/02/1985	13/05/2014	193	21.30	4.62			Mitchell R	Alluvium
67441	28/12/1978	6/05/2014	152	23.78	9.92			Latrobe R	Lower Tertiary (Latrobe Group)
80760	4/06/1970	13/05/2014	326	9.00	2.30			Mitchell R	Alluvium
80761	26/02/1970	13/05/2014	317	8.75	3.25	1	224	Mitchell R	Alluvium
80762	26/02/1970	13/05/2014	330	9.09	3.34			Mitchell R	Alluvium
86464	21/08/1985	12/05/2014	215	5.98	0.39	1	446	Avon R	Mid-Tertiary (Boisdale Formation)
86669	15/11/1989	12/05/2014	189	12.14	-5.57	2	429	Avon R	Mid-Tertiary (Boisdale Formation)
86670	15/11/1989	12/05/2014	174	4.74	1.68	2	507	Avon R	Mid-Tertiary (Boisdale Formation)
86726	2/10/1991	23/01/2011	232	4.48	2.42	43	3251	Avon R	Alluvium
89809	28/12/1978	6/05/2014	86	2.52	11.08			Latrobe R	Lower Tertiary (Latrobe Group)
90149	31/10/1986	7/05/2014	195	5.87	-4.81	2	385	Latrobe R	Mid-Tertiary (Boisdale Formation)
95482	10/10/1990	6/05/2014	221	24.32	0.97	3		Thomson R	Mid-Tertiary (Boisdale Formation)
105196	27/11/1991	7/05/2014	198	16.20	-1.70	2	375	Thomson R	Mid-Tertiary (Boisdale Formation)
105220	20/08/1993	26/08/2008	65	15.88	20.27			South Gippsland (Tarra R)	Lower Tertiary (Latrobe Group)
105222	25/08/1986	6/05/2014	122	11.60	9.10	1	316	South Gippsland (Tarra R)	Lower Tertiary (Latrobe Group)

105476	25/11/1991	13/05/2014	169	24.06	5.31	2	723	Mitchell R	Alluvium
105477	25/11/1991	13/05/2014	164	24.52	5.71	1	94	Mitchell R	Alluvium
105478	25/11/1991	13/05/2014	167	27.53	9.05			Mitchell R	Upper Tertiary (Latrobe Valley Coal Measures)
105479	25/11/1991	13/05/2014	99	28.46	8.15			Mitchell R	Alluvium
107970	15/05/1973	8/05/2014	400	65.98	14.61			Latrobe R	Lower Tertiary (Older Volcanics)
144468	19/12/2001	14/05/2014	130	3.29	1.86	23	1480	Snowy R	Upper Tertiary (Curlip Gravels)
144469	19/12/2001	15/11/2011	120	3.85	8.49	10	167	Snowy R	Upper Tertiary (Curlip Gravels)
WRK990054 (S9037246/1)	18/09/2009	8/05/2014	34	91.28	-5.39			Latrobe R	Lower Tertiary (Childers Formation)
WRK990055 (S9037246/4)	18/09/2009	8/05/2014	34	76.04	10.15			Latrobe R	Upper Tertiary (Hanuted Hills Formation)
WRK990056 (S9037246/3)	18/09/2009	8/05/2014	34	71.75	14.43			Latrobe R	Lower Tertiary (Yarragon Formation)
WRK990057 (S9037246/2)	18/09/2009	8/05/2014	34	66.31	19.85			Latrobe R	Lower Tertiary (Thorpdale Volcanics)

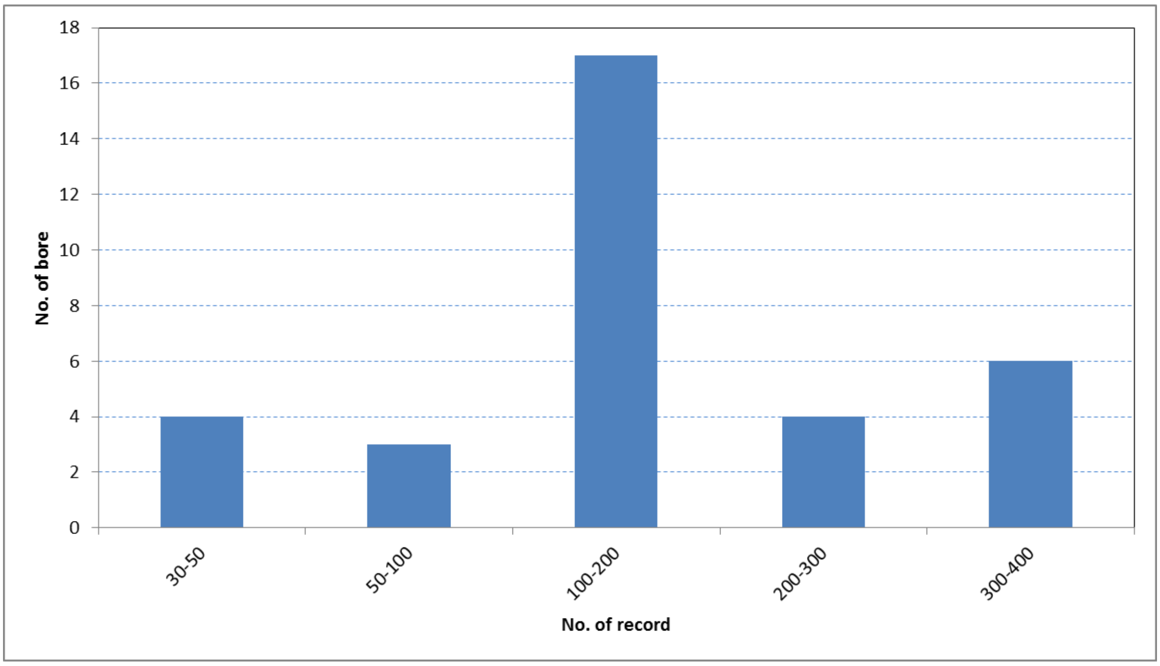


Figure 30 Summary of monitoring records for the 34 selected observation bores for surface water-groundwater interaction analysis in the Gippsland Basin

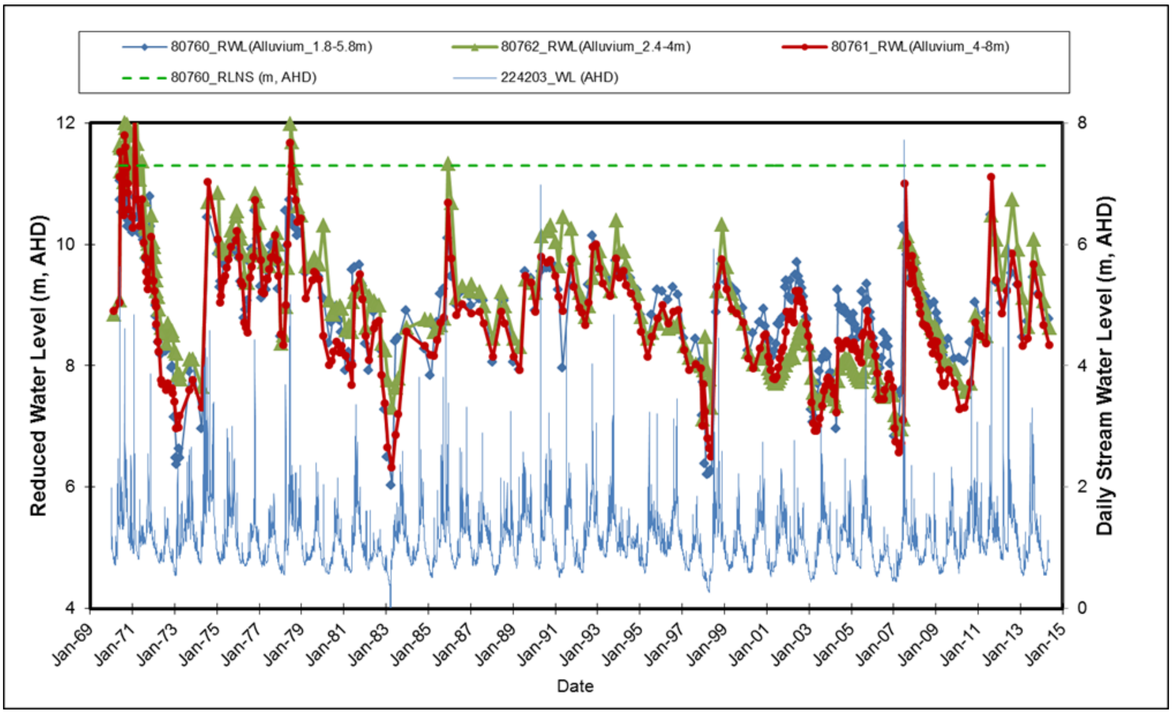


Figure 31 Groundwater hydrographs of a transect of bores located near Mitchell River west of Bairnsdale plotted against daily stream water level of Mitchell River at Rose (gauge station no. 224203)

Table 26 Estimated Baseflow Index (BFI) in 51 unregulated catchments in the Gippsland region (sourced from SKM 2012)

Gauge ID	Gauge name	River basin	Av_BFI (Sum)	Av_BFI (Aut)	Av_BFI (Win)	Av_BFI (Spr)	Av_BFI (all)
221201	Cann River (West Branch) @ Weeragua	East Gippsland	0.81	0.83	0.71	0.74	0.77
221204	Thurra River @ Point Hicks	East Gippsland	0.79	0.78	0.61	0.7	0.72
221207	Errinundra River @ Errinundra	East Gippsland	0.83	0.86	0.72	0.75	0.79
221208	Wingan River @ Wingan Inlet National Park	East Gippsland	0.82	0.79	0.6	0.71	0.73
221209	Cann River (East Branch) @ Weeragua	East Gippsland	0.81	0.8	0.67	0.72	0.75
221210	Genoa River @ The Gorge	East Gippsland	0.8	0.78	0.67	0.72	0.74
221211	Combienbar River @ Combienbar	East Gippsland	0.82	0.84	0.72	0.74	0.78
221212	Bemm River @ Princes Highway	East Gippsland	0.83	0.86	0.71	0.75	0.79
226008	Tyers River West Branch @ Morgans Mill	Latrobe River	0.83	0.83	0.7	0.71	0.77
226012	Tanjil River East Branch @ Tanjil Bren	Latrobe River	0.79	0.77	0.69	0.61	0.72
226016	Waterhole Creek @ Morwell	Latrobe River	0.9	0.82	0.68	0.73	0.78
226017	Jacobs Creek @ Otooles	Latrobe River	0.79	0.81	0.61	0.64	0.71
226204	Latrobe River @ Willow Grove	Latrobe River	0.86	0.87	0.72	0.73	0.8
226217	Latrobe River @ Hawthorn Bridge	Latrobe River	0.85	0.87	0.69	0.72	0.78
226219	Tooronga River @ Noojee	Latrobe River	0.85	0.88	0.7	0.72	0.79

226220	Loch River @ Noojee	Latrobe River	0.87	0.89	0.68	0.73	0.79
226226	Tanjil River @ Tanjil Junction	Latrobe River	0.83	0.87	0.67	0.65	0.75
226407	Morwell River @ Boolarra	Latrobe River	0.85	0.82	0.58	0.66	0.72
226410	Traralgon Creek @ Koornalla	Latrobe River	0.84	0.81	0.55	0.64	0.71
224205	Dargo River @ Dargo (Upper Site)	Mitchell River	0.79	0.8	0.57	0.53	0.67
224209	Cobbannah Creek @ Near Bairnsdale	Mitchell River	0.67	0.69	0.66	0.68	0.67
224213	Dargo River @ Lower Dargo Road	Mitchell River	0.79	0.83	0.48	0.56	0.66
224214	Wentworth River @ Tabberabbera	Mitchell River	0.78	0.86	0.7	0.7	0.76
222202	Brodribb River @ Sardine Creek	Snowy River	0.83	0.86	0.71	0.75	0.79
222206	Buchan River @ Buchan	Snowy River	0.77	0.83	0.6	0.61	0.7
222210	Deddick River @ Deddick (Caseys)	Snowy River	0.79	0.83	0.76	0.77	0.74
222213	Suggan Buggan River @ Suggan Buggan	Snowy River	0.77	0.84	0.57	0.58	0.69
222216	Murrindal River @ Basin Road (Buchan)	Snowy River	0.76	0.75	0.62	0.65	0.7
222217	Rodger River @ Jacksons Crossing	Snowy River	0.79	0.85	0.67	0.71	0.75
227203	Franklin River @ Henwoods Bridge	South Gippsland	0.84	0.79	0.61	0.67	0.73
227210	Bruthen Creek @ Carrajung Lower	South Gippsland	0.82	0.83	0.63	0.68	0.74
227213	Jack River @ Jack River	South Gippsland	0.83	0.84	0.61	0.68	0.74
227220	Greig Creek @ Mumfords	South Gippsland	0.84	0.85	0.67	0.68	0.76
227223	Macks Creek @ Richards	South Gippsland	0.84	0.81	0.68	0.7	0.76
227225	Tarra River @ Fischers	South Gippsland	0.84	0.86	0.68	0.73	0.78
227226	Tarwin River East Branch @ Dumbalk North	South Gippsland	0.85	0.79	0.52	0.62	0.69
227227	Wilkur Creek @ Leongatha	South Gippsland	0.84	0.74	0.45	0.6	0.64
227228	Tarwin River East Branch @ Mirboo	South Gippsland	0.85	0.76	0.54	0.62	0.69
227236	Powlett River @ D/S Foster Creek Junction	South Gippsland	0.9	0.8	0.42	0.6	0.67
227237	Franklin River @ Toora	South Gippsland	0.85	0.8	0.55	0.65	0.71
223204	Nicholson River @ Deptford	Tambo River	0.78	0.8	0.71	0.73	0.75
223206	Tambo River @ Bindi	Tambo River	0.78	0.84	0.57	0.58	0.69
223207	Timbarra River @ Timbarra	Tambo River	0.81	0.85	0.71	0.69	0.76
223212	Timbarra River @ D/S Of Wilkinson Creek	Tambo River	0.79	0.86	0.69	0.69	0.76
223215	Haunted Stream @ Hells Gate	Tambo River	0.77	0.86	0.71	0.73	0.77
225019	North Cascade Creek @ Thomson Valley Road	Thomson River	0.8	0.77	0.7	0.62	0.64
225217	Barkly River @ Glencairn	Thomson River	0.81	0.83	0.45	0.57	0.66
225218	Freestone Creek @ Briagalong	Thomson River	0.73	0.78	0.64	0.68	0.71

225219	Macalister River @ Glencairn	Thomson River	0.8	0.81	0.42	0.53	0.64
225230	Glenmaggie Creek @ The Gorge	Thomson River	0.75	0.8	0.67	0.71	0.73

2.1.8.4 Gaps

Data and knowledge gaps related to surface water - groundwater interactions that could potentially influence achieving realistic simulation and modelling based analysis include:

- A significant number of stream gauges having a large amount of missing or low quality streamflow data.
- Only a small proportion of the main stems of the major rivers have a groundwater observation bore suitably located adjacent to the river to enable the assessment of a groundwater level–river relationship.
- There is limited water chemistry information available for selected stream gauges and groundwater observation bores to quantify surface water – groundwater interactions.
- It is recommended that a standardised method of estimating baseflow be developed. To date numerous methods have been applied resulting in variations in predicted contribution of groundwater to streamflow. Given that baseflow is often used to calibrate both groundwater and river routing models, it may be necessary to further invest in the development of an agreed baseflow estimation approach.

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Datasets

Dataset 1: Gippsland 1 second digital elevation model
https://data.bioregionalassessments.gov.au/datastore/dataset/1e74543b-d1ca-452a-ad09-53b2bc90b055

Dataset 2: Gippsland aspect derived from 1 second DEM
https://data.bioregionalassessments.gov.au/datastore/dataset/1aed26bb-c6b1-43c5-abb3-1f960b7cca39

Dataset 3: Gippsland slope derived from 1 second DEM

https://data.bioregionalassessments.gov.au/datastore/dataset/9051bb0d-1054-42f4-b6c8-5742e40cc389

Dataset 4: Gippsland soil classification

https://data.bioregionalassessments.gov.au/datastore/dataset/d2e3a020-58df-4138-bf28-22c20be2e3a2

Dataset 5: Gippsland land use

Dataset 6: Gippsland climate station zones

https://data.bioregionalassessments.gov.au/datastore/dataset/cf8bfe31-bd59-4d82-b5d5-4d1b5d39df42

Dataset 7: Gippsland mean annual rainfall (mm/yr)

https://data.bioregionalassessments.gov.au/datastore/dataset/033319be-8058-48b5-ba2d-23f3931a25d4

Dataset 8: Gippsland average daily minimum (C)

https://data.bioregionalassessments.gov.au/datastore/dataset/26bd3c85-2262-4e6d-ae91-299672ff4526

Dataset 9: Gippsland average daily maximum temperature (C)

https://data.bioregionalassessments.gov.au/datastore/dataset/80ffe48e-8124-46cd-95d4-d09873db6556

Dataset 10: Gippsland average daily solar radiation (MJ/m^2)

https://data.bioregionalassessments.gov.au/datastore/dataset/3dfaf28b-1e7a-4e44-a8c4-d86c3b2e2f1d

Dataset 11: Gippsland potential mean annual evaporation (mm/yr)

https://data.bioregionalassessments.gov.au/datastore/dataset/33dc8c50-9eb8-41af-9b4b-a7ea7b3c908e

Dataset 12: Gippsland climate geodatabase
https://data.bioregionalassessments.gov.au/datastore/dataset/aa6108b8-a1d8-464c-9562-7d6a69304685

Dataset 13: Petroleum wells used for stratigraphic interpretation.

http://data.bioregionalassessments.gov.au/dataset/bb3f4d30-3572-4ac4-ac77-ee281846f071