Water availability for the Derwent-South East region
CSIRO Tasmania Sustainable Yields Project

Report seven of seven to the Australian Government

December 2009
About the project

Following the November 2006 Summit on the southern Murray-Darling Basin (MDB), the then Prime Minister and MDB state Premiers commissioned CSIRO to undertake an assessment of sustainable yields of surface water and groundwater systems within the MDB. The project set an international benchmark for rigorous and detailed basin-scale assessment of the anticipated impacts of climate change, catchment development and increasing groundwater extraction on the availability and use of water resources.

On 26 March 2008, the Council of Australian Governments (COAG) agreed to expand the CSIRO assessments of sustainable yield so that, for the first time, Australia would have a comprehensive scientific assessment of water yield in all major water systems across the country. This would allow a consistent analytical framework for water policy decisions across the nation. The CSIRO Tasmania Sustainable Yields Project, together with allied projects for northern Australia and south-west Western Australia, provides a nation-wide expansion of the assessments.

In Tasmania, neither surface water nor groundwater extractions are metered in a consistent way. Consequently it was necessary to model the movement and use of water within the project area using a comprehensive suite of river models. For groundwater, three models covering key groundwater areas were also used. Flow stress rankings were used to determine the potential ecological impacts of changes in streamflow on subcatchments and key ecological sites (150 sites were selected comprising all Ramsar wetlands, estuaries with high conservation value, and river sites and riverine wetlands with high conservation value currently impacted by local extractions of water).

Reporting of the CSIRO Tasmania Sustainable Yields Project is covered by a range of products including a suite of region reports (of which this is one) and a suite of technical reports. There are seven region reports:

1. Water availability for Tasmania
2. Climate change projections and impacts on runoff for Tasmania
3. Water availability for the Arthur-Inglis-Cam region
4. Water availability for the Mersey-Forth region
5. Water availability for the Pipers-Ringarooma region
6. Water availability for the South Esk region
7. Water availability for the Derwent-South East region

For citation details of these reports see the back cover of this report and for a full list of the technical reports see the inside back cover.

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Introduction

This report is one in a series* from the CSIRO Tasmania Sustainable Yields Project. The terms of reference for the project required an assessment of the current and likely future extent and variability of surface water and groundwater resources in Tasmania. This information will help governments, industry and communities consider the environmental, social and economic aspects of the sustainable use and management of the precious water assets of Tasmania.

For the first time, the impacts of catchment development (commercial forestry plantations and future irrigation development), changing groundwater extraction, climate variability and anticipated climate change on water resources at a whole-of-region scale have been assessed. This was achieved through the most comprehensive hydrological modelling ever undertaken for Tasmania. Rainfall-runoff models, groundwater recharge models, river models and groundwater models were used.

The project has drawn on the scientific knowledge and technical expertise of national and state government agencies, as well as Australia’s leading academics and industry consultants. The assessments have been subject to a comprehensive process of internal and external review, providing quality assurance on all the work performed and all the results delivered.

Oversight of this and allied projects for northern Australia and south-west Western Australia was provided by the CSIRO Water for a Healthy Country Flagship, a research initiative established to deliver the science required for sustainable management of water resources in Australia.

This report examines current and future surface water and groundwater availability for the Derwent-South East region. There are four other region-specific reports in this series. A sixth report examines climate and runoff for the whole of Tasmania, and a seventh summarises the project results.

For a more detailed technical analysis, readers should also refer to the associated technical reports as listed on the inside back cover of this report.

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Project overview

As shown in Figure 1, the overall approach of the project included: (i) defining different climate scenarios and generating daily climate data to describe these scenarios, (ii) modelling the implications of these climate scenarios for catchment runoff and aquifer recharge, (iii) propagating the runoff and recharge implications through river system and groundwater models, (iv) assessing ecological impacts and (v) reporting the implications for water availability and water use.

Figure 1. Project framework

Scenarios assessed

The assessments of current and future water availability have been undertaken by considering four scenarios of historical, recent and future climate, and current and future development. A fifth scenario represents no consumptive extractions. All scenarios were defined by daily time series of climate variables based on different scalings of the observed climate from 1 January 1924 to 31 December 2007.

The first scenario is a historical climate scenario and is used as the baseline against which other scenarios are compared. Current levels (December 2007) of surface water and groundwater development were used. For groundwater only, results are reported using three 23-year periods selected from the historical sequence, representing a wet extreme, median and dry extreme historical climate.

The second scenario is a recent climate scenario for assessing water availability based on the climate of the recent past (1 January 1997 to 31 December 2007). Current levels of surface water and groundwater development were used.

The third scenario is a future climate scenario. Fifteen global climate models with three estimates of temperature changes due to global warming were used to provide a spectrum of possible ~2030 climates. From this spectrum, three were selected for reporting, representing a wet extreme, median and dry extreme future climate. Current levels of surface water and groundwater development were used.

The fourth scenario is a future climate with future development scenario. This scenario used the same climate time series as the future climate scenario, but future levels of development were used. Future development consisted of 24 proposed irrigation schemes, as well as ~2030 projections of commercial plantation forests and an assumed increase in groundwater extraction to 25 percent of recharge.

The fifth scenario is a without-extractions scenario using historical climate, current infrastructure and no extractions. This allows the impact of extractions to be explicitly considered.

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Project regions

Assessments are presented for five regions: Arthur-Inglis-Cam (including Flinders and King islands), Mersey-Forth, Pipers-Ringarooma, South Esk and Derwent-South East (Figure 2). Collectively these are referred to as the project area. The West Coast region shown in the figure is not covered by the project but is occasionally referred to for context.

Figure 2. CSIRO Tasmania Sustainable Yields Project regions

* A full list of project reports can be found on the inside back cover and the back cover of this report.
Under historical climate (1924 to 2007)

Averaged over the region, the mean annual rainfall under historical climate is 997 mm and the mean annual runoff is 456 mm (46 percent of the rainfall). Rainfall and runoff are winter-dominated, with maximums occurring in August and minimums occurring in February. However, there is less seasonality in the Derwent-South East than any other project region. Rainfall and runoff are both higher in the west of the region and decrease moving towards the east coast. The region contributes 18 percent of Tasmania’s total runoff.

Mean annual streamflow for the region is 8267 GL/year. Of this, about 225 GL/year (3 percent) is extracted for use leaving 8042 GL/year of non-extracted water. The Coal-Pitt Water, Jordan, Clyde and Ouse catchments have the highest levels of extraction with more than 10 percent of the total surface water in these catchments extracted. In all catchments, the amount of water extracted is less than that allocated. The main rivers of most catchments are essentially perennial, flowing for more than 90 percent of the time. Exceptions are the main rivers of the Little Swanport (87 percent), Jordan (80 percent), Prosser (77 percent) and Coal-Pitt Water (62 percent) catchments.

Groundwater extraction for the region is 2.5 GL/year, most of which occurs in the Cygnet-Cradoc groundwater assessment area (located in the Huon surface water catchment). Under the median historical climate, extraction as a percentage of recharge averages 5 percent over the groundwater assessment areas of the region, but is much higher in the Cygnet-Cradoc (31 percent) and Sorell Tertiary Basalt (14 percent) groundwater assessment areas. Under the wet extreme historical climate, these proportions are smaller (23 and 10 percent respectively) but increase to 114 and 51 percent respectively under the dry extreme historical climate.

Less than 1 percent of the region’s subcatchments and six of the 44 key ecological sites (two river sites, two Ramsar wetlands and two estuaries) are potentially impacted by changes in the flow regime due to current levels of catchment development.

Under recent climate (1997 to 2007)

In general, conditions under the recent climate are drier than those of the last 84 years. Mean annual rainfall over the region is 937 mm and mean annual runoff is 421 mm (reductions of 6 and 8 percent respectively relative to historical climate). Decreases are slightly greater over the east of the region and occur primarily in autumn. Reductions in rainfall and runoff under recent climate are less in the Derwent-South East than in any other reporting region.

The mean monthly streamflow is lower than under historical climate in all months with the exception of August, September and October where streamflow is slightly higher in some catchments. For the region as a whole, there is a 1010 GL/year (13 percent) reduction in non-extracted water and a 7 GL/year (3 percent) reduction in extracted water.

Groundwater extraction as a percentage of recharge averages 26 percent in the groundwater assessment areas in the region, but is much higher in the Cygnet-Cradoc (163 percent) and Sorell Tertiary Basalt (83 percent) groundwater assessment areas. This indicates a high risk of declining groundwater levels and possible reductions in groundwater inputs to streams under recent climate relative to historical climate. Groundwater levels are similar to or slightly lower than those under dry extreme historical climate.

About 20 percent of the region’s subcatchments and 16 key ecological sites (six river sites, one riverine wetland, four Ramsar wetlands and five estuaries) are potentially impacted by changes in the flow regime due to recent climate.
Under future climate (~2030)

When considering future climate, the focus is on the wet extreme, median and dry extreme range of future climate. All changes are relative to historical climate.

On average, under the future climate, rainfall ranges from a 3 percent increase to a 6 percent decrease under the wet and dry extreme respectively, decreasing by 1 percent under the median. Runoff ranges from a 5 percent increase to an 8 percent decrease under the wet and dry extreme respectively, decreasing by 3 percent under the median future climate.

The volume of non-extracted water increases by 280 GL/year (3 percent) under the wet extreme future climate and decreases under both the dry extreme and median future climate by 682 GL/year (8 percent) and 252 GL/year (3 percent) respectively. In comparison, extractions change by much less, increasing by 1 GL/year (less than 0.5 percent) under the wet extreme, and decreasing under both the dry extreme and the median future climate by 3 GL/year (1 percent) and 1 GL/year (less than 1 percent) respectively.

Groundwater levels are expected to be similar to those under median historical climate.

Around 1 percent of the region’s subcatchments and two key ecological sites (one river site and one Ramsar wetland) are potentially impacted by changes in the flow regime due to future climate and current levels of development.

Under future development (~2030)

Except where stated, changes under future development are in addition to changes under future climate.

The area of plantation forests in the region is projected to increase by about 143 km² (a 3 percent increase in total plantation forest). Averaged over the region, this increase in forest cover would lead to a decrease in runoff of less than 1 percent.

The reduction in runoff has virtually no impact on inflows to rivers. As a result, currently licenced extractions do not change. Reductions in inflows to hydro-electric power stations across the state lead to an additional 42 GL/year and 63 GL/year of water being released from hydro-electric schemes in the Upper Derwent under the wet and dry extreme respectively (23 GL/year under the median future climate). The combination of these factors leads to an additional 44 GL/year and 66 GL/year of non-extracted water under the wet and dry extreme respectively (24 GL/year under the median future climate) – less than 1 percent in all cases. A proposed new extraction of 9000 ML/year from Cluny Dam can be supplied in all years with appropriate commercial arrangements in place.

Future development of the groundwater resource was not modelled in this region.

Around 1 percent of the region’s subcatchments and two key ecological sites (one river site and one Ramsar wetland) are potentially impacted by changes in the flow regime due to future climate with development.
The Derwent-South East region

The Derwent-South East region is situated in central and south-east Tasmania. It covers 18,697 km², which is about 27 percent of the total area of the state, and is the largest of the CSIRO Tasmania Sustainable Yields Project regions. It is a region of contrasts, with some of the wettest and driest parts of the state and with high mountain plateaus and coastal plain areas; it claims the southern two-thirds of the eastern coastline.

Biophysical facts and figures

The main river of the region is the Derwent which, with a total length of about 187 km, is the second longest in Tasmania. It originates at Lake St Clair and flows south-east, discharging into the Derwent Estuary near New Norfolk. Its main tributaries include the Clarence, Little Pine, Nive, Pine, Shannon, Dee, Florentine, Ouse, Broad and Clyde rivers, all of which contribute to storages used for the generation of hydro-electricity. Other major rivers in the region include the Plenty, Styx, Tyenna, Jordan, Prosser, Huon, Swan and Aspley (Figure 3 and Figure 10).

The region has varying relief, ranging from rugged highland areas in the west and north to rolling agricultural land of the midlands and flatter coastal plains in the east. There are extensive areas with natural and conservation significance, including parts of the Tasmanian Wilderness World Heritage Area, Mount Field National Park and Freycinet Peninsula.

Vegetation of the coastal parts of the region is characterised by predominantly dry sclerophyll forest, with patches of wet sclerophyll forest, relict rainforest, coastal heath and dry coniferous forest. In the Central Highlands the vegetation ranges from dry sclerophyll woodlands and wet sclerophyll forest on the lower plateau to alpine complexes and coniferous forest patches in fertile, fire protected situations on the higher plateau.

The region contains over 25 wetlands of national importance and four that are listed as sites of international importance under the Ramsar Convention: Apsley Marshes at the mouth of the Apsley River near the town of Bicheno, Moulting Lagoon on Great Oyster Bay; Pitt Water-Orielton Lagoon on the south-east coast near Sorell and Interlaken on Lake Crescent in the Central Highlands (Figure 21).

Population and land use

In 2006 the estimated resident population was 233,379 (about 49 percent of the entire state total) concentrated around the centres of New Norfolk, Hobart (Tasmania’s capital city), Sorell, Kingston and Huonville in the southern part of the region, Bicheno, Swansea and Triabunna on the east coast and the inland towns of Brighton, Oatlands, Hamilton and Bothwell.

Based on data from 2001, the dominant land uses in the Derwent-South East region are native vegetation and forestry (Figure 3). Native vegetation covers 43.7 percent of the region, forestry covers 22.4 percent and 0.6 percent is irrigated cropping (Table 1).

Just over 200 GL/year of the region’s surface water is used for consumptive purposes. This is about 34 percent of total surface water resources extracted by the five regions of the project. The region extracts an estimated 7 percent of the total groundwater extraction within the project area (about 2.5 GL/year). Urban land use and uses associated with the generation and distribution of electricity are important in the region. There is also a significant tourism and recreation industry associated with the region’s national parks and other wilderness reservations.

Aquaculture is a feature of this region being undertaken in both highland rivers and lakes and in coastal estuaries; salmon and oysters are farmed.
Table 1. Broad land use of the Derwent-South East region in the year 2001 (Source: Department of Primary Industries, Water and Environment, GIS Section, 2001)

<table>
<thead>
<tr>
<th>Land use</th>
<th>Area</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>percent km²</td>
<td></td>
</tr>
<tr>
<td>Native vegetation</td>
<td>45.7% 8,552</td>
<td></td>
</tr>
<tr>
<td>Forestry</td>
<td>22.4% 4,179</td>
<td></td>
</tr>
<tr>
<td>Grazing and dryland cropping</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Grazing modified pastures</td>
<td>18.8% 3,516</td>
<td></td>
</tr>
<tr>
<td>Livestock grazing</td>
<td>8.6% 1,605</td>
<td></td>
</tr>
<tr>
<td>Dryland cropping</td>
<td>0.0% 7</td>
<td></td>
</tr>
<tr>
<td><strong>Sub-total</strong></td>
<td><strong>27.4% 5,127</strong></td>
<td></td>
</tr>
<tr>
<td>Irrigation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Irrigated pastures</td>
<td>0.1% 12</td>
<td></td>
</tr>
<tr>
<td>Irrigated cropping</td>
<td>0.6% 121</td>
<td></td>
</tr>
<tr>
<td><strong>Sub-total</strong></td>
<td><strong>0.7% 133</strong></td>
<td></td>
</tr>
<tr>
<td>Water</td>
<td>1.7% 319</td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>2.1% 386</td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>100.0% 18,697</strong></td>
<td></td>
</tr>
</tbody>
</table>

Figure 3. Land use of the Derwent-South East region in the year 2001
The Derwent-South East region is the largest project region, covering about 27 percent of Tasmania and receiving 22 percent of its rainfall.

Under the historical climate, the mean annual rainfall and modelled runoff averaged over the region are 997 mm and 456 mm respectively (Table 2). Rainfall and runoff are both greater in the west of the region where elevations are higher and decrease towards the east coast (Figure 4 and Figure 7). There is less seasonality in the Derwent-South East region than in any other region covered by the project. Both rainfall and runoff are winter-dominated with maximum mean monthly rainfall (104 mm) and maximum mean monthly runoff (64 mm) occurring in August. Minimum mean monthly rainfall (58 mm) and runoff (18 mm) occur in February (Figure 5 and Figure 8), but these seasonal differences are less than in any other project region. Under historical climate, the region contributes 18 percent of Tasmania’s total runoff.

In general, the recent past (1997 to 2007) has been drier than the historical 84-year period (Table 2) with less rainfall (a decrease of 60 mm) and less runoff (a decrease of 35 mm). Percentage decreases are greater over the east of the region where conditions have been historically drier, and occur primarily in the autumn. Changes in rainfall over the west of the region are minimal with a slight increase in rainfall particularly in winter and spring. Reductions in rainfall and runoff in the recent past are less in the Derwent-South East than in any other region.

Conditions under the future climate range from slightly wetter to drier than under historical climate with rainfall ranging from 3 percent wetter to 6 percent drier and runoff ranging from an increase of 5 percent to a decrease of 8 percent. Median reductions in rainfall and runoff are 1 percent and 3 percent respectively. These increases and decreases in rainfall and runoff are spread fairly evenly across the region (Figure 6 and Figure 9) and are the smallest of any region in the project area.

Currently there are 4179 km$^2$ of plantation forests in the Derwent-South East region. The area of plantation forests across the region is projected to increase by 143 km$^2$ (a 3 percent increase in total plantation forest). Averaged over the region, this increase in forest cover would lead to a decrease in runoff of less than 1 percent.

Further information on changes in rainfall and runoff for this region as well as the rest of Tasmania can be found in the companion document Climate change projections and impacts on runoff for Tasmania.
Table 2. Rainfall and runoff in the Derwent-South East region under historical and recent climate and changes under future climate relative to historical climate

<table>
<thead>
<tr>
<th></th>
<th>Historical climate</th>
<th>Recent climate</th>
<th>Future climate</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Wet extreme</td>
</tr>
<tr>
<td>Rainfall</td>
<td>997</td>
<td>937</td>
<td>3%</td>
</tr>
<tr>
<td>Runoff</td>
<td>456</td>
<td>421</td>
<td>5%</td>
</tr>
</tbody>
</table>

> Curringa Farm near Hamilton (DPIPWE)
Why the interest in surface water?

Water in creeks, rivers, lakes, reservoirs and farm dams on the land surface is known collectively as surface water. Its importance lies in the role it plays in sustaining life in general and as a key asset within a range of natural and managed environments. Surface water critically influences habitat for numerous aquatic and riparian plants, fish and the invertebrates they depend on, and other aquatic wildlife such as platypus and waterbirds. It is also important for people – providing water for drinking and domestic use, watering stock, irrigating crops, generating power and use by industry. In Tasmania surface water is especially important for tourism and outdoor recreation based activities. Drought, climate change, and future forestry and irrigation developments may all impact surface water resources of a region. To better understand such impacts, and to effectively manage them into the future, it is necessary to assess the current levels and characteristics of surface water availability and to identify the possible threats to it. This section considers the issues from a human-use point of view; the likely impacts on aquatic ecology are considered later in the report.

Assessing the characteristics and availability of surface water: the process

River system models describing current infrastructure, water demands and water management rules were used to assess the implications of changed inflows for surface water availability and the reliability of water supply to users. This enabled estimates of streamflow to be made for the project regions under the five scenarios. The modelling process included consideration of water allocations and extractions, streamflow routing and environmental flows, and it incorporated grid-based runoff, rainfall and evaporation data. Catchment-based modelling was undertaken on a daily time step and the runoff from each subcatchment was routed through the river network to the next subcatchment downstream. The process recognised that the natural and managed behaviour of rivers means that variability in runoff is not uniformly translated to variability in streamflow and water uses.

Surface water management in Tasmania

In Tasmania, surface water quality and supply is regulated by legislation, policies and strategies. A catchment’s water resources can be managed through the application of a Water Management Plan. Each plan outlines environmental, social, cultural and economic objectives for the relevant water resources and describes a management regime that best gives effect to these objectives. Water management provisions within a plan include guidelines and rules for surface water allocations (both licensed and unlicensed) within a framework that identifies objectives related to environment, water use and development, water management, and recreational and commercial activities that are dependent on the water resources.

Plans cover many aspects of surface water including entitlements, unlicensed storages, unlicensed extractions, environmental flows and releases, diversions and storages. They relate to water used for domestic supply, livestock consumption, firefighting, ecosystems, irrigation, commercial purposes and hydro-electricity supply. Prescriptions of water volume and timing are defined at various ‘sureties’ (surety is the probable availability, actual or relative, of a water allocation in any year allowing for the natural variability of the water supply).

Understanding the language of surface water

The following terminology is used throughout this report:

- Extractions (or extracted water) – water extracted for consumptive use
- Non-extracted water – the water remaining in the catchment after extractions have been taken
- Streamflow – the flow in a river or stream at any one particular point in the catchment
- End-of-system streamflow – the water that flows out of the catchment (generally to the sea). It is equal to the non-extracted water minus any losses to evaporation and takes into account diversions into or out of the catchment
- Total streamflow – all of the water in rivers and streams within the catchment
- Inflow – surface water runoff flowing into a defined catchment
Surface water characteristics of the region

The 12 catchments and main storages of the Derwent-South East region are shown in Figure 10. Details of all the catchments in the region are shown in Table 3. Surface water provides drinking water for most of the people living in the region and who depend directly on its surface water resources. Streamflows in the region are relatively unregulated with the exception of the Upper Derwent catchment which has extensive hydro-electricity works within it. Most flow from the region discharges to the Derwent Estuary via the Derwent River. Lakes Crescent and Sorrell are the largest of the region’s storages with an effective capacity of about 80.7 GL. There are over 130 km² of irrigated agriculture in the Derwent-South East region, the majority of which is dependent on surface water (a small portion is also sourced from groundwater which is covered in a subsequent section in this report).

The Upper Derwent catchment is affected by inflows from Tasmania’s hydro-electric system. There are a number of new irrigation developments proposed for this region. However, in this project, only the Cluny Dam to Ouse River development is considered.

Environmental flows have been determined for the Lower Derwent, Coal-Pitt Water, Jordan, Browns River, North West Bay, Mountain River and Swan River catchments. For the Jordan, Clyde, Ouse, Derwent Estuary and Huon catchments, ‘cease-to-take’ flow rules apply, meaning that extractions from the river must be ceased when flow in the river at a specified location falls below a set minimum.

Table 3. Catchments of the Derwent-South East region

<table>
<thead>
<tr>
<th>Catchment</th>
<th>Area (km²)</th>
<th>Mean annual rainfall (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Swan-Apsley</td>
<td>1292</td>
<td>700</td>
</tr>
<tr>
<td>Little Swanport</td>
<td>875</td>
<td>640</td>
</tr>
<tr>
<td>Prosser</td>
<td>1056</td>
<td>705</td>
</tr>
<tr>
<td>Carlton-Tasman Peninsula</td>
<td>1054</td>
<td>810</td>
</tr>
<tr>
<td>Coal-Pitt Water</td>
<td>807</td>
<td>589</td>
</tr>
<tr>
<td>Jordan</td>
<td>1243</td>
<td>565</td>
</tr>
<tr>
<td>Clyde</td>
<td>1131</td>
<td>607</td>
</tr>
<tr>
<td>Ouse</td>
<td>1478</td>
<td>922</td>
</tr>
<tr>
<td>Upper Derwent</td>
<td>3561</td>
<td>1375</td>
</tr>
<tr>
<td>Lower Derwent</td>
<td>1517</td>
<td>956</td>
</tr>
<tr>
<td>Derwent Estuary</td>
<td>762</td>
<td>764</td>
</tr>
<tr>
<td>Huon</td>
<td>3914</td>
<td>1433</td>
</tr>
</tbody>
</table>
Surface water under historical climate

Historically, the region has a mean annual streamflow of about 8267 GL/year, and a relatively low level of extraction of about 225 GL/year which is 3 percent of the total surface water in the region. The relative level of extraction varies between catchments and is 10 percent or more of the total streamflow in the Coal-Pitt Water, Jordan, Clyde and Ouse catchments, due primarily to extractions for irrigation. Total streamflow for each catchment below hydro-electricity schemes in the region is shown in Figure 11. The Upper Derwent catchment is impacted by Tasmania’s hydro-electric system. Water from the Upper Derwent catchment (along with flows from the Ouse and Clyde catchments) is discharged into the Lower Derwent catchment and then into the Derwent Estuary. The Derwent Estuary catchment, however, only represents flow generated within that catchment – it does not include inflows from the Upper Derwent and associated catchments.

Mean annual end-of-system flow is 8060 GL/year (225 GL/year are lost to extractions, and 18 GL/year gained due to model interactions in the Ouse, Clyde and Upper Derwent catchments) but there is a high level of variability between years, ranging from 4,715 to 13,568 GL/year. Total annual extractions for the region are less variable ranging from a minimum of 201 to a maximum of 253 GL/year over the 84-year historical period.

In all catchments, the average amount of water extracted is always less than that allocated. For example, for the Derwent Estuary, an average of 52.7 GL is allocated each year, but only 21.0 GL is extracted. This represents the application of rules which determine when allocated water can be extracted. However, in the absence of information on actual extraction from rivers, the river models assume the full allocation of each water licence is divided evenly over the applicable months. In reality, irrigators may have off-stream storages that can be used to store water for use when there is less water in the river system and thus will extract water from the river when it is available. The methods used in the river modelling may therefore underestimate the volume of water actually being extracted. Full details are given in the associated technical report River modelling for Tasmania Volume 5: the Derwent-South East region.

The rivers of many catchments in the region are essentially perennial, flowing for more than 97 percent of the time. Exceptions occur in the Prosser and Coal-Pitt Water catchments (where flows occur for 77 and 62 percent of the time respectively). The rivers of the Clyde, Little Swanport and Jordan catchments are also slightly less perennial than the others, flowing for 91, 87 and 80 percent of the time respectively.

Figure 11. Share of surface water in the Derwent-South East region by catchment below hydro-electricity schemes. Note the Lower Derwent only includes runoff generated within the catchment and not flows from the Upper Derwent

Water availability under historical and future climate

This section describes how future climate is likely to affect surface water availability in the Derwent-South East region. It looks at projected changes relative to the historical climate for extracted and non-extracted water, end-of-system flows and extraction reliability. Current levels of surface water and groundwater development are used.

Extracted and non-extracted water

Under future climate, there may be slightly more or considerably less non-extracted water available than under the historical climate. Under the wet extreme future climate, the volume of non-extracted water increases in all years, by an average of 280 GL/year (3 percent). Under the median future climate, decreases occur every year, by an average of 252 GL/year (3 percent). Under the dry extreme future climate, decreases occur every year by an average of 682 GL/year (8 percent).

In contrast, the volume of water extracted in the region is not expected to change by as much. This reflects the low level of water use in the region and the extraction rules currently in place. Under the wet extreme future climate, extractions increase in every year, but only by a total of 1.0 GL (less than 0.5 percent). Under the median future climate, decreases occur every year, by an average of 280 GL/year (3 percent).

The relative volumes of extracted and non-extracted water under historical climate and the projected changes under wet extreme, median and dry extreme future climate are shown in Figure 12 for the region and in Figure 13 for each of the region’s catchments. Generally, streamflow under the wet extreme is greater than under the historical climate and streamflow under the median and dry extremes are less than the historical climate but the reductions in the volumes of non-extracted water are greater than those in the volumes of extracted water. Note that the Upper Derwent was modelled using Hydro Tasmania’s system model and thus figures are not available for this catchment.
Figure 12. Extracted and non-extracted shares of water for the Derwent-South East region under historical and future climate

Figure 13. Extracted and non-extracted shares of water for each catchment in the Derwent-South East region under historical and future climate
End-of-system flow

End-of-system flow represents water remaining in the catchment after all extractions and diversions have been made. It is the water available for the environment and for potential future increases in extractions.

The expected changes in the volumes of extracted and non-extracted water under future climate relative to the historical climate impact end-of-system streamflows. In general, the end-of-system streamflow decreases in most months of the year and across the entire daily flow duration curve for inland catchments, and remains steady or increases slightly for east coast catchments. This is shown in Figure 14 for the Clyde and Little Swanport catchments. The Clyde is representative of inland catchments in the Derwent-South East region with a clear winter maximum of streamflow which is projected to decrease under future climate. The Little Swanport is typical of east coast catchments with a second, smaller peak of streamflow in December. Conditions here are expected to stay roughly the same or become slightly wetter. The impact of releases from lakes Crescent and Sorrell can be seen in the slightly elevated low flows compared to without-extractions in the Clyde catchment. Conversely, for the Little Swanport catchment, the impacts of extractions can be seen in the slightly reduced flows. A full description of these responses for all catchments can be found in the associated technical report River modelling for Tasmania Volume 5: the Derwent-South East region.

Figure 14. Mean monthly end-of-system streamflow and daily flow duration curve for the Clyde and Little Swanport catchments under historical and future climate. Streamflow without extractions is also shown.
Extraction reliability

Water users need to know about the reliability of available water to efficiently manage their enterprises. The expected changes in streamflows attributable to future climate have very little impact on the volumes of water allocated for extraction in most catchments in the Derwent-South East region. This is shown in Figure 15 (b) which indicates no difference between historical and future allocations for the Little Swanport catchment. This is representative of most catchments in the region which have a constant volume of water allocated in all years. For the Clyde catchment, however, future climate is expected to lead to a reduction in allocated water in most years as seen in Figure 15 (a). This is seen to a lesser degree in other catchments with a variable volume of water allocated in different years.

However, not all allocations can be met in all years. As shown in Figure 15, in the drier years (towards the right-hand edge of the graphs), allocated volumes are not always able to be extracted. For the Clyde catchment, only around 50 percent of allocations can be met in the driest year, while for the Little Swanport catchment it is around 45 percent. The impacts of future climate can also be seen in this figure, where the percent extracted per unit allocated decreases by around 1 to 2 percent in both catchments under the future climate. These small reductions in the percent of water extracted per unit allocated is fairly representative of all catchments in the region. A full description for all catchments can be found in the associated technical report River modelling for Tasmania Volume 5: the Derwent-South East region.

Figure 15. Allocation and extraction reliability for the Clyde and Little Swanport catchments under historical and future climate
Impact of recent climate on surface water

Changes in surface water availability under recent climate (1997 to 2007) relative to historical climate include reductions in the volumes of both extracted and non-extracted water. Mean monthly streamflow is lower than the long-term mean in all catchments in all months (with the exception of August, September and October when streamflow is higher in some catchments). Streamflows are generally lower with a 13 percent decrease (1010 GL) in the mean annual volume of non-extracted water for the region as a whole. The volume of surface water extracted decreases by 3 percent (7 GL/year). These changes are shown in Figure 16.

![Figure 16. Mean annual extracted and non-extracted shares of water for the Derwent-South East region under historical and recent climate](image)

Impact of future development on surface water

Currently there are 4179 km² of plantation forests in the Derwent-South East region. In future, the area of plantation forests across the region is likely to increase by about 143 km² (a 3 percent increase in total plantation forest) by 2030. Most of this increase is expected to be along the east coast. The largest change in mean annual inflows under future development is in the Prosser catchment with an expected reduction of 1.8 percent (Table 4). For most catchments, reductions in extractions are less than the reductions in inflows, with the exception of Carlton-Tasman Peninsula and Huon. Averaged over the region as a whole, however, reductions in inflows and extractions are minimal, with little impact on end-of-system flows.

The proposed irrigation extraction from Cluny Dam of 9000 ML/year (see Figure 17) can be supplied at all times with the appropriate commercial arrangement in place with Hydro Tasmania resulting in the operation of the hydro-electric system to supply this demand.

![Figure 17. Proposed irrigation developments in the Derwent-South East region](image)

### Table 4. Reductions in inflows and extractions as a result of future development (under median future climate)

<table>
<thead>
<tr>
<th>Catchment</th>
<th>Change in inflows</th>
<th>Change in extractions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Swan-Apsley</td>
<td>−0.7%</td>
<td>−0.3%</td>
</tr>
<tr>
<td>Little Swanport</td>
<td>−1.2%</td>
<td>−0.4%</td>
</tr>
<tr>
<td>Prosser</td>
<td>−1.8%</td>
<td>−0.5%</td>
</tr>
<tr>
<td>Carlton-Tasman Peninsula</td>
<td>−1.7%</td>
<td>−1.8%</td>
</tr>
<tr>
<td>Coal-Pitt Water</td>
<td>−1.4%</td>
<td>−0.2%</td>
</tr>
<tr>
<td>Jordan</td>
<td>−0.2%</td>
<td>−0.1%</td>
</tr>
<tr>
<td>Clyde</td>
<td>−0.2%</td>
<td>0.0%</td>
</tr>
<tr>
<td>Ouse</td>
<td>−0.2%</td>
<td>0.0%</td>
</tr>
<tr>
<td>Lower Derwent</td>
<td>−0.2%</td>
<td>0.0%</td>
</tr>
<tr>
<td>Derwent Estuary</td>
<td>−0.3%</td>
<td>−0.1%</td>
</tr>
<tr>
<td>Huon</td>
<td>−0.1%</td>
<td>−0.6%</td>
</tr>
</tbody>
</table>
Why the interest in groundwater?

Water that occurs below the surface of the earth is known as groundwater and is available throughout most of Australia. Groundwater is held in the saturated pore spaces and fractures of soil and rock and is classified according to the rock types or aquifers in which it occurs. In Tasmania, groundwater resources are not evenly distributed and quality and yield can be highly variable, depending on the aquifer type, the topographic location and the rainfall. Tasmania’s groundwater tends to be found in igneous, sedimentary and metamorphic rocks, as well as unconsolidated sediments. It is tapped by more than 8000 wells, supplying water for irrigation, town water, domestic use, stock watering, mining and other commercial purposes. Data and knowledge are limited, and while it is estimated that less than 5 percent of the state’s groundwater is currently in use, there is uncertainty about how much extra utilisation could be sustained.

Increasing demands to utilise Tasmania’s groundwater resources are driving the need for better understanding about groundwater availability. This is necessary for effective management into the future. This section describes the current levels and characteristics of groundwater availability and identifies potential future groundwater resource availability for key aquifers in the Derwent-South East region.

Assessing the characteristics and availability of groundwater: the process

The groundwater assessment and modelling component of this project involved collating existing data and knowledge to report on the occurrence, status and possible future condition of groundwater resources in the five regions.

Where regions were covered by a dynamic numerical groundwater flow model, a quantitative assessment of the impacts of recent and future climate and development was undertaken. This enabled detailed assessments of changes in diffuse recharge (and associated changes in groundwater levels) and interactions between surface water and groundwater resources. Where groundwater models were available, assessments were made of the impacts of climate change and development on the flows of water to and from streams. However, where groundwater models were not available, the potential impacts were assessed in terms of changes in diffuse groundwater recharge alone.

Surface–groundwater interactions can play an important role in the water budgets of each catchment. Groundwater discharge to streams is often crucial for maintaining ecosystem health during warm, dry summer months. Where possible, this project has determined the nature of surface–groundwater interactions for the main reaches of river networks.

Only areas with significant groundwater resources were assessed, with a total of 21 groundwater assessment areas (GAAs) identified over the project area. Boundaries of GAAs were not always contiguous with the project regions.

Groundwater management in Tasmania

Legislation currently makes only broad provision for managing groundwater in Tasmania. However, a regulatory framework is currently being developed that will include a system for the licensing of groundwater use and result in the development and application of groundwater management plans. Groundwater extraction in Tasmania is not metered but a system to license well drillers has recently been implemented.

Constraints on the assessments of groundwater availability in the Derwent-South East region

As for most of Tasmania, there is a lack of long-term, high-quality groundwater monitoring data for this region. The absence of reliable groundwater extraction data and a regional groundwater level monitoring network introduces great uncertainty into any quantitative assessment of the groundwater resources.
The five groundwater assessment areas (GAAs) of the region are shown in Figure 18. Groundwater salinities are shown to indicate where groundwater extraction occurs. Surface–groundwater interactions have also been mapped showing reaches of streams that are gaining groundwater or losing surface water.

The main aquifers in this region are the Permian and Triassic fractured rock aquifers. Local areas of Tertiary sediments, Tertiary basalt or Jurassic dolerite also provide small but important groundwater supplies to existing development.

Groundwater extraction is estimated to be about 2.5 GL/year, of which about 60 percent is associated with irrigation in the Cygnet-Cradoc GAA.

In the Sorell GAA, streams that are connected to the groundwater system are generally gaining in their upper and middle reaches, and losing in their lower reaches, although these reaches may be periodically gaining during high flow events. Springs are very common throughout the Coal River GAA and often occur at the contact between Jurassic dolerite and Triassic sedimentary rocks, or where topographic depressions intersect the watertable.

The widespread occurrence of springs suggests that groundwater discharge to streams is significant. The Mountain and Huon rivers in the Mt Wellington-Huonville GAA are perennial and gaining along their entire length. These characteristics are shown in Figure 19.

There are a number of groundwater management concerns in the region. Groundwater salinity is somewhat higher in the eastern parts of Tasmania and dryland salinity is known to occur in the Derwent-South East region, for example at Bothwell in the Sorell Tertiary Basalt GAA and in the Coal River GAA.

---

**Figure 18. Groundwater features of the Derwent-South East region**

- **Observation well**
  - Groundwater well salinity (mg/L)
    - <1000
    - 1000 - 3000
    - 3000 - 5000
    - 5000 - 10,000
    - 10,000 - 30,000
    - >30,000

- **Surface water catchment**
- **Groundwater assessment area**
- **Karat**

- **Surface–groundwater interactions**
  - Gaining stream
  - Losing stream
Groundwater responses to climate and development

For groundwater modelling, three 23-year periods were selected from the historical sequence, representing a wet extreme, median and dry extreme historical climate. Similarly, to represent the wet extreme, median and dry extreme future climate, three 23-year periods were selected from recharge model outputs derived using 15 global climate models and three global warming scenarios.

There is a noticeable decline in modelled mean annual rates of diffuse groundwater recharge over the 84-year historical period (1924 to 2007). Under climate of the recent past (1997 to 2007), groundwater recharge rates are the lowest of the historical period, 20 to 50 percent of the historical mean for the GAAs in this region (it was assumed there was no change in land use over this period). Recharge rates under future (~2030) climate are likely to be within the range of rates experienced during the historical period, ranging between 89 and 120 percent of the historical mean for the GAAs in the region.

Groundwater extraction is low in the Coal River and Swansea-Nine Mile Beach GAAs, and negligible in Mt Wellington-Huonville. Little impact is expected from either climate change or future development.

> Irrigated blueberries in the Cygnet-Cradoc groundwater assessment area, Huon catchment (CSIRO)
There are impacts on groundwater extraction under recent climate relative to historical climate in the Sorell-Tertiary Basalt and Cygnet-Cradoc GAAs (Table 5). Extraction is quite concentrated in the Sorell-Tertiary Basalt GAA which has a high level of development and may be an indicator of groundwater resource stress under drought conditions. Impacts are even greater in the Cygnet-Cradoc GAA where groundwater is extracted at a rate greater than recharge can replenish the resource (163 percent) which is probably attributable to drought conditions. If the future climate is similar to that under the historical dry extreme, groundwater levels may decline – but there are no monitoring wells in this GAA to confirm such a trend. Under future climate with development it is likely that there will be a moderate increase in extractions relative to recharge in the Cygnet-Cradoc GAA.

The level of technical assessment for this region is lower than that for other regions. This is due to the lack of both detailed historical data and an appropriate groundwater model for quantitative analysis of climate change and development. A full description of the technical aspects of the groundwater assessment process and results can be found in the associated technical report *Groundwater assessment and modelling for Tasmania.*

### Table 5. Extraction as a percentage of recharge for groundwater assessment areas in the Derwent-South East region under recent and historical climate

<table>
<thead>
<tr>
<th>Groundwater assessment area</th>
<th>Recent climate</th>
<th>Historical climate</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Wet extreme</td>
<td>Median</td>
</tr>
<tr>
<td>Coal River</td>
<td>8%</td>
<td>2%</td>
</tr>
<tr>
<td>Sorell Tertiary Basalt</td>
<td>83%</td>
<td>10%</td>
</tr>
<tr>
<td>Mt Wellington-Huonville</td>
<td>ng</td>
<td>ng</td>
</tr>
<tr>
<td>Cygnet-Cradoc</td>
<td>163%</td>
<td>23%</td>
</tr>
<tr>
<td>Swansea-Nine Mile Beach</td>
<td>14%</td>
<td>5%</td>
</tr>
</tbody>
</table>

ng – negligible rates of extraction

> Irrigated fields in Coal River groundwater assessment area (CSIRO)
Why the interest in the region’s ecology?

Water resource development can impact freshwater ecosystems by changing the flow regime components of the river system – the seasonality and amplitude of seasonal flow variations, the nature of low flows and high flows, and the total volumes of flow. Similarly, changes in climate may also impact river flow regimes. Various water reform initiatives (at both national and state levels) have led to significant decisions being taken on the allocation and management of water resources. Water is a basic necessity of all life and balancing competing demands for consumptive use and ecosystem health is a substantial challenge. Understanding the potential ecological impacts of water resource development and changes in climate will assist managers to strike that balance. This section considers the issues from an ecological point of view; human-use issues are considered in the section about surface water.

Determining likely ecological impacts: the process

Modelling was undertaken at a subcatchment level within each of the five project regions. Key sites of concern were also identified and then assessed to determine their likely condition under the four scenarios of future climate and development and the fifth without-extractions scenario. Impact assessment was based on the degree of change from a reference condition: largely unmodified, slightly modified, moderately modified, substantially modified and severely modified. The reference condition is what the flow regime would have been like without extractions but with current levels of infrastructure in place.

Key ecological sites were identified using the Conservation of Freshwater Ecosystem Values (CFEV) database. Only river sites, riverine wetlands and estuaries of exceptional conservation value with the ‘Very High’ Integrated Conservation Value rating class were considered. Additionally, for rivers and riverine wetlands, sites with conservation features currently under pressure or at risk from local abstraction were selected. All Ramsar wetlands in the region were also selected.

The nature and location of likely impacts were determined through an assessment of river condition using an approach based on the Tasmanian River Condition Index (TRCI) method incorporating the Flow Stress Ranking (FSR) procedure, which links flow components to important ecological processes. The TRCI provides a rapid qualitative ‘snapshot’ assessment of river condition based on physical stream form, streamside habitat and hydrological connectivity. FSR is a tool that provides a quantitative assessment of the potential stress of a river. An FSR assessment indicates where changes in the flow regime are likely to occur, and it is this change that has the potential to impact the environment. FSR scores are grouped to give the rating of condition. Sites that rate as moderately or substantially modified are classified as potentially impacted. Some potential impacts could be mitigated through environmental flow legislation, but this is not considered in this project.

To model future development, FSR assessments included modelled time series inputs that incorporated an increase in the area of plantation forest cover and the consequent potential change in streamflow.

A full description of the assessment process is found in the associated technical report Ecological impacts of water availability in Tasmania.

Ecological management in Tasmania

The management of Tasmania’s ecological resources is addressed by a mix of legislation, policies and strategies. Specific coverage for the provision of water for ecosystems is found in the Water Development Plan for Tasmania which aims to promote ecologically sustainable water development opportunities for Tasmania into the future. Within the context of this plan, the Conservation of Freshwater Ecosystem Values (CFEV) initiative was established to develop a framework for the management, development and conservation of freshwater-dependent ecosystem values. Through a comprehensive audit of the state’s freshwater ecosystems, CFEV identified where aquatic values exist and their priority for management.

In Tasmania a range of organisations use the CFEV framework to prioritise, plan and manage natural resources. Typically, assessments take a strategic approach with the aim of providing increased confidence on behalf of government, industry and the community that high priority freshwater values are appropriately considered in the development, conservation and management of Tasmania’s water resources. CFEV is used to assess the ecological sustainability of future water-related developments, to protect significant freshwater values, and to assist in focusing freshwater management efforts to protect and/or restore high conservation value ecosystems.
Ecological impacts of surface water

River condition

The Flow Stress Ranking procedure is a useful tool to measure potential stress to river condition by describing the degree of modification to the flow regime. Assessments for the Derwent-South East region were undertaken in 709 subcatchments.

Under recent climate, 19 percent of the subcatchments in the Derwent-South East region have moderately modified conditions, compared to less than 1 percent under historical climate. The percentage of subcatchments with slightly modified conditions has also increased substantially compared to the historical climate (Figure 20).

Moderately modified conditions under the wet extreme, median and dry extreme future climate are similar to historical climate. The dry extreme has 28 percent of subcatchments with slightly modified conditions. Future development adds to these stresses, increasing the percentage of slightly modified catchments under the dry extreme to 32 percent.

While this is a relatively large change in the proportion of subcatchments experiencing some kind of modification, the condition of the region as a whole is largely unmodified or slightly modified. This has minimal impact on the ecology. Less than 1 percent of subcatchments are substantially modified under any of the scenarios.

Figure 20. Percentage of subcatchments impacted by changes in catchment condition due to climate and development in the Derwent-South East region

> Mt Field National Park (DPIPWE)
Potentially impacted sites and associated ecosystems

The 44 key ecological sites of the Derwent-South East region are shown in Figure 21. Sites that are likely to be potentially impacted by recent climate, future climate or development (as highlighted in Figure 21) were determined through the application of river condition assessments – sites that rate as moderately modified are classified as potentially impacted (no key ecological sites rate as substantially modified in any of the project regions). This is shown in Figure 22 and is summarised in Table 6. As the recent drought has been so severe, if a key ecological site is potentially impacted under any scenario, it is always potentially impacted under the recent climate. The catchments that have moderately modified conditions under recent climate are in the Ouse, Clyde, Jordan, Coal-Pitt Water, Little Swanport and Huon catchments.

There are five sites on the Shannon River, one site on Orielton Rivulet, the River Derwent riverine wetland, four Ramsar wetlands, and five estuaries that are potentially impacted under recent climate. There are two sites on the Shannon River overlaid on each other on the furthest-most southern point. Of these two sites one is potentially impacted only under recent and historical climate, while the other one is also potentially impacted under the median and dry future climate, both with and without future development. Of the Ramsar wetlands, only Interlaken (Lake Crescent) is also impacted under the same future climate scenarios. One other Ramsar site and two of the estuaries are also potentially impacted under historical climate. The locations of these wetlands are shown in Figure 21 and their locations relative to changes in condition are shown in Figure 22.
Figure 22. Change in river condition under recent, historical and future climate and development relative to reference conditions in the Derwent-South East region.

Flow Stress Rankings
- Substantially modified
- Moderately modified
- Slightly modified
- Largely unmodified

Impacted key ecological sites
- River
- Riverine wetland
- Ramsar wetland
- Estuary

Future climate
- Wet extreme
- Median
- Dry extreme

Future climate with future development
- Wet extreme
- Median
- Dry extreme
Each of the potentially impacted sites in the region (Table 6) has associated special values that may be threatened by climate change and/or development. These are listed in Table 7. Because low and high flows, and to a lesser extent seasonal patterns, are likely to change, some degree of impact on instream ecosystem components (such as macrophytes, macroinvertebrates, fish and platypus) and riparian and floodplain areas (such as riparian vegetation and wetland plants) could be expected. The values identified in potentially impacted habitats in this region include platypus and riparian vegetation, such as Clasping-leaf Heath.

Table 6. Potentially impacted key ecological sites in the Derwent-South East region

<table>
<thead>
<tr>
<th>Site name</th>
<th>Recent climate</th>
<th>Historical climate</th>
<th>Future climate</th>
<th>Future climate with future development</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Wet extreme</td>
<td>Median</td>
</tr>
<tr>
<td>River</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Orielton Rivulet</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shannon River (3 sites)</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shannon River (1 site)</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shannon River (1 site)</td>
<td>X</td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Riverine wetland</td>
<td></td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Ramsar wetland</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Interlaken (Lake Crescent)</td>
<td>X</td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Pitt Water-Orielton Lagoon</td>
<td>X</td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Apsley Marshes</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Moulting Lagoon</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Estuary</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Moulting Lagoon</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Blackman Bay</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pitt Water</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Derwent</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Little Swanport</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: Crosses represent potential impact on key ecological sites. Blank cells represent sites that are not impacted under each respective scenario.

Note that there may be other sites in the Derwent-South East region at risk of impacts from climate change, droughts and future development. The key ecological sites chosen for this project were only those with a very high integrated conservation value and, for rivers and riverine wetlands, those at greatest risk of impact from current water extraction levels.
Table 7. Special values of potentially impacted key ecological sites in the Derwent-South East region

<table>
<thead>
<tr>
<th>Site name</th>
<th>Special values*</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>River</strong></td>
<td></td>
</tr>
<tr>
<td>Orielton Rivulet, Shannon River</td>
<td>Hairy Anchor Plant, Bitter Cryptandra, Clasping-leaf Heath, Native Wintercress, riparian flora communities, highland grassy sedgeland, Eucalyptus roдиwayi forest, shrubby Eucalyptus ovata forest, Duck-billed Platypus</td>
</tr>
<tr>
<td><strong>Riverine wetland</strong></td>
<td></td>
</tr>
<tr>
<td>River Derwent</td>
<td>Sedge/rush wetland, Duck-billed Platypus</td>
</tr>
<tr>
<td><strong>Ramsar wetland</strong></td>
<td></td>
</tr>
<tr>
<td>Interlaken (Lake Crescent)</td>
<td>Drooping Sedge, highland grassy sedgeland, highland Poa grassland, Golden Galaxias, Duck-billed Platypus</td>
</tr>
<tr>
<td>Pitt Water-Orielton Lagoon</td>
<td>Bar-tailed Godwit, Eastern Curlew, Great Crested Grebe, Whitebait (Derwent stock), Duck-billed Platypus</td>
</tr>
<tr>
<td>Apsley Marshes</td>
<td>Swamp Millet, Swamp Wallaby Grass, Lower Poa grassland, sedge/rush wetland, short paperbark swamp, shrubby Eucalyptus ovata forest, Duck-billed Platypus</td>
</tr>
<tr>
<td>Moulting Lagoon</td>
<td>Swamp Millet, Sea Club-rush, Swamp Wallaby Grass, sedge/rush wetland, short paperbark swamp, shrubby Eucalyptus ovata forest, lower Poa grassland, marginal herbfield/grassland, Fairy Tern, White-bellied Sea Eagle, Duck-billed Platypus</td>
</tr>
<tr>
<td><strong>Estuary</strong></td>
<td></td>
</tr>
<tr>
<td>Moulting Lagoon</td>
<td>Sea Club-rush, Fairy Tern, White-bellied Sea Eagle, Duck-billed Platypus</td>
</tr>
<tr>
<td>Blackman Bay</td>
<td>Sea Water Mat, White-bellied Sea Eagle, Duck-billed Platypus</td>
</tr>
<tr>
<td>Pitt Water</td>
<td>Bar-tailed Godwit, Eastern Curlew, Great Crested Grebe, Whitebait (Derwent stock), Duck-billed Platypus</td>
</tr>
<tr>
<td>Derwent</td>
<td>Fairy Tern, Sea Club-rush, Slender Water Mat, Great Crested Grebe, White-bellied Sea Eagle, Australian Grayling, Big-headed Gudgeon, Spotted Hand Fish, Whitebait (Derwent stock), Duck-billed Platypus</td>
</tr>
<tr>
<td>Little Swanport</td>
<td>Lesser Golden Plover, Little Tern, Duck-billed Platypus</td>
</tr>
</tbody>
</table>

* Special values include rare and threatened species and communities, important geomorphic features, sites of high species diversity and sites of ecological significance such as migratory bird sites. Many are recognised through legislation and current management. They were developed as part of the Conservation of Freshwater Ecosystem Values initiative.
Technical reports


All technical reports are available for download from <www.csiro.au/partnerships/TasSY.html>.
Region reports


All region reports and a glossary are available for download from <www.csiro.au/partnerships/TasSY.html>.

Enquiries

More information about the CSIRO Tasmania Sustainable Yields Project can be found at <www.csiro.au/partnerships/TasSY.html>. This information includes the full terms of reference for the project and all associated reporting products.


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