Efficient irrigation for water conservation: guideline for water efficient urban gardens and landscapes

waterwise Queensland

Queensland Government

CS10057_10/20

This publication has been compiled by Irrigation Australia Limited in collaboration with Regional Urban Water Supply Planning, Department of Natural Resources, Mines and Energy.

Summary

The aim of this guideline is to provide residents, as well as people responsible for irrigating public urban spaces, with the knowledge and tools to achieve efficient use of water for outdoor irrigation.

The Queensland Plumbing and Wastewater Code requires that householders with an outdoor irrigation system installed after 1 March 2009 must facilitate the efficient use of water[1]. Compliance with this guideline will satisfy this requirement of the Code. This guideline also provides a good foundation for designing, installing and maintaining outdoor irrigations systems for large scale water users, such as golf courses, active playing surfaces and council parks and gardens. This guideline replaces the *Efficient Irrigation for Water Conservation Guideline* (version 1) and the *Best Practice Guide for Management of Turfed Playing Surfaces* (September 2008).

An irrigation system is a network of permanent piping connected to emitters designed and installed to water a specific landscape area. Emitters are devices fitted on a pipe which are operated under pressure to discharge water in a spray, mist or drip form. An efficient irrigation system is one that has been designed and installed to minimise the water output capacity. Achieving efficient irrigation requires knowledge of how much water should be applied at any given time to replenish the water consumed by the plants and grass and how much water can be held by the soil.

To comply with this guideline, an efficient irrigation system must have the following features:

» The irrigation system must be designed and installed to efficiently deliver the amount of water required at the appropriate time for the plants or grass (guidance is provided in Section 4.4 and Section 7).
» A timer used to operate an irrigation system must be set for a maximum of two hours, or be linked to a moisture sensor or rain sensor.
» The irrigation system must be operated so that it minimises the amount of runoff water.
» Drippers may only be used for irrigation of grass where the installation is certified by a Certified Irrigation Professional[2].

It is recommended that:

» Each emitter in the irrigation system has the Smart Approved WaterMark.
» The irrigation schedule is reviewed and adapted each season.

The design, that is the planning of your landscape and irrigation system, is a significant factor in determining how efficiently water is used for your landscape and garden (Section 4). The setting up your landscape and properly installing any irrigation products (Section 5), along with adequate maintenance (Section 6) and efficient irrigation practices (Section 7) also impact how water wise your garden and landscape are.

In Queensland, installing or maintaining an irrigation system downstream from an isolating valve, tap or backflow prevention device on the supply pipe for the irrigation system is not regulated. The installation of a backflow prevention device must be carried out by a licensed plumber.

If water restrictions are applied in your area, you should use efficient irrigation described in this guideline only in the ways and during the times specified in the schedule of water restrictions.

This guideline provides a number of recommendations and suggestions for water conservation and irrigation efficiency that can be incorporated into your irrigation system at any time. Suggestions that are highlighted in this guideline include (refer to Figure S-2):

» Irrigate uniformly—you can check uniformity by using the catch can or tuna can test (described in Section 7.4.3.1).

» Divide your yard into separate irrigation zones putting plants with similar water requirements together (refer to Table S-1). For example, irrigating the grass more frequently than groundcovers, shrubs and trees.

» Ideally try to water between 5 am and 10 am — when the sun is low, winds are calm, and temperatures are cool.

» Consider your predominant underlying soil texture (e.g. clay, sand or loam) when developing your irrigation schedule.

» Before irrigating, check the weather forecast and soil moisture levels. You can check soil moisture by digging a hole to the root zone or using a screwdriver to make sure it can easily go to about 10 cm depth. For commerical purposes ideally a 1m long push probe would be used to check moisture levels of the subsoil.

» Think about how much you water. The amount of water depends on a lot of factors including your location and climate, soil type, planting scheme, the impact of wind and shade, whether the garden is mulched, and of course the rainfall. The greatest waste of water comes from applying too much, too often, as much of it runs off.

[1] This requirement under the Queensland Plumbing and Wastewater Code is for lots which have a class 1 or class 2 building. Class 1 and 2 in the Code are defined as:
Class 1a: A single dwelling being a detached house, or one or more attached dwellings, each being a building, separated by a fire-resisting wall, including a row house, terrace house, town house or villa unit.
Class 1b: A boarding house, guest house, hostel or the like with a total area of all floors not exceeding 300m2, and where not more than 12 reside, and is not located above or below another dwelling or another Class of building other than a private garage.
Class 2: A building containing 2 or more sole-occupancy units each being a separate dwelling.

[2] For more information about Certified Irrigation Professionals, refer to Irrigation Australia Limited (www.irrigationaustralia.com.au). Irrigation Australia has a search tool on their website to find Certified Irrigation Contractors, Designers and Installers.

» Choose irrigation products, such as sprinklers, irrigation timers and moisture sensors, appropriate for your needs—this can help improve water use efficiency (refer to Figure S-1 for different sprinkler types).

» Try irrigating less frequently— this forces roots down to find water, making the plants more resilient and more able to cope with hot days.

» Mulch to save water by reducing evaporation and runoff. Depending on the type of mulch, it limits weed growth and can improve soil conditions by adding nutrients. Mulching also insulates plant roots from high temperatures.

» Grass should only be cut when necessary, kept at a height of at least 3 cm, and only cut outside the heat of the day. This will prevent your grass from drying out and needing more water.

» Select plants based on the climate and soils of the area. Drought-tolerant plants will have these features:
  » small leaves
  » light coloured leaves
  » sparse or protected pores in the leaf surface
  » hairy or tough leaf surfaces
  » internal water storage in stems, trunks or roots
  » deep root systems
  » strong internal structures.

» Regularly service your irrigation system, annually is recommended. Tasks might include:
  » Inspection and replacement of emitters, including checking spray patterns and reorienting emitters as required.
  » Inspection for breakages and leaking seals in the main lines, testing each zone separately.
  » Change the irrigation schedule to reflect the current season and irrigation needs of the landscape.

Table S-1: Water requirements for different plant types*

Plant type	General irrigation schedule	Approximate water requirements	
		Wet season (Dec – Mar)	**Dry season** (Apr – Nov)
Water smart grass	Regular, thorough	5 mm weekly	20 mm weekly
Mixed plantings (perennial flowers and tender shrubs)	Occasional	25 mm every two weeks	30 mm weekly
Native plants and shrubs and smaller trees (< 5 cm trunk diameter)	Infrequent, thorough	10 mm every two weeks	10 mm weekly

* The purpose of this table is to provide a rough guide to different water requirements of plants in Queensland. Actual water requirements and frequency will depend on the type of plant, climate characteristics and soil type.

Figure S-1: Different sprinkler types used for irrigation

Sprinkler irrigation rates

This table can be used as a guide to program your controller.

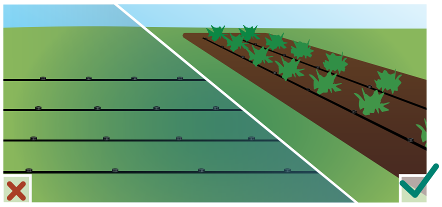
	Dripline	Micro spray	Pop-up/fixed spray	Rotary	Gear drive rotor
Approximate watering rate (per hour)	15–20 mm	35–45 mm	35–45 mm	10–15 mm	10–20 mm
Suggested run time to apply 10 mm	30–40 min	13–16 min	13–16 min	40–60 min	30–40 min

Figure S-2: Guidance and tips for a water efficient garden

Efficient use of water for outdoor irrigation

Irrigation equipment

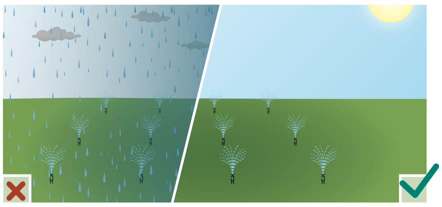
» Use drip irrigation for lawns only when installation has been certified.



» A timer used to operate an irrigation system must be set for a maximum of two hours, or be linked to a moisture sensor or rain sensor.

Water only when needed

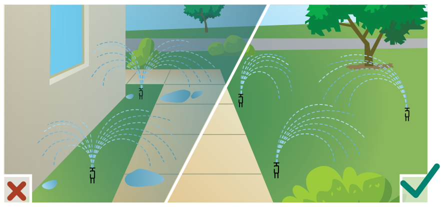
» Don't water when it is predicted to rain or is already raining.



» Ideally water between 5–10 am.

Water only where needed

» Water only plants and grass (not buildings and pathways).



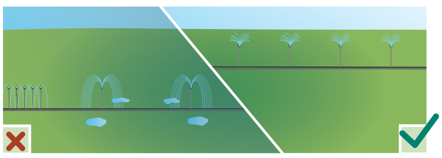
Following the above suggestions will be taken as compliant with the requirement for water efficient outdoor irrigation under the Queensland Plumbing and Wastewater Code.

Tips for a water efficient garden

Check irrigation system regularly

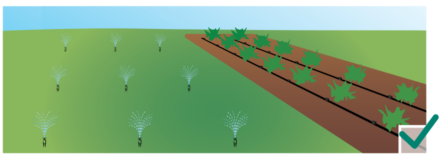
» Look for leaks and blocked nozzles.

» Check the watering rate and distribution by doing a tuna can test.



Plant zoning

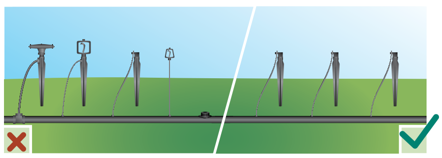
» Group plants with similar water requirements together, e.g. different zones for vegetables, grass and shrubs.



Water uniformly

» Space emitters to apply water evenly.

» Use the same type of emitters in the same zone.



Only mow when necessary

» Keep grass at least 3 cm high, and cut outside the heat of the day, to prevent it drying out.

Encourage deep root growth

» Water at a slower rate, for longer time and less frequently. This can make plants 'hardier.'

Use mulch

» Mulch should be kept away from plant stems and, generally, be at least 5cm deep to reduce evaporation.

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Efficient irrigation for water conservation guideline

1. Purpose

This guideline on efficient irrigation for water conservation is for use by people irrigating gardens and grass in urban areas, including household gardens, public spaces and active playing surfaces. It provides advice on how to achieve efficient use of water, including on the use of different irrigation devices and how to design irrigation systems.

This guideline replaces the *Efficient Irrigation for Water Conservation Guideline* and the *Best Practice Guide for Management of Turfed Playing Surfaces* - September 2008, both published by the then Queensland Water Commission. These superseded documents were developed at a time when there were greater regulatory requirements and applied only to the region of south east Queensland. This guideline applies to all of Queensland.

This guideline contains information to help you:

» calculate how much water your garden requires
» plan your garden and irrigation system
» understand how much water emitters and sprinklers apply.

This guideline provides a framework for waterwise gardening and turf maintenance to allow residents to enjoy their backyards and an outdoor lifestyle while ensuring water is used efficiently, wisely and responsibly.

2. Efficient irrigation

An irrigation system is a network of permanent piping connected to emitters designed and installed to water a specific landscape area. Emitters are devices fitted on a pipe which is operated under pressure to discharge water in a spray, mist or drip form.

An efficient irrigation system is one that has been designed and installed to minimise the water output capacity. It is operated to apply an appropriate amount of water at any given time to replenish the water consumed by the plants and grasses and considering how much water can be held by the soil. Efficient irrigation is based on four main principles:

1. The amount of water applied is appropriate to the plants needs and soil properties.
2. Water is applied effectively and uniformly.
3. Water is 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 suits the plant and weather conditions.

3. How this guideline applies to you

3.1 Who it applies to

This guideline is primarily written for Queensland residents. The Queensland Plumbing and Wastewater Code requires all outdoor irrigation systems, installed or replaced on or after 1 March 2009 in Class 1 and Class 2 buildings[3] (such as homes, townhouses and units) to facilitate the efficient use of water. You can satisfy this code requirement by complying with this guideline when:

- connecting to a water service or
- connecting to a rainwater tank where the rainwater tank has a continuity of supply from a water service through either:
  - a trickle top-up system
  - an automatic switching device where the off take is located downstream of the automatic switching device.

It is suggested all other urban irrigators, including people irrigating a commercial or public area, adopt the recommendations contained in this guideline to help achieve the best use of water.

3.2 Demonstrating compliance with this guideline

To comply with this guideline, an efficient irrigation system must have the following features:

- The irrigation system must be designed and installed to efficiently deliver the amount of water required at the appropriate time for the plants or grass (guidance is provided in Section 4.4 and Section 7).
- A timer used to operate an irrigation system must be set for a maximum of two hours, or be linked to a moisture sensor or rain sensor.
- The irrigation system must be operated so that it minimises the amount of runoff water.
- Drippers may only be used for irrigation of grass where the installation is certified by a Certified Irrigation Professional[4].

In addition to the above requirements it is recommended:

- Each emitter in the irrigation system has the Smart Approved WaterMark.
- The irrigation schedule is reviewed, and adapted, each season.
- Adequate maintenance of the irrigation system is undertaken (as outlined in Section 6 of this guideline).
- Prior to irrigating, give appropriate consideration to if/ when you should water and how much you should (refer to Section 7 of this guideline).
- The planning and sizing of your landscape and irrigation system is undertaken with consideration of the factors listed in Section 4 of this guideline.
- Factors listed in Section 5 of this guideline are considered when setting a landscape and installing irrigation products.

3.3 Water restrictions

Check with your local water service provider for water restrictions that may apply in your local area. If water restrictions do apply, you should use efficient irrigation described in this guideline only in the ways and during the times specified in the schedule of water restrictions.

3.4 Installation requirements

In Queensland, installing or maintaining an irrigation system downstream from an isolating valve, tap or backflow prevention device on the supply pipe for the irrigation system is not regulated. The installation of a backflow prevention device must be carried out by a licensed plumber. This is to protect the drinking water supply from contamination.

Further advice on plumbing and drainage requirements is available from your local water service provider or council. Further information about plumbing, including backflow prevention devices, can also be obtained from the Department of Housing and Public Works.

It is suggested that consideration be given to seeking professional expertise, such as a horticulturist, landscaper, or a Certified Irrigation Professional[2], for aspects of the design, installation and maintenance of the irrigation system where appropriate.

Application rates of common sprinklers may vary between 1.2 and 15 litres per minute depending on the type, angle adjustment and operating pressure. Where possible, the system should be set up to apply the required amount of water to the desired depth within a maximum of two hours. Achieving efficient irrigation requires knowledge of how much water should be applied at any given time to replenish the water consumed by the plants and grasses and how much water can be held by the soil.

[3] Refer to footnote 1 for a definition of Class 1 and Class 2 buildings in the Code.
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4. Planning your landscape and irrigation system

A well-designed irrigation system and landscape is critical for water efficiency. Qualified and practicing horticulturists have the knowledge and skill to analyse the site for appropriate species selection, preparing the surrounding soils correctly, planting the species properly and accurately determining weekly water requirements for each plant. Alternatively, you may choose to have a Certified Irrigation Designer plan your irrigation system or you can design your system yourself.

When planning your landscape and irrigation system, consideration should be given to soil type, slope, root depth, plant material, microclimates, weather conditions and water source (quantity, quality and pressure). If you have a large area of grass to be irrigated, consider installing an efficient irrigation system designed to irrigate the entire area evenly; this will be more efficient than attempting to move a sprinkler around a large area. Also consider the use of alternative water supplies for residential irrigation (refer to Section 8).

The irrigation system should be constructed to be efficient and to distribute water evenly. You can also install a rain shut-off device or moisture sensing device. These devices can be inexpensive and let you take advantage of nature's free irrigation service. Figure 1 illustrates some basics concepts for efficient irrigation. Appendix 1 contains a checklist to guide the design of an urban irrigation system, and Appendix 3 contains more on irrigation efficiency and system calibration.

4.1 Know your soil

Healthy soils are the foundation of healthy plants and gardens which can be watered efficiently. One of the main keys to saving water is to know and to improve your soil (more information about your soil are found on the Queensland Government website). Soils vary dramatically between localities and even within a garden. The three main soil textures are loam, clay and sand; most soils contain some percentage of these thee textures which determine their water holding capacity.

Applying organic soil conditioner to your planting beds helps improve moisture retention, which in turn reduces the amount of water you need to apply. Using soil conditioners also provides plants with nutrients and assists beneficial soil microbes which help plants to develop strong root systems and become more drought tolerant.

4.1.1 Soil testing

Different soils retain different volumes of water and therefore your irrigation practices should be based on the predominant soil type. One of the most important aspects of the soil type is its texture. A simple test to identify soil texture is to take a handful of soil from the garden and add just enough water to mould it into a ball. Test soil from various sites and from different depths in the garden. Figure 2 illustrates the relative difference of particle sizes in the soil.

Loams form a ball that is crumbly, usually brown with a pleasantly earthy smell. They hold and drain water well and provide good levels of nutrients. Loams are considered the best for plants.

Clays ball easily, and can be moulded in the hand. Clays range in colour but are most commonly red, black or grey. There are two main types of clay soils. Non-cracking clays are usually red, have a high infiltration rate and low nutrients. Cracking clays store more water and are more fertile than non-cracking clays. When they are dry, water will rapidly enter down cracks, but once the soil swells (as it wets), the infiltration rate reduces significantly.

Sands crumble, feel gritty and do not form a ball. They are light coloured and have little or no smell. Water drains away from them rapidly and therefore plants growing in sandy soils are likely to need more water to survive. Sandy soils are typically low in nutrients and applied nutrients are quickly leached.

Table 1 provides guidance for irrigation practices depending on the main soil type. For example, applying more than 12 mm of water to sandy soil would cause wastage as the soil would not hold the excess water and it would percolate below the root zone.

If you are unsure about your soil type, or how to improve it, take a sample along to your local nursery, landscaping specialist or soil scientist and seek advice. If buying potting mix, ask about its water retention properties (which are generally low) as there are significant differences between products.

You can achieve water efficiency through a well-designed, installed and operated irrigation system.

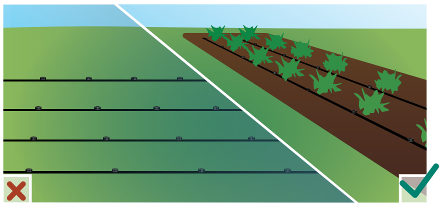
Image 1: Get to know your soil

Figure 1: Guidance and tips for a water efficient garden

Efficient use of water for outdoor irrigation

Irrigation equipment

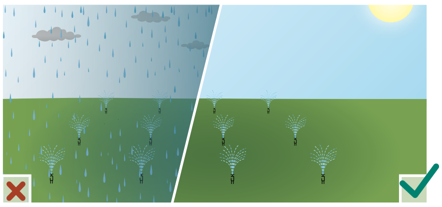
» Use drip irrigation for lawns only when installation has been certified.



» A timer used to operate an irrigation system must be set for a maximum of two hours, or be linked to a moisture sensor or rain sensor.

Water only when needed

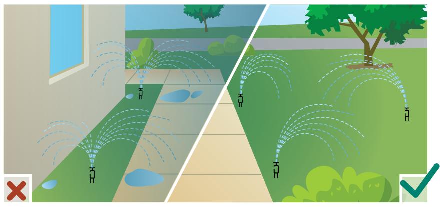
» Don't water when it is predicted to rain or is already raining.



» Ideally water between 5–10 am.

Water only where needed

» Water only plants and grass (not buildings and pathways).



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Tips for a water efficient garden

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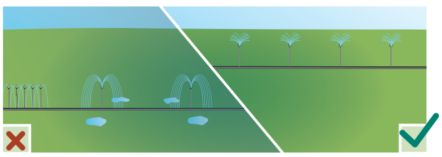
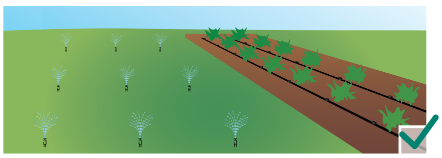
» Look for leaks and blocked nozzles.

» Check the watering rate and distribution by doing a tuna can test.



Plant zoning

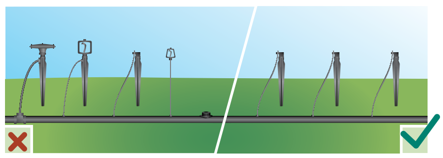
» Group plants with similar water requirements together, e.g. different zones for vegetables, grass and shrubs.



Water uniformly

» Space emitters to apply water evenly.

» Use the same type of emitters in the same zone.



Only mow when necessary

» Keep grass at least 3 cm high, and cut outside the heat of the day, to prevent it drying out.

Encourage deep root growth

» Water at a slower rate, for longer time and less frequently. This can make plants 'hardier.'

Use mulch

» Mulch should be kept away from plant stems and, generally, be at least 5cm deep to reduce evaporation.

Figure 2: Relative size of soil particles in soil[5]

Sand
0.02 to 2 mm
feels gritty

Loam
0.002 to 0.2 mm
feels smooth

Clay
less than 0.002 mm
feels sticky

Table 1: Irrigation practices for different soil types

Soil type	Irrigation practices	Recommended maximum application of water*
Loam	Water deeply and infrequently (e.g. provide the required volume of water in one continuous session)	40 mm
Clay	Water deeply and slowly at long intervals	28 mm
Sand	Water in small amounts more often (e.g. split irrigation into three sessions to provide the required volume)	12 mm

* This volume represents the volume of water stored in 20 cm depth of soil. Applying more water will be inefficient as the water will percolate below the root zone.

[5] Particle sizes referenced from Marshall T. J. 2003 'Particle-size distribution of soil and the perception of texture'. Soil Research 41, 245-249.

Image 2: Using mulch liberally and regularly helps to retain soil moisture

4.1.2 Improving your soil

To improve both sandy and clay soils add organic matter. The water and nutrient holding capacity can be enhanced by the addition of manure, leaf mould, worm farm compost, grass clippings, composted horticulture bark or any other type of organic matter. To do this, cultivate the soil to a depth of 30 cm if possible (making sure the soil is not very dry or very wet when you do this) and then dig in the organic matter. The addition of nitrogen fertiliser at the same time will help the organic matter break down quickly.

To improve water penetration if the soil has become water repellent (which can often affect sandy soils), consider treating the soil with a wetting agent, or applying organic material. In some clay soils (generally cracking clays), adding gypsum improves the soil structure by breaking it up into small crumbly pieces (e.g. for clay soils), making it easier to work and improving drainage.

Aerating your soil can improve its water penetration, by encouraging deeper root growth and reducing run off. It is particularly important for active playing surfaces that are frequently used when wet. For active playing surfaces, it is recommended to aerate the soil up to four times a year in heavily used sports grounds. Solid tine aerators with an additional 'kick' have been found to give good results (Appendix 10 includes a checklist for active playing surfaces).

4.1.3 Mulching

Mulching is an essential element of a water-efficient garden. Mulching around plants saves water by reducing evaporation and runoff. Depending on the type of mulch, it limits weed growth and can improve soil conditions by adding nutrients. Mulching also insulates plant roots from high temperatures.

Mulch can be in the form of leaves and grass clippings, sawdust, rocks and gravel, straw, bark and woodchips. Generally, coarse mulch, like shredded bark, allows water to infiltrate easier, is good for reducing weeds and keeping soil cool, but it might not improve the soil's texture as the mulch does not readily break down. Finer mulch, like lucerne, breaks down quickly, adding nutrients to the soil.

For the best result from mulching, prepare the soil by removing weeds, raking or digging the surface and irrigate the remaining plants. Place a layer of newspaper over the soil to deter weed growth, but make sure it's not too thick as it will reduce air supply to the soil.

The ideal thickness of the mulch layer depends on the particle size of the mulch material. If using large chunks, such as pine bark, a deeper layer (more than 5 cm) is needed. Finer mulch is more prone to compaction so should be applied in a thinner layer. Be sure to keep the mulch about 6 to 7 cm clear of plant trunks and stems or they may rot.

Mulch should be loosened regularly to ensure water penetration. Organic mulch, which breaks down quickly, will need to be topped up several times a year, preferably in autumn and spring.

As organic mulch decomposes it can draw nitrogen from the soil. Watch your plants for signs of nitrogen deficiency (usually indicated by yellowing of the lower leaves) and use a nitrogen-rich fertiliser if needed.

4.2 Know your grass

When planting or laying grass for the first time, make sure you choose one of the many warm-season varieties available. The depth and quality of soil beneath your lawn determine the water retention properties of your lawn to withstand dry periods. Also consider the intended use of the landscape. There are a variety of commercially available grasses belonging to the grass types below which are suitable for the Queensland climate and are water efficient:

- Buffalo grass
- Couch grass (including green couch grass and TifTuf Bermuda grass)
- Kikuyu grass
- Zoysia grass.

For your grass to thrive, the Queensland Turf Producer's Association recommend a minimum depth of 10 cm of quality soil underlay (Australian standard for soils for landscaping and garden use AS 4419:2018). The make up for the underlay should consist of:

- quality loam with sand, silt and clay components
- organic matter
- no weeds.

4.2.1 Grass maintenance

You may want to add organic matter or wetting agents to your grass during planting to improve the soil retention properties. Apply fertiliser during the spring and summer months when there is higher rainfall and the grass is actively growing. Use small amounts of an organic fertiliser as this requires less water post-application than a chemical fertiliser. Grass should be kept at a height of at least 3 cm. It should only be cut when necessary and cut outside the heat of the day. This will prevent your grass from drying out and needing more water.

At the onset of dry periods, you should start preparing your grass for drought. The turf industry recommends that two strategies can be applied:

- Start mowing the grass higher. This will insulate the soil from evaporation—the higher the better during the most difficult times.
- Try to water less frequently and more deeply. Over time this will greatly reduce water usage on grass, as well as force the grass' root system deeper into the soil, where the soil moisture is less prone to evaporation.

4.3 Know your plants

Plants should be selected based on the climate and soils of the area. Planting hardy shrubs and drought-tolerant plants will help save water. When buying plants, look for ones with these features:

- small leaves
- light coloured leaves
- sparse or protected pores in the leaf surface
- hairy or tough leaf surfaces
- internal water storage in stems, trunks or roots
- deep root systems
- strong internal structures.

The following plants will tolerate dry conditions once established, as well as being somewhat tolerant of moist soil:

- Acacia
- Agapanthus
- Agave
- Cordyline
- Correa
- Echium
- Gazania
- Grevillea
- Lavender
- Thyme.

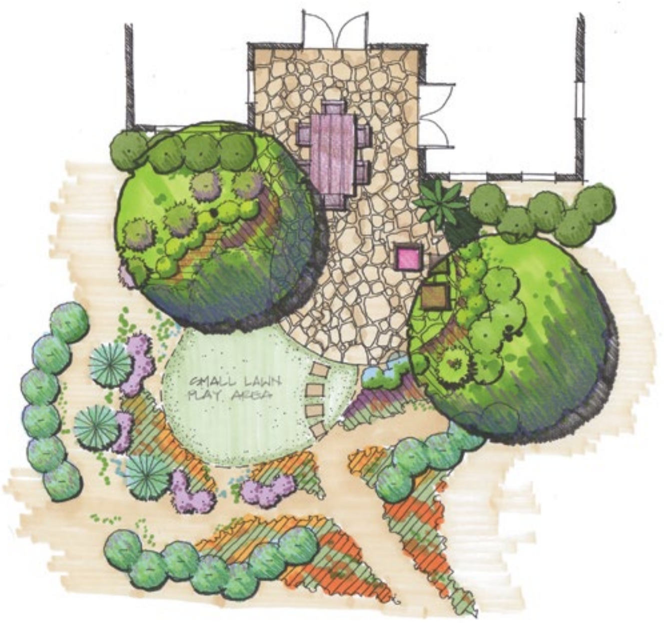
Image 3: Hardy shrubs and drought-tolerant plants

4.3.1 Divide by zones

Different plants need different amounts of water. It is recommended that you hydrozone—that is design your landscape so plants are grouped together based on their water, soil and sun requirements. Preferably, each zone will have plants with similar water requirements. For example, one section of the landscape may need irrigation for 10 minutes while another section of may require 20 minutes. Generally, grass areas have different water needs to, for example, garden beds and trees, and should be separated into a different hydrozone. Climate factors should also be considered. As an example, sensitive plants would be best positioned in the shade, whereas plants that can tolerate more heat and/or wind might be better off positioned by the road.

Irrigation applicators with similar performance should be grouped together, that is, sprays and drip emitters should not be on the same pipe circuit.

Image 4: Hydrozoning: grouping plants together based on similar water requirements



4.4 Know your irrigation products

The irrigation system should be set up so that it can deliver the right amount of water to the right places. You should select an irrigation system and emitters that are appropriate for your:

» microclimate
» plant selection
» soil type.

Different methods of irrigation, sprinklers or drippers, may be more appropriate for different parts of your garden. As outlined in Section 4.3.1, different types of emitters may be more appropriate for different zones of your landscape.

There are a wide range of emitters, including drippers, micro-sprayers, pop up and gear drive sprays, and fixed sprinkler heads (refer to Figure 3). Most drippers generally use between 2–8 litres per hour, micro-sprayers between 0.4–2.5 litres per minute, and medium to low sized gear drive or pop-up fixed sprinklers about 6–9 litres per minute.

There are also a range of control devices that can help save water including:

» Tap timers—allow you to set your irrigation times
» Sprinkler controllers—typically let you have different irrigation programs for different garden zones, and can have programs altered based on weather, soil moisture or evapotranspiration.
» Rain sensors—feeds back to the controllers when there is rain.
» Soil moisture sensors—feeds back to the controller when the irrigated area has reached adequate moisture levels.
» Evapotranspiration sensors—enables the controller to adjust the irrigation for that day based on the sunlight and temperature.

Refer to Appendix 2 for more details and examples of the above devices.

Image 5: Different irrigation system designs

Figure 3: Different sprinkler types

Sprinkler irrigation rates

This table can be used as a guide to program your controller.

	Dripline	Micro spray	Pop-up/fixed spray	Rotary	Gear drive rotor
Approximate watering rate (per hour)	15–20 mm	35–45 mm	35–45 mm	10–15 mm	10–20 mm
Suggested run time to apply 10 mm	30–40 min	13–16 min	13–16 min	40–60 min	30–40 min

4.4.1 Sprinkler irrigation

There are three key sprinkler irrigation types: sprinklers attached to hoses, micro-spays and sprays. They can be moved around the garden or grass to cover the area to be watered if they are not part of a system of buried pipes with fixed applicators. Hose-sprinkler systems are probably the most affordable and simple method to install, but precise water control and therefore water conservation are difficult. Where possible, the use of hose-sprinklers should be minimised during windy conditions (including rooftop gardens) as their efficiency in delivering water to where it is needed will be reduced.

A sprinkler should have an adjustable distribution pattern so that hard surfaces are not watered. Ideally a hose-sprinkler should not be fixed and should be used in conjunction with a timer or an irrigation controller.

4.4.2 Drip irrigation

Drip irrigation, which is a type of micro irrigation, uses small emitters to deliver a consistent amount of water at a low pressure and flow rate. Drip irrigation systems deliver water to, or just below, the soil surface and are used to apply water directly to the roots. This can reduce water waste through minimising evaporation and runoff, reduce weed growth, and avoid damage to the leaves or stems of young and tender vegetation through the wetting of foliage. These systems can be adapted for any level of soil moisture.

In appropriate circumstances, drip irrigation can be the most efficient form of irrigation, when managed correctly. Drip irrigation is best suited for individual trees, flowerbeds, potted plants, other non-grassy areas, and rooftop gardens. Drip irrigation is promoted as an option for small, irregular-shaped planting beds and narrow grass areas. Drip irrigation is best suited for soils with low infiltration rates such as cracking clay and loam soils.

Drippers should only be used for grass irrigation under very specific circumstances. **As such, this guideline requires that if drip irrigation is used for irrigating grass, the installation is certified by a Certified Irrigation Professional.**

Drip irrigation does have a higher initial cost and requires regular maintenance and careful operation. Some products may be easily damaged, and rodents enjoy chewing on exposed and buried drip lines. Consider using pressure compensating emitters, which deliver a precise amount of water regardless of changes in pressure due to long rows or changes in terrain elevation. They can simplify the designing of a system, increase the irrigation application uniformity and greatly reduce maintenance.

Image 6: Drip irrigation

Source: www.smartwatermark.org

4.4.3 Smart Approved WaterMark

When looking for irrigation products, look out for water efficient irrigation products that carry the Smart Approved WaterMark. The Smart Approved WaterMark is Australia's not-for-profit labelling scheme which allows consumers to compare the water efficiency of different products. It is the sister scheme to the Water Efficiency Labelling and Standards (WELS) scheme.

Products are assessed against criteria of:

» water savings
» fit for purpose
» meeting regulation and standards
» environmental sustainability.

Product types that have the Smart Approved WaterMark include:

» Trigger hoses
» Drip systems
» Weeper hoses
» Micro-spray systems
» Tap timers
» Electronic water controllers
» Moisture sensors
» Low water using plants and lawns
» Mulch
» Watering spikes.

For more information on Smart Approved WaterMark products visit www.smartwatermark.org

Image 7: Look for the Smart Approved WaterMark

4.4.4 Irrigation flow capacity

When planning an efficient automatic irrigation system, you need to know how much water is available for irrigation. To be able to determine available capacity, the water pressure and the water volume need to be measured.

A flow test is important as it dictates how many applicators you can run at once. To do this you will need a standard household bucket (9 or 10 litres capacity). Remove any tap fittings from the tap you want to use and turn the tap on fully, then place the bucket under the tap and time how long it takes to fill. If you are going to use more than one tap repeat this process for each tap.

A simple way to find out your water flow is to measure how long it takes to fill a household bucket with the tap fully open. For example, if it takes 30 seconds to fill a 10 litre bucket: the flowrate would be 20 litres/minute (or 1200 litres/hour).

Image 8: Measuring system capacity at home

= 30 seconds to fill

= 20 litres/minute

= 1200 litres/hour

Take these measurements at the time of the day when irrigation will normally occur as water reticulation pressure may vary, and therefore the flow may also vary, at different times of the day.

When designing your irrigation system, the combined flow rate from your taps sets the combined irrigation rate of the emitters.

5 Setting up your irrigation and landscape

5.1 Installing your irrigation system

The various components of the irrigation system should be installed consistent with:

» any Queensland plumbing requirements
» any local government code requirements
» the manufacturer's specifications and recommendations.

Certified Irrigation Contractors or Installers[6] can assist in the installation of your irrigation system.

As discussed in Section 4.4, in Queensland, an isolating valve, tap or backflow prevention device must be in place before installing an irrigation system that will be connected to the water service. A backflow prevention device must be installed by a licenced plumber. Once the isolating valve, tap or backflow prevention device is in place, the installation or maintenance of an irrigation or grass irrigation system is something that you can do yourself.

Further advice on plumbing and drainage requirements is available from your local water service provider or council. Further information about plumbing, including backflow prevention devices, can also be obtained from the Department of Housing and Public Works.

If setting up an irrigation system for an active playing surface, you should contact your local water service provider to find out any conditions that might apply: it is common practice to require registration of the surface, installation of a specific water meter, record keeping and signage.

Appendix 5 includes further recommendations for installation of urban irrigation systems.

5.2 Regular irrigation for landscape establishment

Research has shown that recently planted trees and shrubs establish efficiently with light, frequent irrigations. Research also shows that:

» It is important to provide water to the entire root ball. If the entre root ball is not moistened, it results in significant root die back, which in turn results in either the plants' gradual decline to death or a condition known as 'failure to thrive'.
» Drip irrigation systems are generally only suitable for the establishment of tube stock and other small container sized plants as it only results in isolated moist areas (rather than watering the entire root ball).
» Regular irrigation after planting encourages rapid root growth that is essential for establishment. If trees are not watered sufficiently during the establishment period, it can lead to low, codominant stems and double leaders that can split from the tree.

5.3 Irrigate only what grows

If you have an underground automatic sprinkler system, make sure the heads are adjusted properly to avoid irrigation of footpaths and driveways. A properly adjusted sprinkler head should spray large droplets of water, not a fine mist, to minimize evaporation and wind drift. Installation of drip irrigation for garden beds is an efficient way to efficiently irrigate and conserve water.

Image 9: Improper sprinkler selection or set-up can lead to wasteful practices

5.4 Seasonal irrigation adjustments

Your grass will most likely require more water in the hot summer months in order to stay green, likewise, during winter and autumn, the plant water demands are reduced accordingly with falling temperature. The use of irrigation controllers that are equipped with features to adjust the irrigation scheduling are recommended to make seasonal adjustments easier.

The "seasonal adjust" feature can also be known by other names such as "water budget". These functions work the same way – by increasing (or decreasing) the set irrigation times. The intention of this feature is that you set your controller program at a baseline level and use the seasonal adjust feature to increase or decrease the irrigation time depending on the season. For example, if an irrigation zone is set to go on for 10 minutes daily in June-August, if you set the seasonal adjust to 150% for December-February that zone will now water for 15 minutes daily.

If your system does not have a controller, the seasonal adjustment can be made by reducing the time of irrigation during the cooler months of the year.

Image 10: Save money and apply water only where it is needed

[6] Contact Irrigation Australia Limited for further information (www.irrigationaustralia.com.au.)

6 Maintenance

The irrigation system should be regularly serviced, annually is recommended, to keep its designed performance. Servicing is recommended at the start of the irrigation season (usually spring or summer). Servicing might include:

- Inspect and replace emitters (could be required as often as monthly).
- Check spray patterns and reorientate emitters as required.
- Inspect for breakages and leaking seals in the main lines, testing each zone separately.
- Check any controllers:
  - replace the back-up battery
  - check the functionality, making sure that rain, wind, or soil moisture sensors are connected
  - update date and time.
- Change the irrigation schedule to reflect the current season and irrigation needs of the landscape.
- Flush the system to remove accumulated debris and minimise risk of clogging emitters.

To conserve and protect water resources and the environment, the serviced components should meet the irrigation design specifications, manufacturer's specifications, and any local regulations (particularly for large-scale irrigators). It is recommended that large-scale water users have a maintenance plan in place for their system.

Appendix 6 provides more detailed information on maintenance of urban irrigation systems and Appendix 10 has more information about large-scale irrigation systems.

6.1 Do routine inspections

Periodically check your sprinklers to make sure everything is working properly. A clogged head or a torn line can result in significant water wastage, damaging your landscape.

6.2 Common irrigation problems

There are several common issues found in routine inspections and should be checked for. These issues prevent the systems from operating efficiently and are frequently detected in audits (refer to Appendix 9):

- damaged or malfunctioning emitters (sprinklers and spray heads)
- obstructed (blocked) emitters
- mixed heads and incorrect nozzles in the same irrigation zone
- excessive irrigation run times
- pressure not appropriate for the efficient operation of the system
- excessive sprinkler head spacing
- irrigation system operated more frequently than needed
- lack of uniformity of application.

7 Efficient irrigation

Proper irrigation is a simple step, but it is one of the most important things you can do to keep your grass and garden healthy; a healthy grass can also raise your home's value in the market.

To facilitate efficient irrigation, it is recommended that large scale irrigators have an irrigation management plan and a more detailed system operation manual that includes all the operational information in one place. Appendix 7 provides guidance on the content for an irrigation management plan and Appendix 8 includes guidance on the content for a system operation manual.

7.1 Should I water?

Check the weather forecast. If rain is forecast or if it is raining, hold off on watering your garden.

If you have an automatic sprinkler system, it is recommended it has a moisture sensor to avoid automatically watering when the garden has received enough rainfall. Large scale irrigators are recommended to have a moisture probe to determine the need for irrigation.

Adjust your irrigation system as the seasons and weather change. For active playing surfaces, it is recommended to schedule a heavy irrigation on a rotation when the field is not in use to promote deep root growth.

7.1.1 Know your rainfall

If your local area has recently received significant rainfall (more than 50 mm) it may be weeks before you need to water again. Where possible, it is recommended to have a soil moisture sensor or rainfall sensor connected to your efficient irrigation system. This will prevent the system operating if the soil already has adequate moisture or if it is raining.

There are two ways in which you can determine the volume of rainfall your garden receives each week:

- install a rainwater gauge
- check the rainfall figures from the nearest Bureau of Meteorology (BOM) weather station closest to your property at www.bom.gov.au.

Buy a rain gauge so you know how much rain has fallen in your property.

7.2 When should I water?

Be aware of local water restrictions and only water your garden or grass when permitted (check with your water service provider or council about water restrictions).

Ideally try to water between 5 a.m. and 10 a.m.—when the sun is low, winds are calm, and temperatures are cool. Midday irrigation tends to be less efficient because of water loss due to evaporation and windier conditions during the day. Irrigation in the evening might not be a good idea as leaves can remain wet overnight—an open invitation for fungus to grow. By irrigating in the morning, you give the leaves a chance to dry out during the day.

Stretch the intervals between irrigation based on observations, you can:

- dig a hole to the root zone occasionally to observe the moisture level
- use a manual probe or underground sensor
- push a screwdriver into the soil and ensure it can easily be pushed to a depth of 10 cm, or
- only water when plant leaves start showing symptoms of wilting.

Annuals, vegetables and plants in pots may need shorter, more frequent irrigation events. In comparison, many perennials and grass may benefit from more infrequent but thorough soakings to encourage deep roots. Trees and shrubs have much deeper and more extensive root systems so they should be watered less frequently but for longer periods of time.

For active playing surfaces, try to schedule irrigation to minimise playing on wet soils. High wear areas typically get watered at double the frequency of lesser used areas to assist with grass recovery.

Signs that your grass is ready for irrigation include:

- changing colour
- the soil below is difficult to penetrate using a sharp object
- your grass doesn't spring back after being walked on.

If you observe bright green patches in your grass or the presence of fungus (toadstools) or moss, you may be overwatering.

Did you know that grass mowing practices affect how much water your grass needs? The golden rule is never cut your grass by more than a third of the grass length. Some people like to leave the clippings on the grass to form a mini-mulch and retain moisture longer.

7.3 How much to water?

The amount of water you need to apply to your garden will relate to your location and climate, soil type, planting scheme, the impact of wind and shade, whether the garden is mulched, and of course the rainfall.

The amount of water to apply in any situation depends on the soil type. Sandy soils absorb water the fastest (about 5 mm per hour), followed by loam soils (2.5 mm per hour). Generally, cracking clay soils have the slowest absorption rate (2 mm per hour). By allowing water to penetrate deeper into the soil profile, you are encouraging deeper rooting and a more drought tolerant plant. Frequent, light irrigation will lead to plants that have a shallow root system and that are more prone to water stress.

Different types of plants respond better to different irrigation schedules and different volumes of water (refer to Table 2). To determine how much to supplement the rainfall, you can install a rain gauge or use information from the Bureau of Meteorology (refer to Section 7.1.1). A high–level estimation of irrigation requirements is provided in Table 3 based on five climatic subregions in Queensland (refer to Figure 4).

Instead of watering the entire garden, just water the plants that need it. Many plants are much tougher than you think and will go for quite long periods without additional watering. This also has the effect of training your plants to be more resilient. Less frequent watering forces roots down to find water, making the plants less reliant on surface water and better able to cope with hot, dry days.

Table 2: Water requirements for different plant types across seasons*

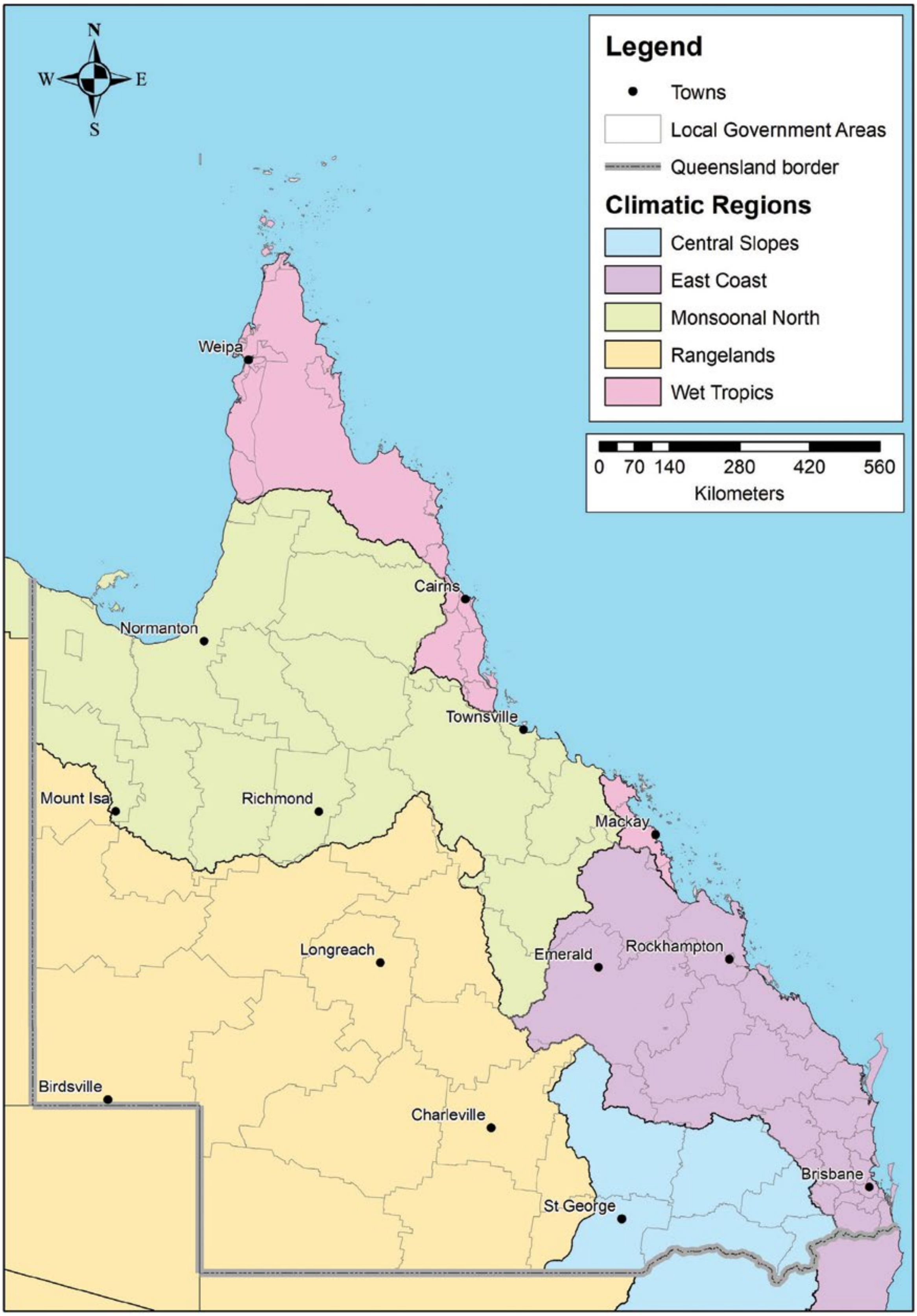
Plant type	General irrigation schedule	Approximate water requirements	
		Wet season (Dec – Mar)	**Dry season** (Apr – Nov)
Water smart grass	Regular, thorough	5 mm weekly	20 mm weekly
Mixed plantings (perennial flowers and tender shrubs)	Occasional	25 mm every two weeks	30 mm weekly
Native plants and shrubs and smaller trees (< 5 cm trunk diameter)	Infrequent, thorough	10 mm every two weeks	10 mm weekly

* The purpose of this table is to provide a rough guide to different water requirements of plants in Queensland. Actual water requirements and frequency will depend on the plant type, soil type and climate characteristics.

Experiment with less irrigation to understand the impact on the plant and adjust your irrigation frequency and amount to suit. Think about what this means for manual and automatic irrigation systems. Does your entire garden need irrigation? Can you hydrozone plants that need more or less water into separate areas so you can focus irrigation on the areas that really need it?

Installing a dedicated water meter to measure the volume of water used for irrigation is recommended for large irrigators. This can help for auditing and leak detection. Appendix 11 discusses weather–based water demand estimation.

Figure 4: Climatic regions across Queensland*



* These regions are based the CSIRO climate regions and are provided for the purpose of giving guidance of seasonal water requirements of grass.

Table 3: Variation in general water requirements across Queensland*

Climatic regions	General description of climate	Estimated average irrigation requirements (mm/week)~^											
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Wet tropics	Characterised by two seasons: the monsoonal wet season (from around December to April), with high temperatures and high rainfall, and the dry season (May to November) with mild temperatures and low rainfall.	0	0	5	5	5	15	20	25	25	35	25	25
Monsoonal north east	A pronounced wet and dry season.	0	0	20	20	20	20	20	25	30	40	40	25
East coast	Predominantly sub-tropical climate, with warm humid summers and mild winters.	20	15	10	5	5	5	5	15	20	20	20	25
Central slopes	Ranges from sub-tropical in the north, through to temperate in the south, with a typically dry and cool winter and wet and warm summer.	30	20	25	20	15	10	10	15	20	30	30	30
Rangelands	Hot dry summers and cold winter nights. Rainfall systems vary from seasonally reliable monsoonal influences in the far north of the region through to very low and variable rainfall patterns in much of the centre.	40	35	30	25	10	10	10	15	25	30	30	40

* The purpose of this table is to provide a rough guide to the irrigation requirements for turf across Queensland. Actual irrigation requirements, including the volume and frequency of irrigation, will depend on the particular type of plant and its stage of growth, climate characteristics (particularly rainfall and evapotranspiration) and soil type.
~ The estimation of monthly irrigation requirements has been based on mean monthly rainfall and average areal potential monthly evapotranspiration for each region (from 1961 to 1990) collated from information obtained from the Bureau of Meteorology website. The effective rainfall was assumed to be 75% of the mean monthly rainfall reported. The irrigation requirements are based on a conservative constant crop coefficient of 1, whereas crop coefficients can vary from between 0.1 and 1.1, depending on plant type (e.g. ornamental plant, vegetables, turf or tree) and its stage of growth.
^ Where the estimated irrigation requirement is zero, it has been determined that no supplementary water irrigation is required based on soil moisture being greater than evaporation for that month.

7.3.1 What is water metering?

It is the act of measuring and monitoring the amount of water used. It can also assist in determining any leakage in equipment and infrastructure associated with the premises the water is supplied to.

The installation of a water meter is considered regulated work, which requires local government approval. This means it can only be installed by a licensed person. Please contact your local council for further information on urban flow meters installation regulations.

7.4 How long to water for?

The greatest waste of water comes from applying too much, too often, as much of it runs off and is never infiltrated. Depending on the type of efficient irrigation system or efficient sprinkler you have, you may only need to run it for a very short time before the required amount of water is delivered to your garden or grass. Instead of irrigating for one long continuous session, try splitting the irrigation time into shorter periods and take 15 minute breaks in between each session. This will let the water soak in, while minimising runoff.

To apply the right amount of water you will need to understand how much water has been delivered by estimating:

- how long it takes to apply the desired quantity using a handheld hose, or
- the watering rate of your irrigation system.

7.4.1 Hand hosing

If you are using a handheld hose measure the flow rate into the bucket using the length of hose and fittings that you normally use (refer to Section 4.4.4). For example, assume you need to apply 10 mm of water to your garden. If you apply 10 litres of water over a one square metre of garden, you will deliver the equivalent of 10 mm. So, if you are using a hose that takes 30 seconds to provide 10 litres (20 litres/minute), you should water each square metre of garden for less than 30 seconds. Any longer irrigation is very likely that you end up using more water than necessary. Figure 5 illustrates this scenario and Table 4 suggests irrigation times for different tap flow rates for a 10 mm application in a square meter.

Figure 5: Schematic of 10 mm application on a 1 m² of garden

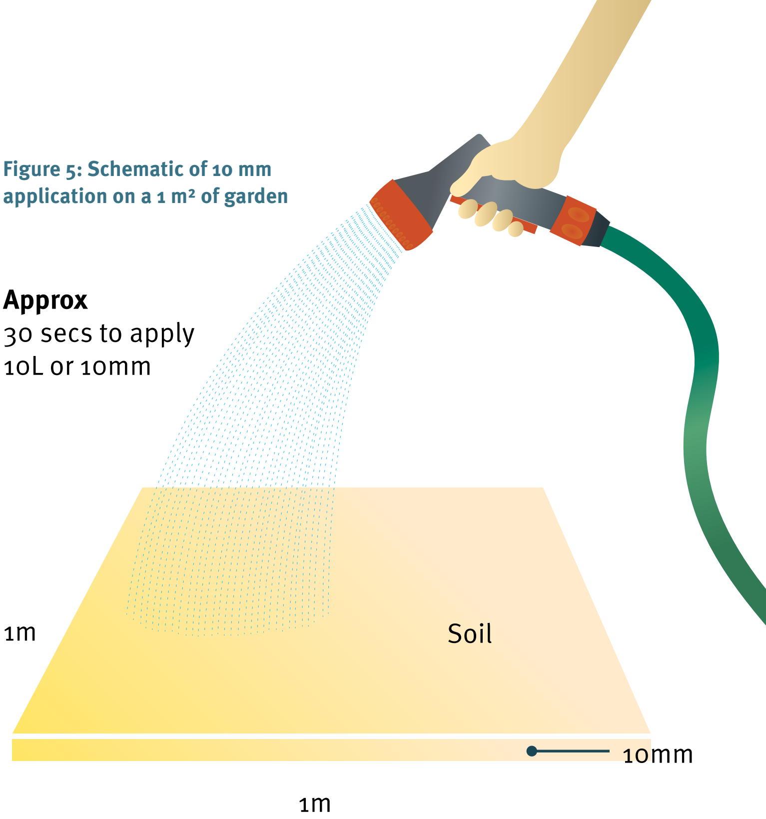


Table 4: Irrigation time guide for typical tap flows for 10 mm of water application

Tap flow (litres per minute)	Seconds to apply 10 mm per m²
10	60
12	50
15	40
20	30

Avoid light sprinklings that barely penetrate the soil and encourage shallow rooting. It is recommended that you use a trigger nozzle or water wand on your hose. This enables a gentle application that allows water to penetrate to the root zone, whereas a hard stream can reduce infiltration. It also prevents you wasting water on paths as you move around the garden. Ensure an even distribution of water across similar plant types. Direct water at the root zone, not at the leaves.

7.4.2 Irrigation rate of the irrigation system

Most good quality irrigation products and emitters will have their output capacity in either litres per minute (L/min) or litres per hour (L/h) clearly shown on their packaging or at the point of sale[7]. You can also look for information such as shelf labels or brochures displayed near the product. You may also be able to find information on emitter flow rates from the manufacturer's website.

To work out the irrigation rate, you can use the irrigation application rate calculation if you know the watering rate of your irrigation system; if you do not know the irrigation rate you can use the water meter test.

[7] Actual discharge rates are affected by the water pressure (at the connection).

Irrigation application rate calculation

Application rate (mm/h) = total flow rate (L/h) ÷ total irrigation area (m²)

For example, there is an irrigation system with five (5) sprays that operate together, the total flowrate for the 5 sprays is:

[(5 x 5 litres per minute emitters) x 60 minutes] = 1500 litres per hour (L/h)

Area to be irrigated 50 m²

Watering rate of this system is = 1500 L/h ÷ 50 m² = 30 mm/h

To find how long to operate this system to apply 10 mm of water

$$\text{Run time (min)} \quad \frac{\text{Depth to be applied (mm) x 60 min}}{\text{Application rate (mm/h)}} = \frac{\text{10 mm x 60 min}}{\text{30 mm/h}} = \text{20 min}$$

Run time = 20 minutes

The water meter test

1. Read your water meter.
2. Make sure no other water is being used on the premises and run your irrigation system for five minutes using a timer (stopwatch).
3. Read your meter again and subtract the first reading from the second reading to find out the total number of litres used by your irrigation system in those five minutes.
4. Divide this number by five (minutes) and then divide this number again by the total number of emitters you have connected to your system. This is the average output of your emitters in litres per minutes.

Working out the irrigation time from the water meter test

Litres used by system in 5 minutes = 200 litres

(This is the difference between the initial and last reading on the water-meter)

$$\text{Water meter flow rate} = \frac{200\ \text{L}}{5\ \text{minutes}} = 40\ \text{L/min (for 5 sprays) or 2400 L/h}$$

$$\text{Average flow rate per spray} = \frac{40\ \text{L/min}}{5\ \text{sprays}} = 8\ \text{L/min}$$

Determining the amount of water needed

Assume that the area to be irrigated is 50 m^2

Knowing the supply flow rate, the run time required to apply a specific amount or depth of water can be determined

For an application of 10 mm, the total volume is:

Volume (L) = Area (m^2) x Depth (mm) = 50 m^2 x 10 mm = 500 L

Irrigation run time to apply 500 L

$$\text{Run time (min)} \ \frac{\text{Volume to be applied (L) x 60 min}}{\text{Meter flow rate (L/h)}} = \frac{500\ \text{L x 60}}{2400\ \text{L/h}} = 12.5\ \text{min}$$

In order to only apply **10 mm** of water through this system (output 2400 L/h) approximately only **12 minutes** would be required

Then, the following application depths apply to this particular situation

20 mm	24 minutes
10 mm	12 minutes
5 mm	6 minutes

7.4.3 Uniform irrigation

A properly designed and operated sprinkler system with underground piping is one of the best ways to be sure the grass is evenly covered. To help know how much water is getting delivered and to where, you can do a catch can test. A catch can test helps measure the performance of the irrigation system. A number of equal diameter containers are placed around the irrigation zone, the irrigation system is operated for a set time and the depth of water is measured in each can. You can do your own catch can test (i.e. a tuna can test), as outlined below.

7.4.3.1 Tuna can test

A tuna can test can be used to determine how long to run an irrigation system or hose-end sprinkler and how well the water is distributed over the landscape (a catch can test is suggested for large scale irrigation—refer to Appendix 3 for more information). Here's how:

5. Place six to eight flat-bottomed cans, such as tuna cans or pet food cans, randomly throughout your lawn. Inexpensive rain gauges may also be used. Place some cans close to the sprinkler head and others several meters away.
6. Turn on the sprinkler or irrigation system for 15 minutes.
7. Measure and record the depth of water in each can with a ruler. Determine the average depth of water for all the cans.
8. Alternatively you can record the time it takes to fill the majority of the cans about 10 mm (i.e. 1 cm). This will provide the time it takes to provide about 10 mm of water.

Note the uniformity of your water application. If non-uniform, individual nozzles may need adjustment.

Table 5: Irrigation times given results from the tuna can test and the irrigation requirements*

Average depth in the can in 15 minutes (mm)	Irrigation requirements (mm/week)									
	5	10	15	20	25	30	35	40	50	60
	Irrigation time (minutes)									
3	1	2	3	4	5	6	7	8	10	12
6	2	4	6	8	10	12	14	16	20	24
10	3	7	10	13	17	20	23	27	33	40
13	4	9	13	17	22	26	30	35	43	52

* Refer to Table 3 in Section 7.3 for a guide to irrigation requirements.

7.5 Auditing

To maximise the efficient use of water the amount of water required should be estimated on a weekly basis. An irrigation audit can help determine if your irrigation systems are working efficiently

Large scale irrigators, particularly those managing active playing surfaces, are strongly recommended to have undertaken an audit to develop the base irrigation schedule and to have a management plan in place. It is suggested that a landscape/playing surface manager be nominated to oversee the management and irrigation of the irrigated areas.

Appendix 9 presents detailed information about irrigation systems audits; Appendix 10 provides further considerations for operators of large-scale urban irrigation systems.

8 Alternative water supplies for residential irrigation

Alternative waters are sources of water not supplied from reticulated systems, such as fresh surface water or groundwater resources which offset the demand for water from reticulated systems. Examples of alternative water sources commonly used in residential irrigation include:

- harvested rainwater from rooves
- greywater
- drainage water from irrigation.

It is estimated that in Australia the average family uses between 250 to 300 cubic metres of water a year, with more than 50% flushed down the toilet and used for garden irrigation. This volume of water can be replaced by alternative water supplies, potentially saving millions of litres a year. Recent data shows that 26% of Australian homes have already installed a rainwater tank and an overwhelming majority reported that they are positive about the tanks[8].

Consider an alternative water supply if your garden is large and needs to be watered often or would not survive extended water restrictions. By using alternative water supplies for residential irrigation, you can:

- reduce water bills by using less treated water
- irrigate the garden during water restrictions
- help save money on new infrastructure for water supplies and wastewater treatment
- decrease demand on infrastructure for stormwater, sewage transport, treatment and disposal, allowing it to work better and last longer.

Before using an alternative water supply, you need to consider the water quality to determine if it is appropriate. Table 6 shows some basic water quality parameters to check for.

Table 6: Relevant water quality parameters for irrigation waters for ornamental plants

Parameter	Suitable water for ornamental plants	Greywater	Rainwater
pH	6.0–8.0	6.5–8.7	6.0–8.0
Electrical conductivity (dS/m)	<1.0	0.3 – 1.2	0.02–0.40
Sodium (mg/L)	<70	30–415	–
Chloride (mg/L)	<110	3–140	–
Boron (mg/L)	<1.0	–	–
Bicarbonate-Alkalinity (mg/L)	120–180	150–380	–

8.1 Rainwater harvesting

Rainwater harvesting is the process of collecting rainwater from above ground impervious surfaces and directing to a location e.g. tank, where it will be stored for later use. Opportunities for rainwater collection and use vary with location.

Rainwater collection and storage is regulated in Queensland by the *Public Health Act 2005*. You should refer to the enHealth document guidance[9] on use of rainwater tanks. For other considerations or requirements for the design and maintenance of a rainwater system, please check any other relevant legislation or development codes[10].

You can find additional information about designing an above ground rainwater harvesting system connected to residential dwellings in urban areas in the guidelines 'Rainwater harvesting: Residential design specification' developed by the Rainwater Harvesting Association of Australia (RHAA) and Urban Water Cycle Solutions (UWCS) available from: https://rainwaterharvesting.org.au
A typical rainwater system consists of the following elements as shown in Figure 6.

The occupier of a place where a rainwater tank is installed (or if there is no occupier, the owner of the premises) must ensure that the tank is maintained to ensure every opening includes:

- mosquito-proof screens that:
  - are made of brass, copper, aluminium or stainless-steel gauze
  - have a mesh size of not more than 1 mm
  - are installed in a way that does not cause or accelerate corrosion
  - stop mosquitos passing through the openings, or
- have flap valves that, when closed, stop mosquitos passing through the openings.

The following are some tips for maintaining rainwater tanks.

Every three months:

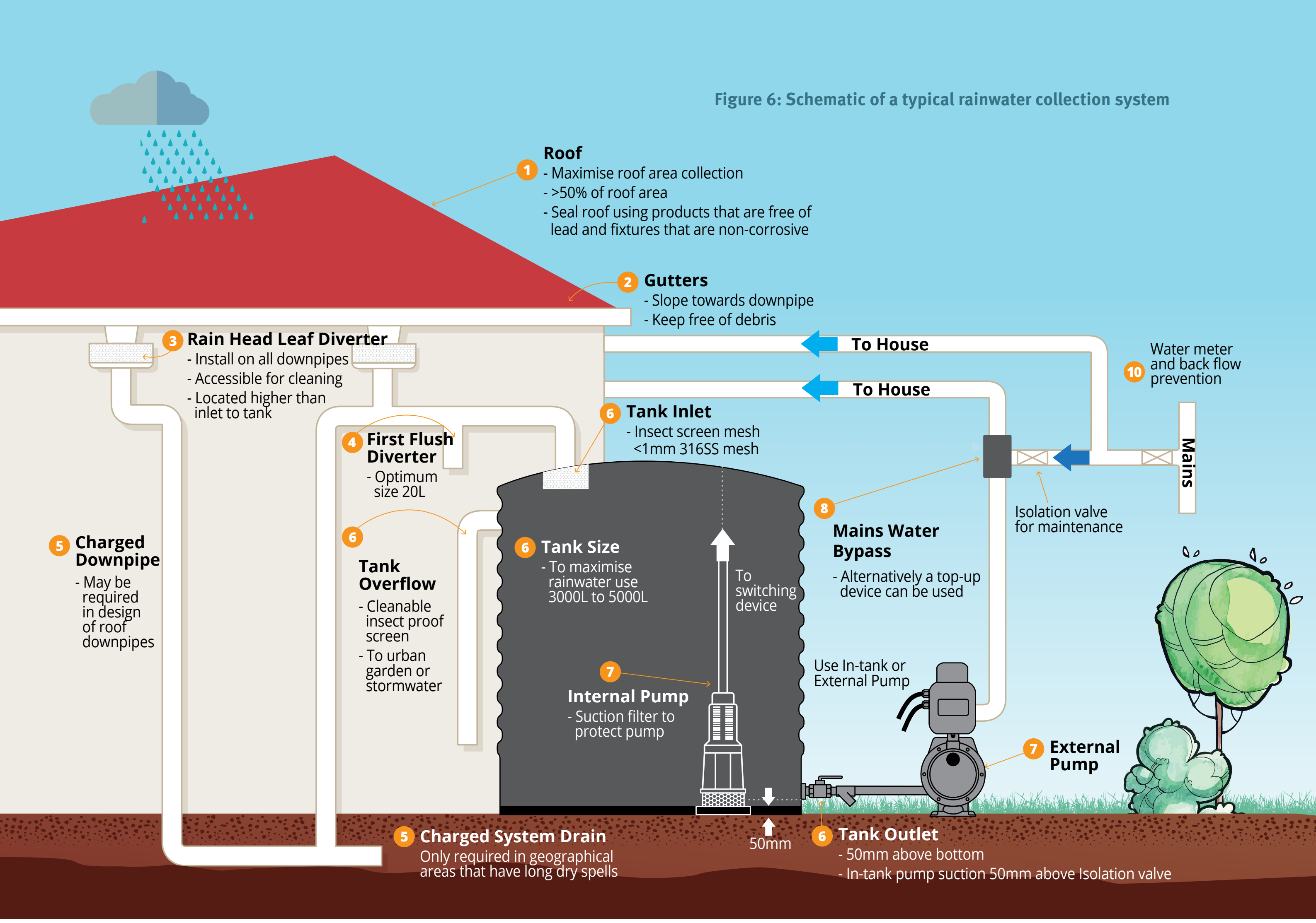
- clean roof gutters
- clean all leaf diverters
- clean first flush device
- clean the trainers at the entry of the tank and on the overflow of the tank.

Every six months:

- check the water quality (odour, colour, sediment)
- check the condition of the pumps.

[8] CSIRO 2015: *It's raining water tanks: keeping them healthy and efficient.* visited 25/07/2019 <https://blog.csiro.au/its-raining-water-tanks-top-tips-for-keeping-them-healthy-and-efficient/>
[9] Department of Health 2012 *Guidance on use of rainwater tanks* visited 25/07/2019 <https://www.health.gov.au/internet/main/publishing.nsf/Content/ohp-enhealth-raintank-cnt.htm>
[10] Other relevant regulations include the Queensland Development Code Part 4.0 Building Sustainability - MP4.2 and MP4.3 and the National Construction Code, volume 3, section B6.

Figure 6: Schematic of a typical rainwater collection system



Source: Rainwater harvesting association of Australia, Rainwater harvesting: residential design specification visited 25/07/2019 www.rainwaterharvesting.org.au/wp-content/uploads/2018/01/Rainwater-Harvesting-Guide-Approved.pdf

8.2 Greywater use

Greywater is wastewater generated from baths, showers, washbasins and laundries. Greywater can be used for garden and grass irrigation, with the appropriate precautions, such as using low or no sodium and phosphorus products and applying the water below the surface[11] (this can also help infiltration). Household greywater must not be sprayed or used in your irrigation system or sprinkler.

Buried irrigation (sub-surface drip irrigation systems) is suggested for greywater irrigation as these systems reduce the risk of human or animal contact and can be designed to suit the soil and other conditions in your garden.

Kitchen greywater is not always suitable for gardens as there can be too much grease, solids, oil and detergents; grease and oil from the kitchen sink can clog the pipes in your irrigation network. For further references to the use of greywater, it is recommended to read the Queensland Plumbing and Wastewater Code.

Greywater should be used with care. The law requires that greywater must not cause a danger, health or nuisance through:

» ponding
» runoff on to neighbouring properties causing an odour.

If greywater is to be used for domestic irrigation, make sure that you check the list for wastewater use found in Appendix 4. Remember to check with your local council or water service provider before you reuse wastewater as standards and permission requirements vary.

8.3 Reusing drainage water

Excess water draining from residential dams and ponds and from large scale irrigation, such as golf courses, can be collected and reused. Reuse of water can also occur in small scale irrigation settings by reclaiming excess water in your garden beds. Drainage can be directed to a central recycling container where it is strained and pumped back onto plants. Starter systems are available at major hardware stores and garden centres, or you can pick up a wide variety of DIY kits. The reuse of drainage water can be both water and nutrient efficient.

[11] Australian Goverment 2012 *Your home* visited 25/07/2019 ‹www.yourhome.gov.au/water/wastewater-reuse›

9 Further information

Table 7 lists some resources that can assist you in planning and maintaining your garden and grass. Government, industry and local council information resources can assist you in planning and maintaining your garden and grass. Local councils often provide material on their websites on gardening and horticultural information specific to your local area as well as general water saving tips.

Table 7: List of sources for gardening and horticultural information

Organisation	Website Address
Australian Government: Your Home Provides information about reducing water demand, including using rainwater and using grey water in your garden	www.yourhome.gov.au/water
Department of Housing and Public Works Provides information about plumbing requirements (including backflow devices) and grey water use	www.hpw.qld.gov.au
Irrigation Australia Limited Provides information on Certified Irrigation Professionals who can provide design, installation and auditing services	www.irrigationaustralia.com.au
Landscape Queensland Industry Association	www.landscapequeensland.com.au
Nursery and Garden Industry Australia Represents commercial growers, retailers and suppliers; provides information about best practice for nurseries	www.ngia.com.au
Department of Natural Resources, Mines and Energy Provides information about using water wisely, including waterwise gardening and education resources about water efficiency	www.qld.gov.au/environment/water
Queensland Health Provides guidance about using rainwater tanks and greywater	www.health.qld.gov.au
Queensland Turf Producers Association (QTPA) Represents the turf production industry; provides information about turf varieties available	www.qtpa.com.au
Smart Approved Watermark Provides information about water efficient products and services	www.smartwatermark.org

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Appendix 1.
Urban irrigation design checklist

This is a checklist for the design of an urban irrigation system.

- ☐ Collect base information including:
    - ☐ irrigation areas
    - ☐ water supply characteristics
    - ☐ determine the system design capacity
    - ☐ local climate
    - ☐ type of vegetation
    - ☐ type of underlying soils.
- ☐ Meet all applicable codes including plumbing and electrical.
- ☐ Mapping (sketching) existing landscaping features including patios, driveways, fences and trees, shrubs and grass.
- ☐ Specify manufacturer, model, type and size of all components.
- ☐ Selection of products should be guided by the expected demand of plants for a minimum of 3 years for establishment and 10 years for trees.
- ☐ Include an estimate of the operating costs including initial capital costs of the installed system.
- ☐ Apply rules of maximum safe flow rate with the lowest safe flow rate prevailing as the design guideline
    - ☐ Maximum allowable pressure loss through the meter should be less than 10% of the static pressure at the meter
    - ☐ The velocity of water through the service line supplying the meter should be less than 1.5 metres per second (m/s)
    - ☐ Select main and lateral pipe sizes so that the velocity of water in the pipe does not exceed the industry standard of 1.5 m/s.
- ☐ Where applicable, specify a water source that meets peak demand for landscapes with irrigation not longer than 10 hours (dependent on actual requirements).
- ☐ Specify how the reticulated water source will be protected in accordance to the plumbing code protection for backflow.
- ☐ For systems on a reticulated municipal supply, allow for a reduction in static pressure of up to 70 KPa (0.7 Bar) to accommodate possible expansion in the supply network. Specify the recommended operating pressure at the maximum design flow rate of the system.
- ☐ For zones utilising drip or micro-irrigation:
    - ☐ Check that the water quality is fit for micro-irrigation
    - ☐ Specify filtration system if needed based on the water quality test
    - ☐ Separate micro-irrigation zones from other zones to allow for adjustment in water requirements.
    - ☐ Specify pressure-compensated devices to improve application uniformity
    - ☐ Use air release valves to minimise the possibility of dirt of other contaminants getting into the emitters.
    - ☐ Use flush valves to flush the laterals after the irrigation cycle is finished.
- ☐ Design the layout of emitters so that there is no over-spraying onto streets, driveways or footpaths.
- ☐ Use separate hydrozones (i.e. 'zones' of groups of plants that have similar water requirements) for areas with different water or scheduling requirements, taking into consideration the sun and wind exposure, plant type and water availability.
- ☐ When selecting system components, place a high priority on avoiding surface runoff by selecting components to keep the application rate below the soil's infiltration rate. Where possible integrate products that can improve water efficiency such as:
    - ☐ automatic controllers incorporating multiple start times, rain delay programming, and evapotranspiration programming
    - ☐ automatic shut-off devices, such as rain and moisture sensor
    - ☐ low-volume irrigation delivery, through systems using drippers, bubblers or micro-jets
    - ☐ pressure-regulating devices
    - ☐ high-efficiency nozzles
    - ☐ stationing of sprinkler systems to match each of the site's hydrozones
    - ☐ hand watering via hoses or buckets for small garden areas.

The irrigation designer should choose appropriate equipment that meets relevant national, Queensland and local standards and site requirements. For large scale irrigation, where appropriate and possible, install a water meter dedicated to measuring only irrigation water and have only commercial quality irrigation system components (Smart Approved Watermark).

Appendix 2.
Water saving devices

Following is some information about some water saving devices that are available.

Tap timers

Manual tap timers are available as mechanical, semi-automatic and automatic. Some do not require batteries; others are equipped with solar panels and others require batteries. They give you the convenience of 'set and forget' irrigation. They connect to the garden tap and enable the desired time to be selected to suit your needs. More sophisticated, battery operated automatic tap timers with different ranges of features including multiple zones, programs and run times are also available in the market.

Conventional timer-based systems water on a fixed schedule and do not have the capability to adjust to changing environmental conditions that can result is overwatering.

Image A2-1: Tap timers

Sprinkler controllers

There are currently many different types of sprinkler controllers in the market from battery powered, web based, solar powered to decoder controllers. To choose one that suits your needs, there are some basic aspects to consider:

- the size of the area to be irrigated
- if you prefer simple or more technologically advanced devices
- your budget.

Sprinkler controllers commonly have different hydrozones or stations. A hydrozone is an irrigation area that is covered by a single sprinkler valve. Commonly controllers can operate from 2 to 12 zones.

Image A2-2: Sprinkler controllers

Sprinkler controllers range from basic to more advanced models. Some can synchronise run times with local weather data.

The price of a residential sprinkler controller will depend on how many features it has, the hydrozones it can control, and the amount of technological wizardry that it can offer. When looking for the sprinkler controller that suits your needs, consider the types of features you will need to be able to irrigate your grass or garden.

Rain sensors

Rain sensors can be stand-alone or built-in to gather weather-based data and adjust the irrigation schedule. The rain sensor shuts off an irrigation cycle as soon as rain begins to fall.

Image A2-3: Rain sensors

Rain-sensing devices are available at different levels of sophistication. Some work by accumulating a set amount of rainfall before a switch is activated that interrupts the circuit from the controller and shuts off the system. Other rain sensors shut the system off right when it starts to rain. Make sure that your rain sensor is compatible with your irrigation controller.

Soil moisture sensors

Soil moisture sensing devices aid in the prevention of water wasting by indicating when the irrigated area has reached adequate moisture levels. They are ideally placed where most of the roots grow. Most soil moisture sensors are compatible with irrigation controllers which can stop irrigation when it is no longer necessary.

By optimising the amount of moisture in the soil, you can save a lot of water.

ImageA2-4: Soil moisture sensors

Image A2-5: Evapotranspiration gauge

Evapotranspiration sensors

Evapotranspiration sensors, or weather sensors, are commonly used for large irrigation areas. These sensors measure sunlight and temperature and use evapotranspiration to determine the correct seasonal adjustment percentage value to send to the controller. The controller then uses its programmed run time and adjusts to the seasonal adjustment value to modify the actual irrigation run time for that day.

Appendix 3. Urban irrigation system efficiency

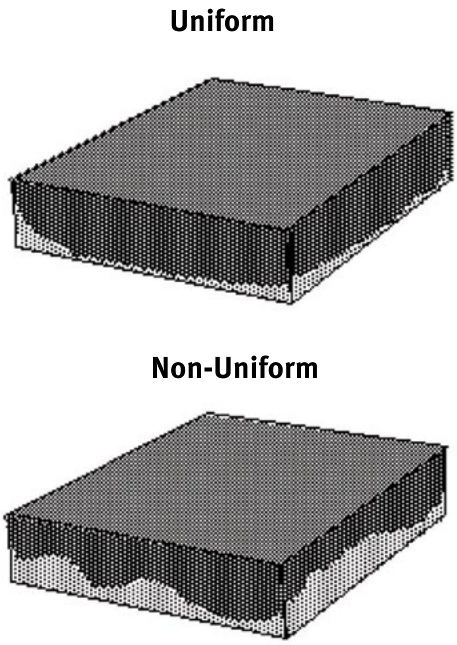
Efficient irrigation practices follow the basic principles of knowing how much water to apply, when to apply it, applying it uniformly as possible, and limiting wastage through runoff or excessive deep percolation.

The efficiency of an irrigation system refers to how much of the water applied is actually used by the landscape. Water may be lost in a number of ways including spray drift losses (if irrigating in windy conditions), runoff (if water is applied faster than the soil can absorb it), and deep percolation (if more water is applied than can be stored in the root zone). There are various terms used to define irrigation system efficiency, including application efficiency, distribution efficiency (or distribution uniformity), and overall efficiency.

Water droplet size is an important factor of irrigation efficiency. Generally, the smaller the droplet size, the more water will be lost to evaporation. Too much water pressure creates small droplets, thus reducing the application efficiency. Poor application efficiency means that the system must be run longer to put out the targeted amount of water.

Distribution uniformity (DU) is a measurement of how uniform water is applied over the intended irrigated area (refer to Figure A3-1). If an irrigation system had a DU of 100%, then all areas would receive the same amount of water. However, 100% DU is not practically possible. Generally, design problems such as poor sprinkler spacing, improper spray patterns, incorrect nozzle selection and too much or too little operating pressure often result in the over-application of water in some areas, and under-application of water in others. The soil type can also influence the effectiveness of the irrigation system, particularly sub-surface irrigation.

Figure A3-1: Schematic of distribution uniformity



Poor distribution uniformity in irrigation is almost always compensated by applying excessive amounts of water to ensure that all irrigated areas receive enough water. This can result in saturation in a portion of the landscape, unnecessary water runoff, and high-water costs. A better solution is to improve the uniformity of water application through proper design and product selection.

Well-designed and well-managed systems can achieve a high application efficiency. In order to do this, the irrigation system needs to be uniform in application and delivery, effective in application, operated at the right time and for the correct length of time. It needs to be recognised that both the application of water and the proper scheduling of the system operation need to be done well to achieve this goal.

Checking the system

The catch can test, or the tuna can test for residential irrigation systems, is one way to check for uniform distribution of water and measure the performance of the system. The test supports:

» The establishment of a distribution uniformity (DU) baseline for future comparison or budgeting upgrades.
» Comparison of old conversions and sprinklers compared to completely new conversions or sprinklers.
» Comparison of different manufacturers' sprinklers.
» Comparison of different nozzles and sprinkler pressure settings.
» Setting of run times and irrigation schedules.
» Comparison of system performance on different areas of the system.

For the catch can test, a number of equal diameter containers are equally spaced around the irrigation zone, the irrigation system is operated for a set time and the depth of water is measured in each can.

The results of the test provide you with the uniformity distribution coefficient (DU) and the precipitation rate (PR). The resulting DU indicates how uniformly water is distributed in that given area at a specific point in time. For more on auditing system performance see Appendix 9.

Tuna can test

Used to determine how long you should water your grass.

1. Place six to eight flat-bottomed cans, such as tuna cans or pet food cans, randomly throughout your grass. Inexpensive rain gauges may also be used. Place some cans close to the sprinkler head and others several metres away.

Figure A3-2: Reading application depth in a tuna can

2. Turn on your manual sprinkler or irrigation system for 15 minutes
3. Measure and record the depth of water in each can with a ruler. Determine the average depth of water for all the cans combined.

   Note the uniformity of your water application. If non-uniform, individual nozzles may need adjustment.

4. Refer to the grass irrigation depth chart below (Table A3-1) to determine the number of minutes you should water each week. Record the times for future reference.

Irrigation schedule

Use the average depth in the cans and refer to the table below to find out how long to water your landscape each week. It is recommended that watering occurs twice a week for half of the time on the table. For example, if your system discharges 10 mm in 15 minutes (based on results from the tuna can test) and you live in the North east subregion, in October you would need to irrigate about 40 mm/week (refer to Table 3 in Section 7.3), which means operating your irrigation system for 27 minutes each week. Therefore you would turn on your irrigation system every three days for 14 minutes.

Table A3-1: Irrigation time based on tuna can test results and irrigation requirements*

Average depth in the can in 15 minutes (mm)	Irrigation requirements (mm/week)									
	5	10	15	20	25	30	35	40	50	60
	Irrigation time (minutes)									
3	1	2	3	4	5	6	7	8	10	12
6	2	4	6	8	10	12	14	16	20	24
10	3	7	10	13	17	20	23	27	33	40
13	4	9	13	17	22	26	30	35	43	52

* Refer to Table 3 in Section 7.3 for a guide to irrigation requirements.

Irrigation schedules should be influenced by the weather. Decrease irrigation time during cool or humid conditions and skip a scheduled irrigation after a moderate rainfall. Additionally, soil types impact irrigation techniques. Generally, clay soil requires the "cycle and soak" method which calls for more frequent but shorter sprinkling cycles with time in between to let the water slowly soak into the soil. For example, a 30 minute cycle might consist of six 5 minute cycles with 10 minutes between cycles.

Appendix 4.
Greywater usage checklist

Use the below checklist if you are considering using greywater to water your garden or grass.

- ☐ Research your land's suitability to receive grey water prior to purchasing or installing a greywater system. This will depend mostly on your soil type.
- ☐ Gain council approval before proceeding.
- ☐ Do not store untreated greywater. Divert untreated greywater to the sewerage system if it is not used immediately (e.g. during heavy rain).
- ☐ Do not allow children, pets or human contact to occur where greywater has been used.
- ☐ Choose laundry detergents that are designed for greywater re–use. These will usually contain low nitrogen, phosphorous and salts and will be labelled appropriately.
- ☐ Do not use greywater if you have used detergents that contain harmful salts as this may kill plants or damage soil structure.
- ☐ Ensure the plants and grass varieties in your garden are greywater tolerant.
- ☐ Do not use greywater that has been used to wash heavily soiled items such as nappies or work uniforms.
- ☐ Do not allow greywater to flow into stormwater drains, or to pollute a watercourse or groundwater.
- ☐ Only use greywater when your garden needs irrigation and try not to over-water as this may damage plants and soil structure.
- ☐ Do not use greywater when there is a person in your home that is unwell.
- ☐ Prevent runoff into neighbouring properties as this may cause a health risk.
- ☐ Do not allow greywater to pond as this may cause offensive odours and potentially become a health risk.
- ☐ Ensure you wash your hands thoroughly after coming into contact with greywater and use gloves if possible.
- ☐ Do not allow greywater to come into contact with vegetables, herbs or edible plants, or allow it to splash onto them.

Appendix 5.
Checklist for the installation of urban irrigation systems

The following checklist provides information to help ensure that the irrigation system is installed to apply water uniformly and to conserve water.

- ☐ Check for underground utilities before installation. The referral service, 'Dial Before You Dig' (www.1100.com.au) can provide detailed information on underground services in the proposed excavation area.
- ☐ Before the installation, the installer should verify that the point of connection, flow rate and static and dynamic pressures meet the design criteria.
- ☐ If engaging an irrigation professional to install the system, it is suggested that you check that they are certified and insured to install irrigation systems.
- ☐ Install the irrigation system according to the design specifications and manufacturer's recommendations.
- ☐ Consider the potential impact of the irrigation system installation on plants and the landscape. Determine if landscape restoration should be part of the scope.
- ☐ Where deviations from the design are required, redline the plan drawing to note the deviation. If in doubt, and where relevant, consult with the designer before making a change to ensure that it is within design performance specifications.
- ☐ Ensure an accurate set of "as-built" drawings is provided that describe the system layout and components including all changes from the original design.
- ☐ Set up the programming for any controllers.
- ☐ If installed by a third party, ensure the installer explains where the controller, valves, sensors, pressure regulators, backflow device and emitters are located, how to operate them and the maintenance requirements.
- ☐ Ensure copies of all product warranties and operating instructions are provided.

What is commissioning?
The commissioning of an irrigation system is a methodical process of ensuring that the system is installed and tested to perform according to the design intent and delivers the agreed operational outcomes. It is the process whereby an agreement is reached that the installed irrigation system meets the design performance specifications.

Commissioning is usually when responsibility for the irrigation system is handed over from the designer and installer to the owner/operator and may have implications for insurances, maintenance programs and compliance. It is the final phase in the installation process and is undertaken by the installer. Where a designer has been involved, they are often involved at commissioning, either at the system testing phase or to provide input on how to correct performance issues.

Commissioning documentation
The documentation should show that the system was checked, and that it was installed and working properly when it was handed over. It should describe the installation and testing procedures followed and the results obtained. When an irrigation system is handed over to the owner/operator, it should be accompanied by:

» a commissioning report
» as-built plans
» operation and maintenance manuals
» any other relevant support information.

Commissioning tests to be performed by the installer

The following tests should be included in the commissioning program for an urban irrigation system.

☐ Check that the pumping plant delivers the design duty (where a pump is required).

☐ Pressurise all main lines and sub-mains to ensure that they can hold the designated pressure under static conditions, for specified periods of time.

☐ Check the flow variation along laterals, between laterals, along driplines and throughout the entire pipe network.

☐ Check the flow variation between outlets along laterals to ensure the system delivery rates are within acceptable limits.

☐ For sprinkler systems, check the precipitation rate and the uniformity of application.

☐ Check the integrity of the control and communication systems to ensure that all functions are operating correctly including any installed sensors (soil, flowrate, rainfall, pressure).

Appendix 6. Checklist for a maintenance plan for an urban irrigation system

A maintenance plan helps ensure that the irrigation system remains operational and efficient throughout its expected life. A suitably qualified horticulturist, landscape designer or Certified Irrigation Installer can prepare a maintenance plan for you. The maintenance plan can cover both the irrigation system and the landscaping together. Below is a checklist for what a maintenance plan should include.

☐ Regular top dressing and aeration to grassed areas.

☐ Top-up mulching.

☐ Ongoing weed suppression and removal.

☐ Regular incorporation of compost into garden beds.

☐ Ongoing maintenance of plants, such as pruning to maintain vigour or size, or the removal of damaged or diseased plant material.

☐ Conducting leak and blockage checks in irrigation lines and emitters.

☐ If appropriate, inspecting moisture sensors to ensure they are working properly.

☐ If appropriate, maintaining tanks and cisterns.

☐ If appropriate, checking water pumps.

☐ Verifying that the backflow prevention device is working correctly (backflow testing).

☐ Verifying that the water supply and pressure are as stated in the design.

☐ If appropriate, checking that the pressure regulators are adjusted to the desired operating pressure.

☐ If appropriate, examining filters and cleaning filtration elements as required.

☐ If appropriate, checking that the controller is operating properly; confirm date/time input and functional back-up battery.

Part of the maintenance plan should be to complete repairs in a timely manner to support the integrity of the irrigation design and to minimise the waste of water.

Appendix 7.
Checklist for a management plan for an urban irrigation system

To ensure that your irrigation system continues to operate efficiently, it is recommended to have a management plan, particularly for large scale irrigators. The management plan should include and allocate responsibility for completing the following tasks.

- [ ] Provide a site map showing the location of each point of connection, water meter, backflow prevention device, controller, valve and area served by each valve.
- [ ] Create a base irrigation schedule by performing an irrigation audit to obtain data for the based irrigation schedule (refer to Appendix 9).
- [ ] For each hydrozone, identify plant type and micro–climate factors. From soil tests, identify the soil type and soil infiltration rate for the purpose of estimating the available water holding capacity of the soil.
- [ ] Provide a monthly base irrigation schedule where the frequency of irrigation is based on replenishing the allowable depletion of the soil moisture between irrigations (based on data from the audit).
- [ ] After the system has been put into service, evaluate the effectiveness of the system water management by monitoring and comparing actual landscape water use with the designed irrigation water application.
- [ ] Evaluate the system performance. The evaluation can highlight strengths and weaknesses in the performance of the system and how it is maintained and managed.
- [ ] Periodically, verify that sensors and other components in the irrigation system are working properly. Inspect the irrigation system during operation.
- [ ] Periodically, visually verify that the plants and grass are healthy, and that soil moisture is adequate. Use a soil probe to evaluate root depth and moisture.

Appendix 8.
Checklist for a system operation manual for an urban irrigation system

A detailed system operation manual that includes all the operational information in one place can be beneficial to ensuring that the system maintains its designed performance. The following provides a checklist for what the system operation manual should include.

- [ ] Service manual and parts list.
- [ ] Schedule of maintenance, specifying frequency of inspection and service for key elements of system.
- [ ] The correct way to operate all equipment and installations.
- [ ] How the system should work and its optimal operating range.
- [ ] How to monitor the system's operation.
- [ ] Any passwords for electronic equipment.
- [ ] Protocols for operating the system safely.
- [ ] Emergency procedures.
- [ ] List of monitoring points, methods and values to be achieved.
- [ ] Contact information for relevant suppliers.

Appendix 9.
Audit for irrigation systems

What is an audit?

An irrigation audit is the process of collecting data from an irrigated area to evaluate the current performance of an irrigation system. An important outcome from the audit and evaluation of an irrigation system, is the information that allows an optimum irrigation schedule to be developed. This is what is known as the "base schedule".

Audits are most often performed on sprinkler-type systems, although methods exist for testing performance of drip irrigation set-ups. Formal audits can be conducted by an independent Certified Irrigation Professional, however, irrigation managers can use the audit methodology set out in this guideline to perform ongoing system checks.

Audits test the irrigation system to ensure that it is efficient, i.e. the irrigation water should be:

- uniformly applied
- with minimum losses due to evaporation, runoff and deep drainage
- to the correct depth to meet the site vegetation needs
- at the appropriate time (considering precipitation and climatological conditions).

Requirements for information in the audits of the performance of an irrigating system should consider:

- the water usage over the irrigation period
- hydraulic operating conditions (pressure and flow)
- uniformity of application
- precipitation rate of the system
- a site-specific irrigation schedule.

These procedures are intended to function as recommendations in the auditing of urban irrigation systems. Recommendations and projections from this guideline and their accuracy depend upon the quality of measurements taken and data provided by the user.

The steps involved in preparation of a base schedule are:

1. Determination of the plant water requirement.
2. Determination of the irrigation requirements.
3. Determination of the irrigation depth and frequency.
4. Determination of the optimum run times and total run times.
5. Determination of the water volumes and cost.

Auditing procedures for large-scale urban irrigation systems

The following are the recommended procedures for undertaking irrigation system audits.

- ☐ Maximum wind allowable during audit is 8 km/h. Wind speed should be monitored and recorded every five minutes during the audit test.
- ☐ Audit should reflect normal operating conditions.
- ☐ Pressure tests should be conducted at normal operating conditions at the sprinkler using the appropriate pressure testing device at the beginning and end of each zone audited.
- ☐ Undertake a catch can test:
  - ☐ Catch devices must be uniform in size and shape. Larger collectors give better repeatable results.
  - ☐ Catchments for a test area should be documented to facilitate repeatability.
  - ☐ A minimum of 24 catch devices should be used. Smaller sprinkler spacing may require more catch devices to improve statistical accuracy.
  - ☐ The catchments along the edge of the zones should be placed 0.3 to 0.6 metres in from the edge.
  - ☐ Minimum catchment device spacing:
    - For fixed spray sprinklers—near a head (within 0.6 to 1.0 m) and half-way between the heads.
    - For rotor sprinkler heads spaced less than 1.2 m on centre—near a head (within 0.6 to 1.0 m) and every one–third of the distance between the heads.
    - Rotor heads spaced greater than 1.2 m on centre—near a head (within 0.6 to 1.0 m) and every one-fourth of the distance between the heads.
    - Unusual or irregularly shaped areas:
      - For rotor sprinklers—uniform grid of catch devices, within 3 to 6 m on centre spacing (i.e. golf greens).
      - For spray sprinklers—uniform grid of catch devices, within 1.5 to 3 m on centre spacing (i.e. curvilinear areas without defined rows of sprinklers).
- ☐ Test run times must be consistent and appropriate for the sprinkler type and arc.
- ☐ When the test area contains multiple stations, the test run times for each station or zone must be adjusted to achieve a matched precipitation rate across the test area.

☐ The following data should be documented and recorded:

- ☐ sprinkler head locations
- ☐ sprinkler head spacing
- ☐ sprinkler make, model and nozzle size
- ☐ approximate catch device locations
- ☐ catchment readings
- ☐ test run time
- ☐ water meter readings
- ☐ pressure readings with locations
- ☐ wind speed readings
- ☐ soil types and root zone depths
- ☐ date and time of testing.

Table A9-1 lists a summary of the procedures for an urban irrigation system audit whilst Table A9-2 summarises the data to be collected.

Table A9-1: Audit test procedure summary*

Step	Procedure
1	Record details of sprinkler make, model and nozzle size. Record sprinkler design operating pressure. Measure distances between sprinklers.
2	Catch can test. Set cans out in a regular pattern. Check that cans are vertical and the tops level.
3	Start the test, writing down pressure and weather conditions. Note start time. Record flowmeter reading.
4	Monitor the pressure and weather conditions throughout the duration of the test.
5	Finish the test, write the time. Record water volume in each catch can.
6	Calculate the distribution uniformity (DU)⁻.
7	Prepare the base schedule.
8	Prepare the report.

* Source: Connellan, G. Water Use Efficiency for Irrigated Turf and Landscape, CSIRO. Sydney, 2013, page 314.

⁻ Distribution Uniformity (DU) is a measure of how evenly water is applied across a field during irrigation. DU is expressed as a percentage between 0 and 100%, although it is virtually impossible to attain 100% in practice. DUs of less than 70% are considered poor, DUs of 70–90% are good.

Table A9-2: Summary table of audit test data*

Category	Description
Test site	Site name and location
	Contact person and details
Site details	Irrigated area
	Vegetation type, areas, condition
	Zone microclimates, plant densities, Soil type, properties, root zone depth
Test conditions	Weather: wind speed, direction, temperature Date of test, starting and ending test time
Water source	Type Hydraulic conditions: pressure and flowrate
Controller	Manufacturer, model, nozzle size(s) Program: days, start times, run times
System review—sprinklers	Manufacturer, model, nozzle(s) sizes Design operating conditions, pressure and flow Layout and spacing Design precipitation rate Sprinkler rotation time, number of rotations
System review—drip irrigation	Type, manufacturer, discharge rate Emitter interval spacing, lateral spacing Pipe and tubing sizes and material Valves: flushing, air release, pressure regulation, filtration

* Source: Connellan, G. Water Use Efficiency for Irrigated Turf and Landscape, CSIRO. Sydney, 2013, page 317

The achievement of high efficiency with pressurised systems depends on a high degree of uniformity of application. However, there are some urban landscape settings that are particularly challenging in terms of high efficiency and uniformity such as in garden bed situations where foliage is usually of varying size, height, type and density. In cases like this, uniformity of application is not a requirement for high efficiency.

Performance indicators and audits

Industry standards for urban irrigation uniformity under operating conditions are distribution uniformity (DU) of higher than 75% and the scheduling coefficient (SC) less than 1.3.

The SC is a measure of uniformity in an area which compares the lowest precipitation rate for a defined adjacent area to the average application rate. SC can be used to provide a time adjustment factor to ensure that the particular area receives an adequate depth of application.

$$\text{Sheduling coefficient (SC)} = \frac{\text{Average of all can readings}}{\text{Selected low readings (dry area)}}$$

Individual water providers or local councils may have policies requiring that new irrigation systems meet certain DU criteria, it is recommended to check with your local council for their requirements. Table A9-3 and Table A9-4 show recommended performance rating categories for both sprinklers and micro-irrigation systems. Values of DU only come from tests performed as described in Appendix 10.

Table A9-3: Performance rating categories for sprinklers and sprays*

	Distribution uniformity (DU_{LQ}) performance rating categories for sprinkler and spray irrigation equipment				
	Excellent	Very good	Good	Fair	Poor
Fixed spray	0.75	0.65	0.55	0.50	0.40
Sprinklers	0.80	0.70	0.65	0.60	0.50

* Source: Connellan, G. Water Use Efficiency for Irrigated Turf and Landscape, CSIRO. Sydney, 2013, page 308.

Table A9-4: Performance rating categories for micro-irrigation systems

Type of zone	Emission uniformity (EU) performance rating categories for micro-irrigation systems		
	Excellent	Very good	Good
Micro-spray	0.80	0.70	0.60
Drip—standard	0.80	0.70	0.65
Drip—pressure compensating	0.95	0.90	0.85

Performance calculations

To calculate the precipitation rate using millilitre readings, the following formula industry accepted, and recommended is used:

$$PR_{net} = \frac{60{,}000 \times V_{avg}}{t_R \times A_c}$$

PR_{net} = station precipitation rate (mm/h)
V_{avg} = average catch volume for station (ml)
t_R = testing run time (min)
A_c = catch device throat area (mm²)
60,000 = conversion factor

To calculate the low-quarter distribution uniformity, that is, the lowest 25% of the can readings, use the following formula:

DU_{LQ} = Low-quarter distribution uniformity (decimal).

$$DU_{LQ} = \frac{\text{Average catch of lower quarter}}{\text{Average catch overall}}$$

Appendix 10. Large-scale urban irrigation systems

Irrigation of urban areas on a large scale may require special consideration as various stages of the design, installation, maintenance and operation phases. Below are some specific notes for consideration. Large-scale irrigation includes irrigation for active playing surfaces, golf courses, parks and recreational areas, garden beds and nurseries.

Active playing surfaces

An active playing surface is an area for playing used for competition. As a rule of thumb, it is the area "inside the lines" where the players are engaging in competition (i.e. it does not include run-on areas, behind the dead ball line or just inside the perimeter fence). Some examples of active playing areas include:

- grass cricket wicket and practice wickets
- grass running or racetrack
- bicycle racecourse
- green (that is, croquet, bowling or golf)
- golf tee-off area
- tennis court
- any other principal part of a sportsground used during a sport game or competition, including in schools.

A checklist for irrigating active playing surfaces

- ☐ Contact the relevant water service provider to find out what conditions might apply to the irrigation of active playing surfaces (it is common practice that active playing surfaces require registration).
- ☐ Where possible, install a water meter to specifically measure and monitor the amount of water used on the playing surface.
- ☐ Where possible, have an appointed manager to oversee the management and irrigation of the active playing surface.
- ☐ Have a management plan in place for the active playing surface (refer to Appendix 7).
- ☐ Where possible, keep a weekly logbook of water consumption for the active playing surface.
- ☐ Regularly maintain the irrigation system and playing surface (such as aeration, mowing, application of wetting agents, replacement of grass, regular checks for leaks in equipment).
- ☐ Regularly audit the irrigation schedule (refer to Appendix 9), adjusting your irrigation system as the weather and usage of the active playing surface changes.
- ☐ Time irrigation to minimise playing on wet soils.
- ☐ Regularly aerate the playing surface.

Golf courses

Golf courses are recognised as large users of irrigation water. One of the main challenges in terms of achieving efficiency on golf courses is the scale of the facility. The demanding requirements of the golf courses industry mean that all inputs need to be carefully and wisely managed (water, fertiliser, mowing and aeration).

A checklist for irrigating golf courses

- ☐ Irrigating the areas that justify supplementary irrigation.
- ☐ Selecting grasses that provide the desired outcome or service but use less water.
- ☐ Where possible, choose plant species that are native or suited to the locality's climate and soils for non-play areas.
- ☐ Consider the opportunity to collect and reuse drainage water from the golf course; this can be very water and nutrient efficient.

Parks and recreation

Open space grass areas (parks and recreation) require maintenance to meet quality, fit-for-purpose and sustainability requirements. Irrigating open space grass areas accounts for a large volume of the water used by councils in Queensland.

However, managing these areas is not just about irrigation water. The soils and type of grasses are often not given the consideration required to have a healthy grass. Successful and efficient open space grass management relies on getting the basics right. This means having the right soil, the right grass plants, the right irrigation and the right ongoing maintenance schedule. A best practice open space grass area should meet community expectations for access, aesthetics, safety and playability.

Parks and recreation managers need to think in an integrated manner appreciating the relationships between soil, grass, irrigation, drainage, users and management practices.

Garden beds

The adoption of some irrigation practices such as using soaker hoses, drip irrigation, rainwater storage and other efficient garden irrigation systems in your plots can save water, grow food crops through drought and heat, and spend less on your summer water bills. In general, the best irrigation methods will depend on planting arrangement and crop type. For drip irrigation of garden bed areas you can engage a Certified Irrigation Professional to design and install the system.

Image A10-1: Garden beds irrigation

A checklist for irrigating garden beds

- ☐ Plant shallow-rooted plants in blocks rather than rows to simplify irrigation, especially if you water by hand.
- ☐ Consider the most appropriate irrigation method. With crops that require more water and space in the garden, such as beans, peppers, sweet corn and tomatoes, better options include using soaker hoses, drip irrigation or carefully managed ditches.
- ☐ Regular weed control. According to research, a combination of good weed control and adequate mulch can conserve up to 3 mm of water per week during peak summer times.
- ☐ Apply mulch. Soil will retain moisture better if compost or manure is added to the soil each time you plant, as well as use biodegradable mulches that break down into organic matter. Another benefit of applying mulch to the garden beds helps by cooling and shading the soil, thus keeping your garden from drying out quickly after an irrigation or rain.

For small domestic garden beds, a good quality and properly installed do it yourself (D.I.Y) kit can be used. Please make sure you use all equipment appropriately and safely when following the manufacturer instructions. If you are unsure, consult an expert, such as the manufacturer or a Certified Irrigation Installer.

Nurseries

The ability to conserve water and apply water efficiently and uniformly over a designated area has a major influence on the agronomic and economic viability of a nursery operation. Nurseries can increase their irrigation efficiency and practically eliminate runoff, root disease, and aeration issues in their fields by following the principles for proper irrigation design, operation, and maintenance.

A checklist for irrigating nurseries

- ☐ Ensure that the irrigation system is appropriately designed.
- ☐ Irrigate uniformly by selecting and spacing sprinklers so as not to exceed the ideal application rate.
- ☐ Choose the appropriate type of sprinkler. High-pressure impact sprinklers also create fine droplets that are easily carried by wind and rapidly evaporate in dry atmospheric conditions. Nurseries can obtain greater irrigation efficiency with sprinklers that instantaneously cover their entire wetted circle. It is important to use sprinkler that can combat wind-drift and evaporation.
- ☐ Regularly inspect the irrigation system for leaks, broken lines, or damaged equipment. This includes checking sprinklers while they are operating to pinpoint any issues such as overwatering, misting, misdirected patterns, or lack of uniformity. Sprinklers and applicators are designed to operate within a range of pressures that provide optimal performance. Pressure regulators eliminate these pressure fluctuations and help maintain sprinkler pattern integrity and performance. Issues like misting and overwatering may be due to changes in pressure and flow along the system. This just means that there may be a need for pressure regulators to keep efficiencies in check.

Image A10-2: Irrigation in nurseries

Appendix 11. Water demand estimation

A generalised equation used for the determination of plant water requirements is:

$$ET_c = \text{Plant coefficient} \times \text{Evaporation reference (mm)}$$

Where ET_c = Plant use

The plant coefficient for grass commonly used is 0.5–0.6 (50–60% of allowable stress). This value has been found to produce good quality grass with no visible stress.

Coefficients for other landscaping plant materials

Very little research has been conducted to determine the coefficients for landscape plants other than grass. One way to estimate coefficients is to classify the plants into one of three categories:

- grass and annual flowers
- mixed plantings (perennial flowers and tender shrubs)
- native plants and shrubs and smaller trees (‹ 5 cm trunk diameter).

For example, grasses and annual flowers will most likely be in the "regular watering" class, perennial flowers and tender shrubs might be in the "occasional watering" class, and tough woody shrubs, vines and trees might be in the "natural rainfall" class. However, the most appropriate classification will change from region to region depending on how well plants are adapted to local climate and rainfall conditions.

Table A11-1: Commonly used plant coefficient for landscaping plants

Once plants are established, plants will thrive on...	Coefficient
Natural rainfall	0.3
Occasional irrigation	0.5
Regular irrigation	0.8

* Source: Connellan, G. Water Use Efficiency for Irrigated Turf and Landscape, CSIRO. Sydney, 2013.

The calculation of water requirement and irrigation generally is expressed as a depth in millimetres. There are numerous terms used to estimate plant water use rates. The equation above allows water use to be estimated using the local evaporation rate and an adjustment factor to reflect the actual use by the plants (grass).

To ensure that the irrigation system is designed to distribute water efficiently and evenly and to conserve water, the final design should consider additional recommendations set out in this guideline.

Glossary

Anti-siphon device
A type of backflow preventer which seals off the atmospheric vent area when the system is pressurised. Should be installed downstream of a control valve in a location which is at least 0.3 metres higher than the highest point in the lateral which it serves. When system pressure drops to zero, the float and seal assembly drops, opening the vent to atmosphere and breaking any siphon effect.

Anti-siphon valve
The combination of an angle valve and anti-siphon device in one unit. In built-in grass sprinkling systems, a siphon is any pipe, hose or tube that is used to move a liquid from a higher location to a lower location.

Application rate
A measurement of the volume of water applied to landscape in a given time, in metric units usually expressed in millimetres per day or per week.

Application efficiency
The ratio of the water that is stored in the root zone for later use by the plants to the total water applied. Expressed as either a percentage or decimal.

Audit or irrigation audit
A detailed review of an irrigation system, including tests to determine overall system efficiency, identify problems areas that need correction, and determine an ideal irrigation schedule. Refer to Appendix 9.

Automatic control valve
A valve which is activated by an automatic controller using electric or hydraulic means. Synonymous with Remote Control Valve.

Backflow
The unwanted reverse flow of liquids in a piping system.

Backflow preventer
A mechanical device which prevents backflow. In irrigation, it is used to protect the potable water supply from potentially contaminated irrigation water. There are several types of backflow preventers. The choice of backflow preventer used depends on the degree of hazard and the particular piping arrangement involved. Virtually all regulatory agencies in Australia require backflow prevention devices to protect the domestic water supply from contamination by the backflow of irrigation water. In areas where it is not required, it is highly recommended. Consult local building codes for laws applicable in your area.

Best management practice (BMP)
An irrigation practice that is both economical and practical that will assist in reducing water use, protect water quality, while maintaining or improving crop production.

Calendar days off
A controller feature that allows you to suspend irrigation on a specific date.

Check valve
A valve which allows water to flow in one direction only. Check valves are used to prevent low head drainage.

Class 1 building
The Building Code of Australia defines a class 1 building as being either:

- A single dwelling being a detached house, or one of a group of two or more attached dwellings, each being a building, separated by a fire-resisting wall, including a row house, terrace house, town house or villa unit (Class 1A).
- A boarding house, guest house, hostel or the like with a total area of all floors not exceeding 300m2, and where not more than 12 people reside, and is not located above or below another dwelling or another Class of building other than a private garage (Class 1B).

Class 2 building
The Building Code of Australia defines a class 2 building as a building containing 2 or more sole-occupancy units each being a separate dwelling.

Coefficient of uniformity (CU)
A numerical expression which serves as an index for the uniformity of water applied to a given area within a specific geometric arrangement of sprinklers (e.g. square or triangular).

Controller or timer
This is the brain of the sprinkler system. The controller automatically opens and closes valves according to a pre-set schedule or weather conditions. Controllers have easy-to-set programs to help you efficiently manage seasonal adjustments. An automatic controller is usually more water efficient that operating sprinklers manually.

Coverage
The area of landscape watered by a sprinkler or grouping of sprinklers.

Crop coefficient
Crop coefficient is used in predicting evapotranspiration of a particular plant type/crop. The most basic crop coefficient (Kc), is simply the ratio of evapotranspiration observed for the crop studied over that observed for the calibrated reference crop under the same conditions.

Deep percolation
Movement of water downward through the soil profile below the root zone. This water is lost to the plants and eventually ends up in the groundwater. These water losses can be significant and are often “out of sight” and therefore “out of mind”.

Diaphragm
Rubberised seal which keeps water from flowing through the valve.

Diaphragm valve
A globe or angle pattern valve which uses a diaphragm to control the flow of water through the valve.

Distribution uniformity (DU)
A calculated value that shows how evenly water is distributed in a sprinkler system to avoid excessively wet or dry areas in the landscape. It depends on the spacing of sprinklers, type of sprinkler used, wind and water pressure among other factors. High distribution uniformity is obtained when an equal amount of water is placed on all areas of the landscape. Refer to Appendix 3 for more information.

Domestic water
Potable or drinking water. It can be used as a source of irrigation water, but once water enters an irrigation system it is no longer considered domestic or potable.

Drain valve
A valve used to empty water from a lateral or main line, usually for winterisation purposes.

Drip irrigation
A low volume irrigation method that delivers water slowly and directly to the plant roots for maximum efficiency.

Dynamic pressure
The pressure of the irrigation system during operation. Synonymous with Working Pressure.

Emitter
A small irrigation device which delivers water at very low rate (measured in litres per hour) and pressure at the outlet port.

Evapotranspiration (ET)
The amount of water lost due to evaporation from the soil and transpiration from the plants. ET is used by some controllers to help determine the amount of irrigation needed by a landscape.

External manual bleed
A feature which allows an automatic valve to be opened manually (without controller) by releasing water from above the diaphragm to the outside of the valve. Useful during installation, system start-up and maintenance operations.

Flow
The movement of water.

Flow control
A valve which modulates in order to maintain a pre-determined flow rate without drastically altering the pressure.

Flow sensor
A device which actively measures water flow through a piping system and reports its data to the computerized central control system.

Friction loss
The amount of pressure lost as water flows through a system. Synonymous with Pressure Loss.

Globe valve
A valve configured with its outlet oriented 180 degrees from its inlet. In irrigation, these valves are generally installed so that the inlet and outlet are parallel to the ground.

Head to head coverage
The practice of placing sprinklers so that water from one sprinkler overlaps all the way to the next sprinkler head. This helps to increase overall system efficiency and prevents dry spots in the landscape.

Impact drive
A sprinkler which rotates using a weighted or spring-loaded arm which is propelled by the water stream and hits the sprinkler body, causing movement around a circle.

Infiltration rate
The rate at which water enters the soil, usually expressed in depth of water per hour. Infiltration rate is determined by the type of soil.

Irrigation efficiency
The percentage of irrigation water which is beneficially used in the soil and available for use by the landscape as compared to the total amount of water provided to the landscape.

Irrigation scheduling
Process of determining when to irrigate and how much. This can be done by monitoring the soil, the crop, or calculating water use (evapotranspiration). The goal is to schedule irrigation timing and amounts such that the soil water content remains between field capacity and the management allowable deficit.

Irrigation system
A set of components which includes the water source (e.g. domestic service or pump), water distribution network (e.g. pipe), control components (e.g. valves and controllers), emission devices (e.g. sprinklers and emitters) and possibly other general irrigation equipment (e.g. quick coupler and backflow preventer). Refer to section 4.4 for more information on irrigation products.

Irrigation requirement
The quantity of water needed by the landscape to satisfy the evaporation, transpiration and other uses of water in the soil. The irrigation requirement is usually expressed in depth of water and equals the net irrigation requirement divided by the irrigation efficiency. Usually expressed in millimetres per day or per week.

Main (mainline)
A pipe under constant pressure which supplies water from the point of connection to the control valves.

Master valve
A valve used to protect the landscape from flooding in case of a ruptured main or malfunctioning downstream valve. The master valve is installed on the mainline after the backflow preventer and the control valves.

Matched precipitation rate (MPR)
Matched precipitation rate (MPR) refers to sprinklers that apply water at the same rate per hour no matter the arc of coverage or part of a circle they cover. For instance, a full-circle sprinkler discharges twice the flow of a half-circle sprinkler and a quarter-circle sprinkler discharges half of what the half-circle unit does. MPR allows the same type of sprinklers, no matter what their arc, to be circuited on the same valve and to deliver the same PR rate. Spray heads have fixed arcs and are matched by the manufacturer, while rotors offer a choice of nozzles to match the Designed arc pattern.

Microclimate
The unique environmental conditions in a particular area of the landscape. Factors include amount of sunlight or shade, soil type, slope and wind.

Moisture sensor
A device which monitors the amount of water present in the soil and modifies the irrigation schedule accordingly.

Nozzle
The final orifice through which water passes from the sprinkler or emitter. Nozzle shape, size and placement has a direct effect on the distance, irrigation pattern and distribution efficiency.

Operating pressure
The pressure at which a system of sprinklers operates. Static pressure less pressure losses. Usually as measured at the base or nozzle of a sprinkler.

Permanent wilting point
The point at which plants can no longer extract moisture from the soil and die.

Point of connection (POC)
The place where the irrigation submain is joined to the water service line.

Polyvinyl chloride (PVC) pipe
A semi-rigid plastic material used in irrigation systems.

Polyethylene (PE) pipe
A flexible pipe used in irrigation systems usually black in colour but purple for recycled water.

Potable water
Domestic or drinking water. It can be used as a source of irrigation water, but once water enters an irrigation system it is no longer considered domestic or potable.

Precipitation rate (PR)
The rate at which a sprinkler system applies water to the landscape. PR is expressed in depth of water per hours of operation. (In Australia, usually expressed in millimetres per hour.)

Pressure
The force per unit area measured usually expressed in Kpa or Bars. Insufficient water pressure can result in poor sprinkler coverage, while excessively high-water pressure may cause misting and fogging leading to water waste.

Pressure loss
The amount of pressure lost as water flows through a system. Synonymous with Friction Loss.

Pressure regulator
A device which maintains constant downstream operating pressure which is lower than the upstream operating pressure.

Program
The irrigation plan or schedule that tells the controller exactly when and how long to run each set of sprinklers. Controllers offer multiple programs which can be useful on sites where different plant groups have different irrigation needs.

Puddling
When water gathers in one location, such as at the base of a sprinkler or at a low spot on the site. Can be caused by low-head drainage, over-irrigation, or slow soil infiltration.

Quick coupling valve
A permanently installed valve which allows direct access to the irrigation mainline. A quick coupling key is used to open the valve.

Rain sensor or rain shut-off device
A device which prevents the controller from activating the valves when a pre-set amount of rainfall is detected.

Rain delay
Allows the irrigation system to be turned off for a specific number of days without having to remember to turn it back on.

Remote control valve
A valve which is actuated by an automatic controller by electric or hydraulic means. Synonymous with Automatic Control Valve.

Retraction
When the pop-up riser of a sprinkler such as a spray head or rotor returns to the case in the ground. Also called pop-down.

Riser
A length of pipe which has male nominal pipe threads on each end. Usually affixed to a lateral or sub-main to support a sprinkler or anti-siphon valve. May also be used underground to connect system components.

Runoff
Water which is not absorbed by the soil and drains to another location. Runoff occurs when water is applied in excessive amounts or too quickly for the soil to absorb.

Scheduling coefficient
A numerical expression which serves as an index of the uniformity of water application to a given area within a specific geometric arrangement of sprinklers (e.g. triangular or square). Used to measure the uniformity of landscape irrigation systems.

Spray head
A type of fixed spray sprinkler that pops up from underground and waters a set pattern, usually from 4 to 5 metres in range. Used for grass and shrubbery areas.

Soil conditioner
A product which is added to soil to improve the soil's physical qualities, including to loosen compacted soils and provide nutrition for plants. They can be organic (e.g. compost) or chemical (e.g. gypsum). Also called soil enhancer.

Soil
Soil is made up mainly of mineral particles, organic materials, air, water and living organisms. The different properties of soils (e.g. colour, texture) influence how well plants can grow in that soil. Refer to section 4.1 for more information, and www.qld.gov.au/environment/land/management/soil.

Solenoid
An electromagnet which is connected to a controller and causes the opening and closing of automatic control valves.

Sprinkler
A hydraulically operated mechanical device which discharges water through a nozzle or nozzles.

Start times
When you program a controller, you schedule the precise time you want to begin irrigation on water days. The start time is the time the first station in a program begins to water. All other stations in the program follow in sequence. Remember, start times usually apply to the entire program, not to the individual stations.

Static pressure
The pressure in a closed system, without any water movement.

Station
A circuit on the controller which activates a single control valve in the irrigation system to control irrigation for a particular zone.

Transpiration
The process where a plant's moisture is lost to the atmosphere through its leaves.

Uniformity
How evenly water is distributed over an irrigated area.

Valve
A valve is like a faucet. Valves respond to commands from the controller. When valves receive a signal to open, water flows to the sprinklers. when they receive another signal to close, the flow of water stops.

Velocity
The speed at which water travels. (In Australia, usually expressed in metre per second)

Water budget
A feature of some controllers that they let you easily change the run times of your sprinklers without having to reprogram the controller. Use water budget to increase or decrease irrigation in response to changing seasonal needs throughout the year.

Water hammer
A damaging shock wave created when the flow of water in a pipe system suddenly stops. Usually the result of a fast-closing valve.

Water pressure
The force which is exerted by water. (In Australia usually expressed in metres of water or Bars.)

Water window
The time of day available when irrigation can take place on a site.

Water meter
A water meter is a device which is used to specifically measure, record and monitor the amount of water being used.

Watering days
The specific days of the week on which irrigation will take place. For example, every Monday, Wednesday and Friday, or every third day.

Wire gauge
Standard unit of measure for wire size. The larger the gauge number, the smaller the wire.

Working pressure
The pressure of the irrigation system during operation. Synonymous with Dynamic Pressure.

Zone
A section of an irrigation system served by a single control valve. Zones are comprised of similar sprinkler types and plant material types with similar water requirements and soil types.