Code of Practice

# Irrigated Public Open Space

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# ACKNOWLEDGMENTS

The development of the *Code of Practice for Irrigated Public Open Space* (IPOS) was supported by SA Water as part of the State Government's *Water Proofing Adelaide Strategy* and was managed by IPOS Consulting Pty Ltd reporting to the following reference group;

- SA Water
- SA Local Government Association
- Murray Darling Association
- Local Government Turf & Irrigation Technical Group
- Irrigation Australia Limited, SA Region
- Australian Golf Course Superintendents Association, SA
- Parks & Leisure Australia
- Bureau of Meteorology
- Turf Grass Australia, SA Region
- Department of Education & Children's Services
- Botanic Gardens of Adelaide.

The specific input provided by the following organisations is acknowledged:

- Rural Solutions SA and HydroPlan Pty Ltd (for technical advice in developing irrigation requirements).
- Mircomet Pty Ltd (for technical input and the development of the TQVS classifications).
- University of Melbourne (for technical input and provision of graphics).

In addition, the input of the many industry representatives who attended industry workshops is much appreciated.

**Disclaimer**

The Code has been developed using a range of information sourced from the public domain and provided by industry representatives. Every effort has been made to verify and correctly source information used to avoid errors or oversights but it is recognised that some may exist. It is also recognised that technology and management methods are changing with time and the methods used in the Code are not the only viable methods to achieve the outcome of efficient irrigation management.

# EXECUTIVE SUMMARY

The Code of Practice for Irrigated Public Open Space (IPOS) provides a template which can be used by open space managers to ensure the planning, management and reporting of water consumption in the urban environment is based on sound principles applied consistently at all levels of management.

The Code can be used by providers, practitioners, and regulating authorities to set policy, manage resources and regulate water use in the provision of irrigated public open space.

The Code provides a management framework for best practice turf and irrigation management for all irrigated public open space, including that managed by local government, the education sector and other IPOS managers. It forms the basis by which the industry can demonstrate efficient, effective resource management.

A commitment to managing irrigation is the first and most critical step to realising water efficient irrigation practices.

While the principles contained within the Code can be applied to all aspects of irrigated public open space, the Code specifically addresses irrigated turf rather than trees, landscape and ornamental gardens.

## Aim

The aim of the Code is to provide the tools and reporting models necessary to implement best practice irrigation management in the provision of public open space.

This Code seeks to provide the following to potential subscribers:

1. The need for developing a Turf and Irrigation Management Plan.
2. The benefits of adopting the Code.
3. The tools and reporting models necessary to implement best practice irrigation management.

## Benefits

Subscription to the Code brings significant benefits not only to the subscriber but to the community and environment in a broader context. These benefits may be summarised as:

1. 'Fit for purpose' turf.
2. Significant water savings translating into reduced watering costs.
3. Increased flexibility for the irrigator in the case of water restrictions.
4. Recognition of the level of irrigation efficiency in assessing exemption applications in the case of restrictions.
5. Efficient irrigators are not penalised for efficiencies already demonstrated.
6. Community recognition/accountability/demonstration of efficient watering practices.
7. Potential aversion of public health and safety issues – particularly in the case of school ovals and sporting grounds.
8. Increased amenity levels associated with appropriately irrigated public open space.

## The model explained

Turf must be maintained to a level that ensures it is 'fit for purpose' and meets its functional objective. A passive irrigated area can be maintained using up to 50% less water than required for an active sportsground.

Benchmark application rates provide a guide to how much water is required on an annual basis to sustain turf at the designated quality level based on average climatic conditions. These benchmarks are expressed in kL/hectare/annum and provide an indication of the quantum of savings available.

In determining the benchmark application rates for the various turf quality levels ranging from elite sports fields to passive recreational areas, the critical factors used can be replicated for any geographic area for which local climatic data is available.

As climatic conditions vary significantly from long term averages in any given year, the Code uses current climatic data provided by the Bureau of Meteorology to determine the irrigation requirement for the current period.

Evaporation rates and rainfall can vary significantly from region to region. However the factor which remains constant is the need for an appropriately designed and managed irrigation system for which scheduling is constantly amended to account for changing climatic conditions and plant water requirements.

**Factors employed to determine the irrigation requirement:**

1. Plant water requirement or evapotranspiration (ETc) based on weather conditions.
2. Functional objective and quality standard of the turf.
3. Irrigation system application efficiency – distribution uniformity of 75% is assumed (in-field).

**Factors used to develop an irrigation schedule:**

1. Soil type and it's water holding capacity.
2. Plant root zone depth.
3. Irrigation requirement.
4. Irrigation system application rate.
5. Site irrigation time constraints.

**Factors used to monitor irrigation efficiency**

1. Irrigation water applied for a given period.
2. Irrigation water required for a given period.
3. Fit for purpose standard of turf.

Using the models developed in the Code, the irrigation manager can demonstrate performance in turf and irrigation management.

## Where will the water savings come from?

Water savings on large irrigated sites are rarely available during the peak irrigation season. Generally, there is a default level of efficiency at these sites due to the number of irrigation stations and nights per week on which the system may be operated.

Water savings will come largely from system scheduling during the shoulder periods either side of the peak season. Significant savings are also generally available at smaller sites where system constraints are not so much of an issue.

Irrigation systems (particularly older systems) may have been poorly designed, resulting in significantly greater water use than would otherwise be required. The Code assumes a distribution uniformity of greater than 75% (in-field) which effectively means poorly functioning systems must be upgraded and or replaced, with irrigation auditing required to assess system performance.

Ultimately the savings will be largely delivered by the ongoing monitoring and reporting of irrigation performance and adjustment of irrigation scheduling to match climatic conditions.

# 1.0 FOREWORD

## Key principles outlined in the Code of Practice - IPOS

*OBJECTIVE: To provide fit for purpose turf based on efficient irrigation management and sound horticultural practices.*

To deliver on this, subscribers to the Code will need to make a commitment to:

MEASURE > MONITOR > MANAGE

There are six steps to the process outlined within the Code:

1. Implement a strategic approach to irrigation management underpinned by a policy statement and commitment by an organisation to appropriately resource and manage the irrigation of sites.
2. Ensure systems are functioning to the appropriate performance standard with periodic system audits and ongoing regular maintenance.
3. Ensure an appropriate horticultural maintenance program is in place to maintain soil structures and turf nutrient requirements.
4. Determine the baseline irrigation requirement using long term average climatic data to set the monthly irrigation schedule.
5. Amend the base irrigation schedule on a regular basis to account for climatic variance from the long term average in any given season. This will ensure turf is receiving the water requirement to maintain it at the appropriate quality level.
6. Monitor irrigation consumption against irrigation requirement and report on irrigation efficiency and turf quality.

On average the River Murray provides about 40% of Adelaide's mains water. However in a drought year this can be as high as 90%. It also supports a large number of country towns, rural communities and regional industries.

The River Murray is of paramount importance to future water availability in South Australia. Combined with water sourced through catchments in the Mt Lofty Ranges it is the major source of fresh surface water in the State.

South Australia's water allocation from the River Murray is determined every year and takes the total available water in the river system into account. The historical annual average flow of water into South Australia is around 4000 GL per year. This average was not reached in the period between 2002 and 2007 and the health of the river has suffered as a result.

In 2003 the SA community faced the first water restrictions since the construction of the Mannum to Adelaide pipeline in 1954. The reduction in rainfall across the Adelaide Hills in 2002 was not particularly significant against long-term averages but combined with several years of low rainfall across the Murray-Darling Basin it helped to cement the realisation that South Australia needed to do more to manage its water supplies in a sustainable manner.

The introduction of Permanent Water Conservation Measures in 2003 was the catalyst for the Local Government Turf and Irrigation Technical Group (LGTITG), comprised of a range of SA Councils, Irrigation Australia Limited (IAL), Murray Darling Association (MDA), Parks and Leisure Australia (PLA) and the Local Government Association (LGA) to consider actions that may assist to reduce water consumption.

The LGTITG set out to formulate a solution that would satisfy the government's water saving targets while providing flexibility for the management of community assets, rewarding those willing to commit to improving irrigation efficiency through the implementation of best practice irrigation.

The Code provides a template which can be used by managers of IPOS to ensure the planning, management and reporting of water consumption in the urban environment is based on sound principles applied consistently at all levels of management.

# 2.0 INTRODUCTION

## 2.1 Why develop a Code?

The SA Government has committed to implement a series of initiatives to ensure that even in drought years the impacts of low water availability on the broad community of South Australia can be effectively managed. The development of *Code of Practice for Irrigated Public Open Space* (IPOS) is a strategic initiative of the Waterproofing Adelaide Strategy (WPA).

The WPA Strategy No 33 states -

*"A Code of Practice that encourages irrigation efficiency for public purposes water use will be developed by the SA Government in consultation with the Irrigation Association of Australia, Local Government Association of SA, Botanic Gardens and sporting associations".*

Water for community purposes has been identified under the WPA Strategy as water used by government agencies, universities, schools, local government, public parks and gardens, sporting grounds, places of worship and hospitals. The majority of this water is used to maintain Adelaide's amenity, particularly parklands, open spaces and gardens. During 2003 community purposes water use represented about 13% (25,000 ML) of total mains water use.

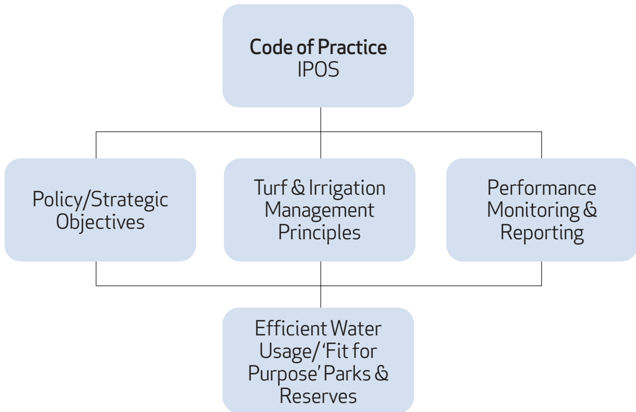
Irrigating parks, gardens, ovals and sports fields uses approximately 15,000 ML per year. A significant amount of water is also taken from groundwater or surface water resources. Through more efficient irrigation practices there is the opportunity to reduce mains water use for public purposes by at least 20% (about 3,000 ML per year).

The Code has been developed by a reference group established by SA Water as the Government's lead agency. Members of the Reference Group included:

- Local Government Association of SA
- Local Government Turf & Irrigation Technical Group
- Murray Darling Association
- Irrigation Australia Limited, SA Region
- Australian Golf Course Superintendents Association, SA Region
- Parks & Leisure Australia
- Bureau of Meteorology
- Turf Grass Australia, SA Region
- Department of Education & Children's Services
- Botanic Gardens of Adelaide.

## 2.2 What is the aim of the Code?

This Code explains how best to plan, manage and report water use for irrigated public open space, ensuring water use efficiency and 'fit for purpose' sports turf, recreational parks and reserves.




While the principals of the Code can be applied to all aspects of irrigated public open space, the Code specifically addresses irrigated turf rather than trees, landscape and ornamental gardens.

The aim of the Code is to provide the tools and reporting models necessary to implement best practice irrigation management for irrigated public open space.

## 2.3 What are the benefits of using the Code?

Irrigators of public open spaces who subscribe to the Code will realise significant benefits, not only to the subscriber, but to the community and the environment.

Benefits include:

- Significant water savings translating into reduced watering costs.
- Increased flexibility for the irrigator in the case of an escalation of water restrictions.
- Recognition of the level of irrigation efficiency achieved.
- Efficient irrigators are not penalised for efficiencies already demonstrated.
- Community recognition of efficient watering practices.
- 'Fit for purpose' recreational turf facilities.
- Potential aversion of health and safety issues – particularly in the case of school ovals and sporting grounds.
- Increased amenity levels associated with appropriately irrigated public open space.

## 2.4 Who should use the Code?

This Code should be used by everyone involved in the management and operation of irrigation systems for IPOS. The Code covers all areas from policy, planning, operation to performance monitoring and reporting. Those who should use the Code are:

- Managers of irrigated public open space.
- Irrigation consultants and designers.
- Irrigation equipment suppliers.
- Irrigation installation and maintenance contractors.
- Irrigation technical officers.
- Horticulture and irrigation operations staff.

## 2.5 What is the legal status of the Code?

The Code provides advice on how to manage irrigation water use efficiently. It is a voluntary Code that is not linked to any regulation or legislation.

The Code sets out principles that can be implemented to ensure best practice turf and irrigation management. Irrigation managers and consultants may already be operating at best practice and above. The methods described in the Code may be adapted or altered to suit individual organisations or as circumstances require.

SA Water endorses the Code and its implementation may be linked to the assessment of applications for exemptions from modifications to water restrictions.

## 2.6 What other advice is available?

The Code has drawn on a wide range of technical documentation and sources in the public domain. A bibliography of reference material is included at the end of each section of the Code.

## 2.7 Glossary of terms and abbreviations

A glossary of terms and abbreviations is included as Appendix No 5 of the Code.

# 3.0 POLICY & PLANNING

## 3.1 Water use policy

In order to ensure that the issue of sustainable water management is a priority for the organisation, a clear policy statement is required. This statement should outline the commitment to sustainable water use in the management of Irrigated Public Open Space (IPOS). The policy should be succinct and be able to guide future decisions in relation to the provision and management of IPOS.

The policy should address the planning and development of new sites and should be used to assess the appropriateness of current irrigated sites.

The objectives of this policy are to:

- Achieve a balance between the provision of an amenity landscape that is aesthetically pleasing, meets the needs of the community and is economically and environmentally sustainable.
- Implement the principles of water sensitive urban design to achieve integration of water cycle management into urban planning and design.
- Achieve a consistent approach in the provision and development of the irrigated landscape.
- Provide a clear direction and framework for irrigation and water management strategies to enable water conservation and financial savings to be achieved.

The policy must be endorsed by the organisation at the highest level.

### **EXAMPLE:** ISSUES TO BE ADDRESSED IN THE WATER USE POLICY

- **Water supply**
  Where possible sources other than potable mains water should be identified and investigated for use on IPOS.
- **Environmental and water quality management**
  Steps must be taken at the planning and design stage to ensure irrigation has minimal negative affects on the surrounding environment and natural drainage systems. Water sensitive urban design principals must be considered and implemented when planning the development of IPOS.
- **Best practice irrigation management**
  All sites irrigated should adopt the principles of best practice in regard to design, installation, maintenance and scheduling.
- **Functional benefit of IPOS**
  The provision of IPOS should be based on an assessment of the functional benefit of the site. Irrigation should only be provided where there is a clear functional benefit (eg sports ground, picnic area). The area being irrigated should be the minimum required to achieve the functional objective, complimented by dry-landscape treatments. Areas with low function but high aesthetic value (eg verges, entry statements) should be restricted to water supply sources other than mains potable water.
- **Water efficiency management planning and reporting**
  All sites should be covered under a water efficiency management plan and reporting process that monitors irrigation efficiency and the quality and 'fit for purpose' standard of the turf.

## 3.2 Water use objectives

Water use objectives are specific statements which provide a framework within which the policy will be achieved. From the objectives come actions and priorities which must be followed to successfully implement the policy.

Water use objectives and strategic actions require funding and the allocation of resources. As such they must be achievable and endorsed by the organisation at the highest level.

FURTHER INFORMATION:
WATER MANAGEMENT POLICY & PLANNING

Connellan, G. Water Management Plan Guidelines, Victorian Golf Association, Vic. November 2005. www.golfvic.org.au

Connellan, G. Water Management Plan Template, Victorian Golf Association, Vic. November 2005. www.golfvic.org.au

Melbourne Water. 2005. Water Sensitive Urban Design – Engineering Procedures (Stormwater). CSIRO Publishing. http://www.publish.csiro.au

### EXAMPLES OF WATER USE OBJECTIVES

- *"To develop a Turf and Irrigation Management Plan for the organisation."*
- *"To audit all irrigation systems to determine their operating efficiency."*
- *"To fund irrigation system upgrades where current performance is below best practice benchmarks."*
- *"To ensure staff have the appropriate skills or access to these skills to ensure efficient turf and irrigation management of IPOS."*
- *"To investigate the viability of alternate water supply options and set targets for replacement of current mains water supply."*

# 4.0 WATER SUPPLY OPTIONS

The sustainability of mains water supply for use in irrigation of public open space is questionable. Alternative water sources to mains supply should be investigated and identified. Where viable they should be developed for irrigation purposes. Alternative water supplies include bore water, effluent water and stormwater. Where alternative supply options prove viable, targets for the development of these supplies should be set.

Information on the availability of alternative water sources can be gained from government departments responsible for the management of water resources.

- Potable mains and recycled effluent
  - SA Water Corporation
    www.sawater.com.au
- Groundwater bores/stormwater
  - Department of Water, Land & Biodiversity Conservation
    www.dwlbc.sa.gov.au
  - Natural Resource Management Boards
    www.nrm.sa.gov.au
  - Local Government Authorities
    www.lga.sa.gov.au

Where alternative water supply to mains water is being used, it is important to ensure water quality is acceptable and Department of Health requirements are met. A water quality analysis should be undertaken reporting on the following;

- Salinity/EC
- pH
- Sodium
- Chloride
- Boron
- Carbonate & Bicarbonat
- Sodium Absorption Ratio (SAR)
- Nutrients (N-P-K)
- Thermo-tolerant Coliforms

Whatever the water supply, a dedicated meter is required to enable water consumption to be monitored.

FURTHER INFORMATION:
WATER SUPPLY OPTIONS


Neylan, J. (2005) Golf Course Water Quality, Victorian Golf Association, November 2005.
www.golfvic.org.au

Use of Surface and Groundwater Resources Versus Availability, Dept of Environment and Heritage, South Australia.
www.environment.sa.gov.au

Environment Protection Agency, South Australian Reclaimed Water Guidelines, Dept for Environment and Heritage, South Australia. April 1999.
www.epa.sa.gov.au

# CASE STUDY No 1

## CITY OF SALISBURY – AQUIFER STORAGE AND RECOVERY

**Origins of Wetland and Aquifer Storage and Recovery (ASR).**

The City of Salisbury has thirty six major wetlands including six aquifer storage and recovery sites injecting 1,895 ML into the underground aquifer annually. In addition, all new residential subdivisions in the past ten years have been required to install wetlands to contain stormwater on site as much as possible. Large industrial developments have been actively encouraged to develop wetlands for the same reason as well as to contain potential industrial spills on site. Collectively, these initiatives have effectively eliminated flood risk in an otherwise flood-prone area and have dramatically increased the wildlife habitat and biodiversity within the City. The development of the Waterproofing Northern Adelaide Project will ensure water security for the northern Adelaide region into the future.

Importantly, flows of polluted surface water into the fragile Barker Inlet estuary have been reduced. New opportunities have been created for the economic recycling of stormwater and reduced demand on water sourced from the River Murray.

For further information refer to the full case study in Appendix No 4.

# 5.0 TURF & IRRIGATION MANAGEMENT PRINCIPLES

## 5.1 Irrigation system design

Irrigation systems must be designed to ensure the efficient, uniform application of water to the site. Design should be aimed at conserving and protecting water resources. Design should take into consideration agronomic, climatic and water supply issues to ensure that the system can operate effectively.

Guidelines for the design of urban irrigation systems have been developed by Irrigation Australia Limited and can be accessed in the IAL publication, Urban Irrigation Best Practice Guidelines (2006).

An irrigation design brief should be prepared to ensure the designer meets all appropriate requirements of the urban irrigation best management practice guidelines.

Issues considered in the design should include:

- Soil type and structure.
- Infiltration rate.
- Plant species.
- Root zone depth.
- Average and forecasted climatic data (ETo/rainfall).
- Water quality, pressure and flow rate parameters.
- Scheduling restrictions.
- Use of technology to enhance water management such as, weather stations, moisture sensors, rain sensors, computerised irrigation management systems.

New systems should be designed to meet following standards:

- A system application rate of between 11 – 15mm per hour.
- Lower Quarter Distribution Uniformity (DU) measure of >85% which must equate to a field DU >75%. DU is the unit of measure used to determine the performance of turf irrigation systems. DU is defined as "the average water applied in the 25% of the area receiving the least amount of water, regardless of location within the pattern, divided by the average water applied over the total area." (refer IAL – Certified Irrigation Audit Manual, 2004.)

Design documentation to include:

- Irrigation plans.
- Design parameters (flow, pressure, DU, precipitation rate).
- Installation specification including component specification to meet appropriate Australian standards.
- Quality control inspection procedures.
- Water budget.
- Irrigation schedule.

Irrigation systems should be designed by qualified irrigation designers (refer section 8.0 – Training & Certification)

### ABOVE GROUND OR SUB-SURFACE IRRIGATION

When planning and designing an irrigation system a critical decision is whether to use a traditional above ground pop-up irrigation system or alternatively a sub-surface in-line drip irrigation system.

Sub-surface drip technology for turf has advanced significantly in recent years with systems performing to a high standard. The benefits of correctly designed, installed and maintained sub-surface drip include;

- High distribution uniformity due to elimination of the effects of wind, misting, poorly aligned sprinklers. As a general rule a high performing sub-surface drip system can achieve DU ratings of between 80 – 90% while similar pop up systems will achieve between 70 – 80%.
- Sub-surface drip can be scheduled at any time as it is not effected by evaporation and does not effect the turf surface.
- Water is applied directly to the root zone and can be scheduled daily to replace evapotranspiration losses, keeping the available water at optimum levels.
- Vandalism is reduced as there are no above ground components such as pop up sprinklers.
- Installation can be retrofitted into established turf.

However, not all situations are suitable for sub-surface drip. Some drawbacks include:

- Higher capital cost for sub-surface systems.
- Some soil types (eg coarse sands) do not allow sufficient lateral water movement through the soil profile.
- Where suitable soil type is not of a consistent friable structure, vertical channelling of water can result causing the leaching of fines and poor lateral movement of water.
- There can be difficulty in establishing new turf.
- Intrusion of roots into the drip lines can be a problem if not addressed in irrigation practices.
- Turf renovation practices (eg aeration and decompaction) must be modified to ensure damage does not occur to the in-line drip lines set at approximately 200mm below the surface.
- Event management must consider the impact of heavy machinery and the erection of marquis, or other variables in relation to sub-surface drip lines.

Regardless of the choice to have above ground or sub-surface irrigation systems it is critical that design, installation and maintenance is of the highest standard.

For advice on system selection consult a qualified irrigation designer or irrigation manager.

## 5.2 Irrigation system installation/supervision

Correct installation of an irrigation system is critical to ensure optimum performance and the achievement of design objectives. Guidelines for the installation of urban irrigation systems have been developed by Irrigation Australia Limited and can be accessed in the IAL publication, Urban Irrigation Best Practice Guidelines (2006).

Installation should be carried out by qualified irrigation installation contractors or personnel (refer section 8.0 – Training & Certification).

Supervision should be carried out by a suitably qualified supervisor or project manager (refer section 8.0 – Training & Certification).

Installation should be in accordance with the irrigation design and technical specification. All components and fittings must meet specified standards. Quality of installation should be checked with stop points signed off at specified stages of the project.

Installation inspection points to include:

- Check all materials and fittings comply with specified Australian standards and codes of compliance.
- Check trench alignment, depth and pipe coverage prior to backfill.
- Check all valve and valve box installation.
- Check all extra low voltage wiring (24 volt) meets specification.
- Check sprinkler installation and placement.
- Check the construction and installation of all thrust blocks.
- Pressure test all mainlines according to the specification.

At completion of installation, contractor to provide:

- System compliance report detailing any deviations from the original design specification.
- As constructed, irrigation system plan detailing any changes to original design layout.
- All product operating manuals and warranties.

Prior to final handover, the following checks should be carried out by the project supervisor or an independent third party:

- Irrigation audit report in accordance with Certified Landscape Irrigation Audit standards. Critical factors include:
    - System compliance report detailing sprinkler, valve and component. Installation conforms to design and technical specification.
    - Operating pressures and flows.
    - Field operational DU >75%.
    - A water budget and irrigation schedule to meet average climatic conditions.

Any faults identified to be rectified by the contractor prior to handover of the system.

## 5.3 Irrigation system maintenance & performance

In order for the irrigation system to continue to perform to design standards in relation to distribution uniformity, application rates and overall irrigation efficiency, it is critical that effective maintenance practices are put into place. Guidelines for the maintenance of urban irrigation systems have been developed by Irrigation Australia Limited and can be accessed in the IAL publication, Urban Irrigation Best Practice Guidelines (2006).

Irrigation system maintenance must be undertaken by suitably qualified irrigation maintenance personnel (refer section 8.0 – Training & Certification).

Maintenance should be programmed to ensure the system operates to design specification and should include:

- Periodic checks of pressure and flows to ensure they are within acceptable ratings for system operation.
- Periodic checks of system components (eg sprinklers, valves, controller, pumps, filters, sensors) to ensure they operate to manufacturer and design specifications.
- Periodic lifting and adjustment of sprinkler heads to ensure they are set and aligned as specified.
- Periodic clearance of vegetation around sprinkler heads.
- Replacement of all worn parts with those matching system requirements in accordance with the original design specification.
- Operation during the non irrigation season, periodically for a short duration, to flush system and operate components.

An irrigation audit in accordance with Certified Landscape Irrigation Audit standards should be undertaken every three to five years to ensure efficient system performance, distribution uniformity and irrigation application rates are as originally specified.

The plant water requirement will be the same for similar sites in similar locations. However, the performance of the irrigation system may vary significantly. Actual system performance could be as low as DU 40 – 50%. This could result in the need to apply up to twice as much water as required to account for system inefficiencies and ensure driest sections of turf receive adequate irrigation.

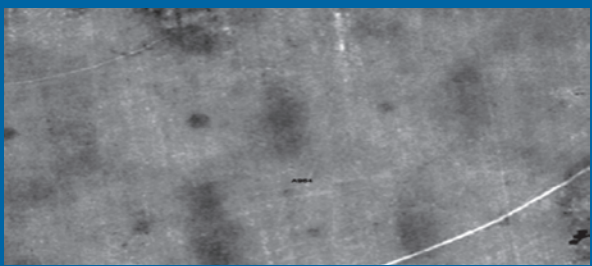
In reality, due to low application rates and restricted timing of irrigation events, it is often not possible to compensate for poor system efficiency by applying additional water. This results in poor turf condition and may jeopardise the 'fit for use' quality standards of the sports turf.

No allowance has been made for poor system application efficiency in the benchmarks developed in the Code, as it is considered fundamental that systems should be designed, installed and maintained to high standards. Where systems have a DU < 75%, upgrade or replacement is advised.

## EXAMPLE: IMPORTANCE OF IRRIGATION SYSTEM UNIFORMITY

The actual system performance of many ageing systems could be as low as DU 40 – 60%. This could result in the need to apply significantly more water than required, to account for system inefficiencies and ensure the driest sections of turf are receiving adequate irrigation otherwise turf quality will be reduced.

**Example of Poor Distribution Uniformity**



The importance of high performing irrigation systems can be demonstrated by comparing the water budget or base irrigation requirement of two sports fields of identical size, in the same geographic region, with the same turf species but differing irrigation system application efficiencies.

The following example is of a local level soccer ground (TQVS Cat. 3) of 1 ha with Kikuyu turf in the Adelaide metropolitan area.

**Irrigation System Application Efficiency Comparison**

| Description | Soccer Field No 1 | Soccer Field No 2 | Variance No 2 – No 1 |
|---|---|---|---|
| Net Irrigation req. (In) kL | 2,890 | 2,890 | - |
| Irrigation System Application Efficiency (Ea) | 80% | 55% | - 25% |
| Water Budget – Base Irrigation Requirement (BIr) kL | 3,620 | 5,210 | 1,590 |
| Water Cost @ $ 1.16 kL | $ 4,200 | $ 6,040 | $ 1,840 |
| BIr for medium council with 75 ha of irrigated reserves kL | 271,500 | 390,750 | 119,250 |
| Water Cost @ $ 1.16 kL | $ 314,940 | $ 453,270 | $ 138,330 |

Soccer field No 2 requires 45% more water to achieve the same standard of turf as Soccer field No 1. When the additional water requirement and cost is extrapolated over the many local government and educational sector sports grounds and irrigated reserves the amount of wastage and additional cost is significant.

# CASE STUDY No 2

## IRRIGATION AUDITING – DEPARTMENT OF EDUCATION AND CHILDREN'S SERVICES

The South Australian Department of Education and Children's Services (DECS) has directed significant resources in recent years toward improvements in irrigation infrastructure and management. DECS irrigation audits are carried out by landscape irrigation auditors certified by the Irrigation Australia Limited and are be done according to the IAL Certified Landscape Irrigation Audit Methodology. Information provided in the audits is sufficiently detailed to:

- Permit efficiency rating of the irrigation system.
- Quantify potential mains water savings.
- Calculate water budgets for each school.

Auditors can develop water budgets around this target figure and provide recommendations to reduce water use without compromising turf quality. Estimated water savings should be quantified for each recommendation to enable actions to be prioritised.

Approximately 20% of mains water used for parks, gardens, ovals and sports fields in South Australia is used in schools. As a significant water user DECS seeks to continually improve its water management practices.

For further information refer to the full case study in Appendix No 4.

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FURTHER INFORMATION:
IRRIGATION SYSTEM DESIGN, INSTALLATION & MAINTENANCE

Cape, J. Urban Irrigation, Best Management Practice Guidelines, Irrigation Australia Limited, NSW, 2006.
www.irrigation.org.au

Cape, J. 2004. Certified Landscape Irrigation Auditor Resource Manual. Irrigation Australia Limited, NSW.
www.irrigation.org.au

Standard Irrigation Contract, Irrigation Australia Limited, NSW, 2007.
www.irrigation.org.au

Information on Certified Irrigation Designer, Certified Irrigation Installer and Certified Irrigation Auditor accreditation can be found at www.irrigation.org.au

Connellan, G. Evaluating Irrigation Performance – Uniformity Auditing, Victorian Golf Association, Vic, December 2005.
www.golfvic.org.au

## 5.4 Plant/turf species selection

Warm season turf grasses (Kikuyu or Couch) use 30 – 50% less water than cool season turf grasses, (Fescues or Ryes). The drought tolerance of warm season grasses is significantly higher than the cool season grasses. Turf species should be selected to meet the functional objective while minimising water use.

Warm season turf grasses (Kikuyu or Couch) should be used as the predominant turf grass species for irrigated public open space in South Australian conditions.

Where turf is subject to intensive winter activity such as football, over sowing in autumn with a cool season turf species such as a transitional rye grass will improve wearability and recovery of the turf during the cooler months without requiring additional water over the summer period.

## 5.5 Turf quality/'fit for purpose'

Turf should be maintained to meet quality and risk management standards appropriate for its intended use. Sporting club associations and ground managers have a duty of care to all people using facilities. This means that sports facilities, including turf surface, must not present an unacceptable risk of injury to those using the facilities.

Passive irrigated areas require a lower standard and have lower risk ratings than active sports grounds. The standard to which turf is maintained has significant impact on water usage. Turf must be maintained at a level that ensures safety for users and meets the functional objective. A passive irrigated area can be maintained using up to 50% less water than an active sportsground.

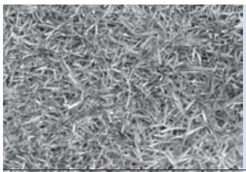
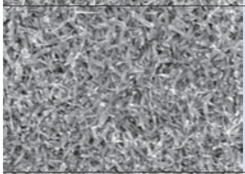
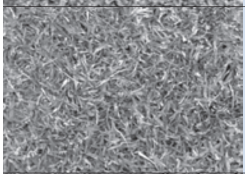
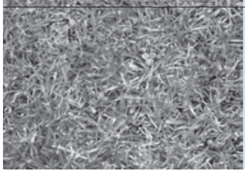
Irrigated turf areas should be classified according to the intended function and the 'fit for purpose' standard. Turf can be rated according to the Turf Quality Visual Standard (TQVS) classifications as detailed in Table No 1.

Turf quality and risk management standards should be developed and include the following criteria:

- Turf Quality Visual Standards (TQVS) indicating 'fit for use' turf standards.
- Turf grass vigour and density.
- Evenness of turf surface.
- Cutting height of turf.
- Presence of weed species or pest infestation.
- Presence of divots, pot holes.
- Presence of sunken or raised sprinkler heads.
- Traction and shear strength of the turf.
- Ground hardness and impact severity.
- Associated infrastructure: goal posts, coaches' boxes and fences should also be assessed for safety.

The quality and risk standards should be detailed in a quality and risk audit checklist which is used by the organisation and the users to ensure risks have been identified and appropriate controls have been put in place. A risk assessment of the turf surface should be undertaken weekly for active sports with a quality audit undertaken monthly to monitor wear trends and turf quality.

**Table No 1 – Turf Quality Visual Standard**
*(Rhizomatous sp. (Kikuyu/Couch))*

| | |
|---|---|
|  | *Classification No 1*<br>**Elite Sports Turf**<br>– State/National Competition<br>AAMI Stadium/Adelaide Oval |
|  | *Classification No 2*<br>**Premier Sports Turf**<br>– State/Regional Competition<br>A Grade Cricket/Football/Athletics |
|  | *Classification No 3*<br>**Local Sports Turf**<br>– Local Competition<br>Local Sports Grounds/Community Parks |
|  | *Classification No 4*<br>**Passive Recreation Reserve**<br>– Non Sports Turf<br>Neighbourhood Parks/Passive Reserves |

FURTHER INFORMATION:
TURF QUALITY/'FIT FOR PURPOSE'

Aldous, D.E., and I.H. Chivers (2005).
Player Perceptions of Australian Football League Sports Grass Surfaces. Report for the Australian Football League Players' Association. The University of Melbourne and Racing Solutions Pty. Ltd., 55pp.
http://www.landfood.unimelb.edu.au/staff/aldous.html

Henderson, C. Best management practices for sustainable and safe playing surface of Australian Football League sports fields, Dept of Primary Industries and Fisheries, Qld. 2006.
http://www2.dpi.qld.gov.au/horticulture/16834.html

Chivers, I. Otago, L. Swan, P. Finch, C. Payne, W. Orchard, J. 'Ground Conditions and Injury Risk – Implications for Sports Grounds Assessment Practices in Victoria.' University of Ballarat. March 2007.

AS/NZS 4360: 2004. Risk Management – Australian/New Zealand Standard – Risk Management.

AS/ANZ 4360: HB 246: 2004 – Guidelines for Managing Risk in Sport and Recreation.
http://www.riskmanagement.com.au/

## 5.6 Turf & horticultural practices

Critical to the maintenance of quality, 'fit for purpose' irrigated public open space is sound turf and horticultural maintenance practices. An annual turf and landscape maintenance program should be developed for each individual location. The aim of the program is:

- To improve soil texture and structure.
- Ensure appropriate nutrient levels.
- Identify and treat turf pests and diseases.
- Promote deep root growth.
- Ensure the turf surface is safe and 'fit for purpose'.

Mowing heights, fertilizer application, compaction relief and rolling top dressing all have an impact on the quality and water requirement of the turf grass. Turf maintenance operations are required to improve soil structure through aeration, decompaction and promotion of deep root growth, ensuring water is utilised to its full potential and turf quality meets its functional objective.

FURTHER INFORMATION:
TURF & HORTICULTURAL PRACTICES

Handreck, K. A. and Black, N. D. (2001) Growing Media for Ornamental Plants and Turf, 3rd Edition, NSW, University Press, Kensington, Australia 2001.

# CASE STUDY No 3

## CITY OF TEA TREE GULLY – IRRIGATION MANAGEMENT STRATEGIES

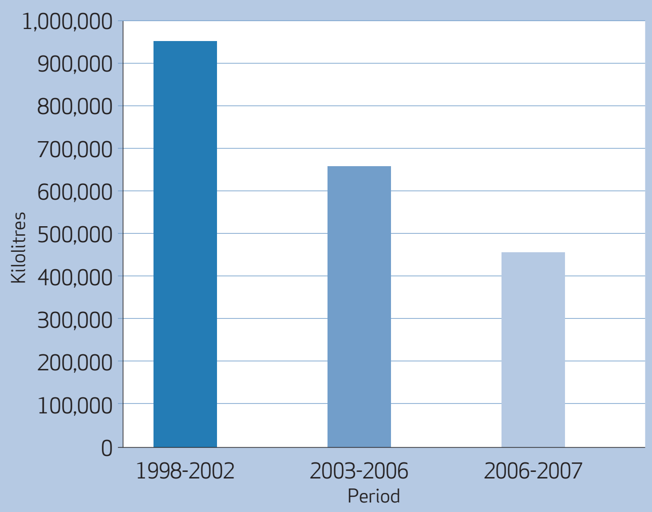
An Irrigation Management Strategy (IMS) was developed by the City of Tea Tree Gully in 2003 when permanent water conservation measures were introduced. The objective of the IMS was to reduce water consumption by a minimum of 20% while ensuring efficient irrigation practices and 'fit for purpose' sport and recreational turf.

The results over the three year period from 2003 - 2006 have seen a reduction of 31% or 290,000 kL per annum from 950,000 kL to 660,000 kL in overall water consumption while maintaining the same area of irrigated turf to satisfactory 'fit for use' standards. Further reductions were achieved in the 2006/07 irrigation season as a result of level 3 water restrictions.

**Average Water Consumption per annum**

| Period | Irrigated area (ha) | Average Annual Consumption kL/ annum | Consumption per Hectare kL/ha |
|---|---|---|---|
| 1998 - 2003 | 171 | 950,000 | 5,556 |
| 2003 - 2006 | 171 | 660,000 | 3,860 |
| Variance kL | | 290,000 | 1,696 |
| Variance % | | 31% | 31% |
| 2006 / 2007 | | 460,000 | |

**Average Annual Water Consumption**




For further information refer to the full case study in Appendix No 4.

## 5.7 Water budget

A water budget should be developed to set irrigation water consumption targets. A water budget calculates the Irrigation Requirement (Ir) of the site for a given period based on climatic, agronomic, turf quality and system performance factors. The outcome is monthly water consumption targets, based on long term average climatic conditions, in mm depth of water which can be converted to kilolitres per hectare. From the water budget a financial budget for water cost can also be developed to enable the management of both water and financial resources.

Due to daily and seasonal variations in weather factors the plant water requirement is continually changing. It is critical to monitor and revise irrigation targets according to prevailing weather conditions. The drought conditions of 2006/07 are an example of significant variation from average climatic conditions for that period, with an irrigation requirement of approximately 30% greater than the average.

Templates have been developed to assist in the development of water budgets and are attached as *Appendix No 1 – IPOS - Irrigation Requirement Model.*

The irrigation requirement has been developed for both the Base Irrigation Requirement (BIr) using long term average climatic data and the irrigation requirement for season 2006/07 ($Ir_{(06/07)}$) using current climate data. The methodology on which the model is based is outlined below.

### 5.7.1 Irrigation Requirement (Ir)

In order to determine how much water to apply to the turf and monitor water usage, the amount of water that needs to be applied by the irrigation system to sustain turf to the accepted standard must be determined. This is called the Irrigation Requirement (Ir).

The methodology for calculating Ir is detailed in the FAO Technical Paper No 56 – Crop Evapotranspiration. Guidelines for computing crop water requirements 1988.

The simplified calculation for the Irrigation Requirement (Ir) is:

Ir = In/Ea

Where:
Ir - Irrigation Requirement (mm)
In - Net Irrigation Requirement (mm)
Ea - Irrigation System Application Efficiency

**Net Irrigation Requirement (In)** is the water requirement of the plant or Crop Evapotranspiration (ETc) less any Effective Rainfall (Pe) for the period.

In = ETc - Pe

Where:
In - Net Irrigation Requirement (mm)
ETc - Crop Evapotranspiration (mm)
Pe - Effective Rainfall (mm)

**Crop Evapotranspiration (ETc)** is a combination of the water used by a specific species of plant for healthy growth, which is called transpiration, and the water evaporated from the soil surface.

The ETc is directly related to climatic conditions and the relevant plant species.

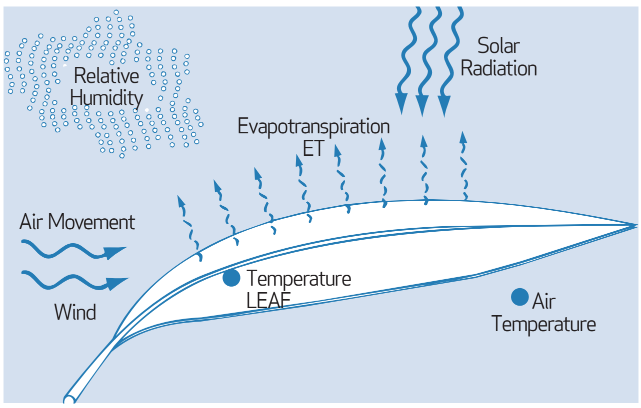
ETc = ETo x Kc x Ks

Where:
ETc - Crop Evapotranspiration (mm)
ETo - Reference Evapotranspiration
Kc - Crop Co-efficient (decimal factor)
Ks - Crop Stress Factor (decimal factor)

**Reference Evapotranspiration (ETo)** is calculated using climate data which directly effects evapotranspiration. The climatic data is sourced from weather stations and includes;

- Air temperature.
- Relative humidity.
- Solar radiation.
- Wind speed.

**Figure No 1 – Factors Influencing Plant Water Use**




Graphic courtesy of Geoff Connellan, University of Melbourne

Using the above climate data the evapotranspiration from a reference crop (tall cool season grass (lucerne) grown to a height of 12cm which covers the ground and is supplied with adequate water), can be calculated. The result is reference evapotranspiration (ETo). ETo is calculated by the Bureau of Meteorology (BoM) and is published on their website or can be accessed from private weather stations in regional areas where the BoM does not have stations.

As the water requirement varies for different turf species under different growth conditions the ETo must be converted to evapotranspiration for a specific crop (ETc). A crop co-efficient (Kc) is required to covert ETo to ETc. Crop co-efficients (Kc) for turf grass are as follows.

**Table No 2 - Turf Grass Crop Co-efficients (Kc)**

| Turf Type | Warm Season Turf Grass Couch sp. / Kikuyu | Cool Season Turf Grass Rye sp./Bluegrass/ Fescue |
|---|---|---|
| Crop Co-efficient( Kc ) | 0.6 - 0.8 | 0.8 - 0.95 |

Note: Kc = 0.7 has been used in calculations in the Code.

**Crop Stress Factor (Ks)** is applied where a management decision has been made to reduce the vigour and quality of the turf grass. As detailed previously, irrigated public open space can be classified into four TQVS standards depending on the function and required standard of the turf surface. The Ks effectively reduces the irrigation requirement to achieve the appropriate functional outcome of the turf. Crop stress factors for IPOS are as follows;

**Table No 3 – Turf Grass Crop Stress Factors (Ks)**

| TQVS Cat. | TQVS 1 | TQVS 2 | TQVS 3 | TQVS 4 |
|---|---|---|---|---|
| Description | Elite Sports Turf | Premier Sports Turf | Local Sports Turf | Passive Recreational Turf |
| Crop stress factor (Ks) | 1.0 | 0.6 | 0.5 | 0.4 |

The calculation for ETc is;

ETc = ETo x Kc x Ks
ETc = ETo x 0.7 x 0.5 (TQVS 3)

**Effective Rainfall (Pe)**

Rainfall or precipitation (P) replaces water lost from the soil by evapotranspiration and thereby reduces the Net Irrigation Requirement (In). Rainfall (P), during the irrigation season can be variable and is not always effective. Small rain events are lost by evaporation and do not soak into the soil, whereas large events may deliver more water than the soil can hold and can be lost either through drainage or run off.

A general rule for a shallow rooted turf grass crop is that only half the rainfall that occurs in the irrigation season is effective and actually replenishes soil to the root zone of the plant. The Effective Rainfall Factor (Pf) used in the Code is 0.5 or 50%. When this is multiplied by the total rainfall, Effective Rainfall (Pe) is calculated.

Rainfall data can be accessed from the BoM website or from local rain gauges.

The calculation for effective rainfall is;

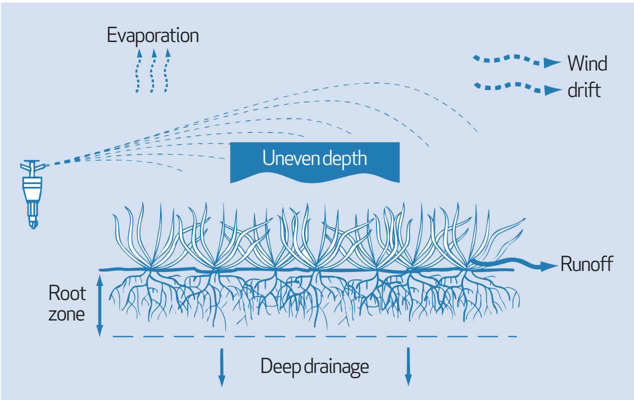
Pe = P x Pf

Where:
Pe - Effective rainfall (mm)
P - Total rainfall (mm)
Pf - Effective rainfall Factor (decimal factor)

**Application Efficiency (Ea)**

Irrigation systems do not apply water at 100% efficiency. The optimum performing irrigation system is subject to inherent system inefficiencies. Factors such as wind, misting, poor sprinkler spacing, nozzle loss and other system performance faults impact on the uniformity of water application. Therefore a factor must be applied to account for irrigation system performance.

**Figure No 2 – Factors Influencing Irrigation System Application Efficiency**




Graphic courtesy of Geoff Connellan, University of Melbourne

A field irrigation audit conducted by a qualified irrigation auditor is required to determine the performance of the irrigation system. The distribution uniformity (DU) is one measure of irrigation system application efficiency. However this can vary with conditions such as high wind or system pressure fluctuations. A high performing pop up sprinkler system will achieve a field DU of between 75% and 85%. In practice many systems fall short of this figure and will achieve between 55% and 65% DU.

An application efficiency factor of 80% or 0.8 has been used in the Code as this represents a high performing system.

Ea = 0.8

Where:
Ea - Irrigation system application efficiency (decimal factor)

No allowance has been made for poor DU in the benchmarks developed in the Code, as it is considered fundamental that systems should be designed, installed and maintained to high standards. Where systems have a DU < 75%, upgrade or replacement is advised.

### Converting Irrigation Depth (mm per $m^2$) to Volume (kL per ha)

Irrigation requirement (Ir) refers to the depth of water which needs to be applied by the irrigation system to replace soil water used by the plant. Each millimetre (mm) of water applied refers to 1 mm depth of water over the entire irrigated area. 1 mm depth of water over an area of one square metre equals one litre of water. Subsequently and irrigation depth of 1 mm per hectare (10.000 $m^2$) is equal to 10,000 litres or 10 kilolitres of water. To convert mm depth of water applied to kilolitres per hectare a multiplier factor of 10 is used. The calculation is:

kL per ha = mm x 10

Where:
kL - kilolitres (1,000 litres)
ha - hectares (10,000 square metres)
mm - millimetre depth of water
10 - conversion factor mm to kL per ha

### Water Cost

The cost of mains water is set by the Government of South Australia and is adjusted annually. The cost of mains water 2007/08 financial year is $1.16 per kilolitre. The cost of water for irrigation is calculated by multiplying kilolitres used by the water cost.

Total water cost = kL used x water cost per kL
= kL x 1.16 (2007/08)

Given the above information, the irrigation requirement can be calculated, as in the following example.

## IRRIGATION REQUIREMENT (Ir) EXAMPLE:

| | |
|---|---|
| Site | - Local soccer ground |
| Area | - 1.2 hectare |
| Location | - Adelaide metropolitan area |
| Turf species: quality standard | - Kikuyu: TQVS Cat 3 |
| Irrigation season | - October – April inclusive |
| Climate period | - Long term average |

Irrigation Requirement (Ir) = Net Irrigation Requirement (In) / Application Efficiency (Ea)
**Ir = In / Ea**

Net Irrigation Requirement (In) = Crop Evapotranspiration (ETc) – Effective rainfall (Pe)
In = ETc - Pe

Crop Evapotranspiration (ETc) = Reference Evapotranspiration (ETo) x Crop Co-efficient (Kc) x Crop Stress Factor (Ks)
ETc = ETo x Kc x Ks
= 1088 x 0.7 x 0.5
= 381 mm

Effective rainfall (Pe) = Total rainfall (P) x Effective rainfall Factor (Pf)
Pe = P x Pf
= 183 x 0.5
= 92 mm

**Net Irrigation Requirement**
**In = ETc – Pe**
**= 381 - 92**
**= 289 mm**

Application Efficiency
Ea = 0.80

**Irrigation Requirement (mm)**
**Ir = In / Ea**
**= 289 / 0.80**
**= 362 mm**

Irrigation Requirement (kL per ha)
Ir(kL/ha) = Ir(mm) x 10
= 362 x 10
= 3620 kL / ha

Irrigation Requirement (Site)
Ir(site) = Ir(kL per ha) x site area
= 3620 x 1.2
= 4,344 kL

Water Cost
= Ir(site) x Water cost ($ per kL)
= 4,344 x 1.16
= $ 5,039

## 5.7.2 Base Irrigation Requirement (BIr)

The Base Irrigation Requirement (BIr) forms the water budget and is calculated using long term average reference evapotranspiration (ETo) and rainfall (P) data available from the Bureau of Meteorology (BoM). The source for the required data is; www.bom.gov.au/climate/averages.

*Appendix No 1 – IPOS - Irrigation Requirement Model* provides a model for the calculation of the Base Irrigation Requirement (BIr).

Table No 4 details BIr for each of the turf classifications.

**Table No 4 – Base Irrigation Requirement (BIr) – Couch/Kikuyu – Adelaide Metro**

| TQVS Cat. | TQVS 1 | TQVS 2 | TQVS 3 | TQVS 4 |
|---|---|---|---|---|
| Description | Elite Sports Turf | Premier Sports Turf | Local Sports Turf | Passive Recreational Turf |
| Month | Base Irrigation Requirement (mm/month) (BIr) | Base Irrigation Requirement (mm/month) (BIr) | Base Irrigation Requirement (mm/month) (BIr) | Base Irrigation Requirement (mm/month) (BIr) |
| Oct | 86 | 42 | 31 | 19 |
| Nov | 121 | 66 | 52 | 39 |
| Dec | 148 | 83 | 66 | 50 |
| Jan | 165 | 94 | 77 | 59 |
| Feb | 138 | 78 | 63 | 48 |
| Mar | 116 | 64 | 51 | 38 |
| Apr | 65 | 30 | 21 | 13 |
| Total (mm) | 838 | 457 | 362 | 266 |
| Total (kL/ha) | 8,380 | 4,570 | 3,620 | 2,660 |
| Total Cost @ $1.16 per kL | $ 9,721 | $ 5,301 | $ 4,199 | $ 3,086 |

In regional areas site specific climatic data can be sourced from the Bureau of Meteorology website, other factors remain the same (refer Appendix No 1).

The water budget or BIr data provides benchmarks for irrigation requirement using long term average climatic data. The climate, evaporation and rainfall can be variable over given periods. The BIr can be used as a forecast of the irrigation requirement. However, it must be monitored against actual climatic conditions and irrigation requirement for the current period when scheduling irrigation events and monitoring irrigation efficiency. The drought conditions of 2006/07 are an example of significant variation in average climatic conditions for that period with an irrigation requirement of approximately 30% greater than the average.

### 5.7.3 Irrigation Requirement 2006/07 ($Ir_{(06/07)}$)

The Irrigation Requirement (Ir) for the current period is calculated in the same way as the BIr, except current ETo and rainfall data is used. Current data can be accessed from the BoM on the following website:

www.bom.gov.au/anon2/home/sa/DATA/evapotrans/

*Appendix No 1 – IPOS - Irrigation Requirement Model* provides a model for the calculation of the Irrigation Requirement (Ir)

Table No 5 details $Ir_{(06/07)}$ for each of the turf classifications.

In regional areas, site specific climatic data can be sourced from the Bureau of Meteorology website or private weather stations in regional areas and other factors remain the same.

The methodology and factors used for calculating the Irrigation Requirement for landscapes other than turf can be found in the Certified Landscape Irrigation Auditor Resource Manual 2004 available from the Irrigation Australia Limited.

FURTHER INFORMATION:
DETERMINING IRRIGATION REQUIREMENT (Ir)

Connellan, G. 2005. Determining Target Water Budget, Victorian Golf Association, Vic.
www.golfvic.org.au

Cape, J. 2004. Certified Landscape Irrigation Auditor Resource Manual. Irrigation Australia Limited, NSW.
www.irrigation.org.au

University of California Cooperative Extension. California Department of Water Resources 2000. A Guide To Estimating Irrigation Water Needs of Landscape Plantings in California.
http://www.owue.water.ca.gov/docs/wucols00.pdf

FAO Technical Paper No 56 – Crop Evapotranspiration. Guidelines for computing crop water requirements 1988.
http://www.fao.org/docrep/X0490E/X0490E00.htm

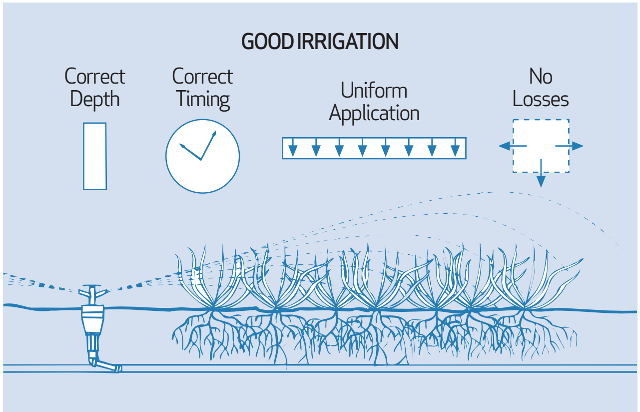
**Table No 5 – Irrigation Requirement (Ir) 2006/07 – Couch/Kikuyu – Adelaide Metro**

| TQVS Cat. | TQVS 1 | TQVS 2 | TQVS 3 | TQVS 4 |
|---|---|---|---|---|
| Description | Elite Sports Turf | Premier Sports Turf | Local Sports Turf | Passive Recreational Turf |
| Month | Base Irrigation Requirement (mm/month) (BIr) | Base Irrigation Requirement (mm/month) (BIr) | Base Irrigation Requirement (mm/month) (BIr) | Base Irrigation Requirement (mm/month) (BIr) |
| Oct-06 | 147 | 88 | 73 | 58 |
| Nov-06 | 149 | 85 | 68 | 52 |
| Dec-06 | 191 | 110 | 89 | 69 |
| Jan-07 | 164 | 89 | 70 | 51 |
| Feb-07 | 181 | 108 | 90 | 72 |
| Mar-07 | 145 | 82 | 66 | 51 |
| Apr-07 | 63 | 19 | 8 | -3 |
| Total (mm) | 1,038 | 580 | 465 | 350 |
| Total (kL/ha) | 10,380 | 5,800 | 4,650 | 3,500 |
| Total Cost @ $1.16 per kL | $ 12,041 | $ 6,728 | $ 5,394 | $ 4,060 |

## 5.8 Irrigation scheduling

Irrigation scheduling is a critical component of efficient irrigation management. Irrigation controllers are often programmed at the start of the season based on either the BIr or operator experience and often not adjusted to respond to changing weather conditions and plant water requirements.

**Figure No 3 – Factors Influencing Irrigation Scheduling**




Graphic courtesy of Geoff Connellen, University of Melbourne.

In order to ensure only as much water is applied to turf as is required without wastage, the irrigation schedule must be matched to the irrigation requirement of the site. To do this the following information is required;

- How much water does the plant need?
- How much water is stored in soil?
- How much water is available to the plant?
- How much water needs to be applied?
- When should irrigation be applied?
- How long should the irrigation system be operated for?

In answering the above questions, an irrigation schedule will be developed for the following site;

| | |
|---|---|
| Site | - Local soccer ground |
| Area | - 1.2 hectare |
| Location | - Adelaide metropolitan area |
| Turf species | - Kikuyu |
| Turf Quality Standard | - TQVS Cat 3 |
| Soil Type | - Sandy Loam |
| Irrigation season | - October – April inclusive |
| Climate data period | - Long term average |
| Irrigation time limits | - 9.00pm - 8.00am |
| Irrigation day limits | - No irrigation Friday/Saturday |

### 5.8.1 How much water does the plant need?

The water requirement of the plant or Crop Evapotranspiration (ETc) less any Effective Rainfall (Pe) for the period is the Net Irrigation Requirement (In) for a given period. Daily net irrigation requirement is used in developing an irrigation schedule to monitor the plant water use and reduction in soil water available to the plant.

The calculation of the Net Irrigation Requirement (In) is detailed in Sect 5.7 of this paper and in *Appendix No 1 – IPOS - Irrigation Requirement Model.*

Table No 6 details the Net Irrigation Requirement (In) for TQVS Cat. 3 (local sports ground).

**Table No 6 – Daily Net Irrigation Requirement (In) – TQVS Cat. 3**

| Item | Oct | Nov | Dec | Jan | Feb | Mar | Apr |
|---|---|---|---|---|---|---|---|
| Net Irrigation Req. (In) | 24 | 42 | 53 | 61 | 50 | 41 | 17 |
| Days per month | 31 | 30 | 31 | 31 | 28 | 31 | 30 |
| Daily In (mm) | 0.8 | 1.4 | 1.7 | 2.0 | 1.8 | 1.3 | 0.6 |

## 5.8.2 How much water is stored in the soil?

### Total Available Water (TAW)

The amount of water stored in the soil and available to the plant is referred to as the Total Available Water (TAW). When the soil reservoir is full it is said to be at field capacity. Any further water applied to the soil will either run-off or be lost below the root zone by drainage. Plants will extract water from the soil as required until the remaining water in the soil is no longer able to be taken in by the plant. This is called 'wilting point'. If water is not applied, either through natural rainfall or irrigation, the plant will become stressed to the point where it will die.

The total available water in the root zone is the difference between the water content at field capacity and wilting point.

The TAW is determined by the soil type and its water holding capacity and the Root Zone Depth (Zr) of the plant.

The calculation is:

TAW = WHC x Zr

Where:
TAW - Total Available Water (mm)
WHC - Water Holding Capacity of the soil (mm/mm)
Zr root - Zone Depth (mm)

### Soil Water Holding Capacity (WHC)

Water is stored in the soil between the pore spaces or the soil particles. Different soils have different sized pore spaces and there is a significant variation in the water holding capacity of different soils. By taking a soil sample and determining the soil type, the water holding capacity of the soil can be determined from the following table.

**Table No 7 – Typical Water Holding Capacity and Infiltration Rate of Soils**

| Soil Type | Soil Water Holding Capacity (WHC) mm/metre | Soil Water Holding Capacity (WHC) mm/metre | Soil Infiltration Rate (mm/hr) |
|---|---|---|---|
| Sand | 60 | 0.06 | >20 |
| Fine sand | 90 | 0.09 | 15 – 20 |
| Sandy loam | 110 | 0.11 | 10 – 18 |
| Loam | 150 | 0.15 | 10 – 15 |
| Silt loam | 160 | 0.16 | 8 – 12 |
| Clay loam | 180 | 0.18 | 5 – 10 |
| Clay | 150 | 0.15 | <5 |

### Plant Root Zone Depth (Zr)

The extent to which the plant roots grow into the soil determines the depth and volume of water in the soil the plant can access. Generally open soils such as sand enable plants to develop root systems to a greater depth than heavier clay soils. The depth of roots in turf can be determined by taking a soil sample and measuring the depth of roots in the profile.

Having determined the soil water holding capacity and the plant root zone depth, the total available water can be calculated as follows;

Where Kikuyu is grown in sandy loam with a root zone depth of 150mm:

TAW = WHC x Zr
= 0.11 x 150 = 16.5 mm

## 5.8.3 How much water is available to the plant?

**Readily Available Water (RAW)**

The percentage of the Total Available Water (TAW) that a plant can extract from the root zone without suffering stress is the Readily Available Water (RAW).

RAW = TAW x MAD

Where

RAW - Readily Available Water (mm)
TAW - Total Available Water (mm)
MAD - Maximum Allowable Depletion (%)

As the soil water level is reduced the ability of the plant to take up water is also reduced. In most situations it is desirable to maintain the soil water level at a level where the plant is able to extract water with no stress. The soil water level must be kept between field capacity and wilting point. This is called the Maximum Allowable Depletion (MAD). When the soil water level reduces to the MAD, irrigation must be applied to bring the soil moisture level back to field capacity.

Determining the MAD is a management decision that may vary depending upon a number of factors including season, usage of the turf and growth phase of the turf. As a general rule the MAD for turf is set at 50% of RAW.

Where Kikuyu is grown in sandy loam with a root zone depth of 150mm

RAW = TAW x MAD
= 16.5 x 0.5
= 8.3 mm

## 5.8.4 How much water needs to be applied?

When the plant has extracted the Readily Available Water (RAW) from the root zone, irrigation needs to be applied to refill the soil reservoir to field capacity. The amount of water that needs to be applied is that extracted from the soil (RAW) plus an additional amount to compensate for irrigation system application inefficiencies (Ea). This is referred to as the irrigation depth or the Optimum Irrigation Event (OIE)

OIE = RAW/Ea

Where:
OIE - Optimum Irrigation Event (mm)
RAW - Readily Available Water (mm)
Ea - Application Efficiency (mm)

**Irrigation System Application Efficiency (Ea)**

As previously indicated, irrigation systems have inherent inefficiencies which reduce the uniformity of application of the system. A field irrigation audit, conducted by a qualified irrigation auditor, is required to determine the performance of the irrigation system. The irrigation system application efficiency factor used in the Code is 0.8 or 80% efficiency

Ea = 0.8

Given the information above the OIE, or the irrigation depth can be calculated

OIE = RAW x Ea
= 8.3/0.8
= 10.3 mm (10 mm)

The OIE of 10 mm is the amount of water that should be applied by the irrigation system to refill the soil moisture level to field capacity after the depletion of the Readily Available Water (RAW) (8.3 mm) in the root zone. Any water applied in excess of 10 mm in any one irrigation event will be wasted through deep drainage or runoff.

## 5.8.5 When should irrigation be applied?

**Irrigation Interval (Ti)**

The Irrigation Interval (Ti) is the interval or number of days between the application of the Optimum Irrigation Event (OIE).

Using long term average climatic data from the BoM to determine the daily net irrigation requirement, the daily soil water depletion can be monitored. When the soil water level reduces to the point where the Readily Available Water (RAW) has been extracted, it is time to apply the Optimum Irrigation Event (OIE).

The Irrigation Interval (Ti) (number of days between irrigation events) is calculated by dividing the Readily Available Water (RAW) in the soil by the Daily Net Irrigation Requirement ($In_{(daily)}$) of the plant.

Ti = RAW/$In_{(daily)}$

Where:
Ti - Irrigation Interval (days)
RAW - Readily Available Water (mm)
$In_{(daily)}$ - Daily Net Irrigation Requirement (mm)

**Table No 8 – Irrigation Interval Per Month (days)**

| Item | Oct | Nov | Dec | Jan | Feb | Mar | Apr |
|---|---|---|---|---|---|---|---|
| Readily avail. water (RAW) mm | 8.3 | 8.3 | 8.3 | 8.3 | 8.3 | 8.3 | 8.3 |
| Daily net irrigation req. ($In_{(daily)}$) mm | 0.8 | 1.4 | 1.7 | 2.0 | 1.8 | 1.3 | 0.6 |
| Irrigation interval (Ti) days | 10 | 6 | 5 | 4 | 5 | 6 | 14 |

## 5.8.6 How long should the irrigation system be operated?

To determine how long the irrigation system should operate per station, Optimum Irrigation Event (OIE) is divided by the Irrigation System Application Rate (Iar) to give the Irrigation Run Time (Irt) to ensure application of the required depth of water. The result is multiplied by 60 to convert the result to minutes.

Irt = (OIE/Iar) x 60

Where:
Irt - Irrigation System Run Time (minutes)
OIE - Optimum Irrigation Event (mm)
Iar - Irrigation System Application Rate (mm)
60 - Multiplier to covert result to minutes.

**Irrigation System Application Rate (Iar)**

The rate at which the irrigation system applies water to the site is determined at the point of design. Factors such as flow, pressure, sprinkler type and sprinkler spacing all impact on the System Application Rate (Iar). Irrigation systems designed for large areas such as irrigated public open space generally have lower application rates than domestic systems. This is due to the size of the area being irrigated.

IPOS irrigation systems generally have irrigation application rates of between 10 – 15 mm per hour. Domestic systems have application rates of up to 40 mm per hour.

The application rate of the system can be determined by checking system pressure, flows and sprinkler spacing against the manufacturers sprinkler performance charts or by a field audit of the irrigation system.

The irrigation application rate used in developing a base irrigation schedule in the Code is 13 mm per hour.

The irrigation system run time per station is:

Irt (min per station) = (OIE/Iar) x 60
= (10/13) x 60
= 0.8 x 60
= 48 mins per station

Where an irrigation system has 12 stations the Irt per station is multiplied by the number of stations.

Irt (minutes per site) = Irt (station) x 12
= 48 x 12
= 571 minutes

Irt (hrs per site) = Irt (mins)/60
= 571/60
= 9.52 hours
= 9 hrs 30 minutes

An irrigation schedule is then developed in consideration of time restrictions in which irrigation can take place (usually night watering between 9.00pm and 8.00am) and usage of the reserve (no irrigation Friday or Saturday pm).

A template for the development of an irrigation program is provided in *Appendix No 2 IPOS – Irrigation Schedule Model.*

Irrigation schedules should respond to changing plant water requirements and should not be set for standard operation over the entire season. The base irrigation schedule is developed using long term average climatic data. The plant water requirement is determined by climatic factors and changes with the weather, i.e. evaporation/rainfall. As such the timing of irrigation events is governed by the irrigation requirement for the current period.

The irrigation schedule detailed in table No 9 has been developed for a standard sports ground example using a high quality water source. Many irrigated sites have a variety of slopes, soil types and use water supplies high in salts, such as treated effluent. In such cases scheduling parameters such as surface runoff, soil infiltration rates and salt leaching factors need to be considered in the development of the irrigation schedule.

**Table No 9 – Irrigation Schedule – TQVS Cat 3**

| Item | Oct | Nov | Dec | Jan | Feb | Mar | Apr |
|---|---|---|---|---|---|---|---|
| No of stations | 12 | 12 | 12 | 12 | 12 | 12 | 12 |
| Total irrigation runtime (mins) | 571 | 571 | 571 | 571 | 571 | 571 | 571 |
| Total irrigation runtime (hrs) | 9.52 | 9.52 | 9.52 | 9.52 | 9.52 | 9.52 | 9.52 |
| Program start time | 9.00pm | 9.00pm | 9.00pm | 9.00pm | 9.00pm | 9.00pm | 9.00pm |
| Program finish time | 6.30am | 6.30am | 6.30am | 6.30am | 6.30am | 6.30am | 6.30am |
| Watering days (wk 1) | M | M | M | M, Th | M, Th | M, Th | Th |
| Watering days (wk 2) | | W | M, Th | M, Th | M, Th | M, Th | |
| Watering days (wk 3) | M | M | M, Th | M, Th | M, Th | W | M |
| Watering days (wk 4) | | M, Th | M, Th | M, Th | M, Th | W | |
| Irrigation events per month | 2 | 5 | 7 | 8 | 8 | 5 | 2 |

## 5.9 Irrigation management technology

In order to manage irrigation efficiently, daily monitoring of the weather and soil moisture levels is required. This can involve ongoing complex calculations and adjustment of irrigation schedules to respond to the ever changing plant water requirements. Technologies have been developed to assist the irrigation manager to monitor climatic and soil moisture changes and adjust irrigation schedules automatically as required. Technologies such as computerised irrigation management systems, weather stations, soil moisture sensors and rain sensors can all improve irrigation management.

### 5.9.1 Weather based irrigation control systems

Irrigation control systems have been developed that use climatic data to calculate irrigation run times or to schedule irrigation events. Such systems are a useful tool in managing irrigation and relieve the irrigation manager from the task of calculating the irrigation requirement and automatically adjust irrigation schedules as a function of the weather.

Some systems are fully automatic and are linked to weather stations from which they retrieve climatic data and automatically calculate reference ETo and effective rainfall. The irrigation requirement is then calculated using preset crop co-efficient and system efficiency factors. Semi-automatic systems require manual input of a base irrigation schedule and daily input of reference ETo and effective rainfall from which the system determines the frequency of irrigation events.

Services are available whereby irrigation management service providers access climatic data from a network of weather stations. The data is processed by a centralised computer and transmitted to irrigation sites adjusting schedules or regulating irrigation events according to the weather.

Climatic data can be accessed from either the Bureau of Meteorology or from private weather stations. A significant factor in the efficiency of the control system is the quality of data used.

### 5.9.2 Weather stations

Weather stations can be installed by organisations to provide real time climatic data from which reference evaporation can be calculated. Weather stations are particularly useful for regional areas where Bureau of Meteorology data is limited or for specific sites where climate data is required.

Weather stations used for monitoring reference evapotranspiration (ETo) should conform to the requirements specified by the Bureau of Meteorology and in the FAO Technical Paper No 56.

The following data is required;

- Air temperature.
- Relative humidity.
- Wind speed.
- Solar radiation.

Weather station data is then used by the system to calculate ETo and subsequent irrigation schedules or events.

### 5.9.3 Soil moisture based irrigation control systems

Soil moisture sensors are able to directly record the soil moisture status of the soil. Information gained from soil moisture sensors provides both data on soil water reduction through ETc and a feedback loop which monitors the accuracy of climate driven irrigation schedules. The sensors record the net effect of the integration of soil, turf grass, climate and irrigation to assist with identifying indicators that drive the decision for irrigation and monitor the efficiency of irrigation.

Soil moisture sensors can be directly linked to the irrigation controller and are set at a threshold between field capacity and wilting point. The sensor will enable the system to activate a preset irrigation event when it records a reduction in soil moisture level to a percentage of field capacity. The irrigation event will apply a quantity of water that replenishes the soil moisture level to field capacity.

Soil moisture sensors can also be used in conjunction with weather based control systems to monitor soil moisture levels and water movement through the soil profile. They provide a feedback loop from which scheduling parameters can be adjusted to improve irrigation efficiency.

Soil moisture sensors also provide conductivity measurements which are useful where treated effluent or water with high salt content is being used. When the sensor readings indicate that salt levels in the soil have reached a critically high point based on the conductivity readings, the turf should be irrigated heavily to leach the salts to below the root zone.

With the use of soil moisture sensors, the irrigation manager can be aware of:

- Root zone activity and root depth.
- Drying out of the profile during hot spells.
- Infiltration levels as the profile builds.
- The timing of when to change the irrigation regime to avoid over watering.
- The effectiveness of rain fall events in filling up the profile
- How effective is the leaching program of salts below the root zone.
- What the actual irrigations events occurred with visual documentation to enable review and improvements.

### 5.9.4 Rainfall sensors

Rainfall sensors are a simple, effective method of interrupting irrigation when an effective rainfall event has been experienced. Rainfall sensors are wired into a controller and can override the irrigation schedule causing the system to shut down in the event of rainfall.

### 5.9.5 Flow and pressure sensors

Flow and pressure sensors are used widely with pumping systems to control pump operation in the event of abnormally low or high flows or pressures. They can also be used on mains water supply systems to detect bursts or sprinkler malfunctions and interrupt irrigation by closing a master valve in the event of failure.

### 5.9.6 Computerised Irrigation Management System (CIMS)

Computerised Irrigation Management Systems (CIMS) can be linked to a diverse range of sensors to remotely control irrigation events based on data collected from the sensors. CIMS will calculate the irrigation requirement based on sound principles using data transmitted from weather stations or soil moisture sensors or entered by the irrigation manager. CIMS can also remotely monitor system flows, pressure, or any aspect of the irrigation system that is sensor installed.

CIMS have the capacity to manage a network of satellite controllers through a centralised computer system. The system can monitor and control the irrigation schedule based on a variety of parameters including flow rates, pressures, weather conditions and soil moisture from a single location.

CIMS can be managed by the irrigation manager or can be managed externally by irrigation management providers.

FURTHER INFORMATION:
DEVELOPING AN IRRIGATION SCHEDULE

Cape, J. 2004. Certified Landscape Irrigation Auditor Resource Manual. Irrigation Australia Limited, NSW. www.irrigation.org.au

FAO Technical Paper No 56 – Crop Evapotranspiration. Guidelines for computing crop water requirements 1988. http://www.fao.org/docrep/X0490E/X0490E00.htm

Australian Bureau of Meteorology (BoM), 2005, "Automatic Weather Stations for Agricultural and Other Applications."

US Department of Interior. Bureau of Reclamation, Lower Colorado Region. South California Area Office. 2007. Weather and Soil Moisture Based Landscape Irrigation Scheduling Devices – Technical Review Report.

Connellan, G. 2005. Best Practice Turf Irrigation Management, Victorian Golf Association, Vic. www.golfvic.org.au

# CASE STUDY No 4

## GLENELG GOLF CLUB – IRRIGATION MANAGEMENT

Glenelg Golf Club is a private course. It is one of Adelaide's four Group 1 Clubs and ranked inside the top 70 in Australia and is based on the sand belt of Adelaide's western suburbs, 1km from Gulf St Vincent and in close proximity to Brownhill and Sturt Creeks and the Patawolonga.

Glenelg has gone through a process of improving turf and irrigation management practices over the past 10 years with the redevelopment of the course commencing in 1998. This process included reconstruction of some greens, fairways and tees; the upgrading of the irrigation system and the installation of a computerised centralised control system; the use of soil moisture sensors to monitor soil water volumes and salt content of the soil and the development of wetlands to harvest stormwater for an aquifer storage and recovery system that will provide a sustainable water supply for the course.

The results of the significant investment have been:

- Overall improvement in the turf quality of the course.
- Significant reduction in water consumption for irrigation.
- Sustainable environmental management practices that minimise impact on the site and ground water reserves.
- Improved water quality and access to a sustainable water supply.
- Improved management of nutrient and salt levels within the soil profile.

Glenelg Golf Club is committed to sustainable management of water and has invested heavily to develop and monitor efficiency improvements.

This case study demonstrates this commitment, which is documented throughout the Club's Environmental Management System and Quality Turf Plan.

For more information refer to the full case study in Appendix No 4.

# 6.0 IRRIGATION MONITORING & PERFORMANCE REPORTING

It is necessary to monitor both water consumption and quality or 'fit for purpose' standard of turf, to ensure the objectives of efficient and effective turf and irrigation management are being met. The objective of irrigation management is to produce a turf quality outcome that is able to meet its functional objective.

## 6.1 Irrigation efficiency reporting

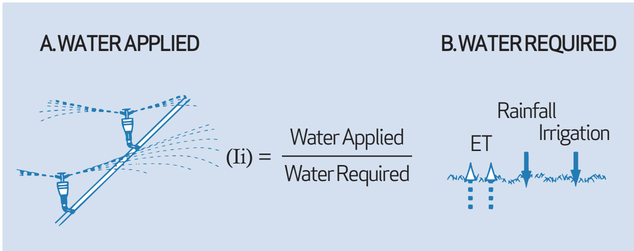
In order to evaluate past and current irrigation efficiency, it is necessary to compare Irrigation Applied (I) with the Irrigation Requirement (BIr or Ir) for a given period.

Irrigation efficiency reporting models compare the Irrigation Applied (I) with Base Irrigation Requirement (BIr) and/or the Irrigation Requirement (Ir) to calculate an Irrigation Efficiency Index (Ii) for each site. The Ii is used as a measure of water use efficiency.

Ii = I/Ir

Where:
Ii - Irrigation Efficiency Index (decimal)
I - Irrigation Applied (mm)
Ir - Irrigation Requirement (mm)

**Figure No 4 – Irrigation Efficiency Index (Ii)**




Graphic courtesy of Geoff Connellan, University of Melbourne.

The Irrigation Applied (I) is obtained by reading the water meter or from SA Water consumption records. Meters should be fitted to all water supplies. Where buildings or other uses come off the same water supply, slave meters should be fitted to record consumption for each function. Meters with electronic flow rate output signals that can be monitored remotely are desirable.

**Table No 10 - Irrigation Efficiency Index - Comparison between various categories of turf**

| Description | TQVS Cat. | Area ha | BIr kL/site | $Ir_{(06/07)}$ kL/site | $I_{(06/07)}$ kL/site | Variance (I–Ir) | Irrigation Efficiency (Ii) |
|---|---|---|---|---|---|---|---|
| AFL Football Ground | 1 | 1.9 | 15,915 | 19,729 | 20,910 | 1,181 | 1.06 |
| District Cricket Ground | 2 | 1.7 | 7,766 | 9,852 | 10,910 | 1,058 | 1.11 |
| Local Soccer Ground | 3 | 1.2 | 4,340 | 5,578 | 5,395 | -183 | 0.97 |
| Local Picnic Ground | 4 | 0.6 | 1,599 | 2,101 | 3,005 | 904 | 1.43 |

Note – $I_{(06/07)}$ values are for demonstration only.

Examples of Ii for each TQVS category of turf using $Ir_{(06/07)}$ data are shown below;

A Ii result of 1.0 indicates that the Irrigation Application (I) is equal to Irrigation Requirement (Ir) which is the aim of good irrigation management. Where the result is >1.0 this indicates more water has been used than required. Conversely where the result is <1.0 the indication is that less water has been used than required.

In principle good irrigation management should aim at achieving an Ii of between 0.90 and 1.10 within 10% of the irrigation requirement.

A template for calculating monthly irrigation efficiency index is provided as *Appendix No 3 – 'IPOS – Irrigation Efficiency Reporting Model'.*

**Assessing Past Irrigation Efficiency**

When comparing past performance of irrigation application, the BIr is used as the benchmark. The past 4-5 year average irrigation consumption ($I_{(avge)}$) per site, taken from SA Water records, is divided by the BIr to determine the historical Ii.

The BIr is also used to assess irrigation efficiency against water use targets. The BIr does not, however, assess irrigation efficiency against the actual irrigation requirement. To achieve this the irrigation requirement for the current period ($Ir_{(06/07)}$) must be used.

**Assessing Current Irrigation Efficiency**

It is important that irrigation efficiency is monitored regularly throughout the irrigation season. The Ir is used to monitor irrigation efficiency for the current period or season. There can be significant variance between the average water requirement BIr and the actual water requirement Ir due to variations in the weather. Water usage can only be measured retrospectively; therefore, adjustments to consumption can only be made in relation to future irrigation events. Actual irrigation consumption AIC should be monitored monthly.

Monitoring of Ii monthly enables the irrigator to adjust irrigation schedules periodically, with minimal impact on turf quality, to ensure irrigation targets are met over the entire season. The cumulative water consumption and Ii can also be monitored throughout the season.

## 6.2 Turf quality/'fit for use' reporting

Assessing irrigation efficiency is only half the job. With the ultimate objective being the provision of safe, 'fit for purpose' turf, the quality of the turf must also be monitored regularly. Reducing water consumption at the expense of the ability of the turf to perform its intended function is an unacceptable outcome.

The Ii can be linked to turf quality and thereby provide indicators as to the performance of the overall turf and irrigation management.

Table No 11 provides a correlation between Ii and the turf quality outcome.

The matrix below provides turf quality indicators according to varying irrigation efficiency indices. The turf must however be monitored and inspected to ensure the actual turf quality and 'fit for purpose' standards are acceptable.

Turf should be maintained to meet quality and risk management standards appropriate for its intended use. Sporting club associations and ground managers have a duty of care to all people using facilities. This means that sports facilities, including the turf surface, must not present an unacceptable risk of injury to those using them.

The standards for turf will vary with the TQVS rating and the usage of the ground. It is important to document the required standards using criteria discussed in section 5.5 of the Code. A quality and risk assessment inspection sheet should be prepared to enable sites to be assessed and a record kept of the assessment outcomes. A risk assessment of the turf surface should be undertaken weekly for active sports with a quality audit undertaken monthly to monitor wear trends and turf quality.

**Table No 11 - Irrigation Efficiency – Turf Quality Analysis Matrix**

| Irrigation Efficiency Index (Ii) | Efficiency Rating | Turf Quality Indicator |
|---|---|---|
| < 0.50 | Extremely poor | I is greater than 50% less than Ir. Turf under significant stress/dying.<br>Sports ground may be unsafe and not "fit for use".<br>Review Irrigation Management Plan and scheduling parameters. |
| 0.69 to 0.50 | Very poor | I is between 31 to 50% less than Ir. Turf wilting does not meet quality standard.<br>Sports ground may be unsafe and not "fit for use". Review and alter scheduling parameters. |
| 0.79 to 0.70 | Poor | I is between 21 to 30% less than Ir. Turf showing signs of stress.<br>Does not meet quality standard. Review and alter scheduling parameters. |
| 0.89 to 0.80 | Medium | I is between 11 to 20% Ir. Turf quality declining. Increased irrigation required.<br>Check scheduling parameters. |
| 0.99 to 0.90 | Good | I is less than 10% of Ir. Turf meets quality standard. Fine tune scheduling parameters. |
| 1.00 | Optimum | Irrigation applied (I) meets Irrigation requirement (Ir). Turf meets quality standard. |
| 1.01 to 1.10 | Good | I is between 1 to 10% greater than Ir. Turf meets quality standard.<br>Fine tune scheduling parameters. |
| 1.11 to 1.20 | Medium | I is between 11 to 20% greater than Ir. Turf quality high.<br>Reduction in irrigation required. Check scheduling parameters. |
| 1.21 to 1.30 | Poor | I is between 21 to 30% greater than AIR. Turf lush, exceeding quality standard.<br>Water wastage. Review and alter scheduling parameters. |
| 1.31 to 1.50 | Very poor | I is between 31 to 50% greater than Ir. Turf lush exceeding quality standard.<br>Wastage of water. Review and alter scheduling parameters. |
| > 1.50 | Extremely poor | I is greater than 50% more than Ir. Turf lush. Significant water wastage.<br>Review Irrigation Management Plan and scheduling parameters. |

# 7.0 DROUGHT RESPONSE PLAN

A drought response plan should be developed to ensure strategies are in place to deal with drought scenarios where water availability for irrigated public open space is reduced.

The objective of the drought response plan is to provide a staged strategy that protects community assets and valuable recreation facilities while reducing water consumption during periods of drought. The costs of re-establishing the landscape and irrigated turf can be significant.

As a result of drought conditions and water shortages in national capitals across Australia, water restrictions have been introduced ranging from permanent water conservation measures where management of IPOS must follow best practice management to Level 5 restrictions where irrigation of public open space using potable mains water is prohibited. Organisations responsible for managing IPOS must be prepared to take appropriate action to comply with water use reduction regimes and restrictions.

In developing a drought response plan the following issues require consideration:

- A Water Efficiency Management Plan (WEMP) should be developed in accordance with the Code of Practice. The WEMP should be implemented as part of permanent water conservation measures.
- All irrigated sites should be categorised according to the TQVS standard and functional objective of the site as part of the WEMP.
- An inventory of all significant and feature trees and garden beds should be made prioritising them in order of importance.
- Turf sites should be assessed against functional standards and reduced in size to the minimum area required to meet the functional objective. Areas where irrigation is withdrawn should be re-landscaped with drought tolerant plantings and treatments.
- A strategy of withdrawing irrigation from less functional sites should be prepared, to be implemented as water availability decreases.
- Alternate water supplies to potable mains water should be investigated and where possible accessed for irrigation purposes. Ground water or recycled water may have to be transported to critical areas of the landscape i.e. significant trees or turf cricket pitches, as mains water availability reduces.
- Sports grounds may have to be closed to competitive sport where grounds become unsafe for play. Turf quality and risk assessment audits will form the basis of such ground closures.

# 8.0 TRAINING & CERTIFICATION

In order to manage IPOS effectively specific skill sets or competencies are required at different levels from the maintenance of grounds and irrigation systems to scheduling, management and design. The following matrix details competencies and qualifications required by personnel involved in the management of IPOS.

**Table No 12 – Irrigation Skills Matrix**

| Position/Task | Competency level | Min. qualifications/accreditation |
|---|---|---|
| Grounds person | General horticulture skills including;<br>- Turf cultural practices<br>- Soils & plant nutrition<br>- Turf grass identification<br>- Operating irrigation systems | Certificate III Horticulture/Turf Management<br><br>IAL Certified Irrigation Operator |
| Irrigation installer/maintenance worker | Irrigation, installation & maintenance | Certificate III Horticulture/Irrigation<br><br>IAL Certified Irrigation Installer |
| Irrigation auditor/scheduler | Advanced horticulture & irrigation maintenance<br>- Monitor performance of Irrigation system & turf quality | Certificate IV Horticulture/Turf<br><br>IAL Certified Landscape Irrigation Auditor |
| Parks/irrigation manager | Advanced horticulture & irrigation management<br>- Manage overall performance of the landscape including human, infrastructure & financial resources | Diploma Horticulture<br><br>IAL Certified Landscape Irrigation Manager |
| Irrigation designer | Advanced horticulture & irrigation<br>- Design landscape irrigation systems<br>- Provide advice on efficient irrigation practices | Diploma Horticulture/Irrigation<br><br>IAL Certified Irrigation Designer |
| Landscape design | Landscape design/plant selection<br>- Plant selection<br>- Water sensitive urban design<br>- Landscape design | Diploma Landscape Design<br><br>Bachelor Landscape Architecture |

# 9.0 CONCLUSION

*The Code of Practice – Irrigated Public Open Space* provides a process which can be used by managers of IPOS to ensure the planning, management and reporting of water consumption in the urban environment is based on sound principles applied consistently at all levels of management. The Code of Practice can be used by providers, practitioners, and regulating authorities to set policy, manage resources and regulate water use in the provision of IPOS.

# APPENDICES

## APPENDIX No 1

### IPOS – WATER BUDGET/IRRIGATION REQUIREMENT MODEL

(refer Excel spreadsheets on CD supplied in the back of this document for Appendices 1 – 3)

## APPENDIX No 2

### IPOS – IRRIGATION SCHEDULING MODEL

(refer Excel spreadsheets on CD supplied in the back of this document for Appendices 1 – 3)

## APPENDIX No 3

### IPOS – IRRIGATION EFFICIENCY REPORTING MODEL

(refer Excel spreadsheets on CD supplied in the back of this document for Appendices 1 – 3)

## APPENDIX No 4

### DETAILED CASE STUDIES

## APPENDIX No 5

### GLOSSARY

# APPENDIX No 4 – CASE STUDY No 1

## CITY OF SALISBURY
## - AQUIFER STORAGE AND RECOVERY

**Origins of Wetland and Aquifer Storage and Recharge (ASR).**

In the early 1970's the City of Salisbury embarked on a project to redevelop a 46 hectare (ha) site in Para Hills known as the Paddocks. The objective of the development was to create a community sport and recreation complex and to provide flood mitigation for proposed residential developments adjacent to the site. 23 (ha) of irrigated passive and active turf was developed while the remaining 23 (ha) was constructed with a series of mounds, swales and shallow wetlands planted out with indigenous terrestrial and aquatic plantings. Stormwater from the adjacent para-escarpment residential area was held within the constructed wetlands providing flood protection for adjacent developments while the irrigated sports grounds provided a valuable recreation facility for the community.

At the time of construction little was known of the potential for wetlands to improve water quality and the main objective was for flood mitigation and to provide a significant landscape feature. It was not until the early 1990's that water quality monitoring of the site identified the success of the wetland in improving water quality to the point where it was suitable for aquifer recharge. Nutrient and pollution loads are reduced by as much as 90% with the treated water having salinity less than 220 gm/l. Subsequently the Paddocks became the first Aquifer Storage and Recovery (ASR) site in Adelaide and became the prototype for ASR projects nationally. Today the stormwater from the para-escarpment in winter is cleansed through the Paddocks wetland, recharged into the underground aquifer and drawn from the aquifer to irrigate the entire sporting complex during summer.

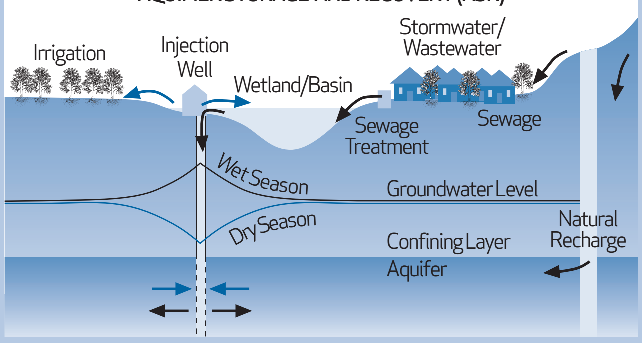
The City of Salisbury now has some thirty six major wetlands, covering several square kilometres in all. In addition, all new residential subdivisions in the past ten years have been required to install wetlands to contain stormwater onsite as much as possible. Large industrial developments have also been actively encouraged to develop wetlands for the same reason and in order to contain potential industrial spills. Collectively, these initiatives have effectively eliminated flood risk in an otherwise flood-prone area and have dramatically increased the wildlife habitat and biodiversity within the City.

Importantly, they have also substantially reduced the flow of polluted surface water into the fragile Barker Inlet estuary, opened new opportunities for the economic recycling of stormwater and reduced demand on water sourced from the River Murray.

### Water for Industry

The City of Salisbury has six ASR sites currently operating, harvesting a total of 1,895 megalitres (ML) of stormwater annually. Two ASR sites are used to provide water to industry which would otherwise rely on mains water as the primary source. The Parafield Wetlands provide 1,100 ML per annum to G H Michell and Sons, Australia's largest wool processing company. The Kaurna Park Wetlands provides 100 ML of water to Heynes Nursery. The Edinburgh Parks Storm Water Supply Project is currently under development and will yield approximately 1,500 ML of water annually supplying General Motors Holden, DSTO, Edinburgh Airport and the Edinburgh Parks Industrial Precinct.

AQUIFIER STORAGE AND RECOVERY (ASR)



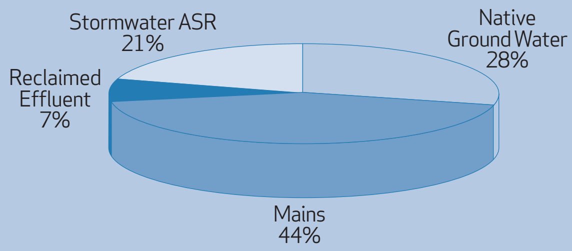

### Water for Irrigated Public Open Space

In addition to supporting industry with supplies of alternative water sources, the City of Salisbury has invested significantly in developing alternative water supplies to irrigated public open space. In 1983 Salisbury had only 6% of its irrigated area supplied by alternative water supplies to mains water. In 2006 this increased to 56%.

### City of Salisbury Water Use Profile 2006 – Irrigated Public Open Space

| Water Supply | Mains | Native Ground Water | Re-claimed Effluent | Storm Water ASR | Total |
|---|---|---|---|---|---|
| Area ha | 75 | 48 | 11 | 35 | 169 |
| Area % | 44% | 28% | 7% | 21% | 100% |
| ML / Annum | 285 | 183 | 42 | 134 | 643 |

CITY OF SALISBURY WATER USE PROFILE 2006




Extension of the ASR program has also seen schools within the council area being provided with water to irrigate their sports grounds. Currently eight schools are being supplied with ASR based water with a further thirty sites identified for connection over the next three years.

### Water for the Community (Mawson Lakes)

The developing suburb of Mawson Lakes in the City of Salisbury local government area will cater for approximately 10,000 residents when complete in 2010. This innovative development uses recycled water technology to provide both potable mains water and alternative recycled water to every house in the development.

This recycled water system is the product of a unique partnership between the State Government's Land Management Corporation, SA Water, Delfin Lend Lease and the City of Salisbury.

The recycled water is a mix of treated wastewater from the SA Water Bolivar Wastewater Treatment Plant and cleansed stormwater from the Parafield Airport Wetlands.

Treated wastewater is chlorinated and pumped from the plant at Bolivar, to a 25 ML tank adjacent to the Greenfields wetlands. Water from the Parafield Stormwater Harvesting scheme is pumped to the tank at Greenfields, where it is mixed with treated wastewater. From the mixing tank it is pumped by SA Water to Mawson Lakes via a separate reticulation system defined by lilac coloured pipes.

The recycled water at Mawson Lakes is used by residents for flushing toilets, watering gardens and washing cars as well as for irrigating public open space within the development.

**Water for the Future (Waterproofing Northern Adelaide)**

In the past decade the City of Salisbury has pioneered the use of wetlands and water recycling projects to improve overall water efficiency in the region. In recognition of achievements to date the Waterproofing Northern Adelaide Project has now commenced. The Australian Government Water Fund is providing a $41.8m grant, the State will provide over $16m and three councils (Salisbury, Playford and Tea Tree Gully) will invest over $22m over the years up to 2010.

This project will integrate stormwater, groundwater, wastewater and drinking water systems in the Northern Adelaide Plains region of South Australia and will include:

- The capture and cleansing of stormwater in urban wetlands, Aquifer Storage and Recovery (ASR) and distribution of water for the irrigation of public spaces and for industrial use.
- An Aquifer Storage, Treatment and Recovery (ASTR) trial to be undertaken by the CSIRO to determine optimum practices of storage and recovery to treat water to drinking quality standards.
- The trialling of a system to utilise domestic rainwater tanks to harvest water and release it for community reuse.
- Hydrological modelling to predict the annual average runoff from regional catchments to enhance regional water management.

The project will also substitute 1.2 gigalitres per year of water currently sourced from stressed groundwater systems and recharge five gigalitres per year to the local over used and over allocated groundwater.

12.1 gigalitres per year of drinking water currently used for industrial and urban irrigation will be replaced with treated stormwater drawn from the Northern Adelaide Plains groundwater system. This will reduce the region's dependence on drinking water by 6%.

The additional recharge to the groundwater will return the Dry Creek, Virginia and Waterloo Corner regions of groundwater drawdown to sustainable levels. The reuse of stormwater will reduce the ocean outfall through Barker Inlet and the regions dependence on water from the River Murray.

**Conclusion**

The City of Salisbury has demonstrated leadership in the area of integrated water cycle management. The construction of swales, wetlands and ponding basins has enhanced the landscape and biodiversity of the Northern Adelaide Plain and has provided opportunity to harvest stormwater for reuse in industry and the irrigation of public open space.

It is hoped the leadership shown by the City of Salisbury in this area will act as a catalyst to achieve the paradigm shift amoung regulators, industry and the community that is necessary if we are to realise the enormous potential of stormwater as a valuable and sustainable resource.

FURTHER INFORMATION:
Go to www.salisbury.sa.gov.au

# APPENDIX No 4 – CASE STUDY No 2

## IRRIGATION AUDITING - DEPARTMENT OF EDUCATION AND CHILDREN'S SERVICES

The South Australian Department of Education and Children's Services (DECS) has directed significant resources in recent years toward improvements in irrigation infrastructure and management. Many schools have received financial grants to automate manual systems to permit night time watering and water efficient scheduling. Others have been assisted in the training of the grounds staff in efficient irrigation techniques and the auditing of irrigation practices. DECS irrigation audits are carried out by landscape irrigation auditors certified by the Irrigation Australia Limited (IAL) and are to be done according to the IAL Certified Landscape Irrigation Audit Methodology. Information provided in the audits is sufficiently detailed to:

- Permit efficiency rating of the irrigation system
- Quantify potential mains water savings
- Calculate water budgets for each school

Comparing historical consumption with the recommended Base Irrigation Rates in the Code of Practice can reveal which schools are potentially over-watering. A school oval should typically be watered to the Turf Quality Visual Standard 'Classification No 3 – Local Sports Turf' (a Base Irrigation Rate of 3620 kL/ha/annum). Auditors can develop water budgets around this target figure and provide recommendations to reduce water use without compromising turf quality. Estimated water savings should be quantified for each recommendation to enable prioritisation of actions. Some of the more significant actions being implemented at DECS schools as a result of recent audits include:

- Reprogramming controllers against a recommended schedule.
- Installation of sub metering.
- Raising, realigning or replacing sprinkler heads.
- Installing rain sensors, flow sensor and moisture sensors.
- Fixing leaking seals.
- Replacing mainlines.
- Replacing leaking heads.
- Installing pumps and tanks to improve system performance.
- Relocating, rewiring or reprogramming controllers.

Approximately 20% of mains water used for parks, gardens, ovals and sports fields in South Australia is used in schools. As a significant water user DECS seeks to continually improve its water management practices.

FURTHER INFORMATION:
Craig Walker, Senior Adviser ESD
Dept Education and Children's Services
Telephone 8226 1295

**The table below lists DECS schools within metropolitan Adelaide that were recently audited.**

| School # | Irrigation System Distribution Uniformity (DU) | Average Irrigation Water Use (kL/annum) | Area of turf under irrigation | Historical irrigation water use (kL/ha) | Base Irrigation required TQVS Cat3 (kL/ha) | Potential water savings (kL/annum) |
|---|---|---|---|---|---|---|
| 1 | 58% | 29,280 | 6.05 | 4,840 | 3,620 | 7,381 |
| 2 | 65% | 19,968 | 3.90 | 5,120 | 3,620 | 5,850 |
| 3 | 68% | 25,154 | 4.27 | 5,891 | 3,620 | 9,697 |
| 4 | 66% | 19,910 | 4.42 | 4,505 | 3,620 | 3,912 |
| 5 | 72% | 17,540 | 4.50 | 3,898 | 3,620 | 1,251 |
| 6 | 68% | 20,469 | 4.41 | 4,792 | 3,620 | 5,169 |

# APPENDIX No 4 – CASE STUDY No 3

## CITY OF TEA TREE GULLY – IRRIGATION MANAGEMENT STRATEGIES

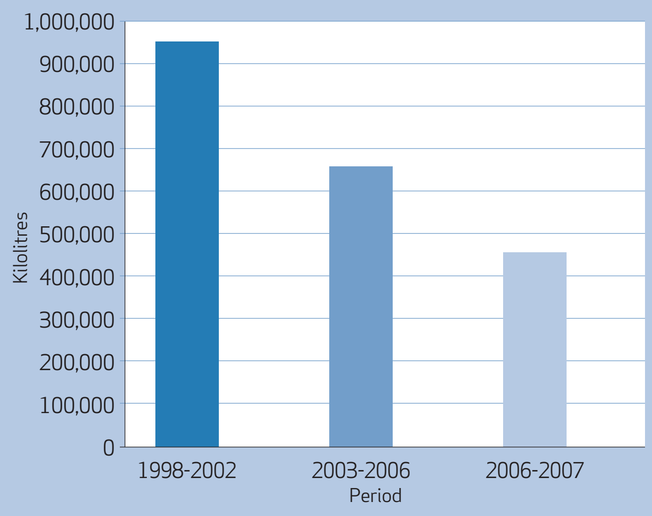
The City of Tea Tree Gully (located in the north of the Adelaide metropolitan area) has a total of 430 irrigated parks and reserves totalling 171 hectares.

An Irrigation Management Strategy (IMS) was implemented by the city in 2003 when permanent water conservation measures were introduced. The objective of the IMS was to reduce water consumption by a minimum of 20% while ensuring efficient irrigation practices and 'fit for purpose' sport and recreational turf.

The results over the three year period from 2003-2006 has seen a reduction of 31% or 290,000 kL per annum from 950,000 kL to 660,000 kL in overall water consumption while maintaining the same area of irrigated turf to satisfactory 'fit for use' standards.

**Average Water Consumption per annum**

| Period | Irrigated area (ha) | Average Annual Consumption kL/annum | Consumption per Hectare kL/ha |
|---|---|---|---|
| 1998 - 2003 | 171 | 950,000 | 5,556 |
| 2003 - 2006 | 171 | 660,000 | 3,860 |
| Variance kL | | 290,000 | 1,696 |
| Variance % | | 31% | 31% |
| 2006 / 2007 | | 460,000 | |




Further reductions of 200,000 kL were achieved in the irrigation season 2006/07. These savings were largely the result of a reduction in irrigated area and the downgrading of some sites in order to meet the requirements for exemptions from Level 3 water restrictions to enable irrigation of sports grounds. The commissioning of ground water and ASR water supply projects also resulted in reduced mains water consumption.

These results have been achieved through the implementation of a number of strategies to minimise water use on irrigated public open space. Strategies have included:

### Establishment of a Proactive Water Management System

The objective of this strategy was to read all council water meters on a monthly basis and use this information to track water use. This strategy has been implemented for the past three years and has resulted in large water savings across the City. The information is also used to identify high water use areas, pipe leaks and assists Council to prioritise irrigation system repairs, upgrades and replacements.

### Irrigation Control Systems Replacement Program

Irrigation controllers throughout the City were aging, faulty and lacked the latest water saving technologies such as water budgeting, central control capabilities and 'cycle and soak' watering.

Over the past three years the Council has updated all of its controllers in the field to central control compatible systems that have many water saving features, even as stand-alone controllers. The larger sites will progressively be connected to a high-tech central control irrigation management system over the next few years.

This system downloads information from a weather station such as evaporation and rainfall on a daily basis and automatically adjusts schedules to suit the environmental conditions. With the addition of an electronic flow meter to the irrigation system the controller will recognise pipe breaks and electrical faults in the field and shut the system down, potentially saving substantial amounts of water.

### Auditing of Existing Systems

Auditing of all Council's irrigation systems is prioritised, starting with high water use reserves and larger irrigated areas. Auditing of irrigation systems is an essential and valuable tool to understand system performance and develop the appropriate schedule for each site. The majority of irrigation system infrastructure is aging (10-30 years old) and was not designed to current industry 'best practice' standards, resulting in high maintenance and poor system efficiency (Distribution uniformities averaging 55%).

### Irrigation System Upgrades/Subsurface Drip Irrigation

Based on the results of the irrigation audits, irrigation systems are being progressively upgraded. Where appropriate, sub surface drip irrigation systems are being installed.

The City of Tea Tree Gully was the first council in Australia to trial sub-surface drip irrigation in a sportsfield in 1993. Sub-surface drip irrigates the turf directly to the root zone where the water is required. These systems are capable of improving irrigation efficiency by 30 – 40%. Vandalism and maintenance costs are also significantly reduced. Council has four sports fields and ten neighbourhood parks irrigated with sub-surface drip.

Council has been successful in obtaining Federal Government Community Water Grant funding to assist in the upgrading of irrigation systems.

### Alternative Water Sources

Council has been proactive over the last five years, and has put in place schemes to reduce reliance on mains water. These strategies have provided for diversion from mains water to reclaimed/reuse water and to date have accounted for approximately 90,000 kL per annum, equating to approximately 15% of the City's water consumption.

Tea Tree Gully Council has joined forces with the Cities of Salisbury and Playford in the Waterproofing Northern Adelaide initiative in a bid to conserve and recycle water in the northern suburbs of Adelaide. This new water resource management scheme will deliver significant social, environmental and economic developments to the City.

Under this scheme the City, for irrigation proposes to totally replace the demand on mains water by using treated wastewater and cleansed stormwater to meet the Council's irrigation needs and to supplement mains water supplied to industries with higher water requirements.

### Conclusion

Over the past three to five years sound irrigation management strategies has resulted in significant reduction of water consumption for irrigated public open space within the City of Tea Tree Gully. Subsequent to reduced water consumption has been significant financial savings which will be ongoing and enable the funding of irrigation upgrades, the introduction of new technology and the development of alternative water supplies which will ensure a sustainable water supply into the future.

FURTHER INFORMATION:
Go to www.teatreegully.sa.gov.au

# APPENDIX No 4 – CASE STUDY No 4

## GLENELG GOLF CLUB – IRRIGATION MANAGEMENT

Glenelg Golf Club is a private course and is one of Adelaide's four Group 1 Clubs ranked inside the top 70 in Australia. It is based on the sand belt of Adelaide's western suburbs, 1km from Gulf St Vincent in close proximity to Brownhill and Sturt Creeks and the Patawolonga.

The geological history of the site has resulted in a complex groundwater system that can be located at depths of one metre in places through to 100m (Tertiary – T1) and 200m (Tertiary – T2) under the course.

Irrigation management at Glenelg Golf Club is driven by the following:

- Expectations for high quality playing surfaces from members and guests.
- Complexity of this groundwater system.
- Environmental sensitivity of the site.
- Potential for public scrutiny of management practices.

### Course Redevelopment/Irrigation System Upgrade

Since the Club was formed in 1927 it has had access to bore water throughout the course for irrigation purposes. This water was delivered via a constantly evolving manual irrigation system up until 1973 when an automatic system was installed. This system was based around single row valve-in-head sprinklers on fairways and single speed full circle sprinklers around greens and tees.

The system was continually upgraded and altered, including the installation of a variable speed pump set in 1991 to improve water delivery efficiency and reduce pipe work stress from water hammer.

In 1998, the Club embarked on a staged Course Redevelopment Project to upgrade the quality of the turf playing surfaces and produce a sustainable course. Water management was a cornerstone for the success of this project, with Irrigation Management identified as an area that needed to be addressed at several levels.

As a result, each stage of the project included capital investment (dictated by budget) in the irrigation system. This process is continuing today (despite the course redevelopment having been completed in 2004), with sectional upgrades planned until 2010. From 2010, an asset management plan for the irrigation system has been projected to 2025 so that irrigation management remains a focus for the Club in years to come.

Some of the features of the irrigation management review and irrigation system upgrade have included:

- Fully computerised central control system.
- More efficient control of applied water, and performance monitoring capabilities.
- Installation of dual (and triple) row fairway irrigation.
- Greater distribution uniformity without increasing irrigated areas.
- Installation of dual head green and surrounds sprinklers.
- More precise control of differing irrigation demands.
- Use of adjustable arc sprinkler heads.
- Flexibility in irrigation management as part of drought response plan.
- Introduction of prospective ET based scheduling.
- Ability to match applied water with plant needs.

### Results

These improvements, along with the introduction of improved turf species and turf management practices, have resulted in water savings of:

- >40% on greens
- >30% across the entire course

Current water application rates are:

- Bent grass greens 10,000 kL/ha/annum
- Couch fairways and tees 7 – 8,000 kL/ha/annum
- Roughs and carries 0 – 4,000 kL/ha/annum

Also

- 75% reduction in chemical use.
- Superior playing surfaces across the course.

### Soil Moisture Monitoring

As significant as these savings and improvements are, Glenelg Golf Club continues to seek ways of further improving water management practices across the course.

The summer of 2006-07 saw the trialling of soil moisture sensors in various locations around the course, aimed at providing 'live' data on soil moisture, temperature and salinity. This technology was used to monitor the performance of current irrigation practices and to understand the impacts of turf management practices over the course of the summer.

The information was particularly valuable as it supported the principles of the Club's Quality Turf Plan and Irrigation Management Plan, both of which take into account the saline nature of the Club's water supply.

It was found that current practices were not resulting in excessive leaching or movement of water beyond the turf root zone and in fact, the principles applied to irrigation scheduling for couch areas (fairways, tees) was resulting in deficit irrigation against ET and still producing high quality surfaces.

Through the latter part of the 2006-07 irrigation season one site was managed based on the data supplied from the soil moisture sensors and visual observations of turf quality. By autumn of 2007, irrigation management and lack of rainfall resulted in Volumetric Soil Moisture (VSM) being as low as 1-2% without seriously compromising playing surface quality, although presentation was slightly reduced.

This exercise highlighted the potential to make further reductions in water consumption.

There is still much to learn about this technology in turf situations, but it has great potential, including the following:

- Understanding the fate of applied water.
- Understanding the impacts of irrigation practices.
- Understanding the impacts of turf management practices.
- Reduction in water consumption based on actual data and plant requirement knowledge.
- Management of salinity.
- Monitoring of nutrient and pesticide fate.
- Timing of turf management practices and applications.

**Water Supply**

Up until 1973 Glenelg Golf Club's irrigation needs were supplied exclusively by bore water. The introduction of the automatic irrigation system in 1973 coincided with the introduction of recycled Class B effluent from the Glenelg Wastewater Treatment Plant, with demand being met for the next 30 years through a "50/50" blend of both bore and effluent water.

Both water sources were of similar salinity (1000-1300ppm), with the effluent containing nutrient loading that was far from balanced with turf needs and had to be factored into fertility programming.

In 2005, Glenelg Golf Club was faced with a choice for securing a longer term higher quality water supply due to price increases in the supply of effluent. The Club was very mindful of its obligation to have a positive impact on the wider community as well as to its members.

Detailed investigations led to the decision to invest in a $2 million Aquifer Storage and Recharge project, which will see the diversion of stormwater from Brownhill Creek into newly constructed wetlands on the course. This stormwater, which would otherwise flow untreated into the Patawolonga and Gulf St Vincent, will be pumped into the wetlands where the water quality will be improved naturally by the plants before it is injected into the underlying aquifer.

The resulting superior water quality (projected to be approximately 600ppm) will potentially result in further water savings due to improved reactions within the soil once applied.

**Summary**

Glenelg Golf Club is committed to sustainable management of water, and has invested heavily to develop and monitor efficiency improvements.

This case demonstrates this commitment, which is documented throughout the Club's Environmental Management System and Quality Turf Plan.

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FURTHER INFORMATION:
Daryl Sellar, Consulting Superintendent
Turfwise Consulting
Glenelg Golf Course

# APPENDIX No 5 – GLOSSARY

## GLOSSARY OF TERMS & ABBREVIATIONS

| Term | Abbreviation | Description |
|---|---|---|
| base irrigation requirement | BIr | The amount water to be applied by irrigation to a given area of turf to produce the desired quality outcome using long term average climatic data. |
| Bureau of Meteorology | BoM | Federal Government organisation responsible for monitoring and reporting on climate. |
| computerised irrigation management system | CIMS | Centralise irrigation control systems that manage a network of satellite controllers through a centralised computer. |
| distribution uniformity | DU | The average water applied in the 25% of the area receiving the least amount of water, regardless of location within the pattern, divided by the average water applied over the total area. |
| application efficiency | Ea | A factor representing the inherent irrigation system inefficiencies in applying water to the site. |
| evapotranspiration | ET | The combination of water that is lost to the soil by a combination of evaporation from the soil surface and transpiration by the plant. A measure of plant water requirement. |
| crop evapotranspiration | ETc | The ET rate of a specific crop. |
| reference evapotranspiration | ETo | The ET rate of a reference crop of healthy grass, completely covering the ground to a uniform height of 75 - 125 mm, evapotranspiration and having an adequate supply of water. |
| irrigation depth | I | The depth of water in mm applied by the irrigation system. |
| irrigation application rate | Iar | The rate at which the irrigation system applies water to the site expressed as mm per hour. |
| irrigation efficiency index | Ii | A measure of performance of irrigation system application which compares the depth of water applied ( I ) to the estimated depth of water required ( Ir ) for a given period. |
| net irrigation requirement | In | The water requirement of the plant (ETc) less effective rainfall for the period. |
| irrigated public open space | IPOS | Irrigated open space which is managed by or used by the general community. Usually managed by the public sector but also includes private schools and golf courses. |
| irrigation requirement | Ir | The amount water to be applied by irrigation to a given area of turf to produce the desired quality outcome for a given period using real time climatic data. |
| irrigation run time | Irt | The length of time the irrigation system must operate to apply the optimum irrigation event (OIE). |
| crop co-efficient | Kc | An agronomic factor that can be applied to Reference Evapotranspiration (Eto) value to convert ETo to an evapotranspiration value for a specified crop (ETc). |
| crop stress factor | Ks | A factor that is applied to the reference evapotranspiration (Eto) value and the crop co-efficient (Kc) to adjust the crop evapotranspiration (ETc) value in consideration of the plant quality required. |
| maximum allowable depletion | MAD | The amount of moisture that is allowed to be removed from the soil before an irrigation event occurs to replenish the soil water level to field capacity. The MAD is a factor representing the percentage of water removed from the TAW. |
| optimum irrigation event | OIE | The amount of water required to refill the root zone of the soil to Field Capacity. |
| rainfall | P | rain or precipitation that occurs naturally. |
| plant available water | PAW | The amount of water held in the root zone of the soil between field capacity and the maximum allowable depletion (MAD). |
| effective rainfall | Pe | The amount of rainfall that is held in the root zone of the soil and is available to the plant after a rain event. |
| effective rainfall factor | Pf | A factor representing the percentage of rainfall that is deemed to be effective. |

## GLOSSARY OF TERMS & ABBREVIATIONS

| Term | Abbreviation | Description |
|---|---|---|
| total available water | TAW | The amount of water held in the root zone of the soil between field capacity and wilting point. |
| irrigation interval | Ti | The number of days between irrigation events. |
| turf quality visual standard | TQVS | A visual indicator of turf quality based on the functional objective and 'Fit for Purpose' requirement of the turf grass surface. |
| water holding capacity | WHC | The amount of water that be held within the pore spaces of the soil. |
| root zone depth | Zr | The depth which the plants roots grow into the soil. |
| field capacity | | When a soil has been thoroughly wetted, then allowed to drain by gravity for a specified period of time, (usually one to two days depending on soil structure) until there is no further water loss. |
| wilting point | | The point at which the plant can no longer extract moisture for the soil. |

Government of South Australia

SA Water