Ipswich City Council and Ipswich Water

Active Playing Surface Pilot Program – Soil Moisture and Turf Performance

Presented to Queensland Water Commission

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Executive Summary

This report details the methodology used and results from a project by Ipswich City Council to demonstrate the water use efficiencies that could be attained using smart technology for irrigation on sports fields.

Ipswich City Council (ICC) and Ipswich Water have implemented a number of initiatives to conserve water over the extended dry period South East Queensland (SEQ) has experienced.

The requirement for Water Restrictions was triggered by declining dam levels in SEQ. As a result, water used for Active Recreation Areas and Sporting Fields, now known as Active Playing Surfaces (APS), has been restricted since Level 1 (May 2005).

The ICC pilot APS program was initiated and endorsed by QWC earlier than November 2007, pre Level 6 Water Restriction. The QWC sanctioned council to undertake a soil moisture irrigation program on council controlled fields in lieu of the QWC Volumetric Allocation, based on historic daily rainfall. Base level data was collected for several months and the pilot operated from date of Level 6 restrictions.

This followed intensive and prolonged discussion at Technical Working Group (TWG) meetings on the merits of using soil moisture as the driver for irrigation of APS.

ICC strongly lobbied the QWC and Peak Sporting Bodies' representatives on the TWG to adopt the Soil Moisture Method. Concerns raised at that time included the costs of the moisture meter probes ($900-1100), and the skill base of the users for both irrigation technology and computer literacy.

The ICC pilot program aimed to demonstrate the legitimacy of the soil moisture method's ability to provide a fit for play surface using the least amount of water.

Initially, ICC used scientific quality manual probes to measure soil moisture and only irrigated when soil moisture dropped to below 15% (approaching wilting point – turf starting to degrade). An irrigation volume was then determined using a turf irrigation calculator developed by ICC (refer to Appendix 2. Screen Shot of calculator). This calculator was subsequently adapted by QWC for the Volumetric Allocation Method.

ICC installed permanent in-ground sensors into 6 preliminary sites during early March 2008. The system provides real time information on soil moisture, soil temperature, water flow rates and volumes which is graphically representative (refer to Appendix 2). The system is web based and allows for irrigation only to occur when soil moisture reaches a predetermined low set point, and will not allow irrigation once a high set point is reached. These set points are specific to each field

and are based on soil type. A Rain Switch is also installed on these fields which stops any irrigation in the event of rain.

For the 6 months December 2007 to May 2008, ICC used an average of 390 KL/Ha over the 11.33 Ha pilot compared to the calculated QWC allocation of 1430 Kl/Ha average for the same fields.

This is a total water saving of almost 11.8 ML for the period and equates to a cost saving of almost $20,640 or $1,822 / Ha.

Whilst the ICC water consumption is low due in part to good rainfall, particularly in December to February (540mm for the period December 2007 to May 2008), it does illustrate the responsive nature of using soil moisture as the determining factor for irrigation.

Given the previously stated lack of skill by sports clubs field managers, it cannot be assumed that fields using the QWC Volumetric Allocation method did not use their allocation, despite the rain.

Water efficiency is becoming more important as the bulk storages continue at low levels and the cost of water is set to rise. Ipswich City Council is committed to continuously improve and adapt new water saving techniques and management practices.

The ICC Pilot study clearly demonstrates the superiority of using real time soil moisture information to determine irrigation over an allocation model based on historical rainfall and recommends that the QWC encourage its adoption over an allocation model.

1.0 Introduction

Water restrictions are in place for all water users, including active playing surfaces. It is essential during the drought that managers and users of active playing surfaces accept that the playing surface quality will not be as high as during non-drought conditions. However, the surface should remain in a safe condition and be maintained to ensure effective moisture absorption.

The program encourages shared use of fields that are in a safe and usable condition, and to temporarily discontinue irrigation of surfaces that (a) pose a threat to the safety of users, (b) are used infrequently, or (c) are in a condition that may require extensive remediation. This program also integrates elements of effective water and non-water maintenance activities.

Ipswich City Council controls a majority of sporting fields in Ipswich. There are three (3) levels of Sports fields. They fall into the APS categories Elite (national and international events are played), Major (state events) and Local (all other and qualify for more than 5 hours of competitive game time per week). These sporting fields make up a large proportion of the water used by Council's Health, Parks and Recreation Department.

Appendix 1, outlines the current and previous water restrictions regarding Active Playing Surfaces.

2.0 Purpose of the Pilot Programme

Most irrigation models aim to maximise productivity or turf growth and there is little information on irrigation management for sportsfields where the aim is to minimise water use while providing a 'fit for play surface'.

The two models that the QWC considered were (A) a system based on volumetric allocation and a (B) a system based on providing a 'fit for play' surface.

- Regulators prefer a system to measure compliance eg. Volumetric allocation.
- Field managers want enough water to provide the 'fit for play' surface; eg. adequate soil moisture.

(A) Volumetric Allocation

- Easy to regulate and audit for compliance.
- Calculation for the allocation based on historical daily rainfall.
- Allocation is likely to be inadequate in drought.
- Does not account for prevailing rainfall.

(B) Soil Moisture

- Can provide the aim of 'fit for play' with the minimum of amount of water.
- Requires understanding of soil profile features – texture, depth, wilting point and field capacity.

- Requires tools to measure regularly.
- Requires knowledge of irrigation system.

The QWC regulated a volumetric allocation for Local Sports – Turf Surfaces. These allocations have been extended to 30 November 2008. A new Town Water Allocation Calculator is available to perform this calculation (qwc.qld.gov.au)

2.1 Ipswich City Council Irrigation and Turf Management Principles

In drought conditions, the responsible volume and frequency of irrigation use of town water for sports fields is the least amount that keeps the surface in a 'fit for play' condition.

Turf needs a level of soil moisture above wilting point to stay alive. Turf growth correlates to soil moisture on a curve of diminishing values. In other words, turf growth increases as available soil moisture increases but then decreases as the soil profile becomes wetter for longer periods.

Additionally, excess water either runs off the surface or drains through the soil profile beyond rooting depth. Ringing true more water application does not always equal better turf quality.

3.0 Methodology

In total 15 council controlled fields were selected to trial the ICC pilot program and have been monitored closely since November 2007.

The total area of the pilot fields equals 11.33 hectares.

Parameters measured at each site are:-

- Soil moisture.
- Volume of irrigation applied.
- Rainfall.
- Area actually irrigated.

Each field was sampled for soil texture and consistency across the field. The texture provides a guide to critical soil moisture parameters such as wilting point, field capacity, and available moisture or water holding capacity.

Using the QWC Volumetric calculator, monthly allocations for each field were calculated at the 'extreme' restriction level. These values were then used in comparison with actual monthly water consumption. All values were presented as litres per square metre. This negates issues of varying areas for the fields.

3.1 Measuring Soil Moisture

Initially, ICC used the manual 'hydro sense' probes to measure soil moisture and only irrigated when soil moisture dropped to below 15% (approaching wilting point – turf starting to degrade). An irrigation volume was then determined using a turf irrigation calculator develop by ICC (refer to Appendix 2. Screen Shot of calculator). This calculator was subsequently adapted by QWC for the Volumetric Allocation Method.

To further investigate moisture technology, ICC representatives travelled to Melbourne, Victoria, where several sports fields were inspected using a permanent web based soil moisture sensor controlled irrigation supplied and installed by MAIT Industries. ICC subsequently installed the MAIT System into 6 preliminary sites (March 2008).

This system provides real time information on soil moisture, soil temperature, water flow rates and volumes which is graphically represented (refer to Appendix 3. Screen Shot of Soil Moisture Graph). The system allows for irrigation only to occur when soil moisture reaches a predetermined set point, and will not allow irrigation once a high set point is reached. These set points are specific to each field and are based on soil type. A Rain Switch was also installed on these fields which stops any irrigation in the event of rain. Also, the use of a Clegg Hammer and Cone Penetrometers to measure compaction and hardness were utilised.

The MAIT Web portal provided real time data and was used to analyse irrigation events on the pilot fields. Each Field Supervisor has access to the Web portal. Soil temperatures and two soil moisture depths enabled officers to track the effect of irrigation to the soil moisture over a period of time.

The intent is to maintain a soil moisture level of between 15% and 25%. This will ensure the turf will not degrade to an unplayable condition but allow for spare capacity to retain as much rainfall within the profile should it rain.

3.2 Measuring Irrigation

Manual water meter readings and areas irrigated were documented weekly for fields without the MAIT system and accessing data downloads where the MAIT system was installed.

Weekly readings assisted in ensuring there was no leakage and monthly totals were used in the analyses.

3.3 Measuring Rainfall

Monthly rainfall from the Bureau Of Meteorology site at Amberley was used. Variations in rainfall across the sites can be expected to give some inaccuracy until automatic rain gauges are installed at each site.

3.4 Measuring Areas Irrigated

The actual areas being irrigated were measured to enable a 'litres/$m^{2,}$' calculation. This unit of measure has the benefit of being able to add rainfall in millimetres directly as part of a water balance process as well as the ability to compare water consumption across fields of varying sizes.

3.5 Other Management Practices Applied

ICC playing surface managers are aware that irrigation is not the only requirement for maintaining playing surfaces and other appropriate management measures are important. Managers have adopted a holistic approach to the management of their playing surfaces with an emphasis on other management measures such as aeration, fertilisation, soil moisture monitoring, and irrigation system auditing.

Maintenance activities are just as important as irrigation to maintain healthy turf, and to ensure the 'playability' and safety of active playing surfaces. Activities include mechanical activities (mowing, de-thatching, and aeration), chemical applications (wetting / absorbent agent, fertiliser, and weed and pest control), periodic audit of irrigation systems, and regular leak checks.

These maintenance activities need to be carefully balanced to take into account the current stress conditions of the turf and the soils, the benefits and the economical impacts.

ICC implemented a simple system check to ensure leakage is kept to a minimum. See Table 1. below

Table 1. ICC Irrigation System Checks

Procedure		
Regular Checks	Undertake these checks on regularly (the suggested frequency of the *check* is provided). Each check should be registered in the Compliance Tool Box as they are carried out (**Part C3**).	
Check	***Description***	***Frequency***
Leakage	Check all pipes within the site for leaks. This can be done by: • These may be evidenced by pools of water that occur when there is no rain or no irrigation is undertaken. • A check of the main site meter against the irrigation meter. While no water is being used on the site, each meter can be checked to see if there is evidence of water being used (through a leak).	Weekly
	Assess individual elements of the irrigation system, such as equipment or fittings throughout the system. If faults are found, these should be repaired immediately.	Prior to each watering event
Delivery jet blockage	On each system, there may be evidence of blockage on the jets delivering water to the APS. This may be caused by build-up from the water being used, or from contact with grassed or soil surfaces. These should be cleaned frequently to ensure the correct operation.	At each watering event
Blockage to delivery stream	Irrigation equipment may be affected by objects on the hoses in the system. Remove these obstructions to ensure correct operation.	At each watering event
Pop up operation	Ensure that all pop-up sprinkler heads raise when the system is turned on. If a pop-up sprinkler head does not raise, switch off the system and determine the issue. These should be repaired as soon as possible.	At each watering event
Inline filters	Inline filters may become clogged by debris (such as soil or gravel) and should be cleared prior to use.	Prior to each watering event

4.0 Findings

The permanent soil moisture sensors were located at 6 sites initially. This report highlights the 4 sites with the permanent soil moisture system for the QWC volumetric allocation comparison. Two sites have not been included; one does not yet qualify as an APS and the other was a new field and irrigation commenced in March of this year. However ICC performed manual soil moisture readings on remaining fields and irrigated accordingly. This data is captured in a total analysis of ICC APS Water Use (Table 2).

For the purposes of analysis, it was assumed that an allocation will be used regardless of need or rainfall. ICC believes this to be a fundamental failing of a volumetric allocation system as there is no control over current conditions. We believe the assumption to be justifiable due to stated poor skills overall in club field managers by members of the TWG.

Table 2 illustrates the volume of water used on ICC fields.
From July to November 2007, ICC fields used an average of 109L/m^2. For the period December 2007 to May 2008, ICC fields used an average of 28L/m^2.

For the six month period December 2007 to May 2008, the 11.33 Ha pilot areas have saved 11.8 ML of town water supply since the introduction of the Level 6 Water Restrictions. This represents the variance between the volume of water that could have been used as allocated by QWC and actual water used.

After an initial settling of the soil moisture sensors in the Pilot Fields, irrigation data was collected and analysed to compare water use to the QWC volumetric allocation.

Table 2 highlights the variation between actual and allocated water use for each field for the periods July 2007 – November 2007, December 2007 – May 2008, and July 2007 to May 2008.

Table 2. ICC and QWC Comparison

Park	Actual Consumption (KL)					QWC Allocated Consumption (KL)			Variance
	Area Irrigated (m^2)	Jul – Nov (KL)	Dec- May (KL)	Jul – May (KL)		Jul – Nov (KL)	Dec- May (KL)	Jul – May (KL)	Dec – May (KL)
Anzac park (2)	13,100	2068	285	2353		1449	2005	3454	1720
Bill Patterson (ath)	5,300	106	0	106		663	641	1304	641
Evan Marginson (ath)	4,000	563	15	578		500	484	984	469
Jim Finimore (5)	26,000	4694	761	5455		3479	3993	7472	3232
Kippen (2)	19,500	417	559	976		2439	2358	4797	1799
Mark Marsh	21,000	943	1226	2169		2216	2982	5198	1756
RPRR (1)	7,600	70	251	321		898	1208	2106	957
Sutton (2)	16,800	2180	1317	3497		1885	2537	4422	1220
Total	**113,300**	**11041**	**4414**	**15455**		**13529**	**16208**	**29737**	11794
	Equiv. 11.33 Ha								
Total Consumption (ML) for Total Area Irrigated			**4.414**				**16.208**		**11.794**
Total Cost			$7,724.50				$28,364.00		$20,639.50
Total Saving		**$20,639.50**							
Average Savings		**$1,821.67 / HA**							
Notes:									
1. Bold type = sites with MAIT system installed 2. Cost of water = $1,750 / ML									

* The QWC allocations have been calculated at the ‘extreme’ level for the entire year. July ‘07 – November ‘07 = pre level 6 Water Restriction.

Rainfall

There was widespread good rainfall for the first three months of the Level 6 Water Restrictions which resulted in no irrigation of APS in Ipswich until March 2008. This should also have been the case across the region.

Table 3 presents the rainfall for the six months, December 2007 to May 2008 for four locations across SEQ.

The table highlights the variation of rainfall across the region and the need to have irrigation systems that respond to the current conditions. Note that millimetres of rainfall equates to litres per square metre.

Because rainfall was higher on the coastal areas than at Ipswich, the water savings in these areas would have been potentially greater than recorded in Ipswich.

Table 3 Rainfall

Monthly Rainfall for Dec 07 to May 08				
Month	**Location**			
	Amberley	Brisbane	Gold Coast	Redlands
Dec-07	123	79	130	110
Jan-08	214	184	171	241
Feb-08	141	217	148	138
Mar-08	33	42	38	55
Apr-08	12	17	84	36
May-08	17	52	48	87
TOTAL	**540**	**591**	**619**	**667**

Source: BOM website: http://www.bom.gov.au/climate/dwo/IDCJDW0400.shtml

APS Water Balance Development

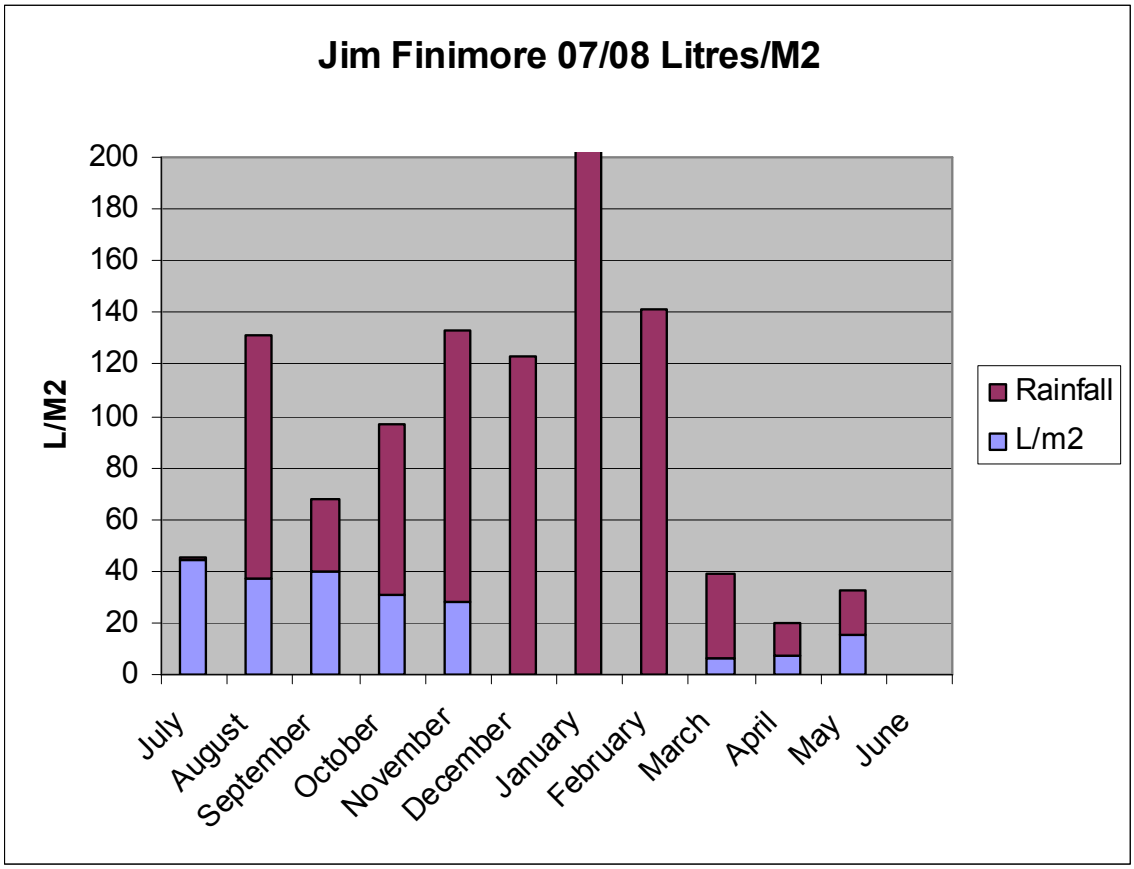
Using rainfall, irrigation, and soil moisture readings, it may be possible to develop a weekly water balance for each site. This could be useful in determining indicative irrigation requirements. That is, deriving a weekly water demand for each week of the year based on empirical rather than theoretical data. Any deficit in any week through inadequate rainfall could then be provided by irrigation to a known volume.

This approach would assist APS managers gauge the volume of water required without exceeding the soil moisture high set point. It could also provide guidance where soil moisture data is not available.

Figure 1 shows the results of using monthly data to test the soundness of this approach on five fields at Jim Finimore Park. Results are encouraging but rainfall distribution across the month can skew the data. Weekly rainfall would provide a more accurate and reliable approach.

Figure 1 – Monthly Water Balance

Jim Finimore Park Water Use 2007 - 2008
Total area = 26,000 m2



5 Recommendations

1. QWC accept this report as a demonstrated performance of soil moisture equipment in the aid of saving water on Active Playing Surfaces.
2. QWC continue the endorsement to manage irrigation of ICC sporting fields as outlined in this report.
3. QWC seriously consider applying elements of the ICC pilot program to South East Queensland regions to implement a long term water efficiency program for APS.
4. QWC work with Ipswich and other SEQ Councils to provide information to Sporting bodies to adopt the soil moisture approach. This is an opportunity to make SEQ a stand out performer in APS irrigation management as the Queensland 'Smart State' slogan suggests.
5. ICC to continue monitoring and fine tuning the system that allows smart and efficiency use of water.
6. QWC support ICC to continue to develop a water balance to turf requirements with the intended outcome of producing a guide or system to educate turf managers that do not have access to soil moisture data/equipment.

6 Conclusions

Water efficiency is becoming more important due to water restrictions continuing at level 6 and will have permanent restrictions in the long term and the cost of water is set to rise. Ipswich City Council is committed to continuously improve and adapt new water saving techniques and management practices.

As part of ICC Water Contingency Plan – a number of water end uses (demand) have been identified in order to establish the various water sources and quality available (supply). The investigation of various smart technology such as soil moisture, rain switches, flow meters, and central controlled systems on all ICC managed sports fields are part of this contingency planning.

Even with the limitation of the relatively short period of the pilot and the welcome 'complication' of good rainfall, the permanent in-ground, web enabled system has demonstrated its capacity to be an excellent platform from which to manage and fine tune irrigation management on sporting fields.

Further expansion of the system and fine tuning will provide additional water savings. Based on the massive savings demonstrated in the pilot, this system would potentially deliver massive water savings should it be applied across SEQ.

Any system can only perform to its capability when the managers have a passion and desire to fully use the system. ICC field staff have been crucial in the implementation of the systems and the authors gratefully acknowledge and thank all involved in collecting and analysing data to produce this report.

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On behalf of Ipswich City Council

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APPENDIX 1. Various APS Water Restrictions

Table of APS Water Restrictions	
Level 1 –	Sprinkler, unattended watering devices or hand held with trigger nozzle, on any day between 4am and 8am and between 4pm and 8pm, to allow competitive sport an/or to maintain ability to be used for intended active purpose. Exemptions to the restrictions may be obtained from Council, which will include the requirement for a WEMP and display a Council approved sign.
Level 2 –	Active playing surfaces can be watered before 7am and after 7pm on any day to competitive sport an/or to maintain ability to be used for intended active purpose. It is compulsory to display a sign if watering using sprinklers or unattended watering devices. Exemptions to the restrictions may be obtained from Council which will include the requirement for a WEMP by 1 December 2005 and the display of a Council approved sign.
Level 3 -	Active playing surfaces can be watered before 7am and after 7pm on any day to competitive sport an/or to maintain ability to be used for intended active purpose. It is compulsory to display a sign if watering using sprinklers or unattended watering devices. Exemptions to the restrictions may be obtained from Council which will include the requirement for a WEMP and the display of a Council approved sign. It is recommended that all properties in this category develop a WEMP that targets to achieve water savings of 20% or best practice water efficiency.
Level 4 –	N8* From 4-31 December 2006, no water to be used unless:- watering is conducted by sprinkler or hand held hose any day before 7am and after 7pm to allow competitive sport an/or maintain the ability of the sporting ground to be used for intended purpose. If a WEMP is in place, watering is in accordance with an existing WEMP. After 31 December 2006, no water to be used unless:- watering is in accordance with a submitted WEMP. Additional requirements apply if the Premises water consumption exceeds 1ML/annum
Level 5 –	From 30 April to 31 May 2007 - Where a WEMP lodged watering to be accordance with this WEMP. Where WEMP not lodged watering is in accordance with Active Playing Surface Guidelines or watering is conducted with a hand held hose or sprinkler between 8pm Tuesday until 4am on Wednesday, and allows competitive sport and/or the ability of the active playing surface to be used for it's intended purpose. After 31 May 2007, active playing surface must be registered with service provider, install a water meter, operate the installed water meter in accordance with the Active Playing Surface Guidelines, display an approved sign, and otherwise comply with any other reasonable direction of the service provider. Additional requirements apply if the Premises water consumption exceeds 1ML/annum.
Level 6 -	No water to be used unless:- APS is registered with service provider, have a water meter installed, operate the installed water meter in accordance with the APS Guidelines, display a sign and otherwise comply with any reasonable direction of the service provider.

APPENDIX 2: ICC Turf Calculator

TURF IRRIGATION MANAGEMENT TOOL
FOR ACTIVE PLAYING SURFACES

The following is self assessable tool to establish watering need at a specific loaction at a specifc time. Input required information into the grey shaded cells.

DATE:

ADDRESS:

FIELD ID:

Name of Person Responsible for this form:

Inputs		
Please Update Shaded Cells		
Input Factor	**Parameter**	**Unit**
Soil type (click on shaded cell and choose from menu)		
Irrigation Type (click on shaded cell and choose from menu)	Sprinkler	
Choose Turf Growth (click on shaded cell and choose from menu)	Moderate	
Season (click on shaded cell and choose from menu)	Autumn	
Rainfall since last Irrigation (smaller rainfall events are discounted automatically)		**mm**
Area to be Irrigated this watering		**m2**
Application Rate for Irrigation System		**mm/hour**
% Soil Moisture before irrigation		**VMC%**

DO NOT IRRIGATE IF SOIL MOISTURE IS ABOVE 15%
DO NOT USE TOWN WATER IF SOIL MOISTURE IS BELOW 5%

Calculation Sheet		
Output	**Result**	
Your Irrigation application is (mm)	**#N/A**	**mm**
Approximate applicaton time this watering	**#N/A**	**minutes**
Your indicative irrigation frequency (days) for the season is ***This frequency is a guide only and will be ultimately determined by soil moisture %***	**#N/A**	**days**
The volume of Water to be applied this irrigation is	**#N/A**	**Kilolitres**
Equivalent no daily residential dwellings for this Usage	**#N/A**	**Dwellings**

Validation Sheet		
WATER METER ID		
Water meter reading before irrigation		**Kilolitres**
Water meter reading after irrigation		**Kilolitres**
Actual Volume applied (Kilolitres)	**0**	**Kilolitres**
Volume Difference Applied Vs Plannned	**#N/A**	**Kilolitres**

APPENDIX 3 – MAIT Data Download

Jim Finimore Park Total area = 26,000m2