LOCAL INFRASTRUCTURE IN AUSTRALIAN TOURIST DESTINATIONS

Modelling tourism demand and estimating costs of water provision and operation

Michael AP Taylor, Simon Beecham, Nicholas Holyoak and Ali Hassanli

SUSTAINABLE TOURISM CRC

Disclaimer

We'd love to know what you think of our new research titles. If you have five minutes to spare, please visit our website or click on the link below to complete our online survey. **STCRC Tech Report Feedback**

National Library of Australia Cataloguing-in-Publication Entry

Title: Local infrastructure in Australian tourist destinations: modelling tourist demand and estimating costs of provision and operation / Michael A P Taylor ... [et al.]

ISBN: 9781921658464 (pbk.) 9781921658969 (pdf)

Subjects:
Infrastructure (Economics)—Australia—Planning.
Water-supply—Economic aspects—Australia.
Sewage—Australia—Management.
Tourism—Economic aspects—Australia.

Other Authors/Contributors: Taylor, M. A. P. (Michael A. P.) CRC for Sustainable Tourism.

Dewey Number: 363.610994

Copyright © CRC for Sustainable Tourism Pty Ltd 2010

First published in Australia in 2009 by CRC for Sustainable Tourism Pty Ltd

Printed in Australia (Gold Coast, Queensland)

Acknowledgements

The Sustainable Tourism Cooperative Research Centre, established and supported under the Australian Government's Cooperative Research Centres Program, funded this research.

CONTENTS

List of Tables

List of Figures

Abstract

This research investigates and reviews the options available to fund, provide and operate water and wastewater infrastructure to meet growing tourism needs. This includes identification of costs associated with tourist use of infrastructure and peak capacity requirements. The major benefits include better knowledge and understanding of tourist demands, and the need for water and wastewater infrastructure and analytical tools, enabling councils and other authorities to quantify present and future tourist demands, infrastructure requirements to meet demand, and the associated costs of infrastructure provision and operation.

Acknowledgements

Sustainable Tourism Cooperative Research Centre, established and supported under the Australian Government's Cooperative Research Centre's Program funded this research.

In addition, the authors would like to acknowledge the assistance of the following:

Hepburn Shire Council
Richard Russell and John Collins

Central Highlands Water
Pat Russell and Hamish Burrows

Byron Shire Council
Ray Collins, Brian Green, Peter Rees

Rous Water
David Patch

Doug MacLaren
KBR Infrastructure and Minerals

SUMMARY

With so many tourist activities in Australia, consideration must be given to the impact of the tourist on the environments in which they are located. Sustainable practices and in particular those associated with water use and wastewater production are important in planning for current tourist activity and future growth of visitors in urban and rural areas.

The objectives of this research include an investigation and review of the options available to provide, operate and fund water and wastewater infrastructure to meet growing tourism needs in a sustainable manner. This has led to the development of a modelling framework for facilitating a range of analysis related to water use at Australian tourism destinations.

The adopted modelling methodology includes procedures for estimating base year and forecasted tourist population at the tourist destination, water and wastewater demands associated with the visitor population, infrastructure required to satisfy water demands at the tourism region and the cost of such infrastructure provisions. This is achieved by incorporating tourist and residential population estimation for a base year and for a series of forecast future years. Population estimations are based on current and available survey data including regional tourism surveys, international and national visitor surveys and Australian census data. Water and wastewater requirements for these combined populations at the tourist destination are calculated with inclusions for irrigation based on CROPWAT software outputs. The corresponding costs of water provision and wastewater collection can then be summarised, based on the preceding estimations. To allow for application to all Australian tourism localities, the modelling process is adapted to suit data that is readily available or easily collected and involves principles that can be readily applied by the user. This methodology outlines some urban water use and wastewater production statistics across Australian capital cities, useful in later calculations.

Case study applications of the model are developed for the Australian tourist destinations of Daylesford in Victoria and Byron Bay in New South Wales. Analysis includes full calculations for the water and wastewater needs and associated costs for the forecast year of 2031. Some key findings from the analysis are that for the year 2031, the costs associated with Daylesford's residential and tourist population demand will be $32,289,650 for the total water demand and $11,128,000 for wastewater treatment. For the town of Byron Bay in 2031, these costs will be $53,601,500 for the total water demand and $18,644,000 for wastewater treatment.

Major benefits of this research include better knowledge and understanding of tourist demands, and the need for water and wastewater infrastructure and analytical tools, enabling councils and other authorities to quantify present and future tourist demands, infrastructure requirements to meet demand, and the associated costs of infrastructure provision and operation.

Chapter 1

INTRODUCTION

The Australian tourism industry makes a significant contribution to overall economic activity in Australia. The Tourism Forecasting Committee (2009), reports that in 2008, total real tourism consumption or spending in Australia was $90.8 billion with a total of 5.6 million inbound visitor arrivals and 271.8 million domestic visitor nights spent. In 2010, this consumption is forecast to increase to $91.5 billion. With so many tourist activities in Australia, consideration must be given to the impact of the tourist on the environments in which they are located. Sustainable practices and in particular those associated with water use and wastewater production are important in planning for current tourist activity and future growth of visitors in urban and rural areas.

This research investigates and reviews the options available to fund, provide and operate water and wastewater infrastructure to meet growing tourism needs. This will include identification of costs associated with tourist use of infrastructure, peak capacity requirements and opportunities to recover costs from visitors and the visitor industry. The major benefits will include better knowledge and understanding of tourist demands and the need for water and wastewater infrastructure and analytical tools enabling councils and other authorities to quantify present and future tourist demands, infrastructure requirements to meet demand, and the associated costs of infrastructure provision and operation.

The end product of this research is a computer-based spreadsheet model (as detailed in Appendix A) that includes both the forecasting of future tourist demand at a given site or development and the estimation of the requirements for water and wastewater infrastructure to service future demand, along with estimates of the costs of providing and operating that infrastructure. The model, which has a strong sustainability focus, provides a superior and innovative analysis tool for use by shires and councils throughout Australia.

This report begins with a review of recent literature on the topic of tourism and sustainable water usage focusing on tourism forecasting techniques and related water/wastewater requirements for tourists. A detailed outline of the modelling methodology is provided including algorithms and processes, data sources utilised and assumptions made. Applications of the model are demonstrated with a selection of Australian tourist site case studies leading into the final section providing conclusions and recommendations.

Chapter 2

REVIEW OF LITERATURE

Much of the specific research into water use is generalised with only single factors in the analysis and little focus on sustainable water measures. This literature review aims to summarise reported research on recent research-based methods for determining water demands at tourist destinations and some general water supply and wastewater treatment principles.

Water Demands at Tourist Destinations

Tourism generally has an 'urbanising effect' on a destination, attracting more people to catchments and increases the environmental load on such places, resulting in short term peaks in demand of varying intensities. In addition, tourism provides economic growth associated with the local population that provides services to tourists. Tourism causes an increased consumption of water for associated facilities and leisure and tourists require constant access to water. A tourist staying in a hotel uses (on average) 30 per cent per day than more than a local inhabitant (European Environmental Agency (EEA), 2003). Moreover, extensive landscaping, water parks, swimming pools and golf courses are typical tourist facilities that require water during the dry season (Stefano, 2004). The surface of a golf course lies between 50 and 150 hectares, which means that the annual consumption of a golf course is around 1 million cubic metres per year or the equivalent of the water consumption of a city of 12,000 inhabitants (World Wildlife Fund Spain (WWF), 2003).

When considering impact of tourists on the environment, it is useful to distinguish between mass tourism, nature-based tourism and eco-tourism. The most common direct impacts associated with each are outlined in the following and are derived from Stefano, (2004). Mass tourism is usually confined to relatively small urban areas where the highest water demand occurs, Due to the high density of land and water uses, if mass tourism is not properly managed and its growth is not carefully planned, its consequences on the environment can be severe. The most common negative impacts on freshwater ecosystems are: high demand on water, due to high density of accommodations and due to existence of leisure facilities; high production of wastewater, with significant peaks; land occupation by accommodation facilities and leisure areas; and developed transportation network to transport tourists and goods.

Nature-based tourism includes low-density rural tourism in small towns and communities and so-called sport tourism which needs natural areas (lakes, rivers, mountains) to develop. This kind of tourism often visits or uses areas with a high ecological value. The main threats of this type of tourism are linked to urban development to accommodate tourists, the transport network to ensure tourists' mobility and the disturbance of wildlife due to the presence of tourists in sensitive areas. Eco-tourism is characteristically low density and is normally less demanding in terms of water consumption facilities. The main problems of this type of tourism are linked to wastewater treatment (isolated resorts are not usually connected to the water treatment network), waste disposals (illegal waste disposals often occur in wetland areas) and to the transport network to access relatively remote places.

United Nations Environmental Fund (UNEP) (2001) identified some 250 voluntary initiatives to raise awareness and set standards of 'sustainable tourism' within the tourism industry around the world. These include codes of conduct, awards, benchmarking, best practices, eco-labelling and certification programs; most of them include a small section on water use and wastewater.

Tourism is making a major contribution to the degradation and destruction of water ecosystems as rivers are fragmented, groundwater levels drop and wetlands dry out (Stefano, 2004). In the Mediterranean region every tourist consumes between 300 and 850 litres of water per day. This rate could be reduced by 50 per cent (Stefano, 2004) by implementing a sustainability program. Ottrerpohl, Grottke and Lange (1997) stated that, to achieve sustainability, a number of philosophies must be adopted, including energy and material usage must be minimised, problems in space and time must not be transferred to others, natural resources must not be reduced or degraded and human activities must be integrated into natural cycles (Kavanagh, 2002). Reducing water consumption can be achieved if the tourism industry, the government and the individual tourist take concrete measures, such as installing water saving devices, using recycled water (re-use water), considering saving policies and adopting a land use plan that respects environmental consideration (Stefano, 2004). The sustainable use of limited water resources leads people to save water and protect water quality. As an example, overexploitation of groundwater which occurs when the volume of abstracted water exceeds the average annual recharge causes a reduction in groundwater table, which negatively affects wetlands whose hydrological dynamics are directly linked to aquifers. In addition, overexploitation in coastal areas (aquifers) affects the equilibrium of the interface between freshwater in the aquifers and sea water, which provokes saline water intrusion. Once the salty water level has increased fresh water treatment or finding a new alternative source would be required. Higher levels of salt in irrigation water also would damage landscape and park plants, which are attractive for tourism and are environmentally important. Coastal groundwater has been reduced to below sea level by excessive pumping in Cyprus, Greece, Libya, Spain and Turkey (EEA, 2003) as a result of high tourist population and high water consumption. As Stefano (2004) reported, the growth of tourism is often associated with the search for complementary water sources to satisfy the great demands on water for this economic sector.

Wastewater has the potential to cause pollution to surface and groundwater reserves and insufficient or inefficient waste water treatment systems have a direct negative impact on the quality of water and therefore on the ecosystems which affect inversely the tourism industry. The lack of trained treatment staff and the seasonal aspects of wastewater production can cause operational problems, which reduce the effectiveness of treatment (European Commission (EC), 2000).

Leakage from solid waste is another source of water pollution. In isolated areas or where the normal solid waste disposal system is not able to absorb water production caused by the seasonal influx of tourists, the quality of freshwater can be affected by leakage from uncontrolled disposal of solid waste. Direct discharges of poorly treated or untreated waste water into water bodies (sea water or rivers), polluted rivers and lakes affect the quality of fresh water and sea water. EEA (2003) estimates tourism contributes to 7 per cent of all pollution in the Mediterranean Sea. As reported by EEA (2003), tourists consume up to 300 litres (up to 880 litres for luxury tourism) and produce nearly 180 litres of wastewater per day. It is also worth mentioning that in some regions such as the Rimini province in Italy, the production of wastes and wastewater in summer is three times higher than in winter. This results in large volume of sewage discharge to sewage treatment plants or to the sea and rivers. This has a particularly detrimental impact when tourist facilities are in isolated areas and are not connected to the water treatment networks. In any case, if water is not treated, recycled or deposed properly, it will cause pollution and is undesirable when considering sustainable tourism.

Tourist areas suffer from significant fluctuation in the number of local residents that have to be supplied with freshwater with consumption peaks normally occurring during the dry season, when tourist demand overlaps with high water demand by agriculture and green space irrigation water demand (Stefano, 2004). Moreover, extensive landscaping, water parks, swimming pools and golf course are typical tourist facilities that require water during the dry season.

Water Supply and Wastewater Treatment

Australia is the driest inhabited continent on earth, and is one of the world's largest consumers of water per capita. Taking into account all uses of fresh water (including the irrigation of crops) Australia use more than 1 million litres of water per capita per year (SA Water, 2009). In terms of average residential (or household) consumption this figure reduces to an average of 246 kilolitres per year for a metropolitan house whereas in the country this figure averages to 224 kilolitres per year.

In Australia water is mainly used for irrigation accounting about 75 per cent, and for urban and industrial use accounting for about 20 per cent. As an example, studies have shown that the following water usage in an average suburban South Australian home are (SA Water 2009):

- garden and outdoor 40%
- bath and shower 20%

- laundry 16%
- kitchen 11%
- toilet 11%
- other 2%.

Currently, an average South Australian household will use about 40 per cent of its water in the garden and so it is logical to look at the garden as a good place to start saving water. The Sustainable Landscapes project demonstrates and promotes appropriate garden and park design, helps to provide advice about plant species selections and sustainable horticulture practices including the efficient use of water.

Wastewater treatment is another aspect of the water cycle when considering the sustainability of water resources. Typically, a comprehensive treatment processes raw wastewater as it enters the conventional water treatment plants (WTP) undergoing a five-stage cleaning process as outlined below in the following:

- *Coagulation and Flocculation:* The first stage collects small particles and dissolved organic matter and is a complex physical and chemical process. A coagulant is added to the untreated water and this reacts with the impurities, forming them into floc particles up to 5mm in diameter.
- *Sedimentation:* Normally after 20 to 30 minutes in the flocculation tanks, the water and suspended floc particles pass through to sedimentation basins where, after several hours, most of the floc settles to the bottom of the basins and forms a sludge. The water, now containing only a small amount of very fine floc particles, passes on to the filters. The sludge is removed for further treatment and disposal.
- *Filtration:* Water from the sedimentation process passes through a filtering media—usually a deep bed of sand or sand/anthracite dual media. As the water passes through the filter bed, any particles remaining from the sedimentation process are trapped in the fine spaces within the media resulting in clear, clean water.
- *Disinfection:* Disinfection is achieved by adding chlorine, generally between the filters and the filtered water storage tank, to destroy any micro-organisms that are not removed in the flocculation and filtration stages.
- *Storage and distribution:* After disinfection the water passes to covered water storage tanks ready for distribution.

A typical sewage treatment plant for the above five treatment process is shown in Figure 1.

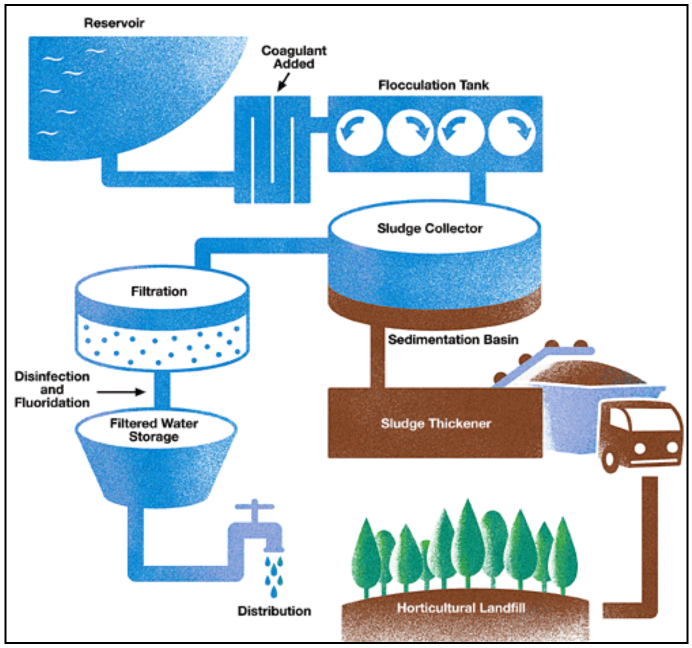


Figure 1: Schematic plan of a sewage treatment plant (STP)

Source: (SA Water, 2009)

The breakdown of annual wastewater treatment cost for sewage treatment plants in SA is as follows:

- depreciation and amortisation (27%)
- finance costs (16%)
- operational services and contracts (19%)
- salaries and benefits (14%)
- services and supplies (19%)
- electricity (5%)

It can be noted that the highest cost is attained through depreciation of assets with operational and service contracts accounting for 19 per cent of annual plant costs.

Sustainable resource usage at locations outside of capital cities locations has been researched in Australia and New Zealand in recent years with an emphasis on water use and wastewater production. Coombes and Foster (2008) investigate water usage at the Armstrong Creek development, with a proposed location approximately 10 kilometres south of Geelong in Victoria. Within the mixed development a total of 22,000 dwellings are proposed at a range of residential densities along with activity and employment centres and green areas.

This research employed a multi criteria analysis to investigate the possibilities for sustainable water use and re-use and also considered greenhouse gas emissions, costs and benefits and timing of the development. Water cycle management options were considered to in a systems analysis approach with results suggesting that an integrated water cycle management strategy should combine best practice stormwater management with reductions in mains water use and wastewater discharges. This included suggestions for:

- the use of rainwater tanks
- water efficient appliances and gardens
- wastewater re-use from treatment plants located within the Armstrong Creek area.

Modelling tourism demand, and estimating costs of water provision and operation

The treated effluent from wastewater treatment plants within the Armstrong Creek development is used for toilet flushing, garden watering and open space irrigation.

More specific to tourist locations, research such as that reported by Patterson and McDonald (2004) aims to assess the indirect and future environmental effects of tourism on the environment in New Zealand. The research employs an input–output economic–environmental account of the tourism sector methodology with accounts developed in terms of:

- integrated economic-environmental accounts of the tourism sector
- lifecycle assessment of the environmental impacts of New Zealand tourism
- projections of future environmental impacts of the tourism sector.

This approach includes an assessment of water use in addition to a number of other attributes, with a rationale, methodology and model outcomes presented. Other environmental attributes included:

- energy, water and land use and related attributes,
- water, nitrate and phosphorus discharges,
- biological oxygen demand and carbon dioxide emissions.

Cullen, Dakers, McNicol, Meyer-Hubbert, Simmons and Fairweather (2003) investigate how tourist contributions to water usage and to waste as wastewater and solid waste may be recognised and compensated economically. The tourist populations are a significant component of the overall population in towns such as Kaikoura and Hamner Springs in New Zealand and require new proposals for financial structures to recoup operational and capital costs.

The research report provides a background to current situation and emphasises the need for change with a snapshot study undertaken at both locations. Following on from this, evaluations on infrastructure attributes (especially in relation to costing), pricing structures and tourist water use include arguments for and against the tourist paying for their impact on the towns' water and waste services. Funding structures that account for seasonality result from the study.

A more generalised benchmarking study is reported by McNicol, Shone and Horn, (2002) focuses on the town of Kaikoura which is part of the Green Globe 21 Community Benchmarking project. The aims include the investigation of environmental indicators with the methodology including data collection and assessment. Comparisons against two other similar studies are also part of the research scope. A wide range of indicators considered water consumption but not wastewater with others assessing air quality and greenhouse gas production, energy factors, biodiversity and so on. This work considers many environmental factors in a generalised and aggregated sense without a great amount of detail in the analysis with recommendations reflecting this approach.

A good example of detailed research into sustainable water usage and wastewater production is reported by Cullen et al (2003) based on the small rural tourist destination of Akaroa in New Zealand. Akaroa is a town that is experiencing a thriving tourism industry. This has introduced issued pressures on the region's water supplies as water shortages have become increasingly frequent and severe. This research reports on qualitative environmental modelling established for Akaroa with a distinct water focus. The three components of this modelling include:

- modelling water and wastewater
- modelling solid waste
- funding systems for water, wastewater and solid waste.

The construction of the modelling is dependent on the existence of a detailed database developed from three four-day intensive surveys involving in the town. These surveys included:

- data from individual accommodation businesses
- data collected from non-residential properties
- surveys of pedestrians with an interview component

- road traffic counts,
- supermarket foot traffic.

As a result of this snapshot survey study the rich datasets have allowed for the development of a family of models and estimates on water use and wastewater production. These are principally a disaggregated set of regression models calibrated with the survey data. Issues relating to funding are also addressed with estimates made for revenue and costs for service provisions. As a result, proposals for funding opportunities are concluded.

This research notes that the approach could be adopted in other towns as noted. The model is specific to Akaroa, but it is likely that a similar model could be developed for other small towns so long as sufficient data is available on visitor numbers, and normalised water use rates for each major sector. The main caveat on this statement is that the model is transferrable, providing that sufficient data is available to drive the modelling process. Such data can potentially require many resources to acquire, especially if the tourism destination is large and/or diverse in nature.

The literature review demonstrates that there are various methodologies that have been applied to the estimation of water demands and wastewater treatments at tourist destinations. The techniques summarised here vary from aggregate to detailed approaches and are often dependent upon the nature of the data utilised. Accurate estimations involve basing the water supply and wastewater treatment estimates on both the tourist and domestic populations. The literature demonstrates research into the connection between infrastructure development and economic resources (i.e. costs and benefits). A background to domestic application water of water resources and the involved processes and infrastructure required for wastewater treatment is also summarised.

Chapter 3

MODELLING METHODOLOGY

The aims of the modelling methodology are to provide the user with a range of tourism water use analysis outcomes, namely:

- base year and forecasted tourist population at the tourist destination
- water and wastewater demands associated with the visitor population
- infrastructure required to satisfy water demands at the tourism region
- cost of infrastructure provisions.

In addition, the modelling process is adapted to suit data that is readily available or easily collected and involves principles that can be readily applied by the user. This methodology will outline some urban water use and wastewater production statistics across Australian capital cities, useful in later calculations. Several useful data resources involved in the modelling methodology are described, many of which are freely available and updated on a regular basis. This may prove to be useful for future applications. The modelling approach is summarised in the form of a flowchart with important individual elements described in more detail.

In essence, the total water used in a house is divided into several segments. Although people use water in different ways, the main areas of water use are as follows, as discussed in Chapter 2:

- garden and outdoors
- bath and shower
- laundry
- kitchen
- toilet
- others.

Across Australia, average water use per capita has been decreasing largely because of widespread need for water restrictions. Water use per property for the Australian mainland capital cities is shown in Figure 2. Based on this figure, Adelaide, Perth and Canberra are higher water consuming cities compared to Sydney, Melbourne and Brisbane. The South Australian Government believes (Government of South Australia, 2009) that the reason for high average annual residential water use per household in Adelaide is partly due to the size of the house blocks, the age of many of buildings, and warmer and dryer conditions. Annual total water use, wastewater produced, storm water harvesting and the portion of water use go to sewers network in three major cities is shown in Table 1.

Table 1: Annual water use, wastewater and storm water in three capital Australian cities

City	Water use(GL)	Wastewater (GL)	Storm water (GL)	% of waste water production
Sydney	650	420	590	64.6
Melbourne	470	330	440	70.2
Adelaide	216	95	160	44

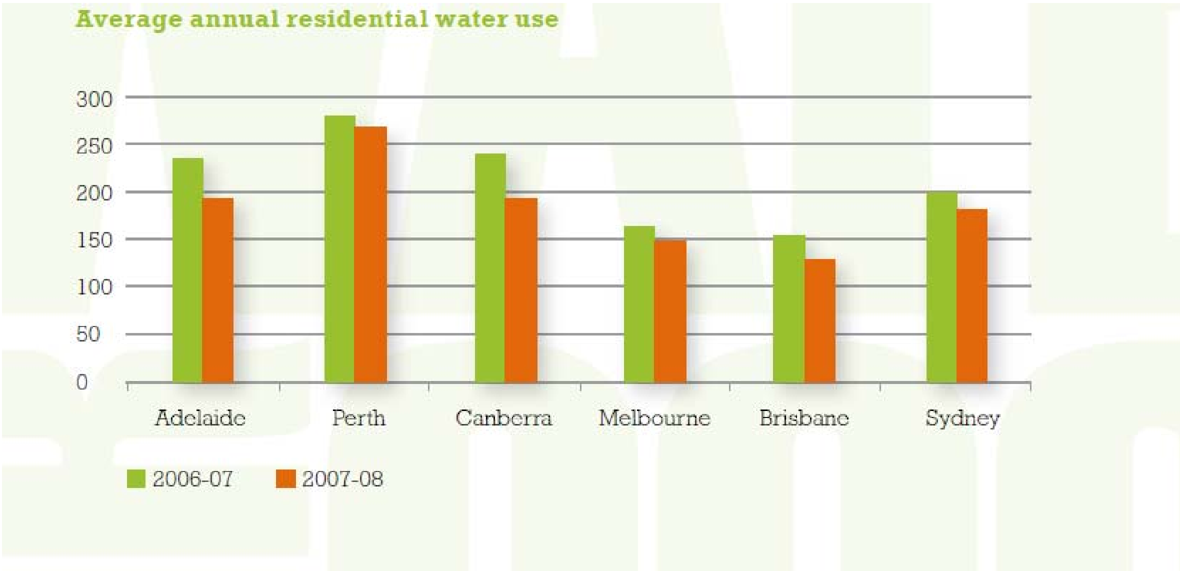


Figure 2: Average residential water use per property for major Australian cities

Source: Water for Good, 2009

One of the reasons for the lower per cent of water use that converts to wastewater in Adelaide (44 per cent) comparing to Melbourne (70.2 per cent) and Sydney (64.6 per cent) is that a large portion of annual water is used for outdoors, predominantly gardening.

Useful Data Sources

To enable the application of the forecasting model to any tourist locality within Australia, it is important to firstly identify potential sources of data that are readily available to the user or able to be collected with minimal resources and effort. The modelling algorithms should adopt this data where appropriate, providing the model with flexibility in application and ease of use. There are a number of reliable and useful data collected by various authorities that have a potential for application in this research and these are described in the following paragraphs.

IVS – NVS database

An essential component of the model development is the International Visitor Survey (IVS) and National Visitor Survey (NVS) database developed by Tourism Research Australia. Performed annually, each survey includes data from approximately 25 000 respondents each year from 2000 to 2004 and from 40 000 respondents between 2005 and 2008. The summary files from these datasets provide information concerning travel made by domestic and international travellers within Australia. Personal and travel behaviour data is collected from each respondent including information such as gender, annual income and country of origin of the tourist and journey information such as travel modes, stop locations and expenditure. For this research, summary figures on tourist numbers who visit the tourist locations are of most interest.

ABS Tourism Accommodation Surveys

The Survey of Tourist Accommodation is a quarterly census of accommodation establishments conducted by the Australian Bureau of Statistics. The survey reports information such as the number of establishments, available accommodation (e.g. beds), persons employed and total takings from accommodation. In addition, the number of visitors and visitor nights is also reported. On a more infrequent basis, a number of derived averages are produced including length of stay, nightly rooms occupied per establishment, nightly guests per occupied room and takings per establishment. Conducted since 1998, the survey covers the following types of accommodation lodgings on an ongoing basis:

- hotels and resorts

- motels, private hotels and guest houses
- serviced apartments.

In addition, (in every third year beginning with 2000), the survey is expanded, for the four quarters, to include:

- holiday flats and units
- caravan parks
- visitor hostels.

The survey is completed by business proprietors and response rates in excess of 90 per cent contribute to the production of high quality small area statistics with important summary statistics reported on a monthly basis where possible.

ABS Census

Although not directly focused on the tourism industry, the Australian Census database provides a demographic snapshot of the residents at all Australian localities including tourist destinations every five years. This dataset's particular strength is its accuracy as the Census is a 100 per cent sample of the population. A vast amount of information is contained within this dataset, and for this research is most useful for providing statistical information about resident populations.

Historic Rainfall and Green Space Irrigation Requirements

Rainfall statistics for all Australian regions is public information made available online from the Australian Bureau of Meteorology (2009) through their website which supplies recent and archived statistics on monthly rainfall. The amount of annual rainfall and its distribution particularly during the dry seasons is very important for green space irrigation water requirements. For green spaces such as golf course and parks the water requirements are estimated by CROPWAT decision support model (Allen, Pereira, Raes and Smith, 1998) for irrigation or any other tools and reduced by the amount of rainfall.

Proforma and water/wastewater reporting form water agencies

A data collection proforma developed by the ISST has been applied for the purpose of collecting information specific to tourism, water supply, water use and wastewater collection at the study site. It also has inclusions on sustainable practice and may be issued to multiple agencies for completion. The proforma includes fundamental questions on water resources, water usage and wastewater collection in addition to supply sources and planning information. Site visits are recommended to accompany the proforma so that agencies can be assisted in answering questions.

Supporting Documentation

Audits of tourist activity can report on a range of tourism and accommodation aspects for select tourist destinations. Data included in such an audit may include an account of tourism activities and expenditure, products provided for consumption by the tourist (including services and a variety of consumables) as well as accommodation provisions. Audits can also contain a summary of tourist visitors derived from the IVS and NVS databases previously described.

These audits provide a very useful summary of tourist activity; however, they are conducted on an ad-hoc basis, often by different agencies and most commonly commissioned by local parties who have an interest in the tourism industry. They are therefore not currently available for all Australian tourist destinations and do not have common data collection requirements. An example of a recent tourism audit reported within the Destination Daylesford document (Causley and Cox, 2008).

Additional strategic planning may also be reported by water authorities and can provide useful supporting information related to water storage and usage both historically and forecast for future years. This may also be accompanied by planned infrastructure developments for future years.

Water Demand Modelling Approach

The water demand modelling process is structured as a series of sequential stages to achieve the desired model outputs. These stages exist as:

- definition of base year modelling scenario—including base year and definition of study region
- base year tourist estimates—both number of visitors and average duration
- identification of tourism peak season—month within the year and estimation of peak tourist numbers
- estimation of water demand and wastewater production from peak tourist season,
- forecasting future tourist numbers and demand for selected forecast years
- infrastructure provision to match water supply and wastewater collection
- costing estimates for infrastructure
- annual and monthly average precipitation
- total available water supply
- resident population and water consumption per capita, water consumption per year and water consumption and wastewater production per capita and in peak month
- green areas and water consumption per hectare.

Figure 3 illustrates the operation of the modelling stages with following report sub-sections identifying the tasks and routines that compile each.

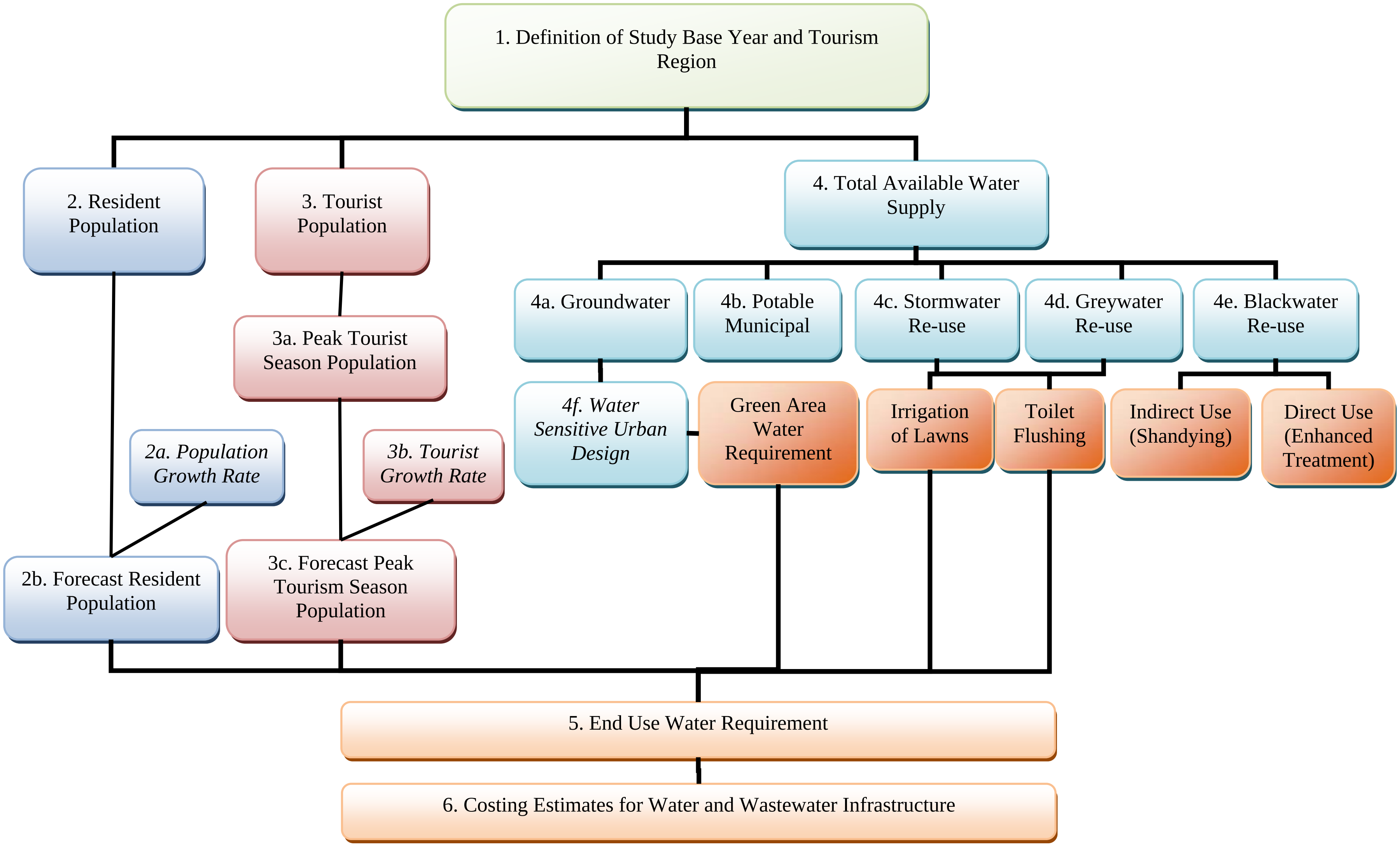


Figure 3: Tourist water demand model algorithm

Base Year Modelling Scenario and Tourist Region (1)

For the purposes of this research, a base year of 2006 is adopted. Data for this year is available for most datasets required in the model and coincides with Australian Census 2006 data release. Some datasets (such as tourism audits) may be close to this date and regarded as compatible as it is not expected that large-scale change will occur to the number of tourism facilities over a short time period.

Study regions defined for the modelling should firstly include the accommodation and service facilities provided to host tourists. It should also include the tourist attraction/s; however, this may depend upon the number and dispersal of attractions. Some localities may have a single annual event at one location which can easily be defined spatially whereas some locations can have several different attractions that are popular all year, in which case more care is required in the study area definition.

It will also assist a simple analysis to align the study area boundary with existing boundaries for visitor counts, IVS – NVS data sources and ABS defined regions to allow their data to be used in modelling. Water supply and wastewater collection coverage can also be a consideration however it is not a necessity.

In later paragraphs, the regions of Daylesford, Victoria and Byron Bay, New South Wales are selected as case studies to demonstrate the modelling approach. These regions represent two popular tourist destinations, with differing tourist activities and attractions, geographic setting, tourism flows across the year, climates and water supply/wastewater treatment approaches.

Resident Population (2)

Australian Census databases are used to estimate the base year resident population as well as historic population statistics. From these historic records it is possible to determine population growth rates for future year population forecasts. Population forecasts are an essential component in the forecasting of future water demands.

Tourist Population (3)

For the base year it is important to estimate the number of tourists to the region both annually and during the peak tourist period as this will impact upon peak water/wastewater requirements. For this purpose the IVS – NVS database is used to estimate the total number of visitors to the region in the base year. Visitors will be composed of international and domestic types with those who visit only as a day trip (no overnight stopover) and others who stay for one or more nights. For this research, all visitor types are combined with assumed equivalent water usage requirements. The IVS – NVS database reports on the overnight stay duration of visitors, allowing for an estimate of the average stay duration per visitor to the region. This dataset is used ahead of other resources as it includes all tourist types, irrespective of accommodation type used, and reports on stopover duration.

The IVS and NVS data includes counts of day-trip visitors to the region and overnight visitors including the number of nights stayed by these visitors. Within this model formulation there are no current data sources that allow for the correction of day-trip visitors reported in the survey data. This correction would be in the form of a day-visitor weighting factor. The day- trip visitors are therefore assumed to stay outside of the study town region and indeed outside of the region defined in the survey. This should be recognised in the interpretation of the results.

Peak tourism season and tourist water demand

For the base year, the peak month is identified using the ABS tourist accommodation survey. This dataset provides the proportion of total tourists visiting the destination each month, within specified accommodation types. From this database it is possible to identify the peak month tourist proportion which, when multiplied by annual tourists in the IVS – NVS database provides peak month tourist estimates.

Forecasting Resident and Tourist Populations

Beyond the estimates of base year water requirements, future year resident and tourist populations and their water/wastewater requirements are calculated. For this purpose, growth rates based on historical data are utilised and applied to base year resident population and tourist peak estimates. It is assumed that water usage rates and the average 'nights stayed' remains constant for all future year estimates.

The calculation of tourist growth based on historical data assumes that the effect of events such as economic recessions, rising fuel prices and natural or human disasters (such as the devastating bushfires that hit Victoria in February 2009) are accounted for, if they have occurred, and recognised in the historic data used to calculate growth rates.

Total Available Water Supply (4)

The Australian Bureau of Meteorology holds detailed historic rainfall records for most Australian regions. Many of the records date back 50 to 60 years and are available at a disaggregate level for many towns. From this information, average monthly rainfall statistics are possible for Australian tourist regions. This information will show how much irrigation water needs to be provided by the water supply authority. The irrigation requirements would be the difference of crop water requirements and the amount of effective rainfall.

Available water supply and wastewater treatment capacity

The total available water supply may come from a number of sources. Potential water sources include:

- reservoirs
- ground water supplies
- water piped in from other locations
- recycled water supplies
- rivers and creeks
- and other smaller localised supplies such as rainwater tanks.

To accompany the total available water supply for the study region, the wastewater treatment capacity is an important consideration. In order to protect environment and meet the EPA guidelines the wastewater treatment needs to be passed through five different treatment stages:

1. Coagulation and Flocculation
2. Sedimentation
3. Filtration
4. Disinfection
5. Storage and distribution

Non-residential demands

Water use on green areas such as parks and ovals in the tourist destination should be given due consideration when estimating the total water usage. Green space water requirement would be estimated using CROPWAT model (Allen et al, 1998) for each month (based on temperature, relative humidity, wind speed and sunshine) particularly for the peak period considering the rainfall.

The total available water supply can be drawn from the following sources, depending on availability at the tourist site:

- potable municipal water—traditionally a common source of water for a wide range of uses including drinking, toilet flushing and irrigation of green areas
- groundwater — the demand for groundwater to irrigate green areas can be reduced with the application of water sensitive urban design

- stormwater re-use—applications in the irrigation of lawns/gardens and toilet flushing purposes
- grey water re-use—applications in the irrigation of lawns/gardens and toilet flushing purposes
- blackwater re-use—application after treatment processes.

End Use Water Requirement (5)

Water requirements at the tourist destination need to consider both the residential and tourist populations, particularly during the peak tourism periods. In this study we assume each tourist would consume 33 per cent more water than a resident (European Commission, 2000). This includes all water areas such as gardening and outdoors, bath and shower, laundry, kitchen, toilet and others. However, water for irrigation the parks, ovals and open and public green spaces would be calculated for lawn as the dominant green space plant.

Irrigation water requirement

In addition to water for gardening belonging to the households which is considered in the residential water use, the public green spaces also need water for irrigation. The green spaces in an urban area may be divided into three types:

Private gardens and green spaces
Private gardens and green spaces belonging to households are irrigated by owners and the water allocated is considered as a part of residential water used.

Public green spaces
This consists of football/cricket ovals, bowling greens, parkland including botanic gardens, golf courses, parks sportsgrounds and ovals and so on. The water requirement of this section of urban green spaces may be dependent on the municipal main water supply that is provided as potable water or may be planned for use of recycled water or harvested stormwater. In this study, the irrigation water requirements of these green spaces which assumed to be predominantly lawn are estimated by implementing the CROPWAT model.

Patch green space
These green spaces can often be up to 12 per cent of occupied land used for buildings in urban areas. In this study it is assumed that the irrigation requirements of these small green spaces would be supplied by the ponds that are designed to harvest the storm water from the adjacent micro catchments in each area. The amount of water that can be collected in each pond would be based on the average annual rainfall and the area of micro catchments using the following equation:

$$V = C \times A \times R \times 10^{-6}$$

Where:

V= the volume of annual harvesting water to be used for irrigation (GL)
C= urban run-off coefficient (in this study assumed to be 0.4)
A= the area of micro catchment (ha)
R= the average annual rainfall (mm).

The irrigation water requirement in this study is estimated using CROPWAT model. CROPWAT is a decision support system developed by the Land and Water Development Division of FAO. Its main functions are calculation of:

- reference evapotranspiration (ET0)
- crop water requirements (ETc)

Modelling tourism demand, and estimating costs of water provision and operation

This model has been developed with the assistance of the International Irrigation and Development Institute (IIDS) of the University of Southampton, UK. The theory of this model is based on the FAO Penman-Monteith equation. Crop water requirement (ETc) is calculated using the following equation:

$$ETc = Kc \times ET0$$

Where:

- ETc = crop water requirement (mm/day)
- Kc = crop coefficient
- ET0 = reference evapotranspiration (mm/day).

To calculate lawn water requirement several climate data items are required such as the minimum and maximum temperature, the wind speed, the relative humidity and sunshine hours. Where these entire climate data are not available for the particular site, the most appropriate and available proxy information is used.

Costing Estimates for Water and Wastewater Infrastructure (6)

In this research, the peak daily tourist population is used for estimating the cost of water and wastewater infrastructure. However, the cost for infrastructure is highly variable and will depend on the type of supply, wastewater and re-use systems selected for each development, particularly if decentralised systems are selected. It also depends highly on the level of treatment required for both water supply and wastewater systems and this in turn depends on the quality of the raw supply water. Because projections are required to the forecast year of 2031, it is assumed that major water recycling will be required by this time. Therefore, to estimate the cost of wastewater infrastructure, the real cost of wastewater recycling at the household scale developed by Fane, Ashbolt and White (2001) has been utilised. Based on this reported work, the lifecycle cost of effluent recycling per household is $4000 and a household (for infrastructure costing purposes) has an assumed unit population of 2.5. The number of residential households and also the equivalent number of households for the peak tourist numbers were considered as the total number of households in each area and the cost of water supply infrastructure was assumed to be $11,500 per household (Fane, 2005). Irrigation requirements for maintaining green areas such as parklands were evaluated for the peak month of tourist population. However, the small ponds required to capture the storm water from the micro catchments and the conjunction system for storing the surface run-off and possible injection in the aquifers are not considered in the costing estimation in this study.

Chapter 5

CASE STUDY—DAYLESFORD, VICTORIA

The town of Daylesford is located within the Hepburn Shire, approximately 100 kilometres north-east of Melbourne in Victoria. For many years tourism activity at Daylesford has been centred on the presence of mineral springs and spa activities in and around the township. Figure 4 identifies the location of Daylesford in country Victoria.

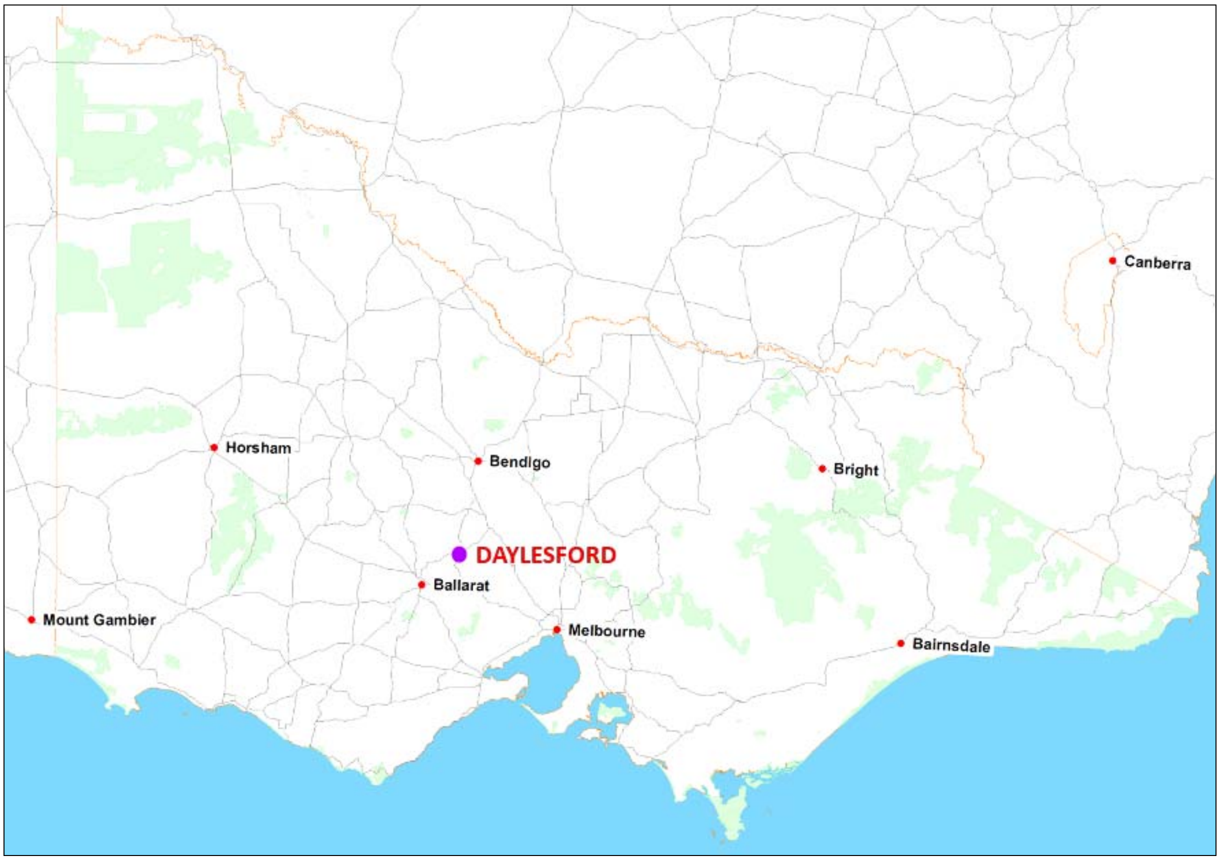


Figure 4: Map of Victoria and location of Daylesford

The Hepburn Shire contains much of the Spa Country attractions in the region and in area is approximately 1500 square kilometres. Figure 5 illustrates the shire boundary and locates the town of Daylesford with surrounding towns and the road network.

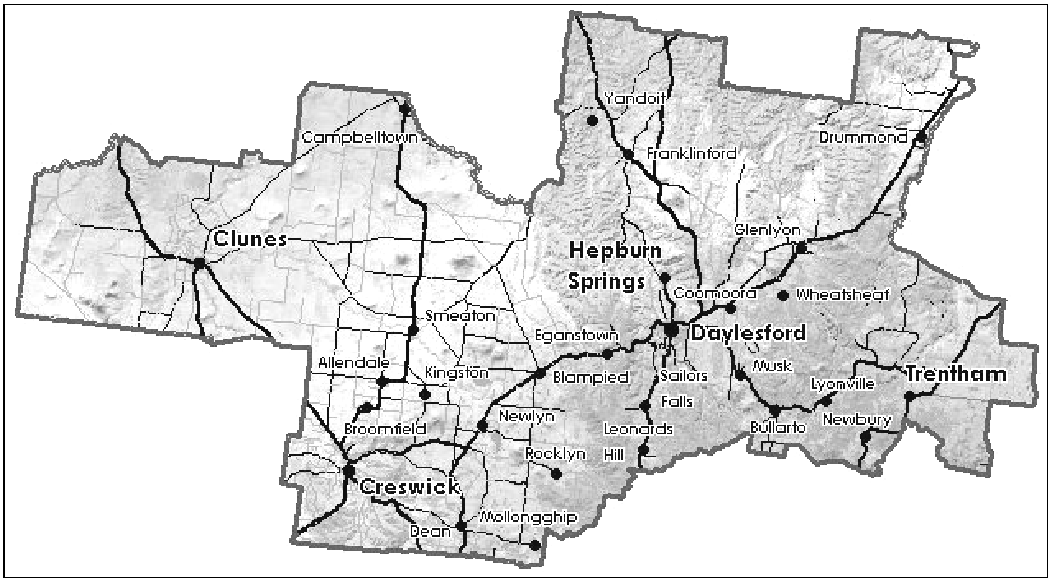


Figure 5: Map of Daylesford located in the Hepburn Shire

Tourism Attractions

With an abundance of natural springs in the region, tourism has for a long time focussed on spa and wellness facilities and services in Daylesford. The largest spa in the region is the Hepburn Spa mineral springs bathhouse and wellness retreat which was founded in 1895 and is located close by in the town of Hepburn Springs. The importance of these types of facilities is evident in the recent Double Life advertising campaign for Daylesford which has been publicised nationally. In addition to this facility there are many other springs in the region such as Peppers Springs and Acqua Vivia Day Spa that offer spa services in addition to mineral water products.

Figure 6: Vincent Street running through the centre of Daylesford town

Figure 7: Hepburn Spa in nearby Hepburn Springs and Hepburn Spa products

Other tourist attractions in the town include galleries, local produce sales including food and wine, natural features such as Lake Daylesford and surrounding forests such as Wombat State Forest and Hepburn Regional Park. Events including the Chill Out Festival and Swiss Italian Festival also attract large numbers of visitors annually. Figures 6 to 10 show some features of the Daylesford region.

Figure 8: Lake Daylesford in Daylesford town

Figure 9: Natural spring water pump in a reserve close to Daylesford

Figure 10: Wombat State Forest in the Daylesford surrounds

Tourist Water Use and Sustainability

Daylesford's water is supplied and monitored by Central Highlands Water with additional interests from the Hepburn Shire Council. Currently the region has Stage 2 water restrictions which by law limit the amount of water to be used when watering outdoor gardens, washing cars, filling pools and other outdoor uses (Figure 11).

Figure 11: Roadside signage reporting current water restrictions in Daylesford

In addition to sustainable residential water usage promoted by the Hepburn Shire Council including strategies to regulating the required rainwater tank provisions at new developments, several local industries employ sustainable practices. Companies such as Cricket Willow cricket bat manufacturers and Friendly Farms have adopted sustainable practices such as recycling water use within their operations.

Definition of Base Year Modelling Scenario

The base year of 2006 has been chosen for this case study and the tourist region is defined as the town of Daylesford. The analysis region definition matches with ABS boundary definitions used in databases such as the Australian Census Tourist Accommodation Survey and Destination Daylesford (Causley and Cox, 2008) tourism audit document. The wider Hepburn Shire Council boundary is used in the zoning definition applied to the IVS – NVS database.

Rainfall

The Australian Bureau of Meteorology's (2009) rainfall records for Daylesford have been made since 1871 and averaged over the past 139 years; the annual rainfall is 876 millimetres with a monthly distribution shown as Figure 12.

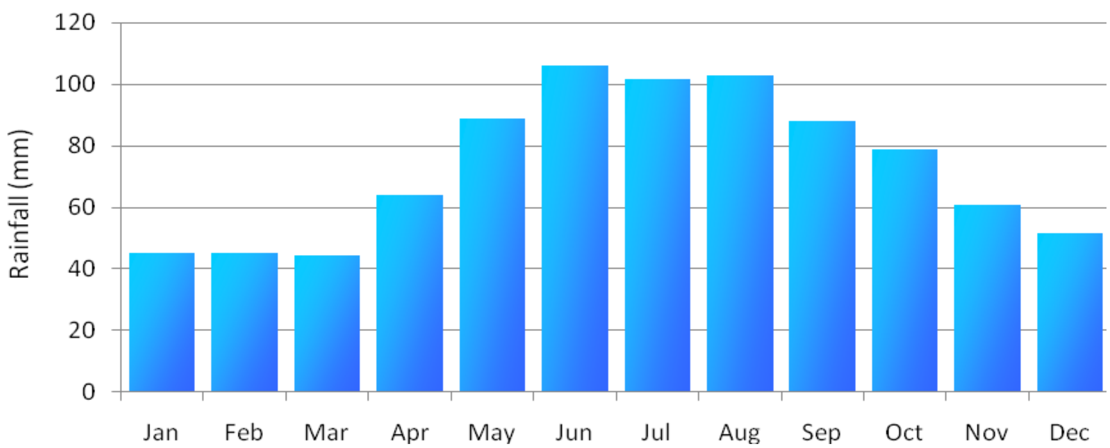


Figure 12: Daylesford average monthly rainfall

Typical of a temperate climate, the maximum rainfall is experienced during the winter months and summers are often quite dry. In more recent years rainfall has been lower than average, resulting in water restrictions in the region.

Available Water Supply and Wastewater Treatment Capacity

Daylesford sources its water from reservoirs located in close proximity. Wombat and Bullarto reservoirs have a combined capacity of 787 megalitres (ML). For drought relief purposes, Coomora Bore is licensed to provide an additional 200ML annually and additional emergency supplies are available from Hepburn reservoir with a 35ML capacity. Average monthly usage from the Wombat and Bullarto reservoirs is depicted in Figure 13.

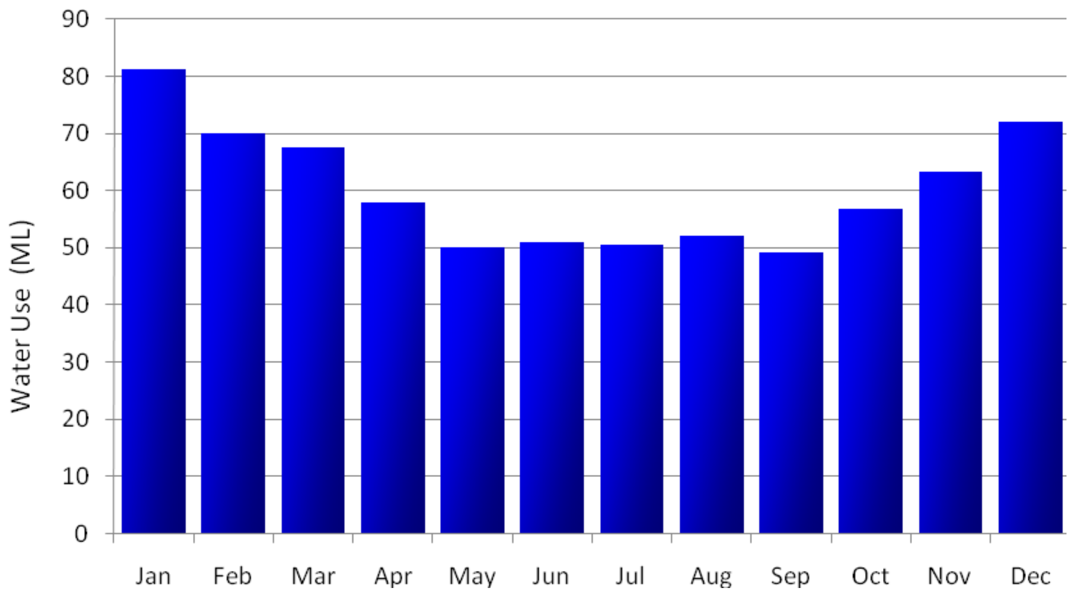


Figure 13: Average monthly usage from the Wombat and Bullarto reservoirs

The total average annual usage is 721.5 ML with a peak monthly use occurring in January with 81.3 ML.

In addition to the reported water reserves, the local aquifers have the potential to contribute to water supplies. One example of this potential is from the Hepburn Spa mineral springs bathhouse and wellness retreat which utilises approximately 10 ML of water annually. Of this total demand, 8.5 ML originates from the local aquifers or is sourced from rainwater. The majority of this water is grey water once it leaves the facility and may be appropriate for re-use.

All of Daylesford's wastewater treatment occurs at Daylesford waste water treatment plant (WTTP) that on average treats 335ML of waste water. Average monthly treatment is represented in Figure 14.

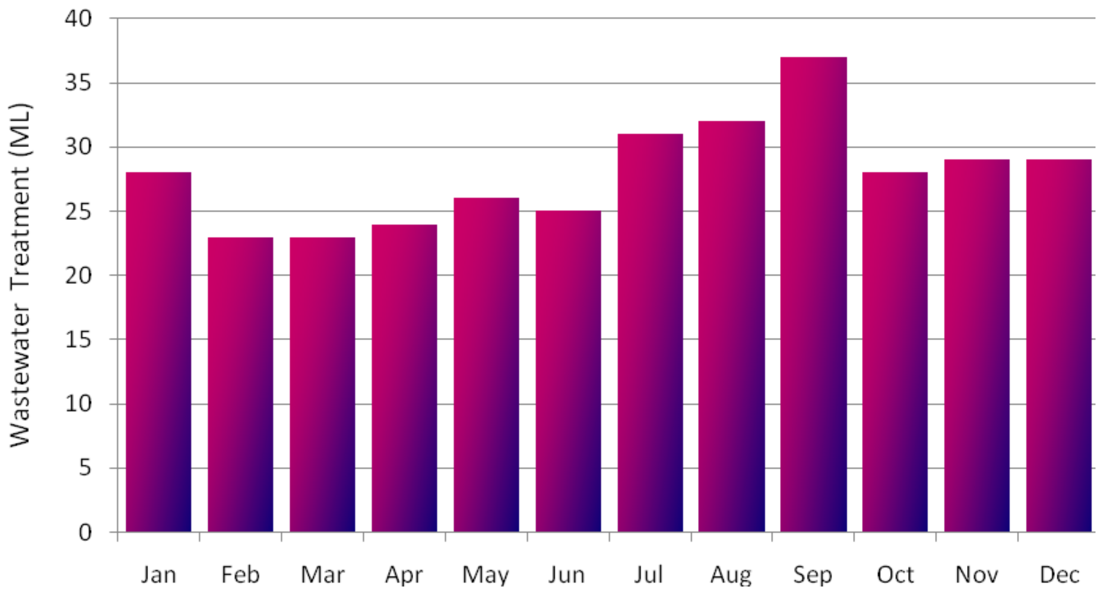


Figure 14: Average monthly waste water treatment at Daylesford WWTP

The Daylesford wastewater treatment plant applies an Intermittent Decant Extended Aeration (IDEA) technique in treatment and has a capacity of 2 ML. The months of February and March have the lowest treatment demand with 23 ML each month and the winter month of September has the peak demand at 37 ML.

Non-Residential Demands

Non-residential water uses in Daylesford are associated with recreational uses such as green areas and swimming pools. The capacity of Daylesford swimming pool is 1.2ML and green areas consist of three ovals (including the school oval) and two parkland regions. The parkland regions include the botanic gardens which have their own water supply.

A more detailed water usage breakdown is provided in the Central Highlands Water report on the Daylesford Water Demand Supply Strategy (Central Highlands Water, 2007), which estimates water usage proportions in Daylesford in Figure 15.

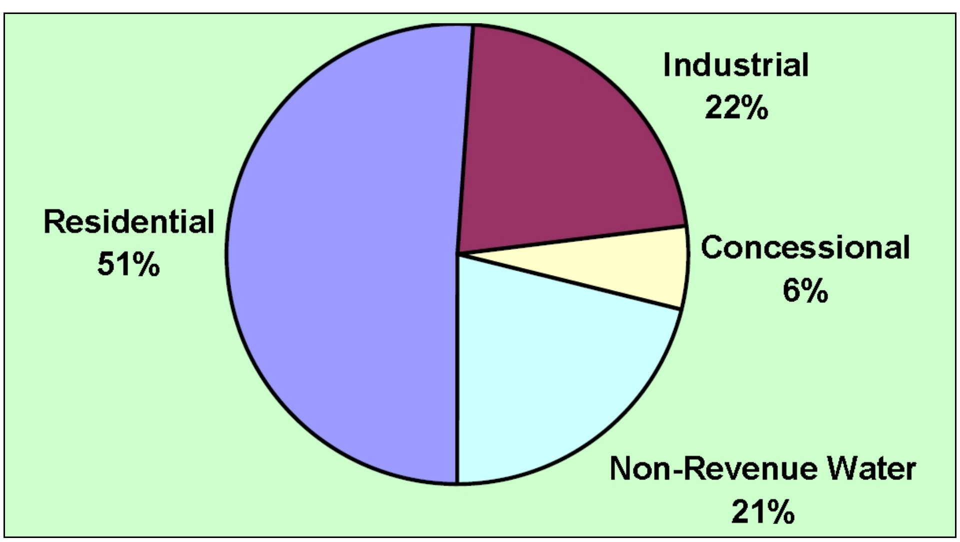


Figure 15: Consumption by user group

Source: CHW (2007)

From this figure it can be observed that the largest proportion of water is used for residential purposes (51 per cent). The remaining 49 per cent is utilised for industrial, concessional and non-revenue uses. Non-revenue can also be considered as un-metered water uses and water losses in the supply system.

Resident Population

The town of Daylesford recorded a total population of 3,073 persons in the 2006 ABS Census (Australian Bureau of Statistics, 2009) with 2,151 private dwellings and 786 families residing. Accommodation and service industries such as cafes, restaurants and general services combined is the single largest employer with approximately 11 per cent of the population employed in these industries followed by schools, hospitals and agriculture industries.

Forecasts of population growth in Daylesford are based on historic population changes since the 1996 Australian Census. Unfortunately data records for Daylesford town have not been published by the ABS since this date; however, they are published for the wider Hepburn East Shire (Table 2), which includes the town of Daylesford. These population figures are therefore considered to be representative of population change in Daylesford.

Table 2: Historic population records for Hepburn East Shire

Census Year	Hepburn East Population
1996	7,075
2001	7,311
2006	7,224

Averaged over the 10-year period, population growth is estimated to be 0.2 per cent annual growth for the Hepburn East Shire. This growth rate is therefore applied to Daylesford in the forecasting of future year population as summarised in following sections of this report. From Table 2 it can be noted that the population has declined between the 2001 and 2006 census. This may be a short-term population anomaly as the decline is small and experienced only since the 2001 census. According to the Hepburn Shire Council, the recent decline in population which the region including Daylesford has experienced may be attributed to younger persons departing the region for larger cities and the sale of housing for bed-and-breakfast type accommodation.

Tourist Population

The IVS – NVS database reports visitor information for the wider Hepburn Shire region which includes Daylesford. From these figures it is possible to estimate the number of visitors to the town of Daylesford with the use of accommodation provisions reported in *Destination Daylesford* Tourism Accommodation Audit document (Causley and Cox, 2008). In 2006 a total of 716,142 persons visited the Hepburn Shire staying a total of 589,843 nights. This total is compiled from trip types defined in Table 3.

Table 3: Hepburn Shire tourist types and visitation characteristics

Traveller Origin Type	Visitors	Visitor Nights
Domestic – Day-trip	446,000	n/a
Domestic – Overnight	265,000	557,000
International – All	5,142	32,843

From Table 3 it is apparent that domestic travellers are by far the greatest proportion of visitors. There are 68 per cent more day-trip travellers as overnight travellers to the region and international visitors are more likely to stay longer with an average of 6.4 nights compared to 2.1 nights for domestic overnight travellers.

Visitors to Daylesford are calculated according the proportion of accommodation provisions in Daylesford in relation to the wider Hepburn Shire. Averaged across all reported accommodation types, the proportion of accommodation the proportion of accommodation in Daylesford equates to 53 per cent. The resulting estimated number of tourists to Daylesford in 2006 is therefore 377,605 persons staying a total of 311,011 nights. Applying the same principle it is possible to estimate historic tourist information from the IVS – NVS database. The following Table 4 reports on tourism activity in Daylesford in the period between 2001 and 2006.

Table 4: Historic visitor data estimated for Daylesford

Year	Total Visitors	Total Visitor Nights
2001	379,545	246,778
2002	383,023	304,365
2003	500,413	312,330
2004	343,468	303,295
2005	382,278	252,013
2006	377,605	311,011

Table 4 contains historic visitor data that allows for the calculation of growth rates and estimation of the average nights per visitor with the average number of nights stayed including day-trip travellers who do not stay overnight. The resulting visitor growth rate equals 2 per cent per annum and visitors stay in Daylesford on average 0.79 nights.

Peak Tourism Season

The peak tourism season is represented by the month with the highest number of tourist visits to Daylesford. This estimate is based on the ABS Tourism Accommodation Survey which records the number of visitors to hotels, motels and serviced apartments with five or more rooms and to caravan parks in Daylesford. The survey reports the number of room/site nights occupied and this is illustrated in the following graph (Figure 16) for the base year.

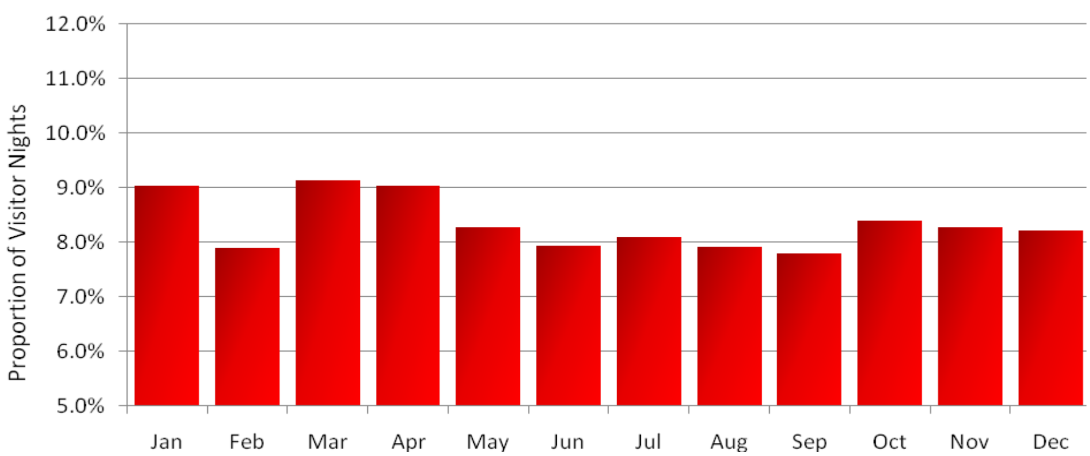


Figure 16: Monthly proportion of 2006 annual visitor nights in Daylesford

From Figure 16 it is evident that Daylesford has a little variation in visitor numbers throughout the year with a 1.3 per cent difference between the highest visitor month of March and lowest visitor month of September. March has a peak of 9.2 per cent of annual nights occupied which, from the total 2006 annual tourists, equates to visitors staying a total of 54,107 nights during this month.

Tourist Population Forecasting

The selected forecast year horizon for Daylesford is the year 2031 with five-yearly increments from the base year. Population forecasts are made for the total resident population and for the annual and peak month of March tourist populations and are based on growth rates estimated in previous sections. These forecast populations are summarised in Table 5.

Table 5: Forecast Daylesford populations

Year	Resident Population	Annual Tourist Population	Peak Month Tourist Population
Base Year 2006	4,981	377,605	34,509
2011	5,033	416,418	38,056
2016	5,055	459,220	41,968
2021	5,086	506,421	46,281
2026	5,108	558,474	51,039
2031	5,140	615,877	56,285

Water Requirements and Wastewater Production

The total water use and wastewater production for residential and tourist population are estimated for the forecast year of 2031. These calculations are based on the water use per capita and wastewater production per capita of Melbourne for Daylesford as shown in Table 6.

Table 6: Residential and tourism population and corresponding water use and wastewater production per capita

City/Town	Residential population	Annual tourist population	Water use m^3/cap	Wastewater m^3/cap
Melbourne	4,002,704	n/a	117.42	82.44
Daylesford	5,140	615,877	117.42	82.44

Calculations of water use take into account 33 per cent (one third) more for both water use and wastewater production for tourists (European Commission, 2000) when compared to local residents. Water use includes the average monthly residential water use, tourism water use in the month with peak number (for Daylesford in March) and the irrigation requirements in the month with the peak tourism number (March). The results of the water use analysis are summarised in Table 7.

Table 7: Total monthly water us at the month with peak tourism population in Daylesford

City/Town	Residential population	Tourist population Peak month	Annual residential water use(GL)	Monthly residential water use(GL)	Monthly tourist water use, peak(GL)	Monthly irrig. water use (GL)	Total monthly water use, peak(GL)
Melbourne	4,002,704	n/a	470	39.17	n/a	n/a	n/a
Daylesford	5,140	56285	0.605	0.0504	0.733	0.063	0.848

The volume of wastewater produced by Daylesford for the forecast year of 2031 is based on the per capita equivalent for Melbourne with the additional consideration that the tourism population is assumed to produce 1.33 times the wastewater that the local residential population produces. This is summarised for Daylesford in Table 8.

Table 8: Total monthly wastewater produced in the month with peak tourism population (March)

City/Town	Residential population	Peak month tourist population	Annual residential wastewater (GL)	Monthly residential wastewater use(GL)	Monthly tourist waste water, peak (GL)	Total monthly wastewater (GL)
Melbourne	4002704	n/a	330	n/a	n/a	n/a
Daylesford	5,140	56285	0.4237	0.0354	0.514	0.55

From the previous calculation summaries, it can be established that for the town of Daylesford, the following total water requirements and wastewater production will be forecast for the year 2031.

The irrigation requirement is calculated based on the CROPWAT model and crop coefficient for lawn and for the area of main green space grounds considering the average annual rainfall.

To calculate lawn water requirement a number of climate data is required such as the minimum and maximum temperature, the wind speed, the relative humidity and the sunshine hours. Since required climate data are not available from the Daylesford weather station, the Eberys weather station (site number 088021) is used for reference evapotranspiration (ET0) estimation. It is the nearest station to Daylesford. Eberys station does not record sunshine and wind speed data, hence the annual average daily sunshine hours of Australia was used to estimate the daily average sunshine for Eberys and the historical wind speed from the Melbourne airport station used for wind speed parameter. The details of climate parameters and finally the water requirements in each month of growing season are summarised in Table 10. Irrigation water requirement for each month is calculated by multiplying the green space area by the irrigation requirements (mm) in the corresponding month.

Table 9: The calculation of irrigation water requirements using the CROPWAT model for Daylesford

	Max tem	Min Tem	RH	Wind speed	Sunshine	ET0	KC	ETc		ETc	rainfall	Irrigation	Irrig. req
	Cº	Cº	%	Km/d	hr	mm/day		mm/day	days/month	mm/month	mm	mm	m^3
Jan	27.5	11.2	48	18.5	8	7.3	0.95	6.935	31	214.99	44	170.99	84210.11
Feb	28.1	12.2	50	16.9	8	6.9	0.95	6.555	28	183.54	43	140.54	69215.95
Mar	25	10.3	56	16.9	8	5.8	0.95	5.51	31	170.81	42	128.81	63438.93
Apr	19.6	7.7	68	16.6	8	3.3	0.95	3.135	30	94.05	64	30.05	14799.63
May	15.6	5.8	78	17.3	8	2	0.95	1.9	31	58.9	87	-28.1	-13839.3*
Jun	12	4	86	18.3	8	1.2	0.95	1.14	30	34.2	102	-67.8	-33391.5
Jul	11.3	3.4	86	20.3	8	1.9	0.95	1.805	31	55.955	105	-49.045	-24154.7
Aug	12.9	3.6	81	21.6	8	3.2	0.95	3.04	31	94.24	104	-9.76	-4806.8
Sep	15.7	4.7	71	22.1	7.5	4.7	0.9	4.23	30	126.9	87	39.9	19650.75
Oct	19.1	6.2	62	21.8	7.5	6	0.9	5.4	31	167.4	82	85.4	42059.5
Nov	22.9	8	54	19	7.5	7.1	0.9	6.39	30	191.7	65	126.7	62399.75
Dec	26	10.2	48	18.7	7.5	4.2	0.95	3.99	31	123.69	50	73.69	36292.33
Annual	19.6	7.3	66	19	8					1516.4	875	641.37	315874.7

In Table 9, the negative values in the last two columns denote that the monthly rainfall exceeds the crop water requirements. Hence there is a surplus of water. In other words, there is no need to irrigate the green spaces. As shown in Table 10, during the year the green spaces should be irrigated except in the months of May, June, July and August.

Storm Water

Storm water is one of the water resources which is readily available and could be captured for residential use or irrigation. The potential amounts of storm water in each region depend on the annual rainfall, area of catchment and the run-off coefficient depending on the permeability of the ground surface.

Based on the residential area of 920.5 ha the average annual rainfall of 875 millimetres and considering an estimated value of 0.4 for the run-off coefficient the potential captured storm water for Daylesford would be calculated as:

$$V = 0.4*920.5(ha)*875(mm)*10^{-5} = 3.22\ GL$$

This amount of storm water may be captured and stored for irrigation or other uses that could be helpful to reduce the problems of potable water availability.

Costing Estimates for Water and Wastewater Infrastructure

The estimation of water and wastewater infrastructure costs for the forecast year of 2031 for Daylesford are based on the forecast residential population of 5,140 and peak month tourist population in March of 56,285 visitors. Table 10 summarises the equivalent number of households and total water supply costs estimate for the town of Daylesford.

Table 10: Estimated total costs of water supply and wastewater treatment for Daylesford

Study area	Household Number	Water supply Cost ($)	Wastewater Cost ($)	Irrigation Cost ($)	Total Water Use Cost ($)	Total Wastewater Cost ($)
Daylesford	2782	31,993,000	11,128,000	296650	32,289,650	11,128,000

According to Fane (2005), the cost of water supply per household ranges from $10,000 to $13,000, therefore this calculation uses an average $11,500. The cost of wastewater effluent recycling per household was assumed to be $4,000 (Fane et al, 2001) and the total cost of sprinkler irrigation systems per ha was taken as $5,000, including capital and annual operation costs. The cost of irrigation water was assumed to be $0.8 per kilolitre with a total green space for irrigation within Daylesford equal to 50 ha. The total irrigation requirements for Daylesford during the peak month total 63,000 kilolitres.

Chapter 6

CASE STUDY—BYRON BAY, NEW SOUTH WALES

The New South Wales coastal town of Byron Bay lies approximately 750 kilometres north of Sydney and 160 kilometres south of Brisbane and is the most easterly settlement on the continent. A range of tourism attractions exist in and around the town including local beaches, national parks, markets, music and other festivals, restaurants and so on. Figure 17 identifies the location of Byron Bay in coastal New South Wales.

Figure 17: Map of New South Wales and location of Byron Bay

The town of Byron Bay is located in the Byron Shire as depicted in Figure 18. This figure illustrates the shire boundary and locates Byron Bay with surrounding localities and topography.

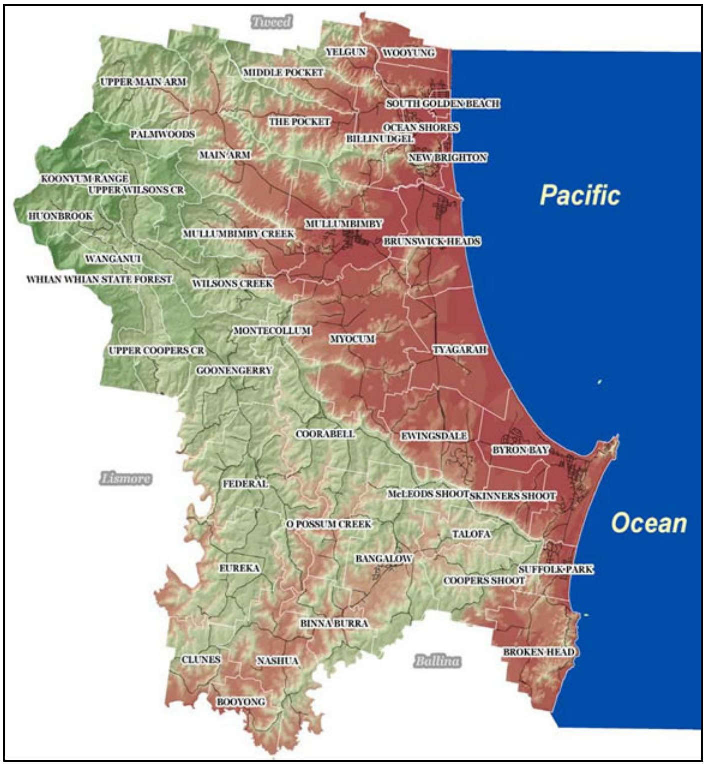


Figure 18: Map of Byron Shire

Source: Byron Shire Council, 2009

Tourism Attractions

Byron Bay town and surrounds offer a diverse range of tourism attractions and activities. Many of these are associated with the beaches and marine parks in the area with aquatic activities such as surfing, swimming, snorkelling and scuba diving popular with visitors.

Figure 19: Beach and surrounds at Byron Bay

The natural scenery of the beaches themselves (e.g. Figure 19) is an attraction along with whale watching in the right season. Australia's most easterly point is at nearby Cape Byron which has a lighthouse and walking trails (Figure 20).

Figure 20: Cape Byron Lighthouse

Nature reserves such as Broken Head, Brunswick Heads and Julian Rocks also attract visitors with diverse flora and fauna. In addition to the attractions associated with nature, Byron Bay is host to several festivals throughout the year. These include the East Coast Blues and Roots Music Festival, Splendour in the Grass Music Festival, the Byron Bay Writers Festival, the Byron Bay Film Festival and the Byron Underwater Festival. The town has many restaurants, pubs and so on for tourists to visit and is a destination that is popular with domestic and international backpacker tourists.

Tourist Water Use and Sustainability

Byron Bay's water supply is provided and maintained by the bulk water authority Rous Water and overseen by the Byron Shire Council. Wastewater services are provided by the Shire council. There are currently no water restrictions in the town with water catchments close to capacity. The Shire Council maintains a policy on water conservation and to promote the conservation of water, council facilities are fitted with low water use devices and are managed to promote efficient water use.

Sustainability of water resources is also an issue as projects such as the Byron Bay Integrated Water Management Reserve project are currently on the agenda. This project includes a 24 hectare Melaleuca wetland regeneration area with a threatened species habitat area that utilises urban reclaimed water. The Reserve also continues to provide reclaimed water for the golf course via the reclaimed water pipeline constructed through Byron Bay as part of the recently completed sewerage augmentation scheme.

In addition, Byron Shire Council actively encourages the use of water conservation measures, including rainwater tanks. Financial incentives are offered for dwellings with 2000 litre plus rainwater tanks.

Rainfall

Rainfall records for Byron Bay from the Australian Bureau of Meteorology (2009) are used since 1950 and averaged over the past 60 years; the annual rainfall is 1717 millimetres with a monthly distribution shown in Figure 21.

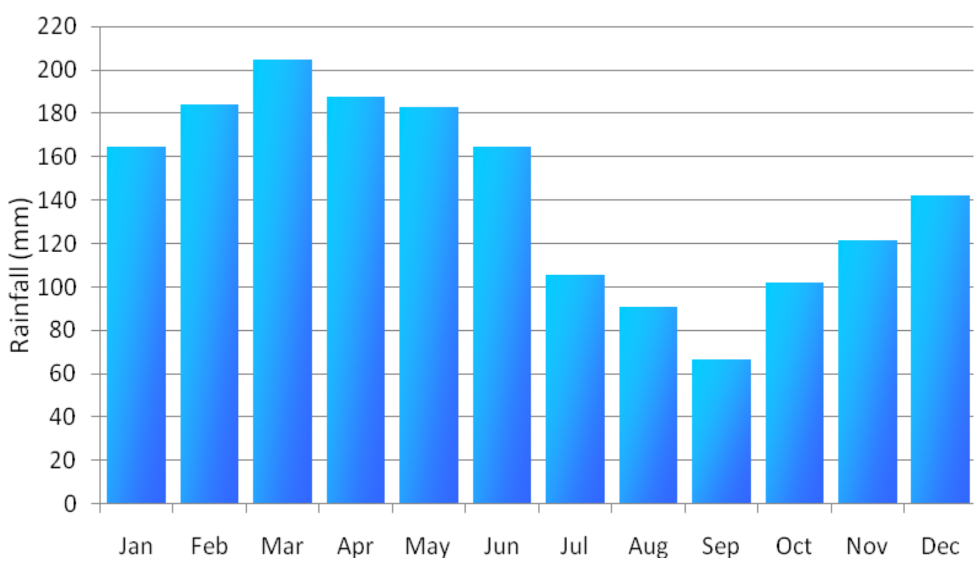


Figure 21: Byron Bay average monthly rainfall

With a sub-tropical climate, Byron Bay's maximum rainfall is experienced during the month of March with most rainfall experienced during the first half of each year. The month of September has the least rainfall on average at 66 millimetres, less than half the rainfall of March with 204 millimetres on average.

Available Water Supply and Wastewater Treatment Capacity

Byron Bay sources its water at reservoirs located in close proximity at Paterson Street, Coopers Shoot and Wategos Beach reservoirs. These Byron Shire reservoirs are fed from a 9.1 ML bulk reservoir located at St Helena, which also supplies reservoirs in Brunswick Heads and Ocean Shores. Averaged between 1996 and 2008, the monthly usage from these reservoirs is depicted in Figure 22.

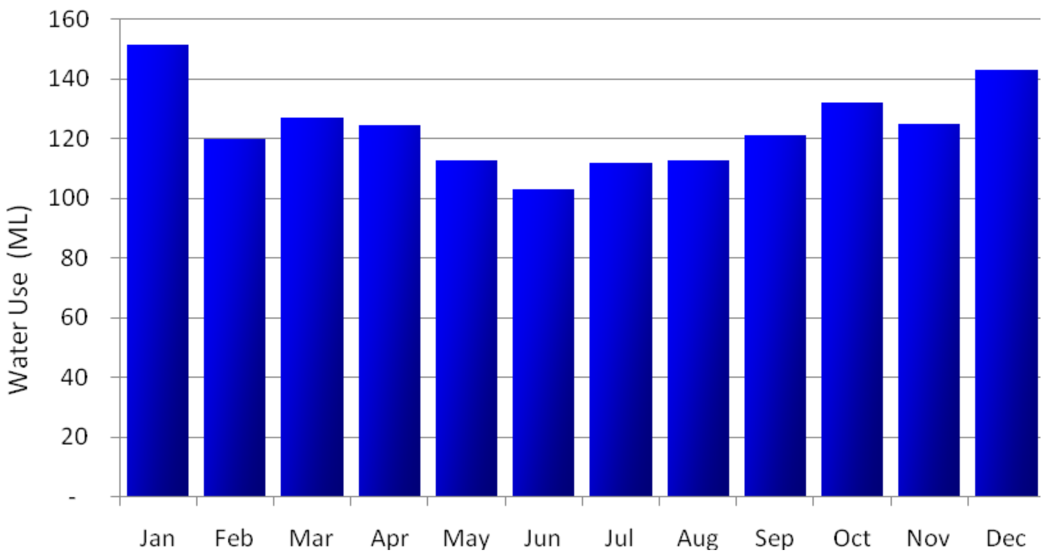


Figure 22: Average monthly water usage from the Paterson Street, Coopers Shoot and Wategos Beach reservoirs

Source: Byron Shire Council, 2009

The total average annual usage in Byron Bay is 1,484.4 ML with a peak monthly use occurring in January with 151ML supply. The water supplier, Rous Water, is a bulk water supplier to the Council supplying water to four constituent Council areas. Rous Water has one major supply dam, St Helena reservoir, and a 70 ML per day filtration plant and a smaller dam and plant. There is also capacity to pump directly from the Wilson River at Lismore and to have several bores. The total yield for all sources is approximately 15,000 ML per annum.

Byron Bay's wastewater is treated at the Byron Bay sewage treatment plant, which on average treats 1,681 ML of wastewater annually. Average monthly treatment is represented in Figure 23.

The Byron Bay wastewater treatment plant has a capacity of 6.95 ML/day and the month of January has most wastewater production at 169 ML, lowest in October at 124 ML. Post-treatment re-use of wastewater annually amounts to 487 ML and is averaged at 41 ML per month.

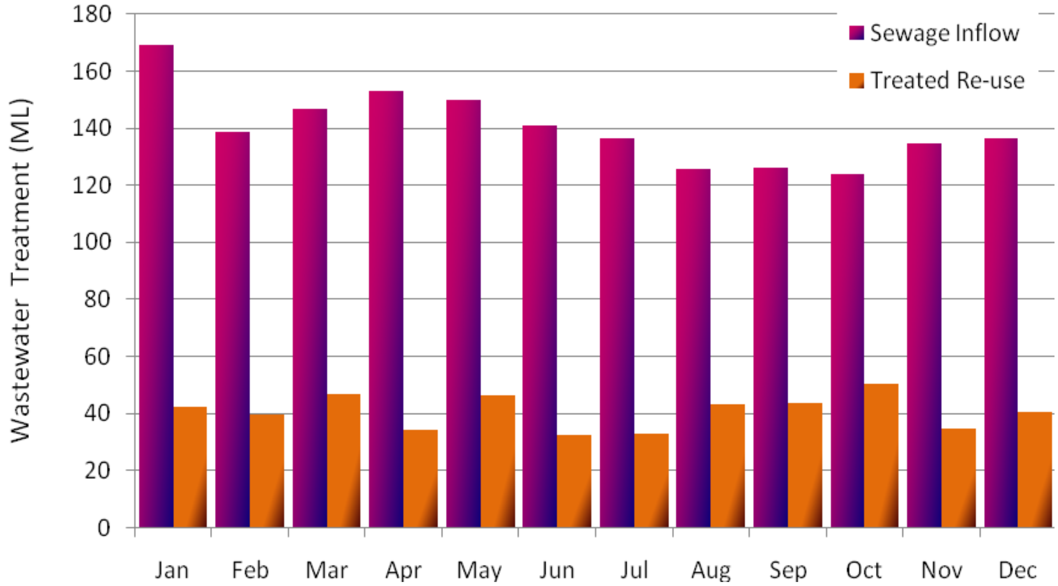


Figure 23: Average monthly waste water treatment and re-use at Byron Bay STP

Source: Byron Shire Council, 2009

Non-Residential Demands

The proportion of mains supply water which is consumed for residential and non-residential use is derived from meter readings in Byron Bay for these respective user types. This is then compared to the bulk water supplied for the same period to gauge water losses in the system. Figure 24 illustrates this breakdown for water supply.

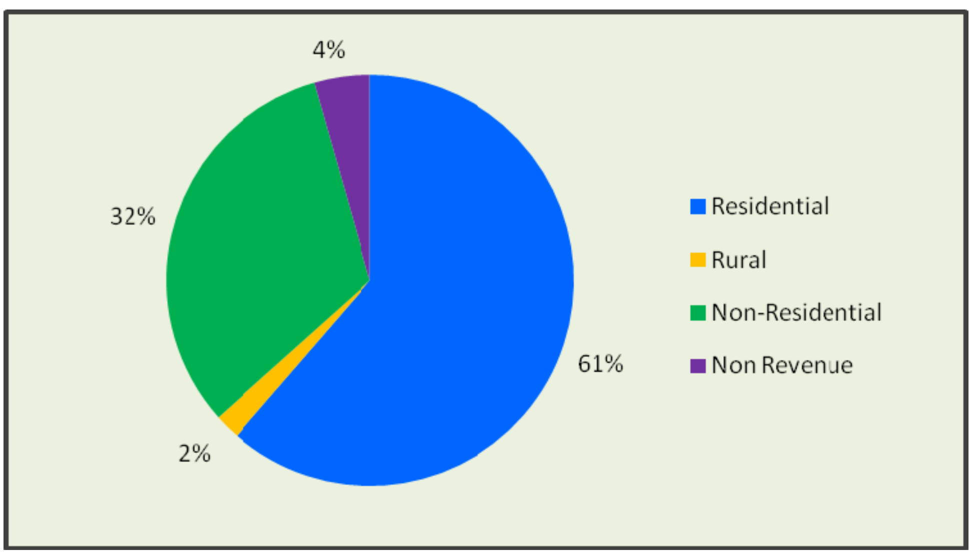


Figure 24: Breakdown of Byron Bay water supply

Figure 24 indicates that 93 per cent of the total water supply is utilised for residential and non-residential (e.g. industrial, retail, commercial) uses. Non-revenue water accounts for system losses and unmetered water supplies.

Resident Population

The 2006 ABS Census reports the town of Byron Bay to have a total population of 4,981 persons with 2,858 private dwellings and 1,028 resident families. Industries associated with tourism such as cafes, restaurants and accommodation are the greatest employers in the town.

Forecasts of population growth in Byron Bay are based on historic population changes since the 1996 Australian Census. Data records for Byron Bay town were not published by the ABS since this date; however, they are published for the wider Byron Shire which encompasses Byron Bay (see Table 11). These population figures are therefore considered to be representative of population change in Byron Bay.

Table 11: Historic population records for Byron Shire

Census Year	Byron Shire Population
1996	27,565
2001	28,916
2006	28,776

Averaged over the 10 year period, population growth is estimated to be 0.4 per cent annual growth for the Shire. This growth rate is therefore applied to Byron Bay town in the forecasting of future year populations.

Tourist Population

The IVS – NVS database reports visitor information for the LGA of Byron as reported for the 2006 base year when a total of 1,303,402 persons visited and stayed a total of 3,101,521 nights. This total is compiled from trip types defined in Table 12.

Table 12: Byron LGA tourist types and visitation characteristics

Traveller Origin Type	Visitors	Visitor Nights
Domestic – Day-trip	655,000	n/a
Domestic – Overnight	474,000	2,055,000
International – All	174,402	1,046,521

From Table 12 it is apparent that domestic travellers are the greatest proportion of visitors. There are roughly equal proportions of day-trip and overnight travellers to the region and international visitors are more likely to stay longer with an average of 6.0 nights compared to 4.3 nights for domestic overnight travellers.

Visitors to Byron Bay are calculated according the proportion of accommodation provisions in the town of Byron Bay in relation to the wider Byron Shire. Averaged across all reported accommodation types, the proportion of accommodation in Byron Bay equates to 68 per cent. The resulting estimated number of tourists to Byron Bay in 2006 is therefore 886,313 persons staying a total of 2,109,034 nights. Applying the same principle it is possible to estimate historic tourist information from the IVS – NVS database. Table 13 reports on tourism activity in Byron Bay town in the period between 2001 and 2006.

Table 13: Historic visitor data estimated for Byron Bay town

Year	Total Visitors	Total Visitor Nights
2001	749,060	216,1683
2002	939,639	215,4286
2003	852,276	212,8172
2004	795,276	201,0360
2005	871,424	1,963,030
2006	881,598	2,097,813

Table 13 contains historic visitor data which allows for the calculation of growth rates and estimation of the average nights per visitor with the average number of nights stayed, including day-trip travellers who do not stay overnight. The resulting visitor growth rate equals 4 per cent per annum and visitors stay in Byron Bay on average 2.4 nights.

Peak Tourism Season

The peak tourism season is represented by the month with the highest number of tourist visits to Byron Bay. This estimate is based on the ABS Tourism Accommodation Survey which records the number of visitors to hotels, motels and serviced apartments with five or more rooms and to caravan parks in Byron Bay. The survey reports the number of room/site nights occupied and this is illustrated in the following graph for the base year (Figure 25).

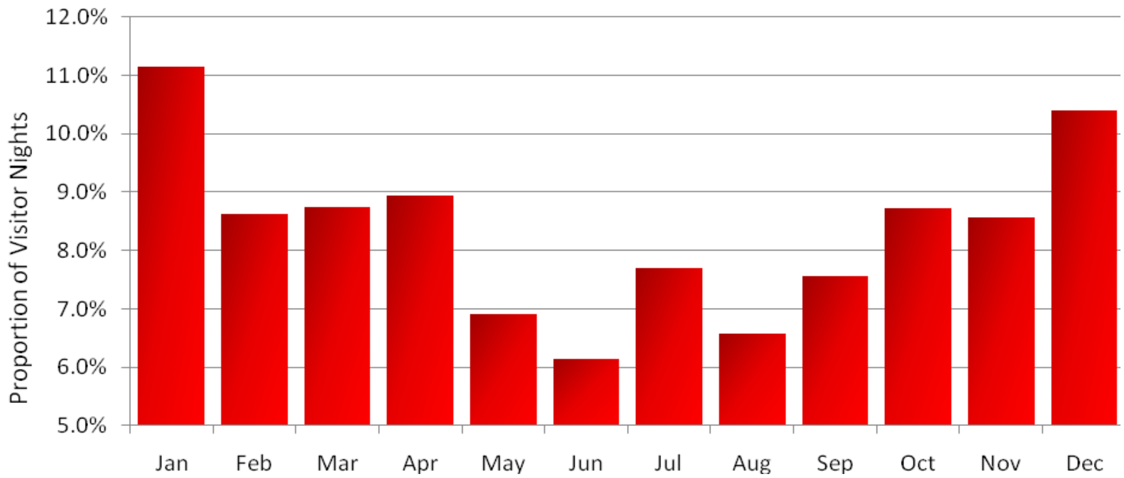


Figure 25: Monthly proportion of 2006 annual visitor nights in Byron Bay

Variation in the previous figure is observed as the high season occurs in the summer months of December and January. June has the least visitors with a 5.1 per cent difference in annual visitors between these months. As the town hosts many festivals throughout the year there is some fluctuation in the monthly visitor proportions. The month of January has the peak tourist population with 11.2 per cent of total annual visitor nights.

Tourist Population Forecasting

The selected forecast year horizon for Byron Bay is the year 2031 with five-yearly increments from the base year. Population forecasts are made for the total resident population and for the annual and peak month of January tourist populations. They are based on growth rates estimated in previous sections. These forecast populations are summarised in Table 14.

Table 14: Forecast Byron Bay population

Year	Resident Population	Annual Tourist Population	Peak Month Tourist Population
Base Year 2006	3,073	881,598	98,351
2011	3,141	1,059,676	118,218
2016	3,209	1,273,725	142,097
2021	3,280	1,531,011	170,800
2026	3,352	1,840,267	205,300
2031	3,426	2,211,991	246,770

Water Requirements and Wastewater Production

The total water use and wastewater production for residential and tourist population are estimated for the forecast year of 2031. These calculations are based on the water use per capita and wastewater production per capita of Sydney for Byron Bay as shown in Table 15.

Table 15: Residential and tourism population and corresponding water use and wastewater production per capita

City/Town	Residential population	Tourist population	Water use m^3/cap	Wastewater m^3/cap
Sydney	4,473,050	-	145.31	93.9
Byron Bay	3,426	2,211,991	145.31	93.9

Calculations of water use take into account 33 per cent more for both water use and wastewater production for tourists when compared to local residents. Water use includes average residential water use, tourism water use in the peak time (January) and the irrigation requirements for green spaces in the time with peak tourism population (January). The results of the water use analysis are shown in Table 16.

Table 16: Total monthly water us at the month with peak tourism population in Byron Bay

City/Town	Residential population	Tourist population peak month	Annual residential water use(GL)	Monthly residential water use(GL)	Monthly tourist water use, peak(GL)	Monthly irrig. water at tourism peak	Total monthly water use, peak (GL)
Sydney	4,473,050	n/a	650	54.17	n/a	n/a	n/a
Byron Bay	3,426	246,770	0.498	0.042	3.974	0	4.016

The volume of wastewater produced by Byron Bay for the forecast year of 2031 is based on the per capita equivalent for Sydney with the additional consideration that the tourism population is assumed to produce 1.33 times the wastewater that the local residential population produces. This is summarised for Byron Bay in Table 17.

Table 17: Total monthly wastewater produced in the month with peak tourism population (January)

City/Town	Residential population	Peak month tourist population	Annual residential wastewater (GL)	Monthly residential wastewater use(GL)	Monthly tourist wastewater, peak (GL)	Total monthly wastewater (GL)
Sydney	4,473,050	n/a	420	n/a	n/a	n/a
Byron bay	3,426	246,770	0.322	0.0268	2.568	2.595

The procedure of calculation for residential water use, tourism water use and irrigation water requirements and also wastewater produced for Byron Bay is similar to the procedure used for Daylesford.

Table 18: The calculation of irrigation water requirements using the CROWAT model for Byron Bay

	Max tem	Min Tem	RH	Wind speed	Sunshine	ET0	KC	ETc	days/month	ETc	rainfall	Irrig. Req	Irrig Req.
	Cº	Cº	%	Km/d	hr	mm/day		mm/day	days/month	mm/month	mm	mm	m3
Jan	27.5	20.8	80	17.5	8	5.07	0.95	4.8165	31	149.3115	164.6	-15.2885	-21984.86
Feb	27.6	20.6	82	18	8	4.28	0.95	4.066	28	113.848	184.4	-70.552	-101453.8
Mar	26.5	19.5	81	17.1	8	4.24	0.95	4.028	31	124.868	204.7	-79.832	-114798.4
Apr	24.5	17.2	79	16.1	8	3.53	0.95	3.3535	30	100.605	187.9	-87.295	-125530.2
May	22	15	75	17.5	8	3.06	0.95	2.907	31	90.117	182.8	-92.683	-133278.2
Jun	19.7	12.5	73	18.7	8	2.87	0.95	2.7265	30	81.795	164.4	-82.605	-118786
Jul	19.3	11.87	71	18	8	2.9	0.95	2.755	31	85.405	105.5	-20.095	-28896.61
Aug	20.3	12.5	70	16.2	8	3.34	0.95	3.173	31	98.363	90.5	7.863	11306.99
Sep	22.2	14.3	71	15.9	8	3.99	0.9	3.591	30	107.73	66.4	41.33	59432.54
Oct	23.3	16.1	74	17.2	8	4.46	0.9	4.014	31	124.434	101.8	22.634	32547.69
Nov	24.7	17.8	77	17.3	8	4.76	0.9	4.284	30	128.52	122	6.52	9375.76
Dec	26.4	19.5	78	17.2	8	5.07	0.95	4.8165	31	149.3115	142.1	7.2115	10370.14
Annual	23.7	16.5	76	17.2	8					1354.308	1717.6	-363.292	-522413.9

In the Byron Bay region, since there is plenty of rainfall, complementary irrigation is only required in the months that the rainfall is less than the crop water requirements. Hence based on the calculation shown in the Table 18 only in months August, September, October, November and December would the complementary irrigation would be needed. The peak irrigation requirement would be in September with 41.33 millimetres or 59,433 m^3. The total irrigation water requirement in Byron Bay for the months that evapotranspiration exceeds rainfall would be 110,034 m^3 (0.11 GL). Considering 20 per cent for irrigation efficiency the total annual irrigation water requirements would be 0.138GL. It is worth noting that in this study the peak number of tourists occurred in January. The crop evapotransapiration and the rainfall in this month are 149.3 millimetres and 164.6 millimetres respectively. The values show that in this month no irrigation would be required.

Storm Water

Storm water is one of the water resources which is easily available and could be captured for residential use or irrigation. The potential amounts of storm water in each region depend on the annual rainfall, area of catchment and the run-off coefficient depending on the permeability of the ground surface. Based on the residential area of 754.5 ha and an average annual rainfall of 1718 millimetres, and considering a run-off coefficient of 0.4, the potential captured storm water for Byron Bay is:

$$V = 0.4*754.5*1718*10^{-5} = 5.18GL$$

This amount of storm water may be captured and stored for irrigation or other uses that could be helpful to reduce the problems of potable water availability.

Costing Estimates for Water and Wastewater Infrastructure

The estimation of water and wastewater infrastructure costs for the forecast year of 2031 for Byron Bay is based on the forecast residential population of 3,426 and peak month tourist population in January of 246,770 visitors. Table 19 summarises the equivalent number of households and total water use costs estimates for the town of Byron Bay.

Table 19: Estimated total costs of water supply and wastewater treatment for Byron Bay

Study Area	Household Number	Water Use Cost ($)	Wastewater Cost ($)	Irrigation Cost ($)	Total Water Use Cost ($)	Total Wastewater Cost ($)
Byron Bay	4661	53,601,500	18,644,000	-	53,601,500	18,644,000

As in the Daylesford case study calculation, the average cost of water supply per household is $11,500, the cost of wastewater effluent recycling per household is assumed to be $4,000 (Fane et al, 2001) and the total cost of sprinkler irrigation systems per ha was taken as $5,000, including capital and annual operation costs. The cost of irrigation water was assumed to be $0.80 per kilolitre with a total green space for irrigation within Byron Bay equal to 144 ha. The total irrigation requirement for Byron Bay during the peak month of tourist population (September) is equal to zero as the rainfall meets the irrigation requirement during this period.

Chapter 7

CONCLUSIONS

The research detailed in this report details a methodology for the investigation of costs associated with water and wastewater infrastructure provision for Australian tourist destinations. A methodology is established to estimate tourist and residential populations for a base year and for a series of forecast future years at the tourism location. Population estimations are based on current and available survey data including regional tourism surveys, international and national visitor surveys and Australian census data. These data are readily available sources and additional data required can be collected with minimal effort. The methodology developed can therefore be applied by local authorities to assist in a development of sustainable water practices.

Water and wastewater requirements for these combined populations at the tourist destination are calculated with inclusions for irrigation based on CROPWAT software outputs. The corresponding cost of water provision and wastewater collection is then summarised, based on the preceding estimations. As a result, the model estimates aggregated water supply and wastewater treatment costs and gives consideration to the sustainable practice of utilising stormwater as a resource for irrigation. A detailed costing may require a more refined analysis as it will be dependent upon the nature of existing water resources (such as distance to the supply and quality of water). Wastewater infrastructure costing may also be dependent upon the involvement of water re-use such as that occurring in Byron Bay.

The methodology is applied to two case study sites, these being Daylesford in Victoria and Byron Bay in New South Wales with full calculations provided for the water and wastewater needs and associated costs for the forecast year of 2031. These two case studies have been selected as two differing examples of tourism destinations to which the modelling methodology can be applied.

The first case study is Daylesford, which is located in the spa country of Victoria and attracts a constant flow of tourists year-round, peaking in March. Daylesford is famous for its mineral springs and associated attractions. From the case study analysis it has been estimated that in the forecast year of 2031, Daylesford will have a resident population of 5,140 and attract 56,285visitors in the peak month of March. The costs associated with this population's demand will be $32,289,650 for the total water demand and $11,128,000 for wastewater treatment. Byron Bay is located on the northern coast of New South Wales and experiences a flow of tourists that peaks heavily in the summer holidays and in particular the month of January. The town has many festival events and attracts tourists to an idyllic coastline. From the case study analysis it has been estimated that in the forecast year of 2031, Byron Bay will have a resident population of 3,426 and attract 246,770 visitors in the peak month of January. The costs associated with this population's demand will be $53,601,500 for the total water demand and $18,644,000 for wastewater treatment.

Included as part of the end product of this research is a computer-based spreadsheet model (as detailed in Appendix A) which includes both the forecasting of future tourist demand at a given site or development and the estimation of the requirements for water and wastewater infrastructure to service future demand, along with estimates of the costs of providing and operating that infrastructure. The model, which has a strong sustainability focus, provides a superior and innovative analysis tool for use by shires and councils throughout Australia.

APPENDIX A: SPREADSHEET MODEL DESCRIPTION

The water and wastewater estimation spreadsheet model (Water_WWater Demand Model.xlsx) includes summary descriptive information and data used in the calculation of forecast residential and tourist populations and respective water and wastewater demands. Modelling procedures utilise resources external to the spreadsheet as data inputs including ABS Census Summaries, tourism audit information, the CROPWAT irrigation water needs model and others.

The model includes the following sheets in the forecasting process as described in the following:

Data

Rainfall and Supply Vol

Average monthly and annual rainfall at the tourism location tabulated and graphed along with total average monthly water supply volumes to the destination. These are summarised from all individual sources which are again tabulated and graphed. Total average monthly treated wastewater volumes from the destination are provided from all individual sources with treated re-use volumes where available.

Census and Audits

This sheet is included to establish a background to the residential population, describe the resident types and employment at the location. The sheet also summarises the amount of tourist accommodation at the study area.

Population data is sourced from the Australian Bureau of Statistics Census database available from http://www.abs.gov.au/), summarised by destination Urban Centre Locality (UCL) for (where possible) 1996, 2001 and 2006 and including information on:
UCL area

- total persons usually resident
- total families
- couple families with children
- couple families without children

One parent families

- other families
- total private dwellings (includes unoccupied private dwellings)

Occupied private dwellings

- separate house
- semi-detached, row or terrace house, townhouse etc.
- flat, unit or apartment
- other dwellings.

Population is also provided for Statistical Local Area as a time series summary of population for 1996, 2001 and 2006. Additional supporting information is provided on industries of employment.

Tourist accommodation summaries are acquired from tourism audit reports on accommodation types such as:

- holiday houses
- caravan/camping
- hotels/motels
- holiday apartments
- B&B/guesthouse

where total accommodation may be summarised in terms of numbers of establishments or available beds.

IVS – NVS

This sheet provides annual tourist flow information including the total number of visitors and the total number of visitor nights where appropriate. This is time series data and in this case the IVS – NVS database is able to provide annual summary information between 2001 and 2008 (only information up to the base year of 2006 is utilised). Tourism figures are provided for:

- international trips
- domestic overnight trips
- domestic day-trips.

ABS Tourist Accommodation 2006

Tourist accommodation summaries are sourced from ABS Tourism Accommodation Surveys (http://www.abs.gov.au/AUSSTATS/abs@.nsf/Lookup/8635.1.55.001Main+Features1Mar%202009?OpenDocument). The base year of 2006 is acquired and monthly data is included to determine the maximum values or the peak month in the following worksheet. The included tourism accommodation types are:

- hotels, motels and serviced apartments with five or more rooms by small area
- caravan parks by small area
- holiday flats, units and houses by small area
- visitor hostels by small area.

The summarised data includes:

- establishments
- rooms
- bed spaces
- persons employed
- guest arrivals
- room nights occupied
- room occupancy rate
- guest nights occupied
- bed occupancy rate
- summaries of operational financial data.

Population Modelling

Within this worksheet, the ABS Tourist Accommodation 2006 Summary section combines the total tourist populations by each accommodation type to determine the peak month and the proportion of visitors n that month. This also infers the tourist populations for the tourist site from the larger region (which may be summarised in the accommodation survey) utilising the site-specific information summarised in the tourism audit reports. The monthly proportions from the accommodation survey apply here also to determine the peak month and proportion of visitors in that month.

The IVS – NVS Summary section tabulates the total annual visitors to the destination between 2001 and 2006 to determine the growth rates and average nights per visitor.

Census Population Growth tabulates the residential population from the 1996, 2001 and 2006 census figures to determine the population growth rate (at the SLA level).

Future Year Forecasting tabulations apply the estimated growth rates to base year (2006) population figures to estimate the future year and peak month residential and tourist populations for 2011, 2016, 2021, 2026 and 2031.

Greenspace

Tourist destination greenspace estimation is made here as required input to the CROPWAT model. This estimation is made from available mapping and other sources and is based on the urbanised region of the tourist destination. This sheet tabulates the total residential area (km^2) which may not be equal to the UCL area provided previously, green space descriptions and the green areas.

Irrigation Requirements

These calculations are based on CROPWAT modelling which provide the spreadsheet model with irrigation water requirements. This sheet provides monthly average values of:

- temperature (maximum and minimum)
- relative humidity
- wind speed
- sunshine hours
- parameters ET0, KC and ETc
- rainfall
- resulting irrigation requirements and volume of water.

Water_WWater

Links to information in previous worksheets including residential and tourist population estimates allow for calculation of total water and wastewater demands of the tourist destination. This estimation bases residential water use on figures acquired from a proxy location and summarises the total water and waste water demands for the tourist location.

Infrastruct_Cost

Establishes the cost of water and wastewater infrastructure based on populations and irrigation requirements.

REFERENCES

Allen, RG., Pereira, LS., Raes, D. and Smith, M. (1998), Crop evapotranspiration—Guidelines for computing crop water requirements—FAO Irrigation and drainage paper 56.

Australian Bureau of Meteorology (2009), *Water and the Land: Forecast Rainfall*, Online: Accessed 16 December 2009, [URL: http://www.bom.gov.au/jsp/watl/rainfall/pme.jsp].

Australian Bureau of Statistics (2009), *Australian Census Data Online*, Online: Accessed 12 October 2009, [URL: http://www.abs.gov.au/].

Causely, K. and Cox, C. (2008), Destination Daylesford—Visitation and Tourism Product Audit, Australian Regional Tourism Research Centre.

Central Highlands Water (2007) Daylesford Water Demand Supply Strategy, Daylesford Water Supply System Strategic Plan 2006–2055

Coombes, P. and Foster, G., (2008) *Responsible Water Use at the Armstrong Creek Development: Analysis of Integrated Water, Stormwater and Wastewater Options*, Bonacci Water, Victoria.

Cullen, R., Dakers, A., McNicol, J., Meyer-Hubbert, G., Simmons, D.G. and Fairweather, J.R., (2003) *Tourism, Water and Waste in Akaroa: Implications of Tourist Demand on Infrastructure*, Tourism Recreation Research and Education Centre (TRREC) Report No. 38, New Zealand.

European Environment Agency (2003), Europe's water. An indicator-based assessment.

European Commission (2000), Towards Sustainable and Strategic Management of Water Resources. Evaluation of present policies and orientation for the future in the Mediterranean basin.

Fane, S. A., Ashbolt, N. J. and White, S. B. (2001) Decentralised Urban Water Re-use: The Implications of System Scale for Cost and Pathogen Risk, IWA–2001 Berlin World Water Congress, Berlin, 2001.

Fane,S.A. (2005) Planning for Sustainable Urban Water Systems Approaches and Distributed Strategies. Institute for Sustainable Futures, University of Technology Sydney.

Government of South Australia (2009). Water for Good, a plan to ensure our water future to 2050. Office for Water Security. Adelaide.

Kavanagh, L.J. (2002), *Water management and sustainability at Queensland tourist resorts*. CRC for Sustainable Tourism, Accessed 10 June 2010, [URL http://www.crctourism.com.au]

McNicol, J., Shone, M. and Horn, C., (2002) *Green Globe 21 Kaikoura Community Benchmarking Pilot Study*, Landcare Research New Zealand Pty Ltd and Tourism Recreation Research and Education Centre (TRREC), Report No. 53/2002.

Otterpohl, R., Grottker, M. and Lange, J. (1997), Sustainable water and waste management in urban areas. *Water Science and Technology*, Vol. 35, No. 9, pp.121–133.

Patterson, M. and McDonald, G, (2004) *How Clean and Green is New Zealand Tourism?*, Landcare Research Science Series No. 24, Menaaki Whenua Press, New Zealand.

SA Water (2009), *Water Treatment*, , [http://www.sawater.com.au/SAWater/Environment/WaterQuality/Water+Treatment.htm]

Stefano, L.D. (2004), *Freshwater and Tourism in the Mediterranean*, WWF Mediterranean Program, Accessed 10 June 2010, [URL http://www.panda.org/mediterranean]

Tourism Forecasting Committee (2009), *Forecast 2009 Issue 1* Tourism Research Australia Canberra.

United Nations Environmental Programme (2001), *Certification programs in the tourism industry*. Martha Honey. UNEP Industry and Environment.

World Wildlife Fund Spain (2003), *Development in the drought. The incompatibility of the Ebro water transfer with sustainable development in the Southeast region of Spain.*

AUTHORS

Michael Taylor

PhD, MEngSc, BEng(Hons), FIEAust, FITE, FCILT, CPEng(NPER3)
Professor Michael A P Taylor is recognised around the world as one of the world's leading travel demand modellers, with special interests in transport-land use interaction, transport network reliability and analysis of the environmental impacts of transport systems. He is the Director of the Institute for Sustainable Systems and Technologies (ISST) at the University of South Australia. ISST–Transport Systems is a national centre of excellence in transport systems modelling, travel demand modelling, traffic simulation and transport policy analysis. It has pioneered the use of the use of GIS platforms for travel demand modelling and analysis, traffic management and control models, and the development of modelling tools for travel demand estimation and transport network analysis.

Email: Michael.Taylor@unisa.edu.au

Simon Beecham

PhD, BSc(Hons), GCHE, FIEAust, CPEng(NPER3)

Simon Beecham is Professor of Sustainable Water Resources at the University of South Australia. He is also Head of Civil Engineering and Director of the South Australian Water Centre for Water Management and Re-use (CWMR). Simon is also a Board Director for Water Quality Research Australia (WQRA). Simon's research interests include water sensitive urban design (WSUD), siphonic roofwater harvesting and the effects of climate change on total water cycle management (TWCM). In the last two years he has been awarded both Australian Research Council (ARC) Discovery and Linkage grants. Overall his Centre, CWMR, holds seven current ARC funded research grants. Simon is also the author of the Syfon software program which has been used to design the roofwater harvesting system for Sydney's Stadium Australia, as well as the siphonic roof drainage systems at the Norman Foster designed Chek Lap Kok airport in Hong Kong and the new International Terminal Buildings at Adelaide, Sydney and Kuala Lumpur airports.

Email: Simon.Beecham@unisa.edu.au

Modelling tourism demand, and estimating costs of water provision and operation

Nicholas Holyoak

PhD (Built Environment), BEng (Civil, Hons)

Since 2004, Nicholas has been a member of the Institute for Sustainable Systems and Technologies – Transport Systems Group as a Research Fellow involved principally with transportation behaviour and demand modelling research. He has detailed familiarity with a range of software including various transportation modelling, GIS, choice modelling, statistical and data management packages. Nicholas also has a detailed knowledge of Australian survey databases including the Australian Census, TRA's tourist survey databases and household-based surveys with experience in data interpretation and analysis. He has been involved in a number of transportation related research projects including the development of multimodal demand forecasting tools, environmental impact models, tourism-related travel research and the assessment of on transport system policies.

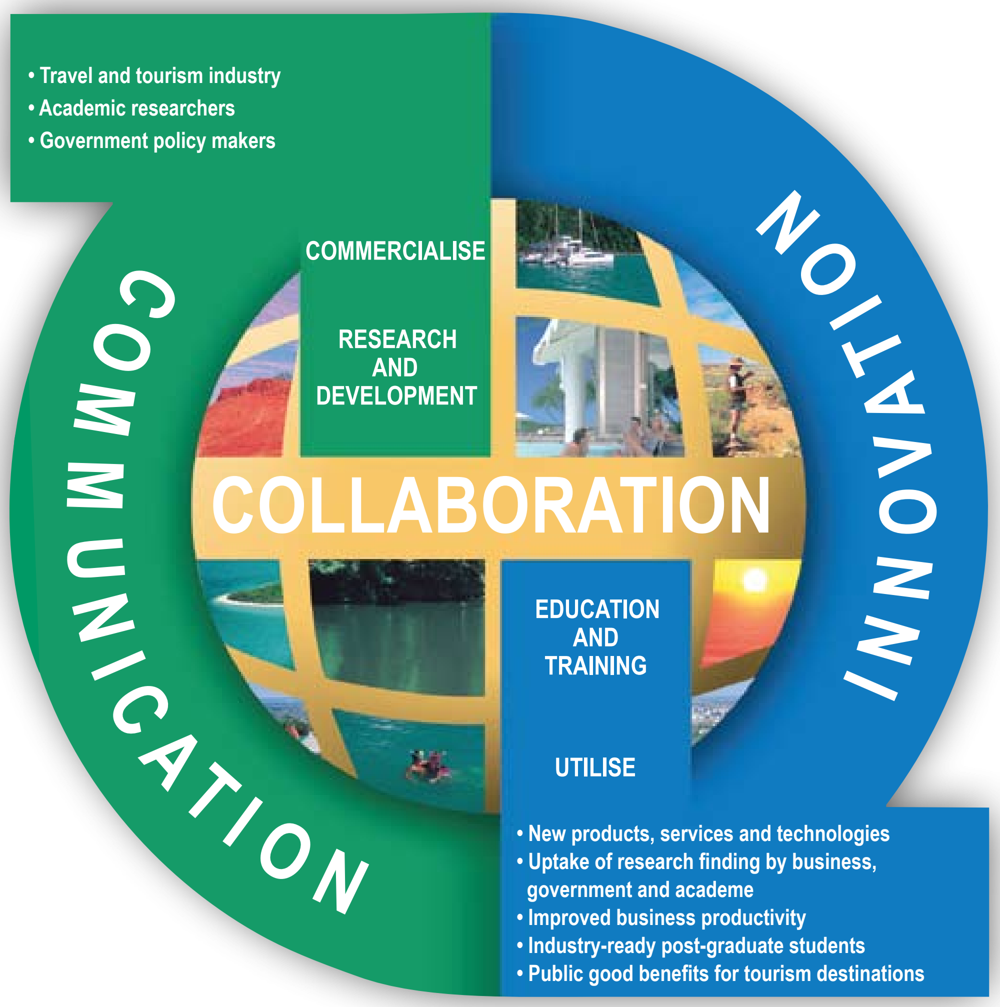
Email: Nicholas.Holyoak@unisa.edu.au

Ali Hassanli

BSc, PGD, PhD

Ali Hassanli is Associate Professor at Shiraz University and senior research fellow at University of South Australia, the Centre for Water Management and Re-use (CWMR). Ali has a long international experience in research and academic activities in water management, sustainable use of water and wastewater re-use, water use efficiency and environmental degradation management. Ali has graduated in Irrigation Engineering from Shiraz University, Hydraulic Engineering (soil and water development) from IHE-UNESCO institute and Water Engineering from Adelaide University. He has undertaken many research projects overseas and in Australia, published more than 35 research papers in international journals, two books, a book chapter and supervised several postgraduate students.

Email:Ali.Hassanli@unisa.edu.au



INDUSTRY PARTNERS

UNIVERSITY PARTNERS

COMMERCIALISATION

EVALUATE COMMUNICATE EVOLVE

EC3, a wholly-owned subsidiary company, takes the outcomes from the relevant STCRC research; develops them for market; and delivers them to industry as products and services. EC3 delivers significant benefits to the STCRC through the provision of a wide range of business services both nationally and internationally.

An Australian Government Initiative

KEY EC3 PRODUCTS

Chairman: Stephen Gregg
Chief Executive: Ian Kean
Director of Research: Prof. David Simmons

CRC for Sustainable Tourism Pty Ltd
Gold Coast Campus Griffith University
Queensland 4222 Australia ABN 53 077 407 286

Telephone: +61 7 5552 8172 Facsimile: +61 7 5552 8171
Website: www.crctourism.com.au
Bookshop: www.crctourism.com.au/bookshop
Email: info@crctourism.com.au

SUSTAINABLE
TOURISM
CRC

Sustainable Tourism Cooperative Research Centre (STCRC) is established under the Australian Government's Cooperative Research Centres Program.

STCRC is the world's leading scientific institution delivering research to support the sustainability of travel and tourism—one of the world's largest and fastest growing industries.

Introduction

STCRC has grown to be the largest dedicated tourism research organisation in the world, with $187 million invested in tourism research programs, commercialisation and education since 1997.

STCRC was established in July 2003 under the Commonwealth Government's CRC program and is an extension of the previous Tourism CRC, which operated from 1997 to 2003.

Role and responsibilities

The Commonwealth CRC program aims to turn research outcomes into successful new products, services and technologies. This enables Australian industries to be more efficient, productive and competitive.

The program emphasises collaboration between businesses and researchers to maximise the benefits of research through utilisation, commercialisation and technology transfer.

An education component focuses on producing graduates with skills relevant to industry needs.

STCRC's objectives are to enhance:

- the contribution of long-term scientific and technological research and innovation to Australia's sustainable economic and social development;
- the transfer of research outputs into outcomes of economic, environmental or social benefit to Australia;
- the value of graduate researchers to Australia;
- collaboration among researchers, between searchers and industry or other users; and
- efficiency in the use of intellectual and other research outcomes.