Best Practice Guidelines for

FUNCTIONAL OPEN SPACE

Smart Water Fund | City West Water™ | IRRIGATION AUSTRALIA | STA Sports Turf Association Victoria Incorporated

Contents

This document is sponsored by the Smart Water Fund (now managed by Melbourne Water) and has been managed by City West Water.

Intent

The document is designed to assist open space managers and administrators in achieving improved water management of irrigated open space. There are many factors, in addition to water, that influence the functionality and sustainability of open space, however this document focuses mainly on water related issues.

Throughout the document, various other sources will be referenced that provide more in-depth detail on various topics. These will be included in the appendix by way of bibliography.

Acknowledgements

This guide was prepared with input from the wider turf and open space industry. It has been prepared as a guide only, and is not designed to represent policy or views of any one individual, stakeholder or organisation.

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1.0

Introduction

The potential contribution of green open spaces to the wellbeing of urban communities is being increasingly recognised. Health benefits, both physical and mental, are provided through the opportunity for exercise, exposure to the natural environment and microclimate modification.

The delivery of these benefits is dependent on the green open spaces' capacity to perform sustainably, under a wide range of climate and use conditions. Population growth with the associated increased use, climate change, and an increased expectation in the quality of sites, amongst other drivers, are putting pressure on open space managers to meet increased demands.

1.1 What is the aim of the guidelines?

The aim of these guidelines is to identify the key factors that contribute to the effective functioning of green open spaces and to provide managers with the knowledge and tools to achieve the required performance, with optimum utilisation of resources, including labour, costs and water.

A core element of the approach presented in these guidelines is identifying the services to be provided by the space, recognition of all of the factors that impact on functions, and making the business case for the establishment and maintenance of these valuable assets.

These guidelines support the establishment and maintenance of open spaces that contribute to the wellbeing of the community.

1.2 Why is open space management important?

Irrigation of open space accounts for over half of the water used by local councils and elite sports venues. During the millennium drought of 1995 to 2012, irrigated open spaces struggled for survival, with water restrictions aggravating already poor turf conditions and management practices. This highlighted the need for open space managers to demonstrate best practice management.

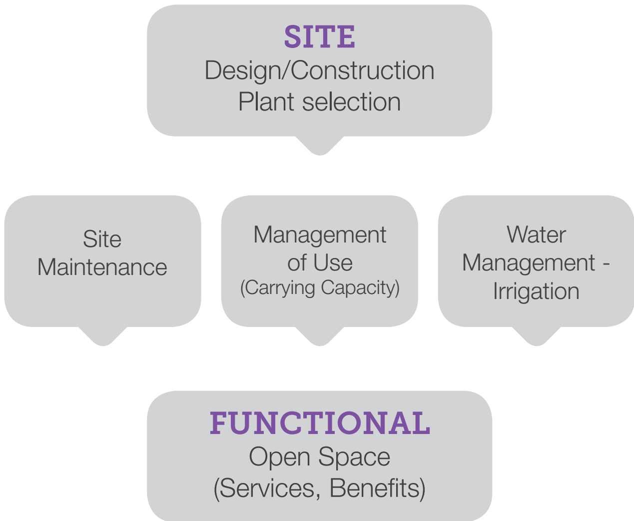
Maintaining open spaces effectively, especially in a drier climate, can have significant community health and social benefits. Loss of sport due to lack of suitable sports fields or closure of sports fields has been found to severely affect communities in a number of ways, including through reduced employment and physical activity.

It has also been linked to reduced health levels for individuals and increased health costs for the community.

These guidelines have been prepared to help open space managers and administrators balance the competing pressures of rising costs of water, fuel, chemicals and labour with open space health benefits and the needs of open space users.

The overall approach to achieving functional green open space is presented in Figure 1. The site provides the foundation asset on which to build, providing multiple benefits to the community, and can be further developed through rigorous maintenance, good water management and astutely managing the use of the space. The figure shows the pathway and core elements (Best Practice) in developing and maintaining a Functional space.

Figure 1: Overall approach to achieving functional green open space



A recent study funded by the AFL and AFL Victoria conducted by the Centre for Sport and Social Impact at La Trobe University identified that: For every $1 spent on a community football club, there is at least $4.40 return in social value.

Figure 2: Return on investment

Refer to: http://www.aflvic.com.au/wp-content/uploads/2015/02/Latrobe-Value-of-a-Community-Football-Club-Final-PDF.pdf

SECTION
2.0

What is green open space?

Open space is any open piece of land that has largely no buildings or other built structures and is accessible to the public.

Green open space can include:

- Green space (land that is partly or completely covered with grass, trees, shrubs, or other vegetation, including parks, community gardens, and cemeteries)
- Schoolyards • Playgrounds • Public areas • Sports fields
- Golf courses • Streetscapes

Open space provides passive and active recreational areas for people and helps to enhance the aesthetic and environmental quality of neighbourhoods.

A quality space that is accessible to the community and is sustainably managed is a core requirement. With increasing urbanisation and pressure on open space areas, there is community concern about accessibility and quality. It is therefore very important that all open spaces are established and managed so that they deliver the functions that they were designed to provide.

With the broad range of open spaces comes an equally broad range of environmental issues. Just as in any other land uses, the way open spaces are managed can have good or bad environmental impacts, including pesticide runoff, and destruction of habitat. Lack of community and public access to safe open space is another critical area of concern for urban residents.

Functional green open space is a space that is accessible and maintained for organised or casual activities. For example; spaces that facilitate sport, recreation and social interaction and provide benefits in terms of improved health and general wellbeing of the community.

Other services provided by functional open space include modification of the local microclimate and modified hydrology (e.g. reduced peak flows) and also the improvement of stormwater water quality.

2.1 Specifying functions for a space

In the planning and management of open space, it is important that the primary functions to be provided by the space are identified. This is critical to ensure that the space provides the services for which it is designed.

Functions provided by open spaces include:

Sports grounds

- Surface and site amenities suit the sport being played
- Surface that is safe to use

Parks

- Attractive/aesthetically pleasing
- Safe to visit use
- Cooling of local environment/microclimate

Trees

- Provision of shade
- Cooling of local microclimate
- Dust and atmospheric pollution mitigation
- Aesthetically pleasing/attractive

2.2 Requirements of Functional Open Spaces to Deliver Benefits

Equally important to identifying the desired function of an open space, it is necessary that the site be designed, constructed and maintained to achieve the desired function.

For each of the different types of open space, there are specific requirements that need to be satisfied to deliver the intended benefits of the functional green space. These requirements are:

Sports turf

1. Uniform and full coverage of grass
2. Consistent and even surface properties
3. Resilient turf grasses (wear tolerant, recuperative capability)
4. Surface minimises risk of injury (playable)
5. Weed free

Parks

1. Healthy plants (trees, grass and shrubs)
2. Trees maintained to reduce risk of injury (limbs falling)
3. Aesthetically appealing
4. Grass cover (adequate) – passive use, dust suppression, erosion control, cooling

Trees

1. Healthy trees
2. Rainfall optimised to benefit soil moisture including passive irrigation
3. Tree species and condition (healthy) provide aesthetic, functional benefits for environmental and social outcomes

Gardens

1. Plantings provide quality aesthetic values e.g. display plantings (healthy plants)
2. Plant species selection – appropriate for site, function, local climate
3. Spaces for visitors to enjoy
4. Attractive
5. Injury risk minimised

These requirements should form the basis of management practices for a functional open space.

2.3 Challenges for Functional Open Space

While each open space has unique challenges, there are some challenges that are common to most. A survey of councils from across Australia (Parks Base 2014 – State of the Sector – Sports Fields) found that there is an undersupply of sports ground in the inner, more densely populated suburbs. This situation is likely to increase in the future, which highlights the importance of managing carrying capacity of existing sports grounds (refer 3.4). The low quality of sports grounds was also highlighted as a major concern.

The following is a summary of the most prolific challenges faced when managing sports grounds.

- Insufficient number of fields to meet demand
- Providing quality surfaces given increased use
- Meeting unrealistic expectations
- Expenditure and income
- Irrigation & drought proofing
- Maintaining sports fields at appropriate frequency
- Preventing/minimising unbooked use

These challenges can be addressed through planning, improved management practices and increased investment.

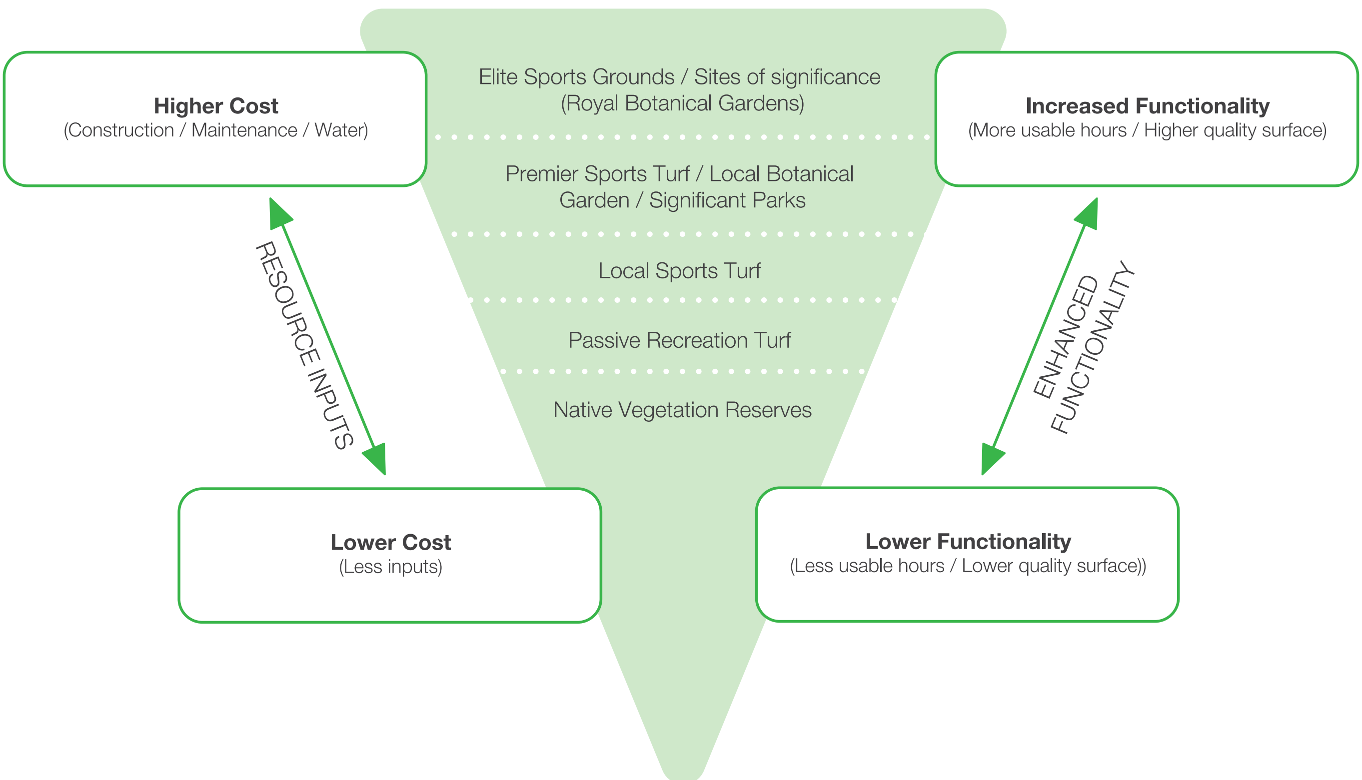
2.4 Quality Standards

Functional open spaces can be designed and managed to provide a range of services at a range of performance standards. These range from low resource input native vegetation reserves to high resource intensity, elite sports grounds (Figure 3).

Higher quality and higher capacity grounds require more water.

Figure 3: Relationship between performance standard and resource inputs

The required performance standards need to be identified to inform the overall site management practices, in order to deliver the appropriate outcomes/services.



2.4.1 Turf Surface Standard for Sports Grounds

There are a number of performance standard rating systems for turf/grass, which are used to inform the turf quality requirements for different uses.

The Code of Practice for Irrigated Public Open Space, published by SA Water (2008), uses a graduated turf quality approach to determine water budgets for sports grounds and similar sites. The turf quality ranges from 'acceptable' to 'lush', and is represented by four levels or standards. These are referred to as the turf quality visual standards. For each performance level or standard, a colour image of the turf condition is used to provide a reference (Figure 4).

Turf Quality Visual Standards (Kikuyu / Couch)

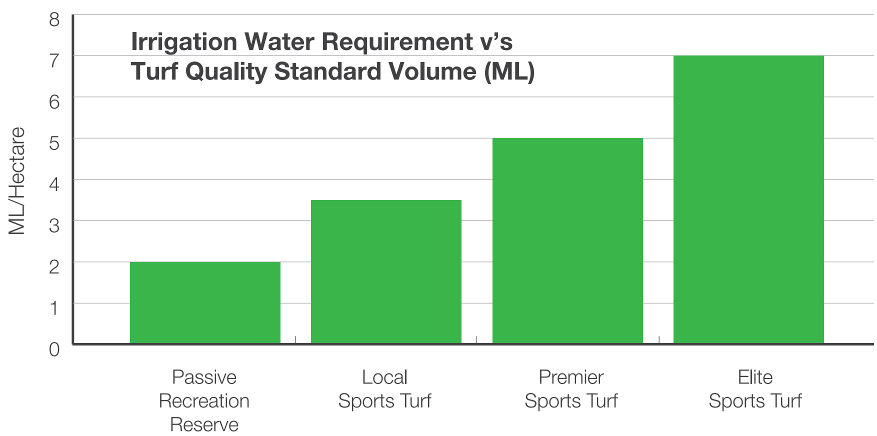
Figure 4: Surface performance standard and presentation quality need to be determined for each site and each activity. The amount of water required increases as the turf standard increases.

Standard	Turf Appearance	Example
Elite Sports Turf (State/National Competition)		MCG AAMI Park (MOPT)
Premier Sports Turf		District/Regional Competition Regional Cricket Football Athletics etc
Local Sports Turf		Local Competition Local Sports Grounds Community Parks Shared Use Facilities
Passive Recreation Reserve		Non-Sports Turf Neighbourhood Park Passive Reserve

Figure 5: Irrigation Water Requirements v's Turf Quality Standard Volume (ML).

The higher standard and demand on a space the higher the water consumption to keep the space functional.

Other classifications, such as Very High, High, Medium and Low and A, B, C and D can be used so long as they reflect a range of surface performance standards and are irrigated accordingly.



2.4.2 Performance Standards for Trees

Performance standards for landscape plantings are strongly influenced by the site's required aesthetic value. Healthy plants are fundamental to any functional open space that is to provide valuable services.

The maintenance of the space, including activities such as pruning, weed control, and removal of dead plant material, is also a strong contributor to the value of a functional open space.

In the case of trees, there are a multitude of factors that contribute to tree health. In addition to having adequate soil moisture, healthy trees require balanced nutrient availability and soil environments that support root extension and growth. Avoiding physical damage to the trunk and branches and the root system is critical. Pest and diseases, airborne and soil borne, are potential risks. Urban environments present the additional risk of atmospheric pollution.

Water management strategies should aim to avoid excessive soil moisture stress, during drought or low rainfall periods, in order to protect the tree in the long term.

At many tree locations providing tree growing conditions that facilitate strong growth and development, more than ensuring survival, will be the core requirement.

2.4.3 Performance Standards for Landscape Planting

The benefits provided by the landscaped open space are strongly determined by the design, site conditions, plant selection and ongoing maintenance of the space. The aesthetic, environmental, health and economic benefits provided by the space are directly influenced by the quality of the planting.

Functions provided by the space may include screening, creation of private spaces, visual relief from buildings, roads and hard surfaces, experiencing the natural environment and the opportunity for social interaction. A range of landscape elements, trees, shrubs and flowers, are used to achieve these functions.

Trees are a very powerful element in urban landscapes, streets and private properties. Healthy, well selected and site-suited trees have a major impact on the space through various functions including shading, cooling, and dust capture and wind protection. The maintenance of soil moisture to avoid significant stress and facilitate the growth of the tree is essential.

Floral displays have a different role in that they are required to be maintained to a high standard in order to present the strong visual benefits. Maintenance of soil moisture for this type of landscape element is generally more intense that that required for deeper rooted plants, such as trees.

Tree water and tree condition Tree health – survival and strong growth

Figure 6: Tree condition and water requirement relationship.

Figure 6 demonstrates the additional water requirements, as the condition or performance of the tree increases, for those tree species that need irrigation to supplement rainfall.

Figure 7: Floral display. Queen Vic Gardens, City of Melbourne

SECTION

3.0

Understanding the site

Managing a functional green open space requires knowledge of all of the factors that may impact on the performance of the site. Understanding these factors requires managers to adopt a holistic approach, as each factor cannot be considered in isolation.

The key aspects that impact on site performance and function are:

1. Soils and drainage
2. Vegetation
3. Local climate
4. Usage of space (carrying capacity)

THIS

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3.1 Soil and Drainage

3.1.1 Soil Texture and Structure

The success or failure of a functional open space is strongly dependent on the site soil and how it is managed. The performance of a turf surface on a sports ground or the health of a tree are both determined by soil conditions.

Soils are highly variable in composition and properties.

Soils are composed of solids and organic matter. The range in particle size from clay to sand is huge. The actual particle size and distribution of particle size in important in classifying and describing a soil in terms of soil texture. The proportion of clay, silt and sand defines the soil texture.

For simplicity, soils are sometimes referred to as being sand, loam, sandy loam, silt and clay, although there are several other classifications that are used. These include silt loam, sandy clay loam, clay loam, sandy clay and silty clay.

Texture can be determined in the field by forming a ribbon of moistened soil sample between your fingers. Long, thin sticky ribbons indicate a clay soil. Samples that break up and are short indicate a sandy soil.

The arrangement of soil aggregates, clumps of soil particles, is the structure of the soil. It is this arrangement, together with the organic content, that provides the basis of a healthy soil. Water and air can enter the soil, the soil will hold water and excess water will drain through the soil. The soil medium will provide an environment for root extension and development.

Healthy plant growth is achieved when all of the influencing soil factors are in balance.

3.1.2 Key Soil Water Properties

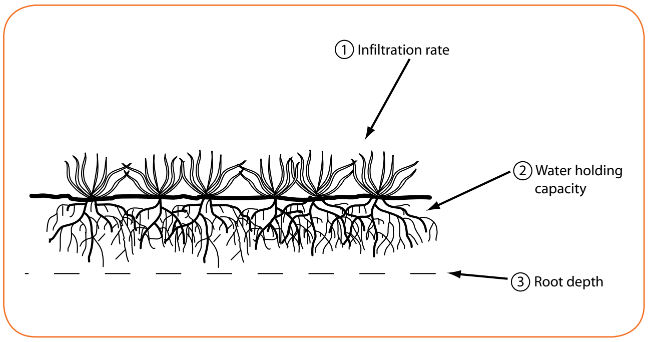
There are a number of terms used to describe the various water properties of soils in irrigation management. It is important to understand these, as they are used to determine how the open space is managed, particularly in terms of water management.

The rate of water entry into the soil, the infiltration rate (IR, mm/h), is important in terms of both irrigation and rainfall. If water applied with irrigation does not enter the soil, then it is potentially wasted. Rainfall infiltration is important in terms of adding to soil moisture and also for drainage. If surface ponding or flooding occurs, due to soil infiltration being too low, then usability of the space is limited and there is risk of damage to soil surface including the grass.

Soil permeability refers to the rate of water movement through the soil profile. This is an important property in terms of drainage of water through the soil profile to deeper soil layers and potential for drainage to groundwater.

The ability of the soil to hold water is another key property. The total amount of water that is available to plants is dependent on the depth of the roots and the available water holding capacity of the soil (AWHC, mm/m).

Figure 8: Key soil water properties for irrigation



The available water-holding capacity (AWHC) of a soil refers to the amount of water that is stored and available to the plant. There is a limit to how much water can be stored in soil. The absolute limit is determined by the total void space in the soil. If the void space is saturated, then some water will drain away. The absolute capacity of the soil to hold water prior to the water draining away is called field capacity. The lower limit of available water is the amount of water that cannot be removed by the plant. It is limited by the capacity of the plant to extract the water and strength of the forces with which the water is held by the soil. This is the permanent wilting point. The water available to the plant in the soil is the amount stored between the Field Capacity and the Permanent Wilting Point. (Connellan, 2013).

The Available Water Holding Capacity (AWHC) and the Infiltration Rate (IR) are shown for a range of soil textures in Table 1.

Table 1: Soil water properties

Soil Type	a) Available Water (AWH) (mm/m)	b) Infiltration Rate (IR) (mm/h)
Sand	60	> 20
Fine Sand	90	15-20
Sandy Loam	110	10-18
Loam	170	10-15
Silt Loam	170	8-12
Clay Loam	165	5-10
Clay	140	1-5

The water holding capacities range from 60 mm per metre up to 170 mm per metre depth of soil.

The total depth of water that can be stored in a 200 mm layer of sand is 12 mm ((60/1000) X 200). The depth of

water that can be stored in a 200 mm of loam is 34 mm ((170/1000)) x 200).

This is a very significant difference and illustrates the limited storage of sandy soil profiles.

3.1.3 Soil survey of the site

Soils may vary greatly across sites and this will directly influence the design of the irrigation system. Knowing the soil type and properties is necessary to manage any open space. Soil sampling across the whole site, known as a soil survey, is recommended.

The soil properties at each location directly influence the management practices employed at the site. Knowing variation in soil properties is very important in influencing the practices that should be used for each part of the site.

Soil testing

Regular soil testing should be carried out as part of the site management.

The current status of soil nutrients, soil physical properties and potentially toxic elements provide direct input into the site maintenance program.

Soil testing needs to be carried out to standard procedures to ensure the test samples collected are representative of the area and will provide accurate results.

Analysis of soil samples should be carried by approved test facility.

Interpretation of the results, with specific reference to the site and management practices, is required. These services are provided by agronomists and horticulturists.

Recommended soil parameters to be tested:

- Total Dissolved Solids (TDS)/Sodium (Salinity)
- pH
- Organic carbon
- Nitrate nitrogen
- Phosphorous
- Potassium
- Cation exchange capacity (Calcium, magnesium, potassium, aluminium)
- Trace elements
- Calcium/magnesium ratio

3.2 Drainage of sports grounds

Effective drainage of sports grounds is fundamental to maintaining a functioning ground.

The main potential consequences of poor drainage are:

a. Reduced usability

b. Risk of damage to surface and grass

c. Risk of injury due to unstable conditions

The type of drainage that is appropriate depends on soil type, the topography and the required carrying capacity of the site.

> Playing on waterlogged grounds damages the surface.

Selection of a specific soil type and profile for a sports ground requires a soil with a balance between effective drainage and good water holding capacity (Table 3). Sand profiles, which drain very well, but have limited water and nutrient holding capacity, present challenges in terms of the need for frequent irrigations and fertilizer applications. The fine particle size and texture of clay soils means that water movement through the soil profile is very slow. It may take days or weeks for the soil water to move a short distance, for example one metre, and the surface will stay saturated for prolonged periods.

Table 2: Soil types and drainage properties

Soil type	Drainage	Water holding	Nutrients
Clay	Very poor	Very good	Very good
Loam	Good	Good	Good
Sand	Very good	Poor	Poor

The types of drainage techniques/systems are:

- Surface runoff
  - Ground shaped/formed from central point or crown to facilitate runoff to edges of the field
  - Ground shaped/formed with constant gradient across the field
- Surface runoff interception trenches or strip drains
  - Slits/narrow trenches backfilled with porous media and sometimes drainage pipes
- Subsurface drainage
  - Drainage system (pipes) installed below ground to collect water draining through the profile
- Sand profile
  - Excess water drains directly through the media for collection and potential reuse and removal from the field area

3.2.1 Site construction types and carrying capacity

The capacity of a grass surface to cope with use and wear is strongly influenced by the type of construction. The key required characteristics are:

- Grass in good condition
- Uniform, even surface
- Well drained surface and soil profile

> Locally constructed grounds, using native soils, have the lowest carrying capacity. If those soils are fine textured, such as clay this represents a significant constraint on the capacity of the ground to handle use in wet conditions.

Table 3: Functional open space/sports grounds construction types

	Open Spaces				
	Open Space Venue Types - By Construction	**Uses**	**Carrying Capacity / Usage**	**Capital cost**	**Annual cost of maintenance**
1	Native soil – natural surface	Parkland/Neighbourhood park	Low	$0	$3,000 - $5,000
2	Native soil – graded/formed – no subsurface drainage	Local sports/General recreation	Low – Medium	$120,000-$150,000	$6,000 – $10,000
3	Native soil – graded/formed – subsurface drainage	Local sports/District sports	Medium	$140,000-$175,000	$10,000 - $15,000
4	Native soil based – sand layer (e.g.200 mm) - subsurface drainage	District/Elite sports	High	$250,000-$400,000	$20,000 - $30,000
5	Full sand profile – perched water table and drainage	Elite sports	High	$500,000-$800,000	$40,000 - $60,000

While capital cost on construction of an Elite or District sports facility significantly outweighs that of local sports spaces, the Carrying Capacity generally provides a greater return on investment.

See Section (carrying capacity) for explanation on Carrying Capacity.

3.2.2 Choosing the right construction

Developing sports fields and green infrastructure in general to achieve higher service levels is a very common requirement.

Undertaking an upgrade or planning of a new facility should be based on maximum expected Carrying Capacity of the space.

What is the expected demand and what time of year is the peak?

What is the expected type and amount of use?

Assessment of an existing facility will generally indicate the contributing factors to capacity constraints. These may be, for example:

- Inadequate drainage
- Poor grass condition
- Inadequate maintenance
- Over use

The first two are directly associated with the type of construction type. The second two relate to the on-ground management/maintenance resource input/allocation of the space and the management of the use of the space.

Case Study 1

Drainage case study – On a sports oval that is approx $12,000m^2$

Background

A local sports field, with drainage issues, even small rain events caused water pooling on the surface. These issues would limit use by the tenant club and limited access for machinery to undertake maintenance.

Proposal for Capital Works

It was proposed and budgeted to reconstruct the oval through significant capital works including:

- New pop up irrigation system
- New cricket centre wicket and synthetic cover
- Reshape the oval surface using site and imported soil
- Install kikuyu turf sods across the surface

The construction works were tendered to an experienced turf oval construction company with an initial budget of approximately $500,000. Works commenced in September 2012 and completed by January 2013, meaning the tenant cricket club was relocated for their entire season.

While the tender process was proceeding, the council engaged a turf consultant to investigate several ovals that had water pooling issues, including the oval about to undergo renovation, and several key factors were identified:

- The oval had extremely poor drainage at 1mm/hr.

The ideal permeability rate based on this test method should be around 100mm/hour at 16 drops for a sports field. Soils with much lower drainage rates will quickly become saturated in winter and in turn both the grass cover and surface quality will be compromised. The Particle Size Analysis at this oval had extremely poor drainage capabilities.

The following comments and recommendations were made:

- The proposed work detailed reusing existing soil blended with new topsoil to a depth of 200mm. It was recommended to investigate installing a sand profile.
- Install a drainage system to remove surface water, i.e. sand slitting.

The proposed work proceeded as originally specified without the installation of drainage or improving the soil profile as recommended. At the time, extra funds were not made available to rectify the potential issue identified by the consultant around the oval drainage.

Due to delays, the winter tenant was not able to access the oval until late May (even with a completion date expected in January). Once access was allowed, due to significant rain, the oval became water logged and damaged, deeming it unplayable after 2 weeks of use. Initial attempts to make the surface playable through remedial works were unsuccessful and the winter club was forced to relocate for the remainder of the season.

After investigation, it was identified the only remedial works to resolve the issues with the ground was to install a suitable drainage system. Due to the wet winter season, this work was carried out over the summer period, again forcing the summer tenant to relocate for the second consecutive season. The approximate cost for the remedial drainage works were approximately $100,000 and the oval was essentially out of commission for 18 months.

Had the drainage work been completed as part of the original works, it would have been less costly to the council and the tenant clubs, but also allowed the oval to be back in use and remain in use in approximately 6 months.

Key Findings

- Prior to scoping any works, commission a turf consultant and irrigation specialist to undertake a full site audit, including soil, irrigation and drainage, and have it recommend remediation works to improve overall standard of site.
- Have turf consultant provide informed estimations on works, to use to allocate capital funding
- The turf consultant can provide contract specifications for the tender, especially when the knowledge and experience around sports field construction and maintenance may be lacking in house.
- Always use experienced turf construction contractors and avoid using civil/other contractors with limited turf construction experience.

3.3 Vegetation

3.3.1 Plant water related properties

Knowledge of the water use characteristics of plants (Crop Coefficient Kc) is essential for irrigation management.

Maintaining plants in a healthy condition and avoiding significant soil moisture stress is fundamental to achieving a functional site.

Understanding the response of the plant to soil moisture stress assists in managing through drought conditions.

The root exploration and development characteristics of plants is important in both the cultural management of the plants/vegetation and determination of the water storage potential of the soil. Deeper rooted plants have access to greater soil water storage.

The following water related information should be obtained about each plant species being managed:

- Species Crop Coefficient value
- Typical rooting depth
- Plant response/sensitivity to soil moisture stress

3.3.2 Turf

The establishment and maintenance of a turf surface requires an understanding of the cultural and environmental needs for each phase. Depending on the turf type maintenance and fertilizer programs are not only determined by the soil nutrient analysis and species requirements but also the soil temperatures that influence root activity.

If an area is being considered for high use during in winter, a cool season turf variety may be preferred over a warm season as it can be maintained effectively throughout peak periods.

Table 4: Turf quality standards

Ranking	Priority	Turf/Grass Expected Performance	Alpha Rating (standard of maintenance)	Guide to Coefficient *K_T
1. Elite sports	Very High	Lush	A+	0.8
2. Premier sports	High	Strong healthy growth	A	0.6
3. Local sports	Medium	Moderate growth	B	0.4 -0.5
4. Passive recreation turf	Low	Acceptable growth	C	0.3-0.4
5. Natural environment park	Natural	Species not requiring irrigation	D	Not irrigated

*Note: Coefficient values are for warm season grasses and are a guide only. Multiple factors, including usage rate, soil characteristics, influence actual K_T (coefficient for turf) value.

Table 5: Landscape Planting Coefficients

Planting Type	Performance	Landscape Coefficient *K_L
Tree - Exotic	High water use	0.6 – 0.8
Tree - Exotic	Low to Medium water use	0.3 – 0.4
Trees & Lawn	Green grass & healthy trees	0.6 – 0.8
Ferns	Lush greenery	0.6
Garden beds	Shrubs medium water use	0.4 – 0.5
Garden beds	Floral display	0.6 – 0.8

Note: The Landscape Coefficient K_L values are a guide only. Plant species, site performance and conditions will influence appropriate value.

3.4 Local climate

An understanding of the local climate, rather than general information for an area (BOM data for Melbourne versus specific data from a local weather station at an irrigated site) at each site is vital in achieving good plant performance and high water use efficiency. The key climate information required is:

- Evaporation rate
- Rainfall
- Wind – speed and direction

The water use rate of the landscape is driven by the evaporative demand of the atmosphere.

Irrigation for each open space is dependent on how much water is used by the space and lost through evaporation.

The evaporation rate strongly influences the plant water demand. There are two reference evaporation rates involved in irrigation management.

The first one is based on evaporation pans which are located within weather stations sites throughout the country. Data from evaporation pans are available from Bureau of Meteorology (BOM) website. **www.bom.gov.au**

The other evaporation rate is called reference evapotranspiration (ETo).

Evapotranspiration, which includes the water transpired by the leaves of the plants and water evaporated by the soil, is determined using mathematical expressions (algorithms).

There are a number of expressions used, however the main one for the irrigation industry is Penman-Monteith.

The calculated evapotranspiration rate is based on climate parameters including solar radiation, air temperature, relative humidity and wind speed.

ETo values are available from BOM or local or on-site weather stations. A weather station specified for Penman-Montieth is reasonably expensive, in excess of $20,000. Lower cost weather stations, which incorporate some estimation of the various climate factors, are available.

These latter types are valuable in providing a good guide to weather conditions and evaporation rates.

Obtaining evaporation data (Class A evaporation pan) from the Bureau of Meteorology or the use of local site weather data to determine the reference evapotranspiration (ETo) is essential.

Rainfall data is also necessary for the determination of the stormwater harvesting potential for water storages.

An appreciation of the strength and direction of wind is important in the design and operation of the sprinkler or spray irrigation systems. This influences the layout of sprinklers and sprays. The closer spacing of sprinkler heads is an important technique used to achieve acceptable uniformity under windy conditions. Wind speeds will also influence the selection of heads and nozzle trajectory angles. Low trajectory sprinkler and sprays are sometimes used for windy sites.

Table 6: Turf water requirement example

Determination of daily evapotranspiration (ETc) requirements for turf (Premier sports K_T 0.6)

Season	Average daily ETo (Tullamarine)	Premier ground	Daily evapo-transpiration (ETc) turf
Summer - January	6.4 mm/day	K_T 0.6	3.8 mm
Autumn - March	4.5 mm/day	K_T 0.6	2.7 mm

Notes:

1. ETc, turf water requirement, is calculated; $ETc = K_T \times ETo$
2. These are average values and the actual weather conditions will mean that the plant water requirements will be higher during hot weather.

Wind speeds are also important in considering and managing recycled water applied with sprinklers. Please refer to the following guidelines or the local water authority prior to irrigating with recycled water.

Stormwater

http://www.environment.gov.au/water/quality/publications/nwqms-australian-guidelines-water-recycling-managing-health-phase2-stormwater

Recycled Water

http://www.environment.gov.au/water/quality/publications/nwqms-australian-guidelines-water-recycling-managing-health-overview

http://www.recycledwater.com.au

3.5 Site Carrying Capacity

3.5.1 Definition

Site carrying capacity refers to the maximum usage the ground can withstand without deteriorating to the extent that it cannot recover in a reasonable time, such as, in the next week. It is the usage rate for the ground to be used indefinitely, in a sustainable way.

3.5.2 Factors influencing site carrying capacity

The provision of a surface to facilitate active recreation is core to our urban functional open space.

The capacity of a green space to support physical activity and recreation use varies greatly depending on the type, properties and characteristics of the space.

Both for the planning of new spaces and the ongoing management of existing spaces, knowing the carrying capacity is essential.

The carrying capacity of a turf surface is influenced by:

a. The ability of the grass to withstand wear

b. The ground conditions

c. The usage rate

Grasses that are resistant to wear and recover rapidly and surfaces that remain stable and not water logged under wet conditions are ideal.

Figure 9: Impact of excessive wear both in dry and wet conditions.

Figure 10: Impact of excessive wear during wet conditions.

Foot traffic causes damage to grass through crushing and tearing of the leaves. Damaged leaves are more sensitive to disease.

Recovery from this damage, though rapid growth rate, is required to maintain a turf surface in good condition. Some grasses, such as kikuyu, exhibit good wear tolerance. Wear tolerance varies with individual species.

Greatest wear tolerance is achieved when the grass is mature or well developed, there is good density and the grass is healthy, free of disease. A common cause of poor turf performance and reduced carrying capacity is the use of spaces when the grass is at a juvenile stage and has not fully developed. It is fragile at this stage and easily damaged. Allowing adequate time for leaf and root development is essential.

3.5.3 Main factors influencing carrying capacity of sports grounds

The capacity of a ground to sustainably support active sports is mainly dependent on:

a. Condition of the grass (cover and density)

b. Construction of ground, including drainage, grass species, soil profile and irrigation

c. Resources ($ and time) allocated to maintaining the area

d. Type, level and amount of use

The use and or misuse of the ground strongly influence the carrying capacity of a ground.

The greatest risk to a sports ground is through over-use at times when the ground is saturated or water logged. Under these conditions, the grass is readily damaged and the surface soil can become compacted as well as being uneven.

Ground use should prioritize competition over training to maintain the safest playable surface.

Guide to carrying capacity

The following table provides a general guide to the relative carrying capacities of different types of grounds

Table 7: Potential usage capacity based on the ground type

Ground Type and Characteristics	Relative Carrying Capacity
Poor drainage & average grass condition	Low
Moderate drainage & good grass condition	Moderate
Very good drainage & very good grass condition	High
Excellent drainage & excellent grass condition	Very high

3.5.4 Measures of Carrying Capacity

Knowing the carrying capacity of a ground, as a quantity, is an extremely valuable measure in managing a turf surface.

The usage can be planned, the site maintenance programmed and users informed about the availability and condition of the ground.

The carrying capacity measure can include: number of users, age of users, sport played, level of activity or competition and duration of use. However, a simple measure is the "team hours". This is the number of hours a team uses the ground for training and competition and should reflect the difference in intensity on the ground when comparing adult sport and junior sport.

A general recommendation is that the maximum team hours should be approximately 25 hours per week.

The following Table provides a guide to the carrying capacity rates for the main types of ground construction.

Ground use should be based on carrying capacity.

Table 8: Guide to usage rates for various sports ground constructions

Ground Construction	Drainage	Category of Usage Rate	Team Hours per Week
Native, clay soil	Poor drainage	Low	< 10
Loam	Medium drainage	Moderate	10 -15
Sand layer	Good drainage	Moderate to High	15 – 20
Sand profile	Excellent drainage	High	20 - 25

Whilst these values provide a guide based on ground construction, the maintenance programs used in continually repairing and restoring ground conditions, including fertilizing and plant health management, are equally important in achieving the required carrying capacity performance.

A more detailed analysis of ground use and capacity, including player hours, age of players and type of sport, are outlined in resources available from Parks and Leisure Australia.

Refer to:
http://www.parksleisure.com.au/documents/item/1077

3.5.5 Irrigation and carrying capacity

Best Practice irrigation contributes to ground capacity through:

a. Assists in maintaining a full cover of grass in healthy condition

b. Through effective and uniform water application the transition to another species is facilitated

c. Washing in of fertilizer and plant health chemicals through light, even application of water

d. Contributes to efficient use of resources

3.5.6 Risks to ground capacity

For each construction type and maintenance regime employed, there is limited capacity to cope with use.

The main risk scenarios are:

a. Overuse in wet conditions that damages the turf

b. Inappropriate and overuse in wet conditions that present an unsafe playing surface

c. Excessive wear that results in bare patches

d. Uneven ground and surface conditions that reduce playability of the surface

e. Excessively hard grounds

3.5.7 Strategies to maintain a functional turf surface

The following strategies should be considered to ensure that the ground provides adequate carrying capacity and is functional.

a. Manage the site within the ground carrying capacity constraints

b. Prioritise competition over training when there is a risk of significant damage due to wet conditions

c. Allow time (weeks) for new, juvenile grass to grow and develop between sports

d. Investigate over sowing warm season turf with cool season turf to ensure adequate turf coverage during peak winter periods

e. Invest in ground constructions and maintenance programs that have carrying capacity suited to meet the expected demands

f. Ensure that the irrigation is of a high standard that allows effective and efficient application of water to maintain a quality grass surface.

Case Study 2: Oversowing with ryegrass

A recent study on over sowing couch based fields with perennial rye grass in Sydney by Dr Phillip Ford (PGG Wrightson Turf Australia) and Dr Jim Hull (Independent Turf Consultants, Sydney) highlighted the value of over sowing in maintaining a functional sports surface on high use areas.

http://www.pggwrightsonturf.com.au/assets/files/Assesment%20of%20football%20surface%20qulaity.pdf

Some benefits of over sowing include:

1. An over sown ground can assist in removing moisture from the top soil layer during winter, as it has a higher ET rate than a dormant couch surface, and so provides an improved playing surface
2. Can resist and recover from wear in areas of high use, reducing instances of ground degradation.
3. The ryegrass actually protects the couch underneath allowing for a faster recovery in warmer months if maintained correctly.
4. Improved colour, playing quality and groundcover retention.

This strategy suits grounds whether they're irrigated or not. On an unirrigated couch ground, sowing ryegrass in April or May will use the normal autumn rain break.

After spring, when the ryegrass is removed, the ground reverts to couch, where irrigation is 'optional', or minimal, depending on the quality and hardness requirements.

Ground managers need to fully understand each fields usage requirements and surface quality expectation prior to investing in a fully managed over sowing regime as it may not be best for every circumstance.

The spring transition should be undertaken with herbicide, as they do an excellent job killing ryegrass without setting the couch back. A natural transition by minimising irrigation and letting heat take out the rye, is unreliable as ryegrass can survive until Christmas which is too long.

Ground comparison in late August of a rye over sown soccer pitch compared to a couch surface.

SECTION

4.0

Efficient Irrigation of Functional Open Space

Table 9: Key aspects of efficient water management

Best Practice Water Management Irrigation. Aim: Effective, efficient and sustainable	
Requirement	**Task/input**
1. System – hardware	Irrigation Design
2. Functioning system	Maintenance – Monitoring & repair
3. Know performance	Uniformity & Precipitation Test: DU & PR
4. Irrigation schedule	Site properties System performance
5. Operate system - Efficiency	Weather, plant, soil moisture
6. Reporting – Efficiency	Consumption Irrigation Index

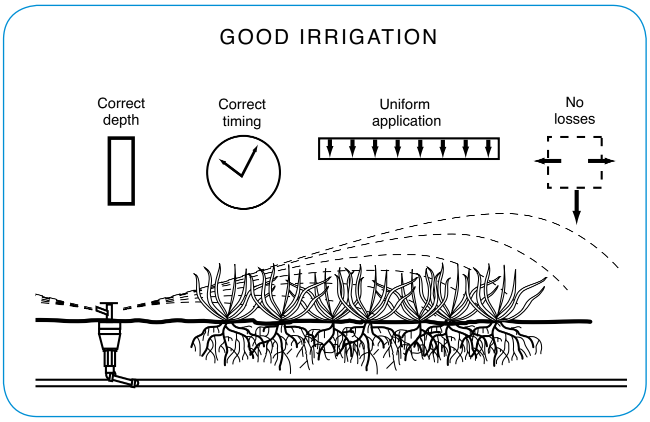
4.1 Principles of efficient irrigation

To achieve overall efficiency of irrigation water use, it is necessary to apply the water effectively to the plant root zone (Application Efficiency) and to time the application so that appropriate soil moisture levels are maintained (Scheduling Efficiency).

Efficient irrigation can be described in terms of the following four principles:

1. The amount of water applied should be appropriate to the plants needs and soil properties.
2. Water should be applied effectively and uniformly.
3. Water should be applied to the plant root zone without wastage through runoff, deep drainage and other water loss sources such as wind drift and evaporation.
4. The timing of water application should suit the plant and reflect weather conditions.

Figure 11: Four principles of efficient irrigation



Applying the correct depth

The depth of water to be applied should maintain soil moisture within the available storage capacity of the soil.

The range of soil water storage is from Wilting Point to Field Capacity. Wilting point is when the soil has dried out to the point the plant cannot extract any more moisture from the soil and the plant will suffer permanent damage. Field capacity is the point at which the maximum amount of water can be stored in the soil and held for later use. If more water is applied to the soil at field capacity, the water will be stored temporarily and then will drain through.

The three key pieces of information required to establish depth of water are:

1. Water holding capacity of the soil (WHC)
2. Depth of root zone
3. Allowable depletion of soil water storage prior to refill

Testing system uniformity is fundamental to efficient irrigation.

Case Study 3

Irrigation Depth to be Applied

Site: Sports ground

Grass: kikuyu

Root zone depth (RZD): 250 mm

Soil: Sandy loam

Available Water Holding Capacity (AWHC): 120 mm/m

Managed Allowable Depletion (MAD): 50%

Water stored in root zone = AWHC x RZD = (120/1000) x 300 = 30 mm

The total stored water is 30 mm. If irrigation in initiated when the storage is 50% depleted (MAD 50%), then the storage will be refilled when the plants have extracted 15 mm.

An allowance needs to be made of the inefficiency of the irrigation system. If the system is 75% efficient, then the gross application of water will be:

$$\text{Irrigation depth (ID)} = \frac{\text{Replacement amount}}{\text{Irrigation system efficiency (Ea)}} = 15 \text{ mm} \times (1/0.75) = 18.8 \text{ mm}$$

The irrigation system needs to be operated for enough time to apply 18.8 mm.

The correct irrigation depth has been determined.

4.3 Effective application without waste

The primary aim of an irrigation system is to deliver water into the root zone of the plants.

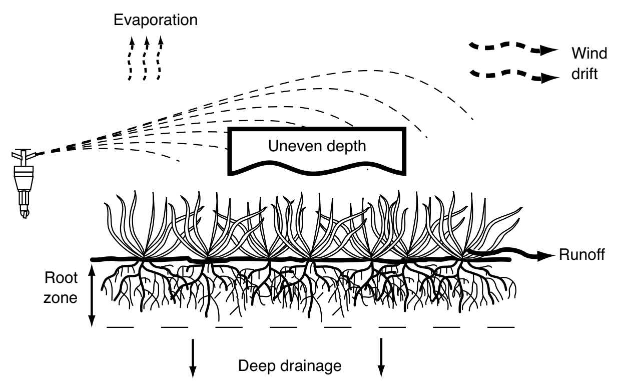
Some of the water applied does not reach the root zone, and reasons for this include;

- some sprayed water evaporates,
- some drifts beyond the target area, and
- due to unevenness of application some water can drain below the root zone.

By operating sprinklers and sprays at the recommended pressure and avoiding operating during windy conditions, (e.g. night-time watering) can assist in improving effectiveness of application.

The various factors contributing to irrigation losses are shown in Figure 12.

Figure 12: Factors contributing to irrigation application losses.



The irrigation design parameters relevant to Best Practice design are outlined in Appendix 4.

4.4 Irrigation design and efficiency

The design of an irrigation system has a strong influence on the potential efficiency of water use.

Selection of applicators, layout and pipe selection all have a direct bearing on how well water can be applied.

The guiding principles for good irrigation design are:

a. Sufficient capacity to meet plant water demands

b. Uniformity of application

c. Optimum hydraulic operating conditions

d. Zoning of application so that all areas of differing needs can be satisfied

e. Control system that allows flexible and precise programming for all areas

Case Study 4: Changing for the better

A council program for improving irrigation control and performance across all open space has seen dramatic improvements in irrigation efficiency, turf health and labour costs.

Undertaking comprehensive irrigation audits on current irrigation practices across the whole municipality, allowed the council to identify a need to change how they irrigated, by control and in some circumstances, the whole irrigation system.

When assessing distribution uniformity (DU) of the irrigation systems, only 20% of test spaces achieved a uniformity of 70% or greater, with some sites recording well below a uniformity of 50% (meaning a significant wasting of water during irrigation)

This audit program led to a retrofit program, where the council installed across the entire municipality, a central control system with weather stations to allow remote control of all irrigation. The council also invested in a capital works program to completely upgrade some irrigation systems that were no longer deemed salvageable.

This capital improvement in irrigation control along with both the major and minor works to the irrigation infrastructure has seen a notable improvement in coverage and health of turf throughout the spring/summer period.

The contract maintenance company estimated the change to central control alone is saving them on average 30% on labour costs just on the sports grounds, by not having to manually switch off irrigation control systems or reprogramming on controllers from each individual site.

By undertaking a full irrigation audit across the whole council, has acted as a great baseline and was able to identify some key areas that needed to be addressed urgently if the whole system was going to improve.

Key costings:

Total cost of minor works needed to improve DU across 19 sports fields was under $100,000.

Percentage improvement on average across the council sites by undertaking the works: approx. 12%.

Potential payback on works including audits: Under 2 years.

4.5 Best Practice Irrigation Design Performance Specifications

To assist in achieving a design that has the capacity to apply irrigation water efficiently, the following performance criteria should be applied to the design process:

a. Distribution Uniformity (DU): Design DU ≥ 85%

b. Scheduling Coefficient (SC5%): ≤ 1.2

c. Mainline and lateral pipeline velocity: ≤ 1.5 metres/sec

d. Flow variation ± 5% between sprinklers (this represents +-/- 10% pressure variation)

> High performance irrigation designs provide payback in less than 2 years.

4.6 Irrigation Scheduling – Managing Soil Water

4.6.1 Scheduling principles

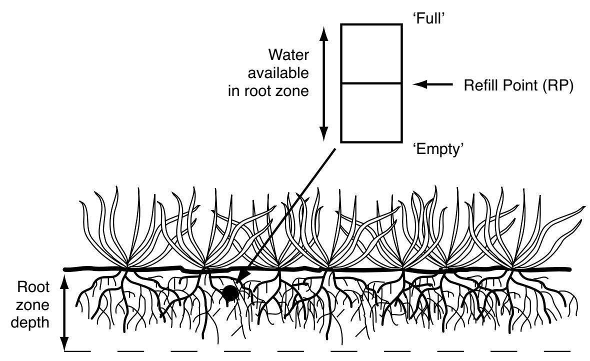
The operation of the irrigation system, so that soil moisture is maintained, within defined levels or limits, is the underlying basis of irrigation scheduling. Good irrigation scheduling has two components:

a. the application of the correct amount or depth of water and

b. the timing of water application.

The basic approach that is used is the refilling of the root zone.

Figure 13: Scheduling concept of refilling of the root zone



The actual soil moisture levels to be maintained depend upon the required performance of the plants and the properties of the soil.

In some circumstances, the soil is maintained close to optimum soil moisture levels (close to field capacity) so that the plants always have ready access to water and growth is not limited in any water.

Strong lush growth is then produced.

In other circumstances, the soil moisture level is deliberately maintained at a partially full level, so that there is some stress on the plant. This strategy, which is referred to as deficit irrigation, is sometimes used as a means of saving water and also in encouraging deeper root systems.

The plant performance, soil water properties and irrigation performance all need to be taken into account in irrigation scheduling.

The scheduling techniques that are available include:

- observation of foliage condition – signs of stress, wilt, leaf curl or, leaf drop
- soil appearance and feel or probing
- soil moisture measurement – using sensors
- canopy or foliage temperature – determine water stress index (elevated leaf temperatures)
- water balance – programmed based using pre-set times
- water balance – using daily evapotranspiration (ETc).

4.6.2 Requirements for precision irrigation scheduling

Precision scheduling involves having a thorough knowledge of the soil properties, plant responses to soil moisture levels and daily ETc rates. The following information is required in order to make sound irrigation scheduling decisions:

- existing soil moisture level
- water-holding capacity of the soil
- plant evapotranspiration rate ETc (daily)
- irrigation precipitation or application rate
- irrigation system efficiency
- rainfall contribution to root zone
- plant response to available soil moisture.

Irrigation scheduling is based on systematically tracking the soil moisture level and adding the required amount of irrigation water in a timely and efficient manner. The timing of the irrigation event and the run times for irrigation delivery are the two core components of irrigation scheduling.

The daily water requirements for the plants needs to be determined using local weather data (ETo) and knowing the appropriate coefficient (K_T or K_L) for the site. Knowledge of the site's soil properties including root zone depth and water holding are also required.

The following Table is an example of the water balance approach where the water storage of the root zone layer has been determined and the additions and extraction of water from the storage on a daily basis is carried out. When the water stored reaches a predetermined level, the Refill point, irrigation is initiated.

Table 10: Example of daily water balance scheduling

Day (number)	1	2	3	4
ET (mm)	4	6	2	6
Rain – Effective	0	0	4	0
Balance (mm)	20	14	16	10

4.6.3 Weather stations and soil moisture sensing in scheduling

Weather stations generating reference evapotranspiration data (ETo) are increasingly popular in the scheduling of irrigation. This approach is well suited to turf, because the performance of the crop or turf, over a defined area, can readily be predicted. Turf is reasonably uniform in terms of water use and the root system is also reasonably well defined and uniform for each soil type.

The irrigation scheduling of landscape plantings or turf requires knowledge of the actual soil moisture conditions, so that the timing of irrigation decision making is correct.

Although good efficiency can be achieved through close monitoring of plants and site conditions some type of soil moisture sensing provides actual, real-time information on the soil moisture status. The soil moisture sensor provides feedback to the irrigation controller or manager, to aid in irrigation scheduling decisions.

4.6.4 Best Practice Irrigation Design – Example

An irrigation design has been prepared, to Best Practice Irrigation Design standards, to illustrate the requirements to achieve high efficiency. The design is also used to demonstrate the consequences of poor design.

Details of the site and performance standards used in the preparation of the design are presented:

Site use: Sports ground

Site area: 1.5 hectare

Turf: Warm season (WS) grass

Soil: Sandy loam

Water supply: Potable mains supply (meter)

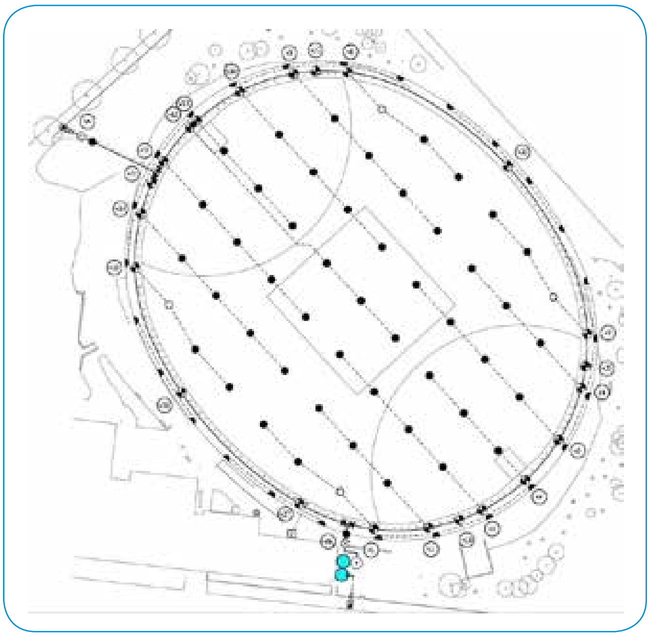
Note: In this design the Design DU is 87% and the $SC_{5\%}$ is 1.1

Key items incorporated in the design process

1) Ring main is to be used so that there are no active supply pipelines in the playing area.
2) Zoning of sprinklers is to allow control separate control of central corridor high traffic areas.

Best Practice Design example

Figure 14: Best Practice irrigation design for a sports ground



The following Table outlines the cost of a Best Practice irrigation desiagn and a number of options that can be incorporated into the irrigation system to achieve optimum performance.

Table 11: Best Practice irrigation design and technology costs. Based on a standard sized AFL oval.

Item	Comment	Approximate Cost *based on 2015 prices
Best Design Irrigation System	Base cost	$60,000 - $80,000 (depending on ground and location)
Added equipment		
Pump and tank	Plus 45%	$25,000 - $50,000 (depending on tank size and pump selection)
Flow sensor including installation wiring	Plus 8%	$ 4,000 - $7,000
Weather station (ETo estimated)	Plus 8%	$ 5,000 - $20,000

4.7 Technologies to improve irrigation performance

4.7.1 Pump and tank

In situations where the mains water supply (pressure and flow) is inadequate or inconsistent to achieve an efficient irrigation, it is advisable to consider a pump and tank system or booster pump (if allowed by the water authority). Water is delivered into the tank over extended periods and then pumped out to the irrigation system at optimum supply conditions. Pump and tank systems generally operate at higher efficiency because of the constant and higher pressure and ability to use higher flow rates. Variation in operating pressure is a consideration for all mains systems, even those that maintain adequate minimum supply pressures, because the pressure can vary considerably during the irrigation event.

Technology cost and benefit comment:

For many sites with inadequate or variable supply conditions the installation of a pump and tank system, whilst relatively expensive (e.g. $25k), is the only solution to achieving uniform and efficient watering of turf areas.

4.7.2 Flow sensor

The capacity to monitor and record the system flow rates so that pipeline breaks, faulty sprinklers and valves can be detected and shut down minimises water wastage.

Flow and pressure sensors, strategically positioned throughout the system, allow the irrigation to be monitored and action taken to alleviate problems.

Monitoring of the irrigation the system hydraulics also provides valuable information (e.g. water volumes) that can be used to evaluate the performance of the irrigation. Monitoring and measurement of water use is a key part of good irrigation management.

Monitoring the flow through an irrigation system in real time provides the operator and/or manager with data that greatly increases the capacity to achieve high efficiency.

Technology cost and benefit comment:

A flow sensor is an essential part of the management of an irrigation system. It not only saves water but also informs the site manager if water is not being delivered to target areas. This situation can result in loss of use or reduced quality of the area and potentially involves high costs to regenerate or replace the surface.

Flow monitoring keeps watch of the equipment functioning.

Higher flow rates provide greater flexibility in water management.

Case study 5: The Business Case for Change

A Melbourne municipality recently developed a business case to replace an outdated and hard to maintain/manage irrigation control system, to a new, user friendly central irrigation control system.

The key issues that needed to be addressed by moving from the present system to a new system:

- Improved Accuracy – having a system that reads weather data from localised weather stations and can be calibrated to each specific site will improve efficiency.
- Improved Control – having a system that provides flexibility to adjust levels of irrigation as part of ongoing ground maintenance or weather events.
- Reduced Labour – having a system that can control site control remotely, rather than driving to each site to turn systems on and off, especially around the maintenance requirements.

It was proposed to change over irrigation control systems to a true central control system, with the benefits of; reduced water waste, reduced labour, improved turf health, safer player surfaces and improved appearance of irrigated areas.

The current system was costing the municipality over $40,000 per year in licensing fees and significant investment to connect new sports fields to the system. New systems would need to be cost effective, easy to use, have 24 hour support, be sound as a company (so will be around for a long time) and be able to train the staff in how to fully utilise the system.

The goal of replacing irrigation control systems for the municipality is to:

- Improve water efficiency by at least 10%
- Reduce labour costs for managing irrigation system by 30% (or approximately 350 man hours)
- Improve turf management by reducing washouts through greater control, saving approximately $7000 per year
- Find a system that has no or lower ongoing fees attached to it.

Potential Savings of new system versus doing nothing

Criteria	Option 1 Status Quo	Option 2 New System
Savings from improved irrigation efficiency, assuming 10% savings on an annual municipality consumption bill of $700,000	$0	$70,000
Labour savings, assuming 350 hours at $45 per hour	$0	$15,750
Maintenance saving by having auto shut offs and warning system for break downs	$0	$5,500
Reduced turf replacement and down time due to repairs due to washouts and bursts from continuous water flow	$0	$7,000
Total Cost Savings per Annum	$0	$98,250*

Potential costs of installing new system versus doing nothing

Criteria	Option 1	Option 2
Set-up costs, Hardware – Onetime cost	$0	$250,000*
Ongoing Annual Costs – Annual	$40,000*	$8,000*

*All prices are indicative and will vary depending on the location and system being replaced.

The savings by upgrading to a new system equate to approximately $130,000 per year. With these indicative figures in mind, and a payback under 2 years, it makes financial sense to upgrade to a central irrigation control system over maintaining the current system.

*Please note, these figures will vary from site to site, and will depend on the size of the municipality, current irrigation system and the product supplier chosen. Several product suppliers have products that can meet the criteria outlined in this example, it is up to each interested parties to get quotes and find the system that best suits their needs.

Case Study 6: Sub Surface Drip Irrigation

The delivery of irrigation water directly into the root zone overcomes some of the losses experienced in traditional irrigation systems. Losses associated with evaporation, wind drift and poor infiltration are eliminated. These may account for 15% to 30% of total losses with sprinklers and sprays. The effective lateral distribution of water is very strongly dependent on the soil type and hydraulic characteristics. It is there essential that a thorough understanding of the site soil is obtained prior to the design of the system.

Monitoring of the system in terms of flow, volume consumption and also soil moisture should be incorporated into the total system design.

There are some practices including plant (e.g. grass) establishment, washing in of chemicals and softening of the ground that still require the use of sprinklers on sites such as sports grounds.

When considering installing sub surface installation, a few key factors need to be considered.

If installed properly, in the right circumstances, sub surface drip irrigation can be highly efficient, and have been known to achieve distribution uniformity of between 80 – 90%, it can only be installed with the right preparation and use of the space.

Some key issues to consider include:

- Higher capital cost for sub surface systems (Up to $150,000 to install properly)
- Must have the right soil profile as some course sands do not allow sufficient lateral water movement through the soil profile
- It can be difficult to establish new turf
- Turf renovation practices need to be modified to reduce the risk of damage to the drip lines as they are generally 200 mm below the surface.
- Drip lines must be considered when looking at the uses of the space to reduce the chance of spikes being driven through lines or heavy machinery damaging the system.

In general, a well-designed and executed sub surface drip irrigation system, can achieve up to 25% better efficiency against traditional sprinkler systems. Maintaining the system in a functional operating condition is essential.

BEFORE:

WORKS IN PROGRESS:

FINISHED PRODUCT:

4.7.3 Weather station and smart controller

The weather station is a tool that can provide a breadth of information relevant to the water management of the whole site. The collection of current weather information by a weather station and the storage of this data for later use have many applications in the management of an irrigated landscape. These include:

a. Provision of daily ET data for use in irrigation scheduling

b. Providing rainfall records – historical data and site water management including water harvesting

c. Wind speed and direction – system operation and application efficiency

Technology cost and benefit comment:

It is estimated that there is between 20% and 40% overwatering that occurs as a result of irrigation programs not changed to allow for varying weather conditions. Irrigating according to plant needs and weather conditions produces higher quality surfaces and plants are maintained in a healthy condition.

4.7.4 Soil moisture sensing

Knowing the actual amount of moisture in the soil provides the irrigation manager with the knowledge to make precise scheduling decisions and to understand the soil water behaviour of the site and soil.

There is a very wide range of technologies available and the cost range is also large. Types of equipment range from portable devices ($100s) through to real time, web linked, multi-point profile sensors ($1000s).

The capacity to monitor other soil parameters including temperature and electro-conductivity (EC) adds value to the sensor as a water management tool.

Key considerations in the use of soil moisture sensors are accuracy in reading site soil, robustness, signal compatibility and the need to select a representative position at which to take readings.

Technology cost and benefits comment

Soil moisture sensors can prevent over-watering, should it be occurring. This has direct benefits in terms of the cost of water. If the sensor results in a saving of 20% at a site that has a typical annual cost of $5000, then in purely economic terms, this represents $1000 per year. If a payback period approach is adopted, say 3 years, then a capital cost of $3000 can be justified. In many situations, it is the improved quality of the surface that justifies the cost of soil moisture sensors.

4.8 Consequences of poor design and poor system performance

The capacity to apply water precisely, according to plant demand, is essential.

A potential consequence of adopting a lowest cost tender for an irrigation system is that some aspects of performance will be sacrificed. This is false economy.

> System design incorporating performance based criteria is the foundation of good water management.

Figure 15: Consequences of a poorly designed irrigation system.

Some of the consequences of poorly designed irrigation systems include:

- Uneven grass and/plant growth
- Bare patches
- Poor playability – uneven, bare
- Increased risk of weed infestation
- Leaching of nutrients in over watered areas
- Groundwater contamination risks through over-watering in parts
- Wastage of water
- Loss of visual amenity
- Lack of control of water application

The consequences of poor performance have significant resource implications for the management of the site.

- Increased time to maintain the area
- Increased water costs
- Increased time to manage/service clients – due to unsatisfactory site performance
- Increased time/resources to manage the vegetation e.g. turf transition CS to WS grasses
- Reduced revenue from use and events

4.8.1 Excessive sprinkler spacing

Good sprinkler design requires high uniformity of application. The spacing of sprinkler heads is directly related to the uniformity of application. Increasing the distance between heads reduces the number of heads and associated equipment (e.g. valves and pipes). However, the increased spacing has reduced the uniformity of application.

As an example, the best practice sports ground design has been modified to increase the spacing between the heads. One complete lateral line has been removed. The sprinkler head spacing has been increased from 16.5 m x 16.8 m triangular pattern to 16.5 m x19.2 m.

In terms of performance, the uniformity of application, Design DU, has been reduced from 87% to 78 %.

The following Table 7 outlines an estimate of the costs resulting from the installation of an irrigation system that does not meet industry best practice standards, in terms of sprinkler layout (uniformity).

Table 12: Capital and annual costs for alternative irrigation systems

Item	Comment	Estimated cost (2015 estimates)
Best Practice Irrigation Design		$60,000
Non-conforming, wide spacing design		$54,000
	Capital cost saving	**$6,000**
Water cost - Example		**Annual costs (estimated)**
Field DU 0.75 (75%)	Site water use: 5.0 ML Potable: $2.21 per kL	$11,050
Field DU 0.60 (60%)	Site water use: 6.2 M Potable: $2.21 per kL	$13,702
	Site: Geelong. Field DU 50%. Water budget: 7,437 kL @ $2.21 per kL	$16,435
	Extra water cost	**$2,652**
Extra Maintenance Items		
Repairing uneven ground, Grass re-establishment, Weed management		$1,500 (Estimated)
	Extra maintenance cost	**$1,500**
	Total extra annual cost	**$4,152**

The capital savings are in the order of $6,000. The additional annual costs are in the vicinity of $4,000 as a result of non uniform cover and extra water costs. Payback on investment is less than 2 years.

4.8.2 Pipe sizes too small

Best Practice hydraulic design standards require that pipe friction losses and pipe velocities be kept within nominated ranges. A maximum velocity of 1.5 m/s is commonly adopted.

Reducing pipe sizes may be considered by some as a means of reducing the capital cost of a system.

The performance consequences include excessive friction loss, which leads to less than optimum operating pressure, excessive pressure variation between outlets and across the system network. Also, high velocities can result in excessive water hammer, when valves are opened and closed. In some systems, the pipe sizes significantly limit the capacity of the system to deliver the required total flow rate. Wear on system equipment/components will be higher, as a result of higher velocities.

Using the Best Practice Irrigation Design example the consequences of reducing pipe sizes by one nominal diameter size would result in a reduced operating pressure of 83 kPa at the end of the lateral. The estimated variation in operating pressure would be 62 kPa.

The impact of system uniformity of application is difficult to determine accurately. It is expected to be in the range of DU 10% - 15%.

Increased pressure requires higher energy input. This increases CO_2 emissions for irrigation.

Cost saving and consequence comment

The cost savings associated with reduced pipe sizes and also reduced pipe pressure ratings are minimal in the overall capital costs of an irrigation system. The consequences in terms of reduced capacity and reduced uniformity as a result of pressure variability are significantly greater.

It is estimated that the cost savings associated with selecting reduced pipe sizes will be in the range of 10 to 20%.

4.8.3 Inadequate zoning

Zoning of irrigation systems is required for a range of reasons. These include catering for areas with similar water requirements, similar soil properties, areas of more intense use or wear, different local microclimate conditions and the need for grouping of irrigation applicators of similar performance, particularly precipitation rate.

Irrigation systems designed for sports grounds should be zoned to accommodate the additional wear that is experienced in the central corridors of play and in the goal areas.

An important benefit of zoning is that areas that do need additional water can be irrigated to meet their requirement without applying this extra water to areas that do not require it. This improves overall efficiency and reduces total water demand.

Cost saving and consequence comment

The main cost saving achieved with inadequate zoning is the reduced costs from fewer valves and control cabling as well as less pipework is used.

In the Best Practice design example the cost saving associated with removing one zone and combining the operation of two laterals together is approximately $1000.

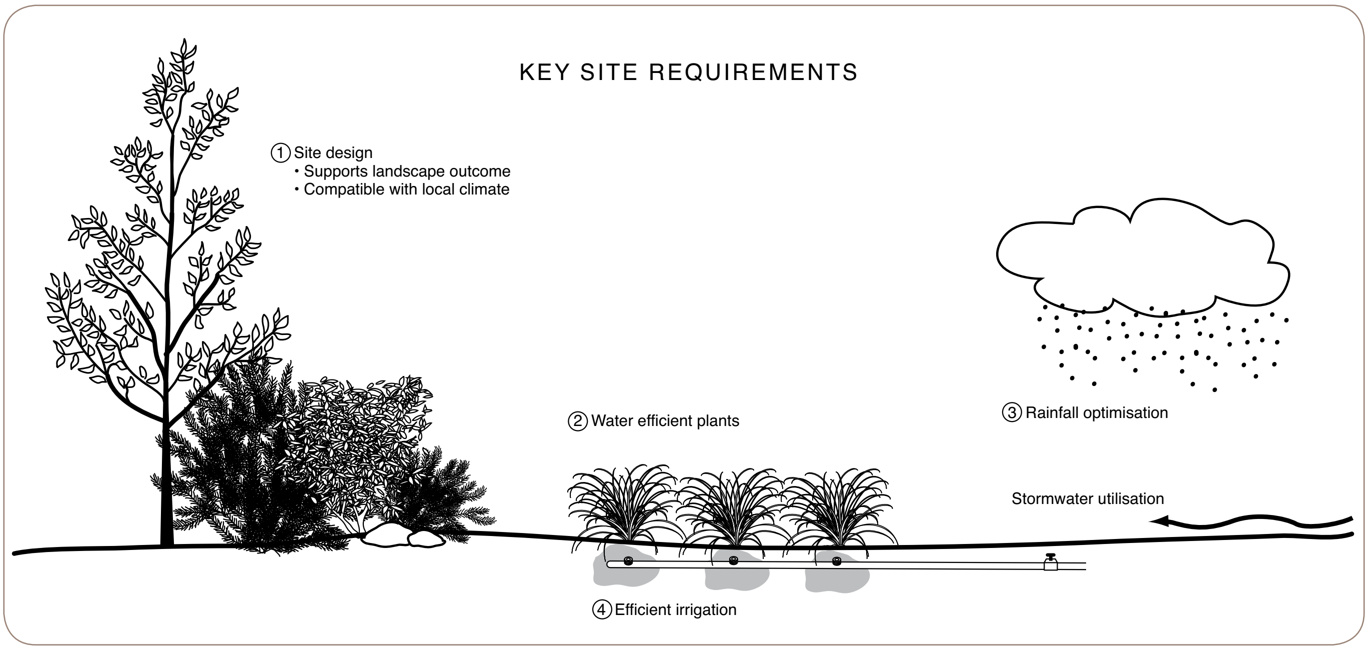
This is a relatively minor amount when the costs incurred as a result of the application of extra water is taken into account. There will also be costs associated with increased maintenance as result of variable growth from the uneven application of water.

SECTION

5.0

Optimisation of the site water cycle and water supply

Figure 16: Optimising site water cycle management



5.1 A sustainable and efficient approach

Prior to the application of irrigation water the site should be assessed in terms of strategies that can be adopted to reduce dependence on irrigation water and to use irrigation water efficiently.

Core elements of an approach that is consistent with the achievement of sustainable use of water in urban landscapes are:

a. The site is designed, including selection of plants, to minimise the demand for supplementary irrigation water.

b. Maximise rainfall contribution to soil moisture (infiltration) and capture local stormwater and rainwater for passive irrigation. (Refer Fig. 16)

c. The amount of supplementary water applied is matched to the site vegetation, soils, weather and performance standards required.

d. Irrigation is carried out efficiently.

e. An annual irrigation water budget is prepared for the site and used for ongoing monitoring and evaluation.

f. A secure, non-potable water supply is a planning objective.

The adoption of these core elements provides a sound basis for the achievement of sustainable landscapes.

5.2 Irrigation water supply

Securing a water source to supply irrigated sites requires detailed assessment of both the requirements and characteristics of the site and the suitability of the water.

To maintain a sustainable irrigated open space it is necessary to have a water source that has:

a. Secure supply

b. Adequate amount or volume of water

c. Appropriate quality – for sustainable use

d. Cost effective for the application

5.3 Potential water sources

There are numerous potential sources of water for urban irrigation:

- potable (suitable for human consumption) mains supplies (reticulated systems)
- recycled water (treated effluent)
- stormwater (runoff from ground, paved areas roads, car parks, etc.)
- rivers, creeks/water courses
- groundwater
- rainwater (roof-harvested rainfall)
- greywater (bathroom, shower, in-house taps)
- sewer mining (water extracted from sewer main and treated locally)
- industrial/reclaimed water (water previously used as part of production or other process)

5.4 Selecting a water source – Characteristics to take into account

The particular characteristics of each water source needs to be considered when seeking a water source for irrigation. The following should be considered:

a. volume available versus total water required

b. water quality – chemical, physical and biological

c. water treatment requirements (if any)

d. hydraulic supply conditions - flow rate and pressure

e. cost of water

f. availability – timing and duration

g. reliability/security of supply

h. conditions of use of water – compliance requirements

i. storage requirements

j. human health issues

k. potential impact on environment

l. license approvals and fees

When considering a potential water supply a water budget should be prepared for the site.

Expected irrigation volumes for an average year are useful, however allowance should be made for a dry year or very dry year. One approach is to use a 1 in 10 rainfall year (Decile 1) as the basis for determining the required water budget.

Water source and water quality

The quality of the water is determined by the source. Groundwater, treated effluent and stormwater all have their own quality characteristics and should be considered from both a human health and environmental health perspective. The human health risks tend to be more associated with the biological properties, such as ecoli, and environmental risks tend to be associated with the salt concentration or salinity of the water.

Salinity is a specific risk for turf surfaces. It is not only the total salts in the water it is also particular elements, such as sodium, that can impact negatively on grass and the soil. Potential effects include damage or stress to the plants and changes in soil properties, such as reduced permeability, through particle dispersion in some soils. Soil testing is recommended to determine if this is an issue at each individual site.

Table 13: Climate considerations on Irrigation Demand
Irrigation water requirement Vs Turf Quality Standards

Irrigation Volume Estimates per Hectare (10,000 m^2)			
Turf Quality	**Turf Coefficient KT**	**[1]Climate – Long term Average**	**[2]Climate – Decile 1 Annual**
Elite	0.8	8.6 ML/ha	10.3 ML/ha
Premier	0.6	6.6 ML/ha	8.3 ML/ha
Local sports	0.4	2.3 ML/ha	2.9 ML/ha

Notes:

1. Estimates
2. Climate data is for Tullamarine, annual rainfall 536 mm.
3. Decile 1 is a year of annual rainfall of 403 mm. This rainfall distributed monthly to long term pattern.

5.5 Irrigation system hydraulic requirements

Irrigation systems have specific hydraulic requirements to ensure that the system achieves efficient use of water.

These are:

1. Supply flow rate
2. Supply pressure (dynamic pressure)

For an existing irrigation system, the available flow rate is already determined. For example, size of mains meter, pipe pressure or an existing pump with a given performance characteristics.

It is necessary to operate the irrigation system within these constraints.

If the flow rate is low, this may mean extended hours of operation or irrigating over multiple nights.

The required supply pressure is determined as part of the irrigation design process. Knowing the design system supply pressure and the optimum sprinkler or emitter operating pressure is essential to the good management of the irrigation system.

(Appendix4: Irrigation design Best Practice)

5.6 Water quality

5.6.1 Water quality considerations

The quality of water has an impact on the method of application, operation of the system, the ongoing sustainability of the irrigated site, the selection of water filtration and water treatment equipment and the selection of materials used in the system.

Water quality needs to be considered under the following categories: chemical, physical and biological.

For each of the water quality categories the properties include:

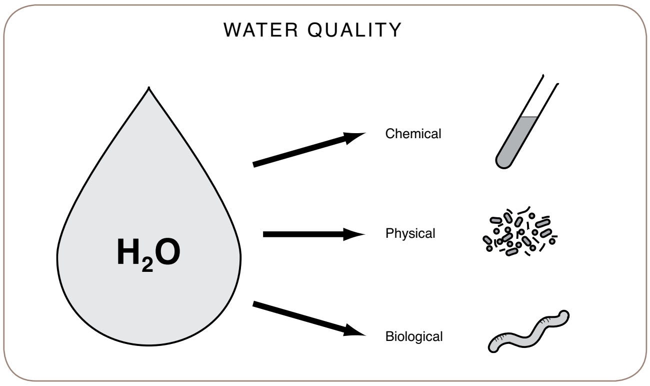
Physical – temperature, colour, taste, odour, light transmission (turbidity), suspended solids.

Chemical – pH, acidity, alkalinity, hardness, total dissolved solids (TDS), electro-conductivity (EC), specific ions including sodium and chloride, bicarbonates, heavy metals, sodium adsorption ratio (SAR), macronutrients, micronutrients

Biological – algae, fungi, bacteria (e.g. ecoli), pathogens, animal and plant material

The quality of water to be used for irrigation potentially has an impact on each part of the total system.

Figure 17: Main categories of water quality



Monitoring water quality is an ongoing commitment.

Plants

The potential, impact of low quality water on landscape plants include both above ground (aerial) material/ vegetation and below ground (roots). The specific aspects include:

a. foliage scorch or injury
b. reduced growth or damage due to salinity intolerance
c. toxicity due to contaminant levels above threshold levels
d. diseased plants due to pathogen infection

Soil

The physical, chemical and biological properties of the soil may be altered to the degree that the sustainability of the landscape is threatened. The specific aspects include:

a. toxic effects due to contamination above threshold vales/levels
b. stability of soil structure diminished through chemically induced soil dispersion
c. reduced water availability due to elevated soil salinity
d. reduced growth or damage due to excess salinity/ salinity intolerance
e. reduced availability of soil nutrients due to chemical imbalance e.g. increased phosphorous levels impact uptake of iron
f. reduced growth or damage due to pathogen (disease)

Water treatment and water quality

Whilst the role of the treatment process is to modify the properties of the water to suit the intended use, there are potentially some risks. These include:

a. the process is ineffective in achieving required water quality parameter threshold values

b. failure or breakdown of treatment system

c. suspended material limits effectiveness of treatment process (e.g. chemical and optical treatments)

d. suspended solids cause excessive build up/loading of filters

Water storage and water quality

The type of storage, open to the atmosphere, such as a pond or dam, or closed, such as in a tank, is the major factor influencing risks associated with storages. These include for open storages:

a. excessive algal and water growth if water body is eutrophic (nutrient rich)

b. build-up of excessive algal and water plant growth from eutrophication for new water bodies if pollutant removal treatment is poorly sized and inadequate

c. pathogenic microbial contamination (human and plant diseases)

Irrigation system functioning and water quality

The physical, chemical and biological properties of irrigation water can contribute to reduced efficacy and reduced reliability of irrigation systems. The specific issues include:

a. blockage of micro-irrigation emitter pathways and orifices

b. blockage of small orifices in solenoid valves

c. corrosion, due to acidity, of components

d. build up and blockage in pipework i.e. iron deposition and or calcification

5.7 Water quality testing

All non-potable water supplies should be tested as part of an initial assessment for potential use and then on an ongoing regular basis to ensure that the water being used is compliant with the chemical properties of the soil and plants.

Please refer to Appendix 2 regarding parameters for water testing.

SECTION
6.0

Keeping the site functional

Figure 18: Simonds Stadium, pre-game storm delayed game by 90 mins in 2014

Figure 19: Simonds Stadium – Game started after delay, once drained still a high quality surface

A full cover of healthy dense grass is considered the requirement for a functional sports ground. To maintain this condition, it is necessary to manage the grass and soil on a continuous basis.

Recognising risks is a core duty. These risks may arise through; weather conditions (hot and wet), pest and disease incidents and soil moisture deficiency.

Responding to the natural growing cycle of the plant is also a core requirement in maintaining a functional surface.

The following practices describe maintenance that assists in providing a surface that delivers the required outcomes.

Reference further information from AGCSA and Sydney Water.

6.1 Main challenges

a. High use and wear rates
b. Wet weather conditions
c. Hot/dry weather conditions – dry, hard grounds
d. Limitations of the site – construction type
e. Resources available are limited

Functional spaces require healthy plants and healthy soils.

6.2 Best Practice Maintenance Tasks

Figure 20: Key tasks that ground managers need to understand to operate at best practice.

Best Practice Maintenance Elements/Tasks

1. Know the site usage – type, timing and rate
2. Understand the site – soil, climate
3. Grass species selected are appropriate for the use and site
4. Water/irrigate to maintain grass to required standard
5. Mowing practices
6. Fertilizer program
7. Turf (sports) surface management - Dethatching and aeration
8. Weed and pest control program
9. Soil management
10. Continued monitoring and evaluation (against targets)

6.2.1 Know the site usage

a. Numbers of users
b. Time of use
c. Degree/intensity/type of use
d. Measures of use: Hours, Player hours, Visitors

6.2.2 Understand the site

a. Site assessment
b. Soil test
c. Plant leaf analysis

6.2.3 Grass species appropriate for use and site

a. Establish species selection criteria
b. Local trial results - obtain evidence

6.2.4 Water/irrigate to maintain grass to required standard

a. Refer to Guidelines Section: Best Management Practice – Water Mgt and Irrigation
b. Efficiency of water use
c. Measurement and analysis of water use

6.2.5 Mowing practices

a. Height and frequency (changing between seasons and sports to meet recommended heights, and taking weather and ground conditions into consideration prior to mowing)

6.2.6 Fertilizer program

a. Based on soil nutrient analysis and species requirements
b. Minimising risk to environment (leaching of nutrients)

6.2.7 Turf (sports) surface management

a. Dethatching
b. Aeration
c. Other cultivation practices

6.2.8 Weed and pest control program

a. Regular monitoring and assessment
b. Skills/capacity to manage chemicals (treatments and application)
c. Minimise environmental risks of chemicals

6.2.9 Soil management

a. Regularly inspect soil profile (spade, corer, and sampler)
b. Measure soil/ground properties – infiltration, water holding, wettability, compaction

6.2.10 Continued monitoring and evaluation

a. Establish targets for use, performance level and ground conditions
b. Respond to conditions including review of site design and construction to meet required services

Figure 21: Sample of soil provides valuable current information

6.3 Assessment of Natural Turf Surfaces

Figure 22: Sport being played on a safe functional surface

Surface assessment

Criteria:

a. Grass cover – Expressed as a percentage of area e.g. multiple small area samples

b. Grass length – mm

c. Surface evenness – Deviation in mm from a straight edge (2 m length)

d. Surface hardness – Clegg impact hammer

e. Surface (rotational) traction – e.g. studded plate

Figure 23: Clegg Impact Hammer

Ground conditions impact on functionality and Carrying Capacity

Figure 24: Saturated, impacts on playability and ground recovery

Figure 25: Surface is dry, hard, injury risk

Table 14: Various limits for site turf srurface limiting components and testing ranges (Sports Turf Institute 2011)

Component	Test Method	Comments	Limits (Indicative Guide)
Surface Evenness	3 metre straight edge and/or 5 metre string line	Surface unevenness can impact on player safety and surface playability	<100 mm variation under a 5 metre string line <20 mm over 3 metre straight edge (Premium surface) <30 mm over 3 metre straight edge (Lower standard)
Ground Cover	Visual assessment – Use of a 0.25 sqm	Relates to surface appearance, stability and uniformity;	High wear areas of the ground total turf cover to be > 98% start of season; >than 85% mid-season (end May) No bare patches > than 200mm diameter start of season; < 10 bare areas >200 mm diameter per field mid-season
Sward height (mm) (Grass height)	Use of a floating disk	Grass height relates to performance in relation to ball bounce and roll, as well as impacting on surface hardness and traction. Sward height will be sport and species/cultivar specific. Mowing height should be adjusted for turf types and sport requirements	• Hockey - 8mm to 20mm • Cricket (excluding wicket) - 10mm to 35mm • Soccer - 20mm to 40mm • AFL - 20mm to 50mm • Rugby Union / League - 40mm to 55mm
Surface hardness (g)	2.25 kg Clegg Hammer® for player/ surface interaction	Hardness relates to injury potential after impact with the ground Gmax readings above 150 indicate cause for concern, the absolute upper limit is 200 Gmax	• Clegg hammer readings should fall between 50 to 120 g 3rd drop • Above 150 is considered at high risk
Traction (Nm)	Use of studded disk apparatus	Relates to surface stability and injury riskdue to insufficient or excessive traction	Test values to ball between 30 – 50 Nm

Table 15: Turf surface maintenance details provided by Sydney Water
– Best Practice Guidelines for holistic open space turf management, Sydney Water 2011

Management Technique	Comments	Depth	Issues
Deep Slitting or Knifing 	Traction-driven machines are attached behind a tractor at speed to facilitate tine or blade entry into the soil	100 – 300 mm	Blade penetration limited in tight compact soil. Some machines are designed so that blade travel through the soil in an offset way, which creates a more effective disturbance
Deep Slicing or 'Earthquaking' 	Tines gently lift and shatter the compacted soil sideways and downward. Ideal for dry hard soils and for soils with many stones, as they do not harvest materials to the surface	100 – 300mm	This machine is not suitable for wet soils or soils high in clay, because the soil sways to and fro as the blades pass, becoming smeared rather than fractured
Hollow Tined Corers 	Self driven or powered by a tractor. Hollow tines 10 to 25mm in diameter punch vertical holes in the topsoil, with the spacing between holes varying from 60 to 150 mm on a square pattern, depending on the machine brand.	100 – 200 mm	Continued use of hollow tine machines in and around the same depth in medium to heavy textured soils can cause a hardpan to develop at the bottom of the tine 'punch'. This action of the tine in penetrating finer textured soils can also cause soil glazing and compaction around the individual holes, resulting in long term soil structure degradation
Solid Tine Forking 	Solid tines punch vertical holes in the topsoil, with the spacing between holes varying from 60 to 150 mm on a square pattern, depending on the machine brand	100 – 200 mm	This is not regarded as an effective long term de compaction technique because it aggravates the problems of glazing and perimeter compaction
Solid Tine Aeration 	Similar to solid tine forking, except with 'kick' action at the bottom of the downward thrust. Aeration is similar to putting a garden fork into the soil and rocking it back and forth, which forms a cavity underground. This action overcomes many of the disadvantages of standard solid tine forking	100 – 200 mm	Operators of solid tine forking machines must use the 'kick' feature. If contractors do not use this feature, they may provide cheaper quotes but it will not improve the playing surface as much.
Vibrating Tines and Knives 	Uses a tractor operated powe take-off to drive a rotary drum with numerous tine boots attached, that independently vibrate as the rotary drum travels forward over the ground. Each boot has a number of tines in a square pattern that penetrate the soil while vibrating, shaking and fracture the soil. This leave holes in the soil allowing water to penetrate	100 – 200 mm	Continual use can still cause a hardpan to develop at the bottom of the tine 'punch'.
Recycling Top Dresser 	A European tractor-attached machine that decompacts, mixes and incorporates soils. Soils are aerated by a high speed rotor which drives a 10 mm wide tungsten tipped blades into the soil. The blades are spaced 180 mm apart. These blades saw trenches into the soil profile, harvesting soil and depositing into a conveyor attachment that distributes the soil evenly at the rear of the machine, thus aerating and top dressing in one press	110 – 180 mm	Will not improve the lack of topsoil depth. For this you will need to add material. The top-dress material generated by the machine will have a texture that matches the soil profile as it is derived from the underlying soil. So, if you have unsuitable subsoil, this is not the best option to use

SECTION

7.0

Trees Landscapes and Parks

7.1 Value of trees

Trees are highly valuable elements in urban environments and are essential to liveability.

Individually and collectively they provide numerous aesthetic and functional benefits including microclimate modification, shade, stormwater moderation, wind breaks and improve air quality through absorption of gaseous pollutants (e.g. nitrogen oxides), intercept particulate matter (e.g. dust) and release oxygen.

To deliver these benefits trees need to be maintained in a healthy condition.

The need for supplementary watering depends on the species, local climate, site conditions and constraints, particularly soil volume, and the functions required of the tree/to be delivered by the tree. Some watering is generally required during drought periods.

7.2 Tree establishment

Successful tree establishment of urban trees is essential. Loss of newly planted/young trees is a waste of resources, including water.

The following is Best Practice for tree establishment:

a. Species selected appropriate to the site and purpose

b. Quality nursery tree stock used

c. Planting hole of adequate size

d. Transplanted by personnel skilled in these practices

e. Planting hole prepared with sufficient soil moisture

f. Regular watering of tree (root ball) to initially support root growth and development

g. Two years of establishment watering is commonly used, however if the tree is not fully established then watering should be continued

h. Effective watering e.g. create an earthen berm to contain applied water.

7.3 Watering of mature trees

The following is Best Practice for the watering of mature urban trees:

a. Ensure that the tree site fully utilises rainfall, e.g. effective infiltration close to the tree. For example, use of permeable paving for street trees.

b. Identify trees that are vulnerable to water stress, for example due to limited or constrained root systems, high water demand species or inadequate rainfall will require supplementary watering.

c. Adopt pro-active tree watering practices rather than waiting until the tree is showing signs of stress.

d. Signs of stress include leaf loss, change in colour, scorching, wilting or leaf curl it is nearly too late.

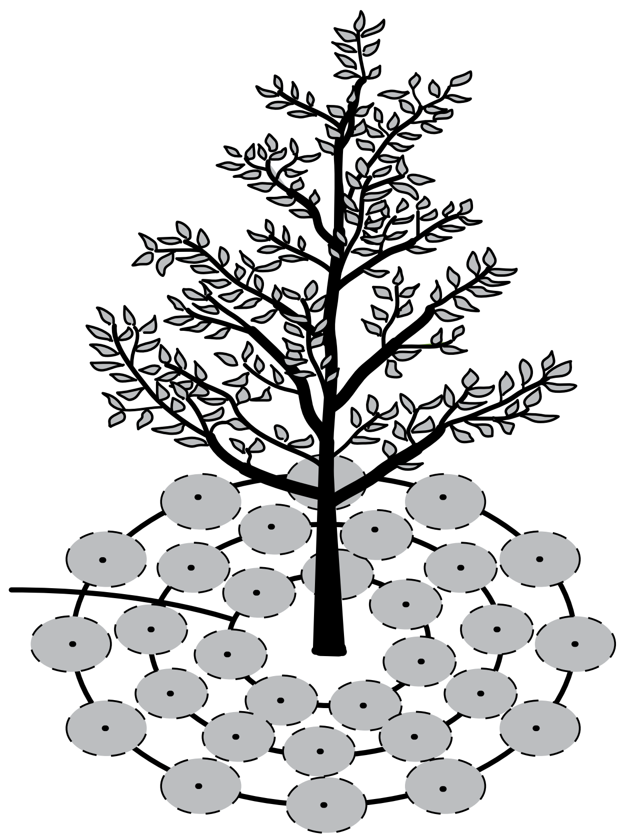
e. Apply water effectively, for example drip systems or if tanker water, use devices or an earthen berm (mound) to contain/store water for absorption over time to avoid runoff.

f. When using recycled or treated water check that the water chemical properties e.g. salts, toxic elements and pollutants, are not going to present a short term or long term risk to the tree.

g. Mulching provides effective soil protection, weed control and reduces soil water evaporation. Use coarse mulches that allow water (rainfall) to infiltrate.

h. Employ stormwater diversion and similar WSUD systems to direct water to the tree root soil environment as a passive watering strategy.

Figure 26: Drip system should apply water to a signficant portion of the majority of the tree root zone



7.4 Evaluating tree health

The current condition of trees can be assessed through visual inspection by qualified arborists. Evidence of stress, particularly low soil moisture, may include stunted growth, smaller leaf size, leaf drop, presence of deadwood and dieback and reduced canopy density.

Disease can also usually be assessed through a visual inspection and evidence of pests, infections and changes in leaf colour or texture.

SECTION

8.0

Evaluating performance

8.1 Performance evaluation of a Best Practice Functional Open Space Site

The evaluation of an irrigated green space should consider the services provided by the space as well as the condition of the vegetation and the resources, including water, that are being used.

The following aspects of green space should be evaluated as part of an ongoing management program:

a. Usage level and services provided – quantity and quality

b. Plant health and surface condition for sports grounds

c. Soil health

d. Water use and management

8.2 Services provided

The potential measures for services provided that are appropriate to a particular site depend on the purpose of the site. Sports grounds are very different to botanic gardens, in terms of services provided.

The following are some of the terms and units that are used:

- Turf surface quality – Visual assessment
- User/player-hours
- User/player-hours per ML of irrigation water used
- Visitors (number)
- Visitors per ML of irrigation water used

8.3 Evaluating Turf Surfaces/ Sports Grounds

Sports grounds can be assessed in terms of the quality of the turf, the quality of the surface, the irrigation and drainage infrastructure and ground fixtures.

Turf quality can be assessed by examining grass colour, grass coverage and density, presence of thatch, weeds and evidence of disease.

Surface quality can be assessed by checking the evenness of the ground, existence of any holes or disruptions, uniformity of surface conditions (traction and playability), and evidence of water logged areas and hardness.

Exposed irrigation equipment, such as valve boxes, can be checked for soundness and risk for injury or hazard.

8.4 Evaluating the Water Performance of Irrigated Sites

Some of the reasons why the performance of an irrigated site should be measured are:

- Understand the current operating effectiveness of the system
- Identifying areas of weakness and equipment for improvement
- Assist in the preparation of a site Water Budget
- Allow optimum irrigation schedule to be determined
- Provide a report on water consumption
- Benchmark performance with industry Best Practice

It is very important that quantitative performance measures are used and that these results are available to all directly involved in the management of an irrigated site and also available to stakeholders both within the organisation and external stakeholders including the community, water authorities and relevant government agencies.

8.5 Overview of water performance

There are numerous techniques and parameter values available to evaluate urban irrigation performance. Indicators include volumes, depths, efficiency indexes, scheduling coefficients and uniformity coefficients.

The two core components of irrigation efficiency are the Application Efficiency and the Scheduling Efficiency.

The Application Efficiency describes how well the water delivered to the site is applied to the soil and subsequently enters the plant root zone for uptake.

The Scheduling Efficiency (Sometimes referred to as the Irrigation Management Efficiency) takes into account how well the irrigation system has been operated to meet the water needs of the plants and delivers the required amount of water, in response to the local weather (rainfall and evaporation) conditions.

8.6 Major Categories of Measures – Key Indicators

The following measures provide a suite of information that not only achieve the primary task of performance measurement but also can be used to analyse the system and the irrigation management. These are:

a. Volume of water used (kL, ML)

b. Application Rate (ML/ha)

c. Uniformity of application – Distribution Uniformity (DU)

d. Efficiency of water use – Irrigation Index (Ii)

8.7 Water volumes and performance measures

Recording the volume of water used to irrigate a site provides the basis for performance measurement.

By monitoring the volume used, relative to a Water Budget for the site, this provides the foundation for optimum scheduling of the irrigation.

The Water Budget is prepared by taking into account the required standard of the vegetation/turf and the long term climate data. The monthly water budget value is referred to as the Base Irrigation Requirement (BIr) and is determined for each month. The Code of Practice Irrigated Public Open Space (IPOS), SAWater Adelaide, describes the methodology, including the various turf visual quality standards, to be used.

To evaluate the water volume consumption performance, the following can be determined:

a. Water consumption (Actual) for each site (kL or ML) – Monthly and annual

b. Water Budget for site (kL or ML) – Monthly and annual

c. Comparison or difference between Actual and Budget – Monthly and annual

d. Actual water use relative to previous year or a nominated Reference Year

Water Application Rate (WAR)

The amount of water used per unit area is a useful performance indicator.

It is calculated by; Volume of water used (AIV) divided by the Irrigated area (Ai).

8.8 Uniformity of application

Uniformity of application is essential to achieve efficiency of application, whereby a designated depth of water is applied evenly to the ground.

The following are the uniformity of application measures currently being used in urban irrigation:

a. Distribution Uniformity (DU)

b. Christiansen Coefficient of Uniformity (CU)

c. Scheduling Coefficient (SC)

Distribution Uniformity (DU) term

The uniformity measure most commonly used in evaluation of turf and landscape systems is the DU, which compares the average of the lowest 25% of test can readings to the average of all readings. A DU of 1.0 or 100% would indicate that the application was perfectly even. In practice, this does not happen. As an example, if the average reading of the lowest-reading five (5) cans, out of a total of 20 cans, is 15 mm, and the average of all readings is 20 mm, then the field DU is 0.75 or 75%.

The value of DU is presented both as a percentage and a decimal. Strictly speaking it should be a decimal because it is not a true efficiency term. However, due to the widespread use as a percentage, both terms are used.

The value of DU is calculated using the following expression:

$$DU_{LQ}\ (\%) = \frac{V_{c25} \times 100}{V_{cav}}$$

V_{cav} – Average value of all catch can readings

V_{c25} – Average of lowest 25% of catch can readings

The DU value is used in both the design of the irrigation system, referred to as the Design DU, and also in the testing of uniformity in the field, referred to as the Field DU.

The industry standard for Field DU is 75% or 0.75.

The DU term can however be determined in a number of ways. The number or percentage of the lowest readings used in the calculations can vary. A DU25%, is also referred to as the DULQ , where LQ refers to the lowest quarter (25%) of readings, is the most commonly used DU term. This is the term referred to in this Best Practice guide.

The following Table 8 provides a guide to the rating of an existing irrigation system using the measured Field DU value. This approach assists in communicating the overall condition of a system in a simple way and is based on actual field performance measures.

Table 16: Guide to irrigation system ratings and Field DU values

	Distribution uniformity (DU_{LQ}) performance rating categories for sprinklers/rotors					
System Rating	Excellent	Very Good	Good	Fair	Poor	Very Poor
DU% Result	>0.80	0.70	0.65	0.60	0.50	<0.50

8.9 Irrigation Index – Efficiency measure

There are a number of terms that can be used to determine the efficiency of irrigation. The Irrigation Index (Ii) is currently being used by a number of organisations managing irrigated open space.

The Irrigation Index takes into account the climatic conditions that were experienced during the irrigation season.

It is a measure that compares the actual amount of water used to the amount that should have been used.

Calculation of Ii

$$Ii = \frac{\text{Actual Water Used (AIV)}}{\text{Irrigation Water Required (Ir)}}$$

The amount that should have been used (Ir) is determined from the plant species being grown, the performance standard required of the site, the amount of evaporation, the amount of effective rainfall and the assumed efficiency of the irrigation system.

The basic terms and example values, used in calculating Ii, are shown in Table 5.

This relatively simple measure provides the irrigation manager with a visible, readily understood measure of how well, or how efficiently, the system is performing and how the performance compares with other sites. An irrigated area that is being well managed would have an Ii value of 1.0 or less. If the Ii value is greater than 1.0, it would suggest that there is some wastage of water.

Figure 27: Components of Irrigation Index (Ii)

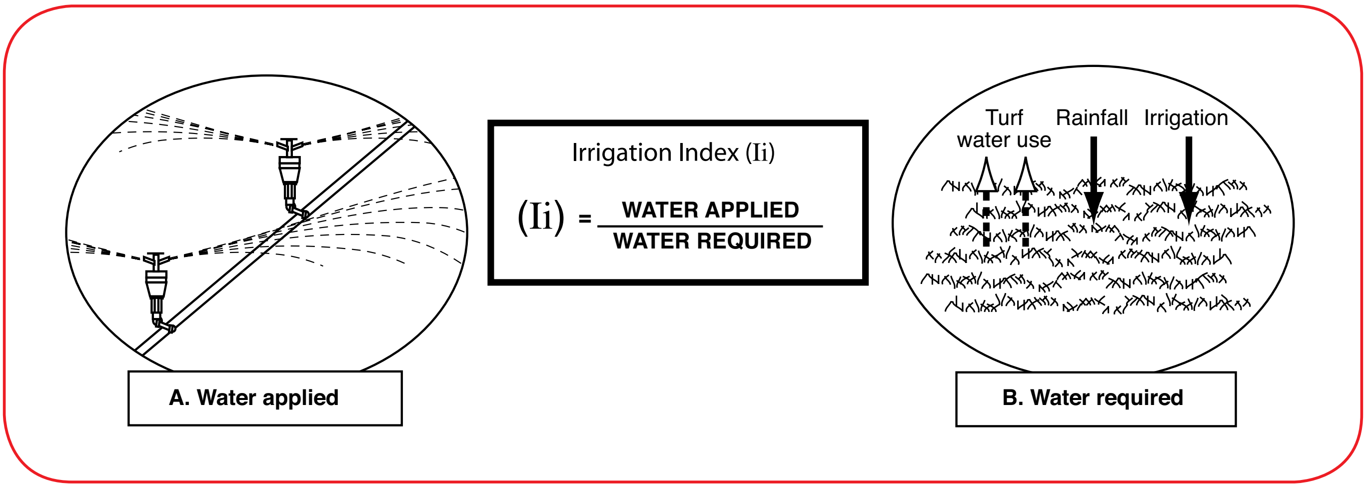


Table 17: Guide to irrigation index values

Irrigation I (Ii)ndex	Performance rating	What does it mean?
>1.3	Poor to very poor	Very wasteful irrigation, much overwatering
1.1-1.3	Medium	Significant over-watering
0.9–1.1	Good to very good	Watering close to optimum
0.7–0.9	Medium	Under-watering, landscape quality may be affected
<0.7	Poor to very poor	Serious under-watering, landscape at risk, sports surface may be unsafe (too hard)

Figure 28: Fuel gauge indicating irrigation efficiency

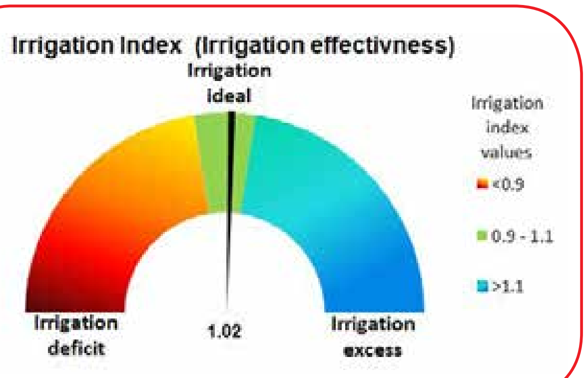


Figure 28 shows a fuel gauge with the Irrigation Index value displayed. This is a very effective communication tool. The degree of over-watering and under-watering can be readily conveyed. (Source: Developed by Richard Dilena of City of Greater Geelong).

The Ii value can be used to provide an assessment of current irrigation practices and provide a target for improvement.

An irrigation index of 1.0 is the best practice target value. A guide to the interpretation of Ii values is shown in Table 17.

Calculating Irrigation Index (Ii)

Site area of sports ground: 1.7 ha (17,000 m^2)

Turf: Premier – Warm season grass

Water applied (AIV): 5.109 ML
Depth of water applied (AIV):
300 mm per m^2 of 1.7 ha

Data for Water Required (Ir)

Turf coefficient: K_T 0.55
Eto (actual): 1050 mm
Rainfall: 240 mm
Effective rainfall rate: 50%
Irrigation efficiency: 80%

Irrigation depth required (Ir): 245 mm

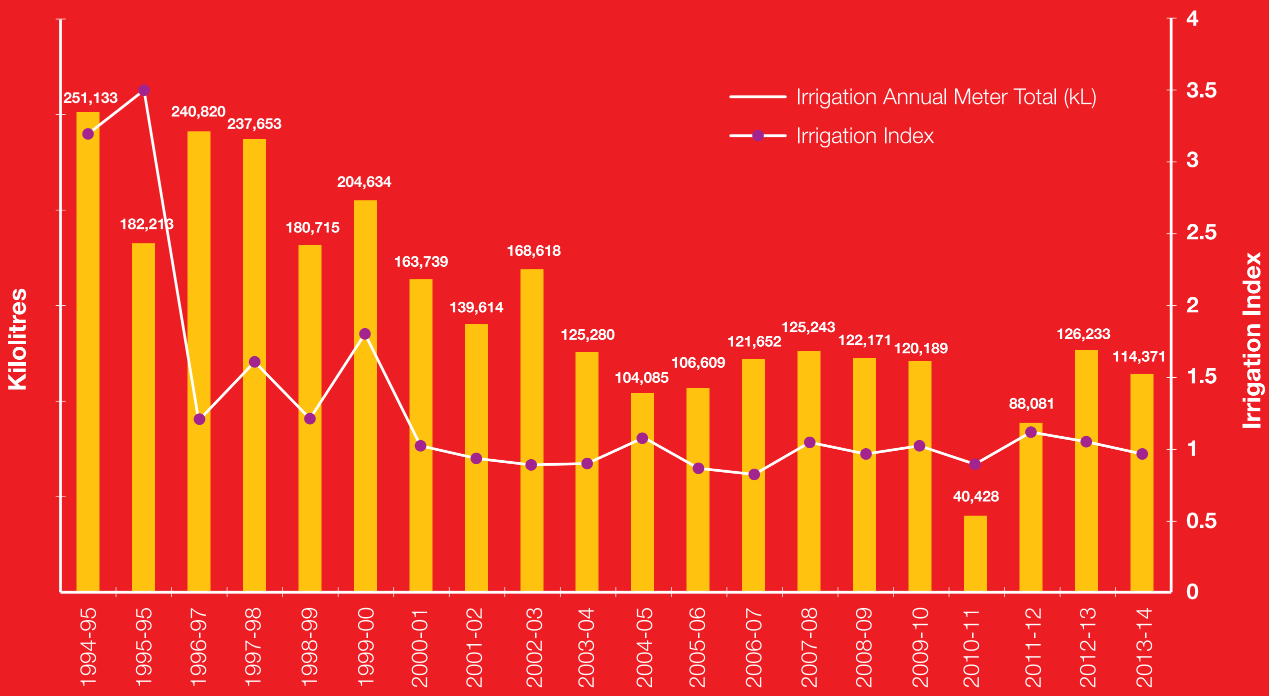
Irrigation Index (Ii) = $\frac{AIV}{Ir} = \frac{300}{245} = 1.22$

Comment:

1. This value of 1.22 indicates over watering
2. Full details on determining Irrigation Index are outlined in Water Use Efficiency for Turf and Landscape, Connellan 2013.

Case Study 7: Royal Botanic Gardens Victoria, Melbourne Gardens, South Yarra

RGB Melbourne - Landscape Irrigation Use and Irrigation Index



The Irrigation Index is reported by the Royal Botanic Gardens Victoria, Melbourne Gardens, South Yarra shows the high standard of water management carried out at the site as the value is tracking close to 1.0.

The graph shows how very significant improvements have been made, mainly through training and technology, over time. The graph illustrates the point that whilst the water volume may vary from year to year, due to weather variability, the efficiency is maintained.

SECTION
9.0

Appendices

Appendix 1: Case Study - Site Investigation Report

1.0 Background

The sports field is a large sized open space area, which can accommodate most sporting activities but is used primarily for football and cricket matches and training, and has a strip synthetic cricket wicket in the center of the ground.

Council is considering options and issues to upgrade the playing surface.

The purpose of this site investigation was to assess the current condition of this ground, determine the extent of some of the problems and issues that existed, and formulate options for the Council to address these problems as part of a possible surface upgrade or improvements.

This site investigation will assist in determining the issues and possible budgetary issues and options that should be allocated to upgrade the grounds surface to the standard required and to address as many issues as possible that presently exist on this ground.

The investigation also consisted of a preliminary inspection of the existing soil type and characteristics to a determine depth. This was done by practical excavation at site with auger holes excavated and core samples taken and identified.

2.0 Site Investigation

2.1 General

At the time of the visit, the following was found:

- Most of the oval was well grassed but does have an incomplete grass cover. The overall cover on the playing surface approaching 85%.
- Large areas on the surface were well grassed, but there were numerous weakly grassed and bare patches on the surface.
- The weakly grassed and bare areas were more evident in the northern and southern side of the ground.
- The weakly grassed areas correspond to previous wear areas including training areas, interchange areas and entrance areas to the ground.
- Cool season grasses such as winter grass and ryegrass were present on the surface with the primary species of warm season grass being couch. The un-over sown warm season grass was in a dormant or semi dormant appearance
- The couch exists in large patches on the oval, some of which has been introduced as sod with previous repair and improvements of the oval surface. These areas include center areas and in general the center corridor of play including goal mouths.
- The surface was generally firm but wet and with the recent heavy rain that had fallen on the area in the previous couple of days water was observed on the surface.

2.2 Infrastructure

The following infrastructure exists on and surrounding this ground:

- A post and rail metal pipe cyclone fence runs around the perimeter of the ground spanning an approximate circumference of 490 linear metres. The fence appears in good condition.
- A red brick spoon gutter (600mm wide) spans the perimeter of the ground. This red brick spoon gutter is situated on the inside of the fence and depending on where the boundary line / perimeter were set, it should not come into play for matches.
- Turf synthetic wicket bench situated approximately in the middle of the ground.
- Clubrooms and public stand are situated on the northern side of the ground.
- There are approximately five gated entrances to the surface of the ground. Three pedestrian gates are located at North West and northern points of the ground including one vehicle entrance gate. There is also another vehicle entrance gate located at the south eastern corner of the ground near practice nets.
- The surface is generally neutral and has a slight dome shape surface with run off towards all sides of the ground.
- Practice cricket facility exists at the ground but is external to the surface at the south eastern corner. This structure doesn't encroach upon the playing surface.

Apart from the synthetic turf wicket, these features should not impact on any proposed upgrade of the playing surface providing there is no requirement for expanding the size of the playing surface.

2.3 Sports Field Dimensions

The size of the playing surface at this Reserve is estimated at 20,925 square metres. This ground has the following dimensions:

- Length of 155 linear metres by width of 135 linear metres approximately
- Circumference of 487 linear metres

The wicket bench situated towards the middle of the ground is approximately 70 square metres with the following dimensions:

- Length (north to south) of approximately 27 metres
- Width (east to west) of approximately 2.6 metres.

2.4 Usage

This ground is used for football and cricket extensively for both matches and training as well as daily recreational use by various schools and community groups and some small business operators.

The ground is also open to the public at all times other than for specified works.

Football training at the ground has probably been responsible for the wear and damage to the playing surface on the eastern side of ground and goal areas.

Football clubs should change some of the training practices in the past, and reduce concentrated training in the northern and southern most ends of the ground. This will helped to reduce the extent of wear and damage on the playing surface.

2.5 Soil Conditions

2.5.1 Description of Soil Profile

A series of 10 auger holes were dug at different locations over the playing surface to a depth of up to approximately 800mm.

The following was found:

- The thickness of the thatch/root mat layer ranged from 0 to 30mm and was consistent across the playing surface.
- Two distinct soil layers were found in the profile. Both soil layers were consistent across the ground, however, their color differed.
- The first topsoil layer consisted of dark brown sandy loam and appeared to be slightly more organic matter in this layer.
- The second soil layer consisted in the main of grey sandy loam.
- The consistent sandy loam layer meant that it would be likely that the soil would become easily saturated and water should move through this profile until it hits the based profile.
- The soil was relatively moist at depth given the wet conditions and there was no water table found in any of the holes dug in this investigation.

2.5.2 Soil Analysis

Soil tests were conducted on the topsoil layer to determine the soil physical properties, including the saturated hydraulic conductivity and particle size distribution.

Results revealed the following:

Particle Size Analysis

The fine and medium sand fractions and gravel fractions fall within limits. However, as a result the high very fine sand, silt and clay soil fractions at site it will have a tendency to compact and there will

always be a compromise in the quality of surface that can result.

Saturated Hydraulic Conductivity

Ideally the permeability rate based on this test method should be around 100mm/hour at 16 drops for a sports field and amenity areas. Soils with much lower drainage rates will quickly become saturated in winter and in turn both the grass cover and surface quality will be compromised.

- The two soil layers found in the profile appear to have similar soil physical properties. The particle size analysis was done primarily from material in the first soil layer.
- Although the drainage rate was lower than the desired rate of at least 100mm per hour, upon visual investigation the soil drained reasonably well and has a manageable drainage rate.
- The drainage rate of the first layer top soil type suggests that there is a consistency with the soil profile and could be attributed to the increase in organic matter towards the surface.

2.6 Details of Surface Shape

Visual assessment of the surface shape revealed the following:

- The surface had some variations and undulations.
- Numerous slight depressions and undulations existed throughout the surface on the eastern and western side of the ground.
- Many of the depressions corresponded to areas that had not had some turf replacement or previous heavily used areas.

- Evidence of topdressing in many low lying areas, however considerable unevenness still existed which needs to be rectified.
- The synthetic cricket wicket that existed towards the middle of the ground appeared level with the surrounds.

More drastic measures are needed other than topdressing to resolve the issues with the existing surface shape.

2.7 Irrigation

An automatic irrigation system exists in the ground. The system uses potable water. The effectiveness was not assessed. An independent report was carried out by G & M Connellan Consultants

The need for an improved automotive system needs to be determined before any upgrade takes place. It is recommended that if an upgrade of the surface is undertaken then an upgraded irrigation system should be installed.

2.8 Subsurface Drainage

The ground currently has a subsurface drainage system based on a series of lateral lines and trenches with a screenings base. Subsurface drainage should provide a means of removing excess water that accumulates and assist to direct the movement of the water from the site.

3.0 Summary of Problems and Issues That Exist

The following problems currently exist on this ground that needs rectifying:

- Deficiency with the current surface shape with minimal fall and a rise in the south western corner.
- Permeability rate at ground is not ideal and given the very fine sand, silt and clay fractions compaction would be an issue.
- Incomplete turf grasses cover on the northern and southern sides of the ground.
- Primary species (warm season grass) mainly in high use areas and in areas that have recently had turf installed. Other areas have a mixed sward of grass species.
- Slight deficiency with soil type and physical properties with the very fine, silt and clay fractions.

4.0 Recommendations

4.1 General

Three recommended options are discussed in this report. The implementation of any of these options depends on the funding made available for the works and the management of those works when undertaken.

4.2 Option 1 – Best Option

An option for a high usage cricket and football ground is a ridge or dome shape sand based profile utilizing the existing network of subsurface drains if they are still functional.

This option will involve the following and other works not included:

- Removing the existing grass and thatch layer from the surface to expose the topsoil.
- Remove the existing topsoil of the field to a depth of approximately 200mm or depending upon when the base drainage layer is reached.
- Consolidate base and reshape according to design drawings.
- Check and repair the existing drainage system if required and ensure no contamination or capping of the screenings in the drainage trenching system has occurred.
- Upgrade or replace of irrigation system
- Supply and apply 200mm deep layer of suitable sand and amendments as per design specification.
- Reshape the surface to provide a ridge shape or dome shape with adequate surface shape with a slope of 1 in 100
- Grass the surface with warm season grass sod.

This option will help to optimise high frequency usage on this site and improved condition of a year round surface.

This is the more expensive option and would be in a major reconstruction of the ground incorporating a sand profile to the depth of 200mm and having an instant sod turf primary species (couch grass) layer across the entire surface. Up grading of the irrigation system and or re-installation of drainage may be required. The estimated cost of this option is around $780,000 (ex-GST).

4.3 Option 2

This option in the main focuses on the resurfacing of the entire ground after initial earthworks and reshaping of the surface. Given the permeability rate at ground currently (70mm/Hr) is not ideal with the very fine sand, silt and clay fractions it will not produce as higher quality outcome as option one. However, the cost benefit of using the in-situ soil at site is worth considering.

This option will involve the following:

- Strip the existing grass and thatch layer from the surface to expose the topsoil.
- Power harrow ground to a depth of approximately 150 to 200mm.
- Reshape to provide a ridge shape or dome shape with adequate surface shape with a slope of 1 in 100 according to design drawings.
- Upgrade or replace irrigation system as per (Mr. G. Connellan report circa 2012).
- Apply suitable sand and amendments to the surface if required for levels.
- Grass the surface with warm season grass sod.

The estimated cost of this option is around $269,000 (ex-GST).

4.4 Option 3

This option focused on replacement of turf on the north and south sides of ground similar to the recent works and replacement of turf undertaken at the ground late 2012.

This option will involve the following:

- Strip the existing grass and thatch layer from the surface area that needs to be replaced to expose the topsoil.
- Top Make the area to a depth of approximately 50mm.
- Upgrade or replace irrigation system recommendations in independent irrigation evaluation report.
- Mill out areas and apply suitable sand and amendments to the surface if required for levels.
- Grass the surface with warm season grass sod.

The estimated cost of this option is around $158,000 (ex-GST).

Table outlining cost comparisons below:

	Option 1	Option 2	Option 3
Site Clearing	$7,000.00	$7,000.00	$5,000.00
Preliminary Work	$5,000.00	$7,000.00	$5,000.00
Initial Earthworks	$55,000.00	$15,000.00	$5,000.00
Earthworks	$410,000.00	$17,000.00	
Irrigations Works	$TBC	$TBC	$TBC
Final Surface Works	$260,000.00	$180,000.00	$110,000.00
Maintenance Period	$35,000.00	$35,000.00	$25,000.00
Additional Works	$8,000.00	$8,000.00	$8,000.00
Lump Sum Total Ex-GST:	**$780,000.00**	**$269,000.00**	**$158,000.00**

Appendix 2: Guide to irrigation water quality parameter

Parameter	Ideal Range
pH	6 to 8
Salinity – EC	< 0.28 dS/m
Salinity – TDS	< 175 mg/L
Total Suspended Solids (TSS)	< 50 ppm
Turbidity (NTU)	< 5.0
Alkalinity	< 150 mg/L
Bicarbonate	< 90 mg/L
Chloride	< 100 mg/L
Sodium	< 70 mg/L
Boron	<1.0
Iron	< 0.2 mg/L
Sodium Absorption Ratio (SAR)	< 5

Appendix 3: Water quality analysis and report - Example

Chemical analysis Water characteristics	Ideal range	Recycled water sample
pH, units Total alkalinity, as $CaCO_3$ (calc.) Bicarbonate, as HCO_3 (mg/L) Carbonate, as CO_3 (mg/L) Calcium, as Ca (mg/L) Magnesium, as Mg (mg/L) Hardness, calculated as $CaCO_3$	5–8 <150 – – <100 <100 <150	7.3 75 75 <1 25 22 –
Impact on plant growth (total salinity)		
Electrical conductivity (microS/cm @25°C) Salinity by calculation (mg/L)	<750 <450	1226 817
Impact on foliage contact (ion toxicity)		
Sodium, as Na (mg/L) Chloride, as Cl (mg/L)	<70 <100	196 272
Impact on root growth (ion toxicity)		
Sodium, as Na (meq/L) Chloride, as Cl (meq/L)	<3 <3	8.5 7.8
Impact on soil structure (Na permeability hazard)		
Electrical conductivity (microS/cm @25°C) Salinity by calculation (mg/L) Residual sodium carbonate (calc.) Sodium adsorption ratio – SAR (calc.) adjSAR (calc.)	<750 <450 <1.25 see Note 1 see Note 1	1226 817 –1.85 6.9 –
Nutrients		
Nitrate + nitrite, as N (mg/L) Total Kjeldahl nitrogen, as N (mg/L) Total nitrogen, as N (mg/L) Phosphorus, reactive filt as P (mg/L) Phosphorus, total as P (mg/L) Potassium, as K (mg/L)	see Note 2 see Note 2 see Note 2 see Note 2 see Note 2 see Note 2	– – 2.0 – <0.5 18
Other		
Iron, as Fe (mg/L) Manganese, as Mn (mg/L) Copper, as Cu (mg/L) Zinc, as Zn (mg/L) Boron, as B (mg/L) Sulphur, as SO4 (mg/L)	<1 <0.2 <0.2 <2.0 <2.0 <100	0.08 0.13 - - 0.16 115

Source: Tests performed by ALS Water Resources Group for AGCSATech.

Notes:

1. Reference to additional information is required regarding SAR results.

2. Nutrients such as nitrogen and phosphorous need to be accounted for in the fertiliser program.

Water analysis report for A-One Golf Club (example)

Report prepared by: Australian Golf Course Superintendents Association (AGCSA)

The recycled water sample submitted for analysis has been tested and the results are attached. The following comments are made:

Recycled water sample

- The pH is slightly alkaline.
- The water has a medium salinity hazard.
- The water contains elevated levels of sodium and chloride.
- The water contains no residual sodium carbonates.
- The water has a low sodium adsorption ratio (SAR)
- The water contains 2 mg/L of total nitrogen, which is equivalent to 2 kg of total nitrogen per megalitre of water applied, which is only minor.
- The water contains very little phosphorus.

Comments

1. Electrical conductivity (salinity): The EC is 1226μS/cm, which is equivalent to 817 mg/L (ppm). As a result, the salinity is classed as medium and it would be expected that some accumulation of salts in the soil would occur by the end of the irrigation season; however, with the use of warm season grasses on sand constructions (greens and tees), the turf quality would not be affected. The use of gypsum and aeration and decompaction coring (e.g. verti-draining) would be required before and after the irrigation season on fairways to assist with leaching of any accumulated salts through the profile.
2. Sodium: The sodium concentration is elevated, although at levels where it is not a major concern. The use of gypsum as previously recommended will assist in displacing these ions from the soil solution.
3. Chloride: The chloride levels are elevated, but only at much higher levels would cause occasional leaf burn on warm season grasses. However, irrigating during the heat of the day should be avoided where possible.
4. Nutrient Levels: The total nitrogen levels are generally insignificant and will not affect turf management.
5. Summary: While the water is not the quality of potable water, the supplied data indicates that the water quality would be suitable for use with all warm season grasses and on the majority of soil types. In heavy clays, the accumulation of salts and sodium may eventually cause some turfgrass decline if no supplementary soil management techniques are employed.

The quality of treatment water does vary considerably over time and regular testing is required.

AGCSATech.

Appendix 4: Sports grounds – Best Practice Irrigation

A Design guidelines for safe irrigated sports grounds

The requirements for a sports ground to be safe are that it should be level, even and the surface conditions such that the area can be used without injury or harm. The potential injury risks associated with an irrigated sports ground include:

- presence of holes, depressions and sudden changes in levels
- abrupt changes in surface conditions and traction properties
- raised and protruding equipment (e.g. pop up sprinklers that may cause tripping)
- exposed or sharp surfaces or edges that may cause injury
- unstable surface conditions that do not support player loads.

Irrigation design considerations that support the development and maintenance of a safe and functional surface include:

- sprinkler heads with small exposed tops
- sprinkler top and other exposed surfaces are safe on impact from human contact (e.g. rubber tops)
- anti-drain valves installed (avoid soggy patches)
- compacted trenches to minimise subsidence
- remote-operated master valve to reduce risk of flooding
- flow monitoring to detect leaks
- precision control, including sensors
- regular maintenance
- regular testing of uniformity of application

B. Sprinkler irrigation design guidelines for sports grounds

The development of sustainable sports grounds is a high priority for the managers of open space turf sports facilities. The following are the broad requirements of irrigated sports grounds:

- healthy turf surfaces
- efficient in the use of water
- safe for users.

The practice guidelines outlined here are to assist in the achievement of high-quality irrigation systems.

C. Overall system performance

- The irrigation system has the capacity to meet the daily peak water demands of the landscape within water supply and functional constraints.
- The design of the system, including selection of equipment and installation, allows water to be applied uniformly.
- The application of water by the system is effective in delivering water into the turf root zone.
- The system uniformity of application performance standards are: design DU 85% minimum and scheduling coefficient less than 1.2 and field DU 75% minimum.

D. Player safety

- Valve boxes should be located outside the active playing area.
- Valve boxes should be of robust construction to withstand expected impact loads and fitted with non-slip lids or covers.
- Sprinklers should have small (not greater than 80mm diameter), exposed tops and fitted with rubber top covers.
- Sprinklers should not to be located in high-use areas (e.g. goal square).
- Sprinklers should be of robust design and construction to reduce risk of injury from damaged heads or malfunction, such as sprinklers stuck in the raised position.

E. System design, layout and zoning.

- Pipeline route should be ring main design, and positioned outside the active play area, to deliver water efficiently to sprinkler laterals.
- Sprinklers should be grouped into zones that have similar watering requirements. The selection of zones should reflect potential variations due to soil, microclimate and use patterns.
- Coverage by the irrigation system is not to extend beyond the designated playing area of the ground. Part-circle sprinklers should be used on boundaries to avoid or minimise overthrow into non-target areas.

F. Effective application

- System design precipitation rate should be selected to be less than typical soil infiltration rate.
- Only sprinklers of similar precipitation rate to be operated from the one solenoid valve. Part and full circle sprinklers not to operate on the same circuit.
- Sprinklers should be fitted with an anti-drain facility.
- Pop-up sprinklers should have adequate lift height to clear surrounding grass.

G. Hydraulic design

- Hydraulic design should allow sprinklers to operate at optimum flow and pressure conditions.
- Pipework should be designed to keep pressure loss, within a sprinkler group, within acceptable limits. Lateral pressure variation should not be greater than 10% overall within a sprinkler zone.
- Pipework should be designed so that the maximum flow velocity, within the pipe network, does not exceed 1.5 m/s.
- Pressure regulated solenoid and other supply valves should be used to allow optimum operating pressure at each sprinkler head in a lateral, and throughout the system.

H. Water supply – safety

- Backflow prevention devices should be selected to meet system hydraulic and regulatory requirements of the local water authority and be effective in providing ongoing safe operating conditions.

I. Water supply – general

- A remote controlled master valve should be installed on the supply side of the irrigation system to ensure that the distribution pipelines and laterals are not pressurised unless the irrigation system is programmed to operate. This reduces the risk of pipe bursts and leakage within the irrigation distribution pipe network.
- Isolation valves should be installed upstream of solenoid valves and at strategic points within the network.
- System flow rate should be within specified limits of the rated capacity of supply pumps and water meters.

J. Control system

- The control system selected should allow each station to be operated to meet irrigation requirements in an effective and timely manner. Ease of programming and flexibility in programming are key requirements.
- The flexibility of the control program should accommodate time and date constraints imposed by water authorities.
- The control system should be capable of accepting inputs from environmental sensors including rain gauges, soil moisture sensors and system monitoring devices.
- The system should be designed and equipment selected to provide for future compatibility with central control.
- Provision for local weather data should be used in irrigation scheduling decisions.
- Controller features should include water budgeting, cycle and soak, global and individual station changes, percentage adjust options, multiple cycles and day skip.

K. Monitoring and measurement

- Dedicated measurement of irrigation water consumption is required, as is provision for automatic monitoring.
- A digital flow meter should allow continuous monitoring of system flow performance, including breaks and valve malfunctions, and alarm generation facility.

L. Plans and documents

- Accurate records of irrigation designs, using GPS, and incorporated into the organisation's GIS system should be kept. Irrigation infrastructure should be referenced to the site engineering and landscape features.
- Final 'as-built' drawings (AutoCAD format, GPS-generated) should be prepared. Notes outlining changes to specified works should be included on the as-built drawing.

Appendix 5: Key References

Best Practice Guidelines for Holistic Open Space Turf Management inn Sydney

https://www.sydneywater.com.au/web/groups/publicwebcontent/documents/document/zgrf/mdq1/~edisp/dd_045253.pdf

Code of Practice – Irrigated Public Open Space (SA Water)

http://www.sawater.com.au/__data/assets/pdf_file/0009/6696/IPOSPrinciples.pdf

Water Use Efficiency for Irrigated Turf and Landscape (Geoff Connellan)

http://www.publish.csiro.au/pid/5263.htm

Australian Golf Course Superintendents Association

http://www.agcsa.com.au

Irrigation Australia Limited

http://irrigation.org.au

Sports Turf Australia – Victoria

http://vicsportsturf.asn.au

Notes

Notes

Notes

City West Water
ABN 70 066 902 467
247-251 St Albans Road
Locked Bag 350
Sunshine Vic 3020

Account and general enquiries: 131 691
Faults and emergencies: 132 642
Interpreter service: 131 450
Internet: citywestwater.com.au
Email: enquiries@citywestwater.com.au