Re-use of Irrigation Drainage Water on Date Palms

Proof of Concept

By Dave Reilly

October 2015

Foreword

Given that Riverland irrigators are among the worlds' most technologically advanced and efficient, it is surprising that the significant volume of irrigation drainage water created each year is not available for additional food and fodder crops. Instead it is treated as a pollutant and disposed of at significant cost. For regional drainage schemes, this waste water is pumped into large shallow lagoons at sites such as Noora Basin and Kataraptko Island where it is allowed to evaporate. Seepage into the ground water and environment is known to occur.

Drainage water from irrigation districts throughout the Riverland is so undervalued that it is not metered. At best, volumes are estimated from power usage of the pumps used for disposal. Given the technological excellence of on-farm water metering, it is surprising there isn't any volumetric metering of regional drainage water collection schemes. It is hard to manage what isn't measured.

Typically irrigation drainage water is moderately saline. The degree of salinity varies with location and through-put. Readings from caissons in the Loxton/Loxton North districts in August 2015 ranged from 1282 – 5300 and averaged 2178 EC units. This is well within the tolerance of several selected plant species capable of producing food, oil and fodder. There are many examples in Australia and internationally of producing crops using a saline water supply.

This report investigates the utilisation of irrigation waste water for the production of date palm fruit. Re-using drainage water in agriculture adds economic value and employment opportunities whilst minimising negative environmental impacts. It also improves the regional irrigation efficiency.

Acknowledgements

- Darren and Tara Pfeiler for allowing this project to be conducted on their property and Darren's assistance with managing drainage water and installing irrigation meters, etc. Thank you.
- Loxton to Bookpurnong Local Action Planning committee and Project Manager Craig Ferber for supporting this project and lodging the funding application.
- Natural Resources SAMDB – thank you to Tony Randall and Mark May (Sustainable Farming Program) for financial and technical support, in particular Mark May for collecting and organising water and soil sampling.
- Central Irrigation Trust Management and Steve Heinicke who very kindly allowed us to accompany him while monitoring drainage water caisson and providing background information on salinity and volumes.
- Edward Scott BSc, Injekta Field Systems – for supplementary report and overview of this project.
- Thank you to Anita and Brian Reilly for their assistance in collating this report.

This project is supported by the Loxton to Bookpurnong Local Action Planning Committee through funding from the Australian Government's National Landcare Programme and the South Australian Murray-Darling Basin Natural Resources Management Board.

Australian Government | National Landcare Programme

Government of South Australia
South Australian Murray-Darling Basin Natural Resources Management Board

Natural Resources SA Murray-Darling Basin

Loxton to Bookpurnong Local Action Planning

GURRA DOWNS

Jireh Citrus

Abbreviations

EC – Electrical conductivity

CIT – Central Irrigation Trust

CSIRO – Commonwealth Scientific and Industrial Research Organisation

GDDC – Gurra Downs Date Company

Ha - hectare

Kg - kilogram

Kl - Kilolitre

LAP – Local Action Planning

LBLAP – Loxton to Bookpurnong Local Action Planning committee

Mm - Millimetres

ML – Mega litre

NRM – Natural Resource Management

Natural Resources SAMDB – Natural Resources SA Murray-Darling Basin

PIRSA – Primary Industries and Resources South Australia

Ppm – parts per million

SA – South Australia

SIS – Salt Interception Scheme

UAE – United Arab Emirates

USA – United States of America

Contents

Introduction

This project looks at in-field trialling of the re-use of irrigation drainage water. The project monitors and reports on the application of drainage water to irrigate date palms to grow a secondary crop, date fruit. It assesses water quality, plant and soil health and the capacity of the date palm to produce fruit on a commercial basis.

This report fills knowledge gaps in the application of drainage water to date palms and demonstrates 'proof of concept'. It provides baseline data on salinity, Boron and pH readings of drainage water; assesses impacts on soil conditions at re-use sites; and assesses date palm performance under these conditions. It investigates the threshold limits of the date palm to tolerate salinity.

The project ran from 1/11/2014 to 30/06/2015.

How this project came to be

Male date palms produce only pollen (no fruit). The pollen is produced in large spathes (pods) and is collected at flowering time. Pollen is needed to set fruit on female date palms. Dave, Anita and Shaun Reilly from the Gurra Downs date farm regularly drive past several large date palms on a citrus property north of Loxton. The Reilly's saw these palms as a source of pollen for their commercial date palm plantation.

In 2013 they met with farm owner Darren Pfeiler of Jireh Citrus. Darren agreed to the Reilly's pruning the overgrown palms and collecting pollen from the males. Of the five palms, three are male and two are female. Darren said that for the past four years the palms had been irrigated with water from a private drainage system beneath his citrus block.

The Reilly's saw this as an opportunity to add value to irrigation drainage water whilst disposing of waste in an environmentally responsible way. The experiment of growing dates over a season could also be documented for the wider community.

The Loxton to Bookpurnong LAP committee supported the project and Project Manager Craig Ferber applied for funds of $4000. This project is supported by the Loxton to Bookpurnong Local Action Planning Committee through funding from the Australian Government's National Landcare Programme and the South Australian Murray-Darling Basin Natural Resources Management Board. Natural Resources SAMDB Sustainable Farming team assisted in the design of the project and provided many hours of support with collecting water, soil and fruit samples for analysis.

Jireh Citrus

Dave Reilly, Darren Pfeiler, Shaun Reilly, Darren Harding.

Before clean up

After

Who this report is targeted at

The report serves the irrigation community by exploring the possibility of re-using waste water on a salt tolerant crop type that can provide an economic return. It will be of interest to stakeholders who contribute to the creation, management and disposal of waste water. This includes irrigators, water delivery providers, managers of drainage water collection and disposal, government agencies and local council. It has application for private irrigators responsible for on-farm disposal of saline drainage water and regional drainage schemes covering hundreds of irrigation properties. It will also be of interest to irrigators relying on a saline water resource such as bore water.

Objectives

- Create discussion on the existing disposal of drainage water
- Present alternative re-use options for irrigation drainage waste water
- Recognise opportunity for this resource
- Create an economic return from the waste stream
- Increase existing regional irrigation efficiency
- Reduce negative impacts on the Riverland environment

Background

Applying more irrigation water than is actually used by the crop is a necessity. This is known as ‘the leaching factor’. Water is a precious resource and a significant input cost to irrigation businesses. The majority of modern day irrigators are very efficient at managing their crop water requirements but without periodic over-watering (leaching), salinity can build up in the soil profile. This can reduce plant vigour and yield.

It is accepted among horticulturalists that 90-95% irrigation efficiency is ideal practice. The 5-10% leached beyond the root zone is referred to as irrigation drainage water and is considered a waste. It needs to be managed to prevent raising the water table. There is a cost involved with installing and maintaining a subsoil drainage system which disposes of drainage water to a suitable refuge.

Not all irrigation land is serviced by a drain. Deep, well-draining soils may not require a drainage system as there are no negative impacts such as a high water table or salinity build-up. Drainage water is still being generated – it’s just moving off site. Groundwater usually manifests itself as seepage along cliffs and banks, re-entering the river system. Salt Interception Schemes targeting prime high impact seepage sites adjacent to the river are proving to be very useful at intercepting highly saline groundwater and re-directing it to the Noora Basin.

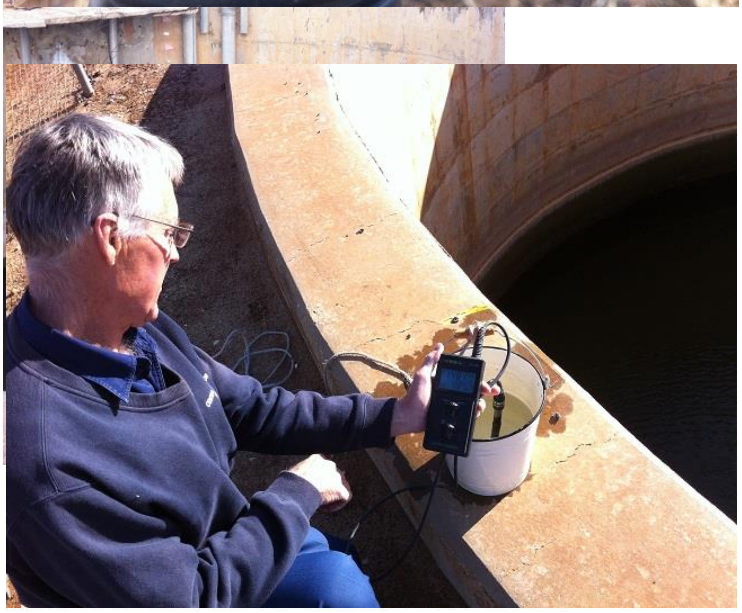
Major rainfall events can add to volumes. Historically irrigators have used flood, furrow and overhead sprinkler irrigation to apply water. Water was delivered to farms through open concrete channels which leaked. After decades of irrigation, a high water table began to threaten productivity. By the mid 1960’s an extensive drainage system was installed throughout the Loxton/Loxton North irrigation district. This scheme has operated for the past 50 years. Drainage water collected in caissons is pumped to Kataraptko Island through pipes under the River Murray. Other districts dispose of drainage water in local evaporation lagoons but the majority is pumped out to the Noora Evaporation Basin.

A brief description of the design and function of a drainage system

A trench is dug across the irrigated area allowing groundwater to run down a slight gradient into it. The trench is fitted with a slotted poly hose or clay tiles and backfilled with coarse sand to create permeability in the soil profile. Irrigation water not used by the crops and large rainfall events are channelled into sumps connected to large caissons from where it is pumped off-site. The drainage system is installed at a depth such as to allow an ideal root zone function for the crop. 1-2 metres is common.

Slotted poly drainage hose installed beneath crop root zone. This collects and runs drainage water into sumps.

Regional schemes connect a series of sumps and run into large caissons.

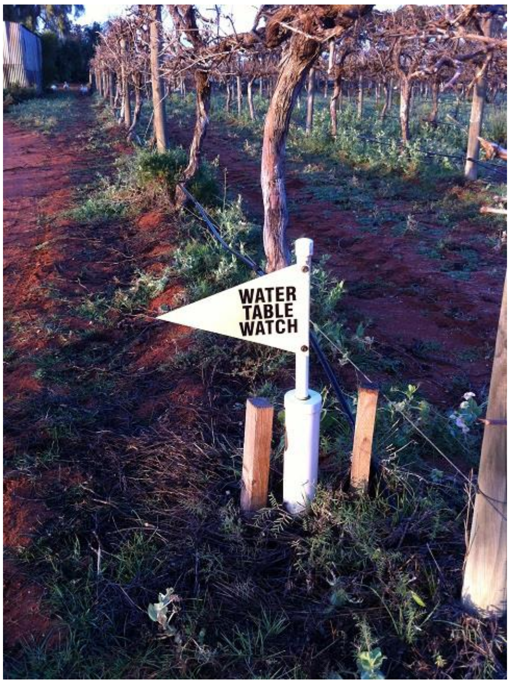


Visiting active caissons in the Loxton drainage scheme with Steve Heinicke from Central Irrigation Trust on August 20, 2015.

District Salinity Monitoring results:

Caisson #	EC reading
LX3	5300
LX4	1282
LX5	1665
LX6	2140
LX7	1462
LX8	1850
LX10	1550
Average	2178

In the late 1990's, the Local Action Planning groups in the Riverland partnered with Government to run a water table watch program. This saw the installation of hundreds of floating flags on privately irrigated properties. The floating flags rise to indicate the height of the water table. This practical monitoring device helped educate growers about high water tables created by over-irrigation. This supported the transformation towards regional high irrigation efficiency. Drainage water has significantly reduced in volume over the past 1-2 decades. Drip technology replaced flood, furrow and sprinkler irrigation. Continuous soil moisture monitoring eliminated over-irrigation.



Floating flag rises to indicate high water table alerting farmer of problem.

Previous Studies

An investigation into “The Feasibility of Drainage Water Re-use in the Golden Heights Irrigation Area” was undertaken in 2004-2005 by CSIRO Land and Water, and Ken Smith Technical Services.

The Golden Heights Irrigation Trust was engaged to measure flows, salinity and pH of drainage water between December 2005 and December 2006. “Feasibility of Drainage Water Re-use throughout the Golden Heights Irrigation Drainage Bore Network Extension project” (February 2007) assesses the technical and agronomical feasibility of re-using approximately 140ML of drainage water. Crops under consideration were lucerne, olives, pistachios and date palms.

The report from this investigation provides a comprehensive guide to the seasonality of drainage water availability, and recorded data on typical salinity, pH and Boron levels of the drainage water. It assesses the impacts of irrigation at the re-use site. It is recommended for its technical merit and as a template for future study of drainage water projects. A copy of this report is available from Riverland West Local Action Planning Association.

Regional Drainage Volumes

Drainage water disposal remains a requirement even though volumes have greatly reduced in recent decades. High pressure PVC mains have replaced leaky concrete channel delivery methods; dripline technology has replaced flood and overhead sprinkler irrigation; water restrictions and high water prices during the millennium drought resulted in growers focussing on efficiency.

In 2001, the Loxton/Loxton North districts generated 2067 mega litres of drainage. Today’s volumes are much lower. In 2013, 358ML was collected and in 2014, 360ML. A total of 3254 hectares is serviced by the Loxton drainage scheme. Given the reduction, some may argue that no further refinement is necessary. However 360 mega litres (360,000 kilolitres) is still a substantial yield and by comparison is approximately double the volume of the Loxton township waste water which is treated and re-applied to horticulture. (Appendix A: Loxton Irrigation Area)

The volume of drainage water collected each year is variable and rain events can add significantly to the base load of leaching irrigation water. For example an additional 60 mega litres was received in the Loxton scheme in February 2014 following a 114mm drenching.

It is difficult to estimate the total volume of drainage water collected throughout the Riverland each year. Surprisingly there is a regional absence of metering of waste water. Most of the major collection and disposal systems are unable to provide exact volumes of waste water managed. At best, volumes are calculated from electricity usage of caisson pumps. There is currently no automated volumetric metering of regional drainage systems in the Riverland. Volumes of drainage water actually collected by each Riverland scheme can only be estimated.

Central Irrigation Trust manages 14,000 hectares of irrigation serviced by regional drainage schemes at Loxton, Berri, Cadell, Chaffey, Cobdogla, Moorook and Waikerie. Renmark Irrigation Trust also manages significant areas. Other drainage schemes include Golden Heights, Sunlands and Rilli Reserve.

Numerous privately operated drainage systems on irrigated developments operate independently of the regional schemes. For private irrigators, on-farm disposal is at the individual’s discretion and may involve pumping to a dam for evaporation or application to native trees and shrubs. Irrigation drainage water quality varies with salinity levels. Careful consideration of the salinity and Boron tolerance of plant species is needed.

It should be noted there are legislative requirements for waste water disposal which are enforced by the Environmental Protection Authority. A designated disposal site needs to be approved, managed and monitored to remain compliant (Appendix L).

The Date Palm

Dates are among the world's oldest cultivated fruit and were domesticated in Mesopotamia (now Iraq). Archaeological evidence indicates date cultivation began at least 8000 years ago. The date palm (*Phoenix dactylifera*) has long been an integral part of desert culture. This versatile tree provides food, building material, shade, fuel and an income source. In the desert environment human survival depended on the date palm – thus it earnt the reputation as the "Tree of Life". To this day, many cultures still celebrate its heritage.

In modern times the date palm is cultivated in over 40 countries. With approximately 800,000 hectares under production, annual production is 7.3 million metric tonne (FAO 2010). Date palms are widespread in North Africa, the near and Middle East and southern Asia. Over the last century, date production has been introduced into new world locations including the USA, Mexico, South Africa, India and Australia.

The geographic distribution of commercial date production is concentrated in semi-arid or arid regions with an abundant water supply. The best date growing districts are characterised by having long, hot, dry summers with minimal rainfall. In recent years, enterprising farmers in tropical countries like Thailand and Indonesia have established production during the dry season using specially selected varieties.

The date palm is more than a fruit tree – it is considered a "Blessed Tree" having pre-eminent religious significance. Dates have found a place in scriptures - the Quran, the Bible and the Vedas. During the holy month of Ramadan, dates are eaten to break the daily fasting. This is one of several events celebrated by various religions and cultures which lead to a high period for date sales and consumption on world markets.

Dr Paul Popenoe in his 1924 book "The Date Palm" stated 'since the beginning of written records it (the date palm) has been prominent as a means of sustenance, a source of materials for manufacture, a fount of beverages and an object of worship for many peoples.'

There is a range of date fruit styles/types – *khalaal* or fresh dates (50% moisture, firm and crunchy), *rutab* or ripe dates (30-35% moisture, high sugar) and *tamar* or cured dates (10-15% moisture, very high sugar, very long shelf life). However, not all of these types are readily available in Australia.

Dates have excellent health and well-being attributes. They are a particularly sweet and satisfying food thanks to their natural sugar and fibre content. The fibre moderates the speed at which energy from the sugars is released, so that dates make a good energizing food for snacks and for eating both before and after exercise. The natural sugars have a soothing influence by helping to raise levels of calming serotonin in the brain. Dates contain beta-carotene, vitamins B6 and B3 (niacin), which helps maintain healthy skin and nervous and digestive systems.

Global date production occurs almost exclusively in the northern hemisphere. North Africa and the Arab States, Egypt, Saudi Arabia, Iran, UAE, Pakistan and Algeria are the largest producers. Much of this production is for local consumption, however Iran, Pakistan, Tunisia, Saudi Arabia, UAE, Iraq and Algeria are the major exporting countries by volume. The USA and Israel are smaller producers but achieve the highest export unit value.

The market for date fruit in Australia is based around imported fruit as the Australian date industry is still in its infancy in terms of production. Australian imports of dates have shown significant growth from 4,961 tonne in 2003/04 to 7,222 tonne in 2006/07 but fell back to 5,049 tonne in 2007/08. It is not clear whether this decline in 2007/08 is due to a supply problem or a demand issue. Most Australian imports of dates come from Iran (74% of supply in 2007/08) with the remainder mostly from the USA, UAE, Mexico, Israel and Tunisia.

(Reilly, D., A. Reilly, I. Lewis. 2010 "Towards an Australian date industry: an overview of the Australian domestic and international date industries")

Shaun Reilly, Gurra Downs

Characteristics

The date palm has a cylindrical trunk and grows to a height of 30 metres over a century. Fruit is formed in bunches which hang from the crown of the tree.

The date palm is a hardy plant species which can survive periods of both water-logging and drought. It occurs naturally around water sources such as springs, seeps, riverbanks or high water tables. It has a high tolerance to elevated salinity and boron levels although fresh water is better for commercial fruit production. With the use of a saline water source some yield loss can be expected, however the date palm will still produce fruit.

Australia has a long heritage with date palms resulting in well-established populations which can still be seen along outback transportation routes. Their survival at abandoned homesteads and in remote settings bear witness to their ability to withstand drought and their adaptability to a wide range of environmental conditions.

Salinity Tolerance

Given drainage water is typically saline in nature, careful crop selection is imperative. There are a few crop species suitable for saline conditions. See below, salinity tolerance of selected crops.

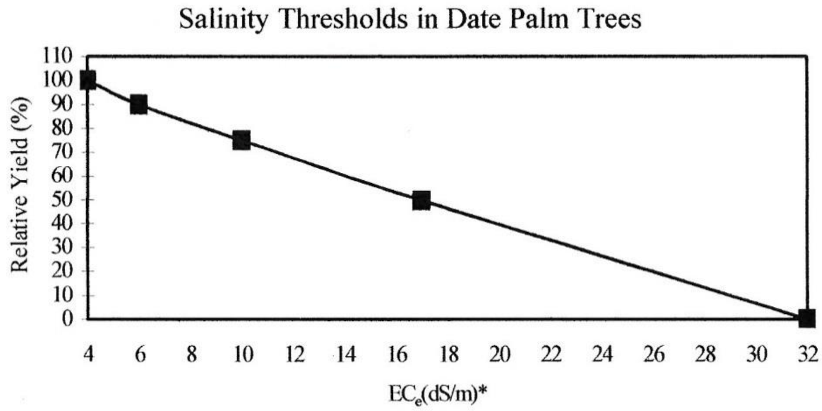
SOIL SALINITY – TOLERANCE OF SELECTED CROPS

	Yield Decrease Expected			
	0%	10%	25%	50%
CROP	Soil ECe-deciSiemens per metre (dS/m)			
Almonds	1.5	2.0	2.8	4.1
Apple	1.7	2.3	3.3	4.8
Apricot	1.6	2.0	2.6	3.7
Avocado	1.3	1.8	2.5	3.7
Cherry	1.6	2.1	2.8	4.1
Citrus	1.7	2.3	3.2	4.8
Olives	2.7	3.8	5.5	8.4
Peach	1.7	2.2	2.9	4.1
Pear	1.7	2.3	3.3	4.8
Pecan	2.0	3.0	4.5	7.0
Pistachio	4.0	4.5	5.0	6.0
Plum	1.5	2.1	2.9	4.3
Walnut	1.7	2.3	3.3	4.8
Winegrape	1.5	2.5	4.1	6.7
Barley/Canola	8.0	10.0	13.0	18.0
Beans	1.0	1.5	2.3	3.6
Carrots/Onions	0.9	1.7	2.8	4.6
Clover	1.5	2.3	3.6	5.7
Lucerne	2.0	3.4	5.4	8.8
Potatoes	1.7	2.5	3.8	5.9
Tall Wht Grass	7.5	10.0	13.0	20.0
Waxflowers	1.1	1.8	2.8	4.3
Wheat/Sorghum	6.0	7.4	9.5	13.0
* Date Palms	4.0	6.0	10.0	17.0

* Source: Emirates Centre for Strategic Studies and Research

SOURCE: Primary Industries and Resources SA
Irrigated Crop Management Service
Rural Solutions
Loxton Centre

A simple Google search will identify a significant number of scientific papers on the salinity tolerance of date palms. Many of these originate from Arab Gulf countries where sea water intrusion into fresh water aquifers is problematic. Ground water used for agriculture in the Middle East has salt content which commonly varies from 4,500 – 15,500 EC units.



*EC_e(dS/m) = Electrical conductivity of soil paste extract in deciSiemens per meter
Source: Adapted from Ayers and Westcot, 1985.

(Dakheel, A. "Date Palm and Biosaline Agriculture in the United Arab Emirates")

Dave Reilly reviewing plant performance at the International Centre for Bio-saline Agriculture, UAE (2012).

The International Centre for Bio-saline Agriculture is trialling date palms at 5,000, 10,000 and 15,000 EC units. This institution is a fantastic resource as it assesses a large range of salt tolerant fodder and food crops from all over the world.

Riverland irrigators Dave & Anita Reilly (2014) growing commercial date crops using Gurra Wetland water source. Salinity levels variable, usually ranging 2,000-3,000 EC's but up to 5,800 in 2010.

Coward Springs (SA) (2015)
These palms are being grown with Great Artesian water, Lake Eyre South on the Oodnadatta Track, 5536 EC units. Note accumulated salt on soil surface.

Winkie woodlot - Using winery waste water typically high in potassium and highly variable in pH levels. (2015)

Site description

The project site at Jireh Citrus is located on Bookpurnong Road, Loxton North. A private drainage system is installed beneath a mature orange orchard and drainage water is collected and gravity fed to the lowest sump pit. A submersible pump operates on a float valve and pumps it through a 25mm pipeline about 75 metres up a slight gradient to the date palms. Low-throw sprinklers and a partially open end tap deliver the water. A meter has been installed to measure volume of water delivered.

Drainage sumps which service citrus orchard, date palms in background. (2014)

One of the Jireh female palms in fruit. Protective bags eliminate bird and insect damage. (2015)

Methods used

Analytical data was collected at the start and throughout the project. The following samples were collected. Sample results can be found in the Appendix.

14/01/2015 - Drainage water sample

16/01/2015 - Nematode testing

30/01/2015 - Leaf tissue sample

17/02/2015 - Microbiology sample

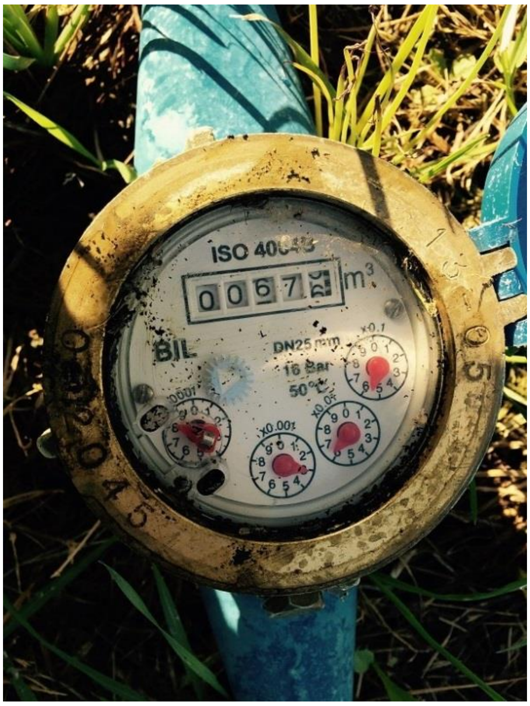
22/02/2015 - Soil sample

13/03/2015 - Drainage water

15/06/2015 – Leaf

25/06/2015 – Soil

30/07/3015 – Fruit



Flow meter measuring volume

Water samples were collected from drainage sump and analytical values assessed against Murray River water.

Leaf tissue analysis performed at beginning and end of project examined nutrient levels contained in the date palm fronds. This were compared with data from date palms grown with fresh Murray River irrigation water.

Soil samples collected at the beginning and end of the project were examined in particular for levels of salinity, boron and pH. Samples were taken throughout the soil profile to a depth of 90cm and extracted by core hole punch. A soil microbiology report looks at soil biota. Drainage water has been applied for the last 4 years.

Soil and plant performance specialist Ed Scott BSc. from Injekta Field Systems was commissioned to provide an independent overview of project outcome and to identify potential risks to soil and plant health using drainage water to irrigate long term. (See Supplementary report page 24)

Mark May (Natural Resources SAMDB Sustainable Farming Project Officer) taking soil core samples January 2015.

Fruit samples were tested for analytical composition to identify if there were higher levels of salts etc. Fruit quality was also tested for appearance and taste, and fruit bunches were counted and weighed.

Mark May (Natural Resources SAMDB), Lindsay Dowley (LBLAP), Matthew Dowley, Darren Pfeiler (Jireh), John Kelly (LBLAP), Dave Reilly (GDDC), Tony Randall (Natural Resources SAMDB). (2015)

Results and Findings

A total of 675 kilolitres was applied to the 5 mature date palms between November 2014 and 30th June 2015. This translates to approximately 135 Kl per palm and compares favourably to a requirement of about 129 Kl per palm (based on 15.87 ML/ha Ken Smith Technical Services). Salinity readings were 2140-2250 EC units.

At times it appeared the date palms were being overwatered and the drainage water was briefly redirected to native vegetation. These intervals did not register on the meter but it is estimated a further 20% of drainage water was available but not required.

At an early stage of the project, leaf tissue samples from the palms indicated some nutrient deficiencies – mainly calcium, zinc, iron, magnesium and manganese. Fertiliser was applied during February and a subsequent leaf test in June reflected some improvement. It is assumed that nutritional deficiencies affected the performance of the date palms with reduced fruit yield.

Yield from the two female palms were 58.5kg and 44kg. Each produced 5 fruit bunches. In comparison, commercial date growers would aim for around 90kg per palm from 10-12 fruit bunches. The Jireh female palms originate from seed whereas selected elite cultivars are used to establish commercial plantings. With time and management these Jireh females will increase output. New plantings however, should be based on elite commercial varieties aligned with market demand for end product.

Given the salinity of the Jireh irrigation drainage water is only 2140-2250 EC units which is consistent with water quality from the Loxton drainage scheme at an average of 2178, date palms are highly suited to perform under these conditions. International scientific research publications indicate there is no yield loss on water quality less than 4,000 EC units. At 10,000 EC units a 25% yield loss can be expected.

Based on the results of this project we are satisfied that it is possible to re-use irrigation drainage water to grow date palms and produce fruit.

A supplementary report by Edward Scott

Review of Soil/Water and Plant Analytical Data

Compiled by Injekta Field Systems Pty Ltd
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The analytical data and information was presented to Injekta Field Systems to assess the information for possible immediate and long term issues or potential risks with the soil condition, water quality and plant and fruit quality.
A collection of 2 soil samples, 2 plant tissue analysis, 2 water samples, 1 microbiological activity sample, 1 nematode analysis and 1 fruit quality analysis were provided for review.

Soil Analysis

pH of the soil: The pH of the soil is strongly alkaline (pH H_2O – 9.48, 9.22) which will impact on biological functionality in the soil and nutrient availability (refer Figure 1).

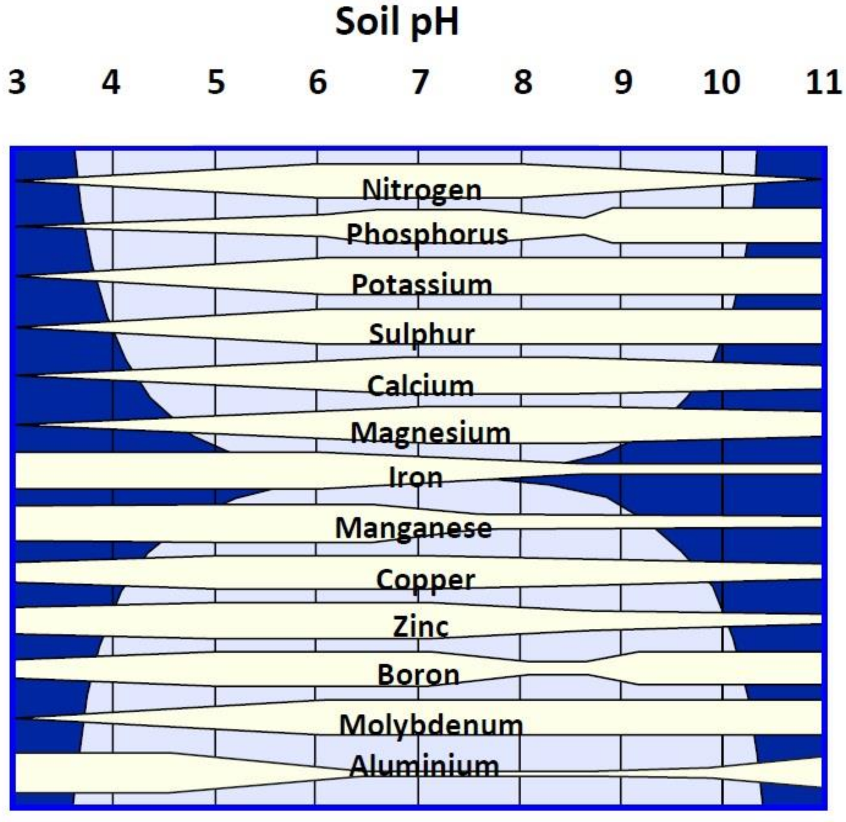

Figure 1: Nutrient availability in relation to soil pH Chart. (wider bars indicates higher availability of the nutrient, narrow bars indicates low nutrient availability)

Electrical Conductivity (EC): The EC of the soil is elevated at 0.2dS/m for general agronomic crops however the tolerance for Date palms is significantly greater therefore the osmotic stress (water stress) will not be as significant for the Date Palms.

The phosphorus and nitrogen levels are low in this soil and the phosphorus availability will be limited by the high pH of the soil. The sulphur levels are marginal and should also be monitored and managed.

Cation Exchange Capacity (CEC) and Exchangeable Cations – Due to the clay content of this soil this soil has a high capacity to retain positively charged nutrients (Cations). In the cation analysis it is evident that there are high reserves of calcium, magnesium and sodium however the potassium levels in relation to these other cations is relatively low.
Due to the nature of this soil being high in pH and the elevated level of sodium in the soil, the availability of the calcium in reserve will be comparatively low in relation to the sodium. This is due to sodium being weaker in its absorption to clay particles than calcium.
The elevated sodium in this soil will impact on the soil structure. When the Exchangeable Sodium Percentage (ESP) is greater than 6% the soil is considered sodic. This soil is currently at an ESP level of 4.8% which will result in some soil structural decline and should be continually monitored. Soil structural decline results in the fine clay particles breaking apart and blocking soil pores which impacts on water infiltration into the soil. The ESP can be managed and improved in this case by calcium based amendments.

In the micronutrient analysis it is evident that there are low levels of zinc, copper, manganese and iron. These are all plant essential nutrients and should be managed especially due to their low availability in high pH soils. The boron levels are high in this soil and the levels are reflecting the boron contents in the applied irrigation water. Boron is toxic to many plants at high levels and has capacity to accumulate at depth in the soil profile.

The key factors for management in this soil will be to manage the plant available nutrition due to the limitations imposed by the high pH of the soil. Furthermore monitoring the accumulation of sodium and boron in the soil profile.
The current soil analysis has focussed on a general sample collected via core sample from 0-90cm in the soil profile, this provides an 'averaged' assessment of the soil condition but any excessive values will effectively be diluted across the 0-90cm sample. We would advise that individual soil tests should be collected at multiple depths down through the profile, determined by soil horizon. For example if three to four soil samples were collected from 0-10cm, 10-40cm, 40-60cm, 60-90cm etc, insight can then be provided to assess accumulation of nutrients down through the profile. As Date Palms and also the surrounding citrus trees have capacity to have deep root systems there may be accumulation of nutrients at varying layers in the profile that may impact on long term production.

Soil Biological Analysis
In the nematode analysis the Date Palm sample had low levels of nematodes which is positive, however as indicated above, the soil nutrition needs to be monitored and maintained to ensure proliferation of nematodes does not occur in the date palm roots.
The control sample had high levels of pin nematode (*Paratylenchus*). Monitoring over time of the Date Palm site will highlight if any increase in pin nematode numbers occurs however from this analysis limited impact on Date Palm health and vigour is being influenced by the presence of nematodes.

In the Microbial Activity Indicator analysis the overall microbial activity was low. Due to the low carbon content of the soil (0.5% Organic Carbon) there is limited 'feedstock' for microbial respiration. Furthermore due to the nature of the soil structure which is low to poor due to the elevated sodium content the porosity of the soil is low which provides a less favourable environment for beneficial biological proliferation and the functional diversity of biological species. The soil and irrigation water Electrical Conductivity (EC) will also impact on microbiological performance due to the osmotic stress imposed by elevated 'salt' content in the soil and water. Improvement of the overall soil structure, organic matter and soil nutrition will improve the microbial activity in this soil.

Water Quality Analysis

The water quality data collected indicates the pH of the water is alkaline ranging from pH 7.9-8.2 and has a Langier Index of 0.49-0.74. When the Langier index is a 'positive' reading it means the water may deposit lime scale in irrigation lines – which is manageable. The water has high levels of bicarbonate and carbonate which will contribute to scale deposits and can also bind with positively charged nutrients (such as calcium, magnesium, potassium, zinc) in the soil.
The sodium levels in the water analysis range from 436-475 and the Chloride levels are at 224-257mg/L which are high readings and may lead to accumulation in the soil profile if not leached through the soil system. The elevated sodium and chloride levels contribute to the high Electrical Conductivity (EC) reading of 2140-2250µS/cm which is also relatable to the Total Dissolved Solids (TDS) of 1200ppm. These high levels classify the water as saline irrigation water however Date Palms have high capacity to tolerate and thrive in saline conditions.
In the water analysis the boron levels are high at 4.1-6.86mg/L which is reflecting the elevated levels in the soil. The boron levels may be accumulating at depth and then being cycled around with the water so it will be important to assess if the boron levels in the water accumulate over time or if it remains at a steady level to ensure greater concentrations aren't accumulating in the topsoil. However as indicated in the Soil Analysis section, testing down through the soil profile will highlight any accumulation of these salts or boron in the soil profile.

Plant Tissue and Fruit Analysis

The plant tissue analysis showed the overall nutrition from the leaf samples was low. The target ranges provided by the laboratory analysis were for miniature date palm (*Pheonix roebelenii*) however still provides a reasonable guide and insight into the plant nutrient status and distribution of nutrients in the plant. The calcium, magnesium, phosphorus, nitrogen and sulphur levels are all low, and the potassium levels are marginal to low. The micronutrients present in the plant reflect the soil condition where the zinc, copper and manganese are all low. The boron level are however not accumulating in the plant tissues which is beneficial for the Date Palms and highlights the potential capacity for date palms to regulate and exclude boron from accumulating in the plant tissues.

The results from the fruit analysis have been compared to U.S Department of Agriculture Data (National Nutrient Database for Standard Reference) on Medjool Date quality and nutrition information. The comparison of Jireh Date fruit and Medjool data is tabled below

Table 1: Jireh Date Fruit Nutrient Analysis

Date Fruit Quality Analysis		
	Jireh Date Fruit	**Medjool**
Calcium (mg/100g)	31	64
Magnesium (mg/100g)	60	54
Sodium (mg/100g)	0.79	1
Potassium (mg/100g)	684	696
Phosphorus (mg/100g)	51	62
Iron (mg/100g)	0.71	0.9
Medjool data sourced from USDA National Nutrient Database for Standard Reference Release 27		

From the comparison between the Jireh Fruit and the Medjool Data it is evident that the nutritional quantities are of comparable densities identifying the fruit quality is being maintained under the current growing environmental conditions.

Curiosity of the Jireh date palms

Given that each of these palms originates from seed it is true to say that each is a new variety in its own right. Any traits from parent trees if known, cannot be presumed on a new seedling as it resulted from the contribution of both a male and female parent. The sex of the seedling is not established until the seedling matures and produces flowers. Quality remains unknown until the first fruits are tasted. And so it was with the female palms at Jireh.

Immature fruit

Ripening fruit

Ripe fruit (2015)

The Jireh palms produced medium-sized bunches of fruit which ripened from green to orange to red, through to a dark purple/black skin colour. The fruit was solid medium in size and elongated in shape. It was very high in moisture content and best enjoyed fresh - or frozen in the fresh stage and eaten direct from the freezer. Flavour is complex but sweet with a hint of sarsaparilla. Favourable comment was received from samplers. This date is not suited to drying due to high level of fruit moisture which causes skin separation and results in poor storage outcome.

The overall health and vigour of the Jireh palms was reflected in the prolific flowers produced by the male palms. Flowering occurred in spring and also autumn. This double flowering is unique as Northern Hemisphere palms flower just once a year in spring. One male palm produced very large flowers which were loaded with pollen. It bears so much pollen that it has been selected for micro-propagation and included in commercial pollinators for the Riverland.

Dave Reilly and Darren Pfeiler with male flower spathe at Jireh (2014).

Economic Summary

Farm-gate price for Riverland grown fruit averaged $15/kg in 2015. Production of dates is a new commercial activity for the Riverland. While production remains small, there is high demand for fruit. With an increasing number of palm trees reaching maturity, long term pricing is difficult to forecast. Australia is almost entirely reliant on imported dates (approximately 5000-7000 tonnes Source: ABS 2007/08) and this provides opportunity for import replacement.

The aim of this project was to establish that it is possible to re-use drainage water to grow dates. It was never intended to generate fruit sales from this project however if we assumed these were elite varieties also worth $15/kg then the two female palms at 58.5kg and 44kg respectively would have grossed $1537.50. If a new date palm disposal site was to be established then elite cultivars would be selected and the ratio of male to female palms would be 1:15. Yield of the best female palm was 58.5kg which is modest in comparison to a fully commercial plantation which may average 90kg/palm.

Implications

Pressure on water resources can only increase over the medium to long term. It is important that a currently poorly valued resource in waste water is granted appropriate appreciation. The total volume of waste water produced annually throughout the Riverland is substantial. It presents an opportunity to recycle and convert waste into iconic production on irrigated farms.

Aspirations to world-best irrigation efficiency cannot be achieved while this bi-product of our irrigation communities is not being utilised. There are many international examples of saline water being used in agriculture.

The Riverland could lay claim to irrigation best practice by simply re-using this waste water. In the case of the Loxton Drainage Scheme, 25 hectares strategically located adjacent to existing infrastructure should enable utilisation of approximately 350 ML of this resource.

Date palms, lucerne, olives and pistachios are all capable of crop production under these moderately saline water conditions. Some risk mitigation measures at early adoption stage would be wise. Access to fresh Murray River water would allow soil moisture levels to be topped up during low drainage water production times and periodic leaching of accumulated salts.

Unlike town effluent waste water, irrigation drainage water does not require expensive treatment before it is re-usable for irrigation.

Recommendations

- Install loggers at each of the regional drainage schemes to measure discharge volumes. Ideally these data loggers would also record salinity values. For private on-farm disposal systems a simple flow meter is inexpensive and will provide valuable data for on-farm irrigation management. The meter installed on the Jireh discharge line (25mm) cost approximately $200 (Photo page 23)
- A regional audit of drainage water throughout the Riverland is desirable. It should include a review of volumes, water quality, current disposal methods and environmental impact. Some of the older schemes which are 50+ years old are still disposing of this waste water stream into the Murray River floodplain environment.
- A strategic re-think of how we manage drainage water needs to occur. The majority of the modestly saline drainage water is pumped many kilometres to the Noora Evaporation Basin. This site also receives hyper-saline ground water from salt interception schemes. Unlike irrigation drainage water, hyper-saline SIS water is not suitable for agriculture. These two waste water streams need to be kept separate.
- An environmental impact study needs to be undertaken on the effects on groundwater movement, from removing the volumes of drainage water pumped to the Noora Basin site.
- A list of crop/fodder plant species which have the necessary salinity tolerance to be economically suitable for irrigation with drainage water needs to be compiled.
- Assess each of the irrigation districts serviced by drainage schemes for re-use capability. Farmers who already grow lucerne, olives, pistachios, dates etc would welcome additional water if the price was favourable.

- Environmental impacts on any proposed new site for recycling drainage water for horticulture should be investigated.

About the Author

Dave Reilly, Gurra Downs Date Company Pty Ltd

Dave & Anita receiving Khalifa International Date Palm Award in Abu Dhabi 2010

Dave holds an Advanced Diploma of Agriculture, Diploma in Production Horticulture and a Certificate IV in Training and Assessment. In 2012 Dave was awarded a Nuffield Australia Farming Scholarship which enabled four months of international study of date production throughout USA, Mexico, UK, Spain, Egypt, Kuwait, Oman, India and United Arab Emirates. He and wife Anita:

- Have established a tissue culture date palm nursery located in the Riverland of South Australia.
- Developed a field evaluation/repository trial site for ongoing research into selection of best climatically suited date palm varieties.
- Established and own a date palm plantation.
- Created a farm demonstration site for date production where information is shared with the wider Australian community.
- Supplied an Australia-wide network of farmers with elite date varieties. Information and experiences are shared amongst this network on the cultivation of new date varieties in new districts.
- Partnerships with Australian Government agencies and Research and Development agencies to establish and promote a commercial Australian Date Industry.

- Winners of the 2010 Khalifa International Date Palm Award for Best New Development.
- Winners of the 2007/08 SA Landcare Awards and finalists in the 2005 Banksia Environmental Awards.
- Dave and Anita have travelled extensively throughout inland Australia assessing suitable date growing regions and working with a network of other growers. They hold a long-term interest in regional infrastructure, environmental and natural resource management.
- Committee member of Loxton-Bookpurnong Local Action Planning.

Other publications by D&A Reilly:

Towards an Australian Date Industry (2010)
https://rirdc.infoservices.com.au/items/10-174

Dave Reilly Nuffield Report: Date Palms for Australia – further developing the industry. Establishment, management and production of premium table dates. (2012)
http://www.nuffieldinternational.org/rep_pdf/1369198887DaveReillyfinalreport.pdf

Date Palm Weed Assessment (2013)

In 2014 Dave & Anita were invited to write for the Emirates Journal of Food and Agriculture. The Gurra Downs story appeared in the November issue of the Journal.

Chronicle of a New Date Palm Grower – Developing a date industry in Australia (2014)
http://www.scopemed.org/fulltextpdf.php?mno=186178

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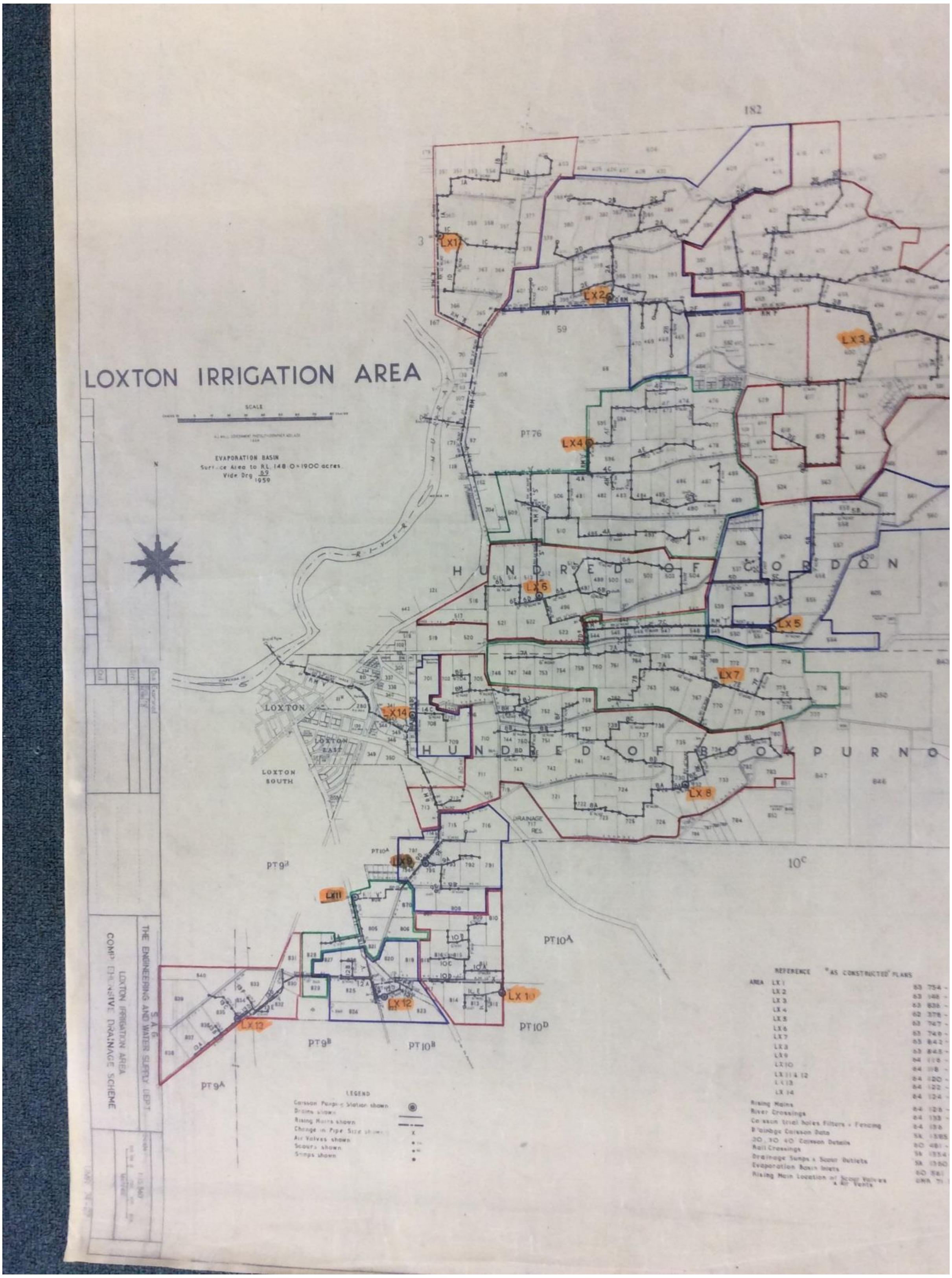
Reilly, D., A. Reilly, I. Lewis. 2010 "Towards an Australian date industry: an overview of the Australian domestic and international date industries". Rural Industries Research and Development Corporation, Publication 10/174. Barton, ACT.
https://rirdc.infoservices.com.au/downloads/10-174

Scott, E. 2015 "Review of Soil/Water and Plant Analytical Data". Injekta Field Systems Pty Ltd (Appendix #2)

Smith, K. 2007 "Feasibility of Drainage Water Re-use throughout the Golden Heights Irrigation Drainage Bore Network Extension project"

Appendices

APPENDIX A
Loxton Irrigation Area



APPENDIX B
Drainage water sample

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Email : awqc@sawater.com.au

Australian Water Quality Centre

FINAL REPORT: 150310

Report Information

Project Name	AWQC-88863
Customer	DEWNR
CSR_ID	123673-2015-CSR-1

Analytical Results

Customer Sample Description	Irrigation water
Sampling Point	90995-DEWNR
Sampled Date	14/01/2015 12:00:00AM
Sample Received Date	15/01/2015 3:50:07PM
Sample ID	2015-000-3777
Status	Endorsed
Collection Type	Customer Collected

Inorganic Chemistry - Metals	LOR	Result
Sample temperature at time of receipt NA		
Boron - Soluble TIC-006 W09-023		
Boron - Soluble	0.020	6.86 mg/L
Calcium TIC-004 W09-023		
Calcium	0.1	24.6 mg/L
Langelier Index W09-023		
Langelier Index		0.49
Magnesium TIC-004 W09-023		
Magnesium	0.05	45.1 mg/L
Potassium TIC-004 W09-023		
Potassium	0.05	13.9 mg/L
Sodium Adsorption Ratio W09-023		
Sodium Adsorption Ratio - Calculation		12.1
Sodium TIC-004 W09-023		
Sodium	0.1	436 mg/L
Sulphur TIC-004 W09-023		
Sulphate	1.5	154 mg/L

Inorganic Chemistry - Nutrients	LOR	Result
Sample temperature at time of receipt NA		
Chloride T0104-02 W09-023		
Chloride	4.0	257 mg/L
Nitrate + Nitrite as N T0161-01 W09-023		
Nitrate + Nitrite as N	0.003	16.1 mg/L
Nitrate as N W09-023		
Nitrate as Nitrogen	0.005	16.1 mg/L
Nitrite as N T0107-01 W09-023		
Nitrite as Nitrogen	0.003	<0.003 mg/L

NATA
WORLD RECOGNISED ACCREDITATION

Corporate Accreditation No.1115 Chemical and Biological Testing
Accredited for compliance with ISO/IEC 17025

Notes
1. The last figure of the result value is a significant figure.
2. Samples are analysed as received.
3. # determination of the component is not covered by NATA Accreditation.
4. ^ indicates result is out of specification according to the reference Guideline. Refer to Report footer.
5. * indicates incident have been recorded against the sample. Refer to Report footer.
6. & Indicates the results have changed since the last issued report.
7. The Limit of Reporting (LOR) is the lowest concentration of analyte which is reported at the AWQC and is based on the LOQ rounded up to a more readily used value. The Limit of Quantitation (LOQ) is the lowest concentration of analyte for which quantitative results may be obtained within a specified degree of confidence.
8. Where collection type is AWQC Collect, NATA has confirmed that due to a robust system in place for maintaining the temperature integrity for samples collected by AWQC's Field Laboratory Services, the recording of temperature when samples arrive at the AWQC is out of scope.
9. Where applicable Measurement of Uncertainty is available upon request

ABN 69336525019 A business unit of the South Australian Water Corporation

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Australian Water Quality Centre

FINAL REPORT: 150310

Analytical Results

Customer Sample Description	Irrigation water
Sampling Point	90995-DEWNR
Sampled Date	14/01/2015 12:00:00AM
Sample Received Date	15/01/2015 3:50:07PM
Sample ID	2015-000-3777
Status	Endorsed
Collection Type	Customer Collected

Nitrogen - Total W09-023		
Nitrogen - Total	0.06	17.1 mg/L
Phosphorus - Filterable Reactive as P T0108-01 W09-023		
Phosphorus - Filterable Reactive as P	0.003	0.009 mg/L
Phosphorus - Total T0109-01 W09-023		
Phosphorus - Total	0.005	0.012 mg/L
TKN as N T0112-01 W09-023		
TKN as Nitrogen	0.05	0.96 mg/L

Inorganic Chemistry - Physical	LOR	Result
Sample temperature at time of receipt NA		
Alkalinity Carbonate Bicarbonate and Hydroxide T0101-01 W09-023		
Alkalinity as Calcium Carbonate		619 mg/L
Bicarbonate		755 mg/L
Carbonate		0 mg/L
Hydroxide		0 mg/L
Conductivity & Total Dissolved Solids T0016-01 W09-023		
Conductivity	1	2250 µScm
Total Dissolved Solids (by EC)	1.0	1200 mg/L
pH T0010-01 W09-023		
pH		7.9 pH units

Inorganic Chemistry - Waste Water	LOR	Result
Sample temperature at time of receipt NA		
Suspended Solids T0160-01 W09-023		
Suspended Solids	1.0	2 mg/L

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Australian Water Quality Centre

FINAL REPORT: 150310

Analytical Method

Analytical Method Code	Description	Reference Method
T0010-01	Determination of pH	APHA 4500-H B
T0016-01	Determination of Conductivity	APHA 2510 B
T0101-01	Alkalinity - Automated Acidimetric Titration	APHA 2320 B
T0104-02	Chloride - Automated Flow Colorimetry	APHA 4500-Cl- E
T0107-01	Nitrite - Automated Flow Colorimetry	APHA 4500-NO3-I
T0108-01	Filterable Reactive Phosphorus - Automated Flow Colorimetry	APHA 4500-P G
T0109-01	Total Phosphorus - Automated Flow Colorimetry	APHA 4500-P F
T0112-01	TKN - Automated Flow Colorimetry	APHA-N org A
T0160-01	Suspended Solids	APHA 4500
T0161-01	Nitrate + Nitrate (NOx) - Automated Flow Colorimetry	APHA 4500-NO3-I
TIC-004	Determination of Metals - ICP Spectrometry by ICP2	APHA 3120
TIC-006	Analysis of waters elemental analysis by ICP/MS	EPA method 200.8
W-052	Preparation of Samples for Metal Analysis	

Sampling Method

Sampling Method Code	Description
W09-023	Sampling Method for Chemical Analyses

Laboratory Information

Laboratory	NATA accreditation ID
Inorganic Chemistry - Metals	1115
Inorganic Chemistry - Nutrients	1115
Inorganic Chemistry - Physical	1115
Inorganic Chemistry - Waste Water	1115

NATA
WORLD RECOGNISED ACCREDITATION

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Notes
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9. Where applicable Measurement of Uncertainty is available upon request

P:

APPENDIX C
Nematode testing

Horticultural diagnostic service

FINAL REPORT

19 January 2015

Loxtob to Bookpurnong LAP
PO Box 1834
Loxton SA 5333

Attn Craig Ferber: craig@lblap.org.au

Cc Mark May: Mark.may@sa.gov.au

SARDI
SOUTH AUSTRALIAN RESEARCH AND DEVELOPMENT INSTITUTE

Waite Research Precinct
Gate 2b Hartley Grove
URRBRAE SA 5064

Correspondence
GPO Box 397
Adelaide SA 5001

Telephone 08 – 8303 9562
Facsimile 08 – 8303 9393

E-mail
Barbara.hall@sa.gov.au

SPECIMEN No.: **22/15**
Date received: 16.01.2015
Crop affected: date palm seedlings
Test undertaken: nematode test

Diagnosis:

Sample	Nematodes present	Number / gm dry soil
Water	Plant parasitic nematodes	0
Date Palm	Root Knot Nematode (*Meloidogyne*)	0.07
	Stunt Nematode (*Tylenchorhynchus*)	0.02
Control	Pin Nematode (*Paratylenchus*)	2.94
	Stunt Nematode (*Tylenchorhynchus*)	0.40
	Root lesion Nematode (*Pratylenchus*)	0.07

Water: There were no plant parasitic nematodes present in this sample

Date Palm: There were low levels of root knot present in this sample. Some damage to the plants may be caused by the root knot nematodes and care will need to be taken to ensure water and nutrients are not limited. There were very low levels of stunt nematode present in this sample. Damage to the plant by this nematode would be negligible.

Control: There were very high levels of pin nematode present in this sample. Some damage may be occurring to the plants although the effect of pin nematode on Date Palm seedlings is not well known in Australia. There were moderate levels of stunt nematode present in the sample which may affect the growth of the seedlings but again the effect in Australia in unknown. There were very low levels of root lesion nematode present in the sample. As the seedlings develop, there may be a corresponding increase in the population of root lesion nematodes if Date Palm is a host for this species.

Nematode tests were completed and advice supplied by Dr Jackie Nobbs, Nematode taxonomist.

(Barbara Hall)
PLANT DIAGNOSTICIAN
HORTICULTURE PATHOLOGY

APPENDIX D
Leaf tissue analysis

Apal

Date palm

PLANT TISSUE ANALYSIS

Agent:	**APAL**	Date Received:	**29/01/2015**
		Date Reported :	**30/01/2015**
Client Name:	**GURRA DOWNS**	Plant/Product :	**Date palm**
Sample Identification:	**JIREH PALMS**	Plant Part:	
Analytical Number:	**P004**	Growth Stage:	**Vegetative**
Batch Number :	**1257**	Actual Growth Stage:	**Not Specified**

NUTRIENT ELEMENT BALANCE CHART

		Result		Deficiency	Below Normal	Normal	Above Normal	Excess	Target	
Nitrogen	N	1.45	%	■■■■■■■■■■■	■■■■■				2.60	%
Nitrate NO_3	-N	<113	ppm						#	ppm
Sulphur	S	0.17	%	■■■■■■■■■■■	■■■■■■				0.35	%
Phosphorus	P	0.14	%	■■■■■■■■■■■	■■■■■■■■■■				0.34	%
Potassium	K	2.14	%	■■■■■■■■■■■	■■■■■■■■■■■	■■■■■■■■■			2.18	%
Magnesium	Mg	0.15	%	■■■■■■■■■■■	■■■■■■■■■				0.27	%
Calcium	Ca	0.19	%	■■■■■■■■■■■					1.28	%
Sodium	Na	0.008	%						#	%
Chloride	Cl	1.08	%						#	%
Iron	Fe	32.44	ppm	■■■■■■■■■■■	■■■■■				163	ppm
Aluminium	Al	19.57	ppm						#	ppm
Manganese	Mn	17.85	ppm	■■■■■■■■■■■	■■■■■■				156.3	ppm
Boron	B	15.76	ppm	■■■■■■■■■■■	■■■■■■■■■■■				26.5	ppm
Copper	Cu	7.17	ppm	■■■■■■■■■■■	■■■■■■■■■■■	■			16.5	ppm
Zinc	Zn	9.15	ppm	■■■■■■■■■					101.3	ppm
Cobalt	Co	0.08	ppm						#	ppm
Molybdenum	Mo	<0.08	ppm						#	ppm
Selenium	Se		ppm						#	ppm

* Source references for graphing are available on request NT = Not Tested IS= Insufficient Sampl #-Target levels are not available

* The Normal Range levels may be altered without notification if new information becomes available.

* All due care has been taken in the analysis and reporting of this sample. However APAL takes no responsibility for the adequacy or accuracy of sample collection and submission or the subsequent use of these results.

ASPAC

Analysis by APAL, PO Box 327, 489 The Parade. Magill SA 5072
Tel.: 08 8332 0199 Fax: 08 83612715 Email: info@apal.com.au Website: www.apal.com.au

APPENDIX E
Microbiology

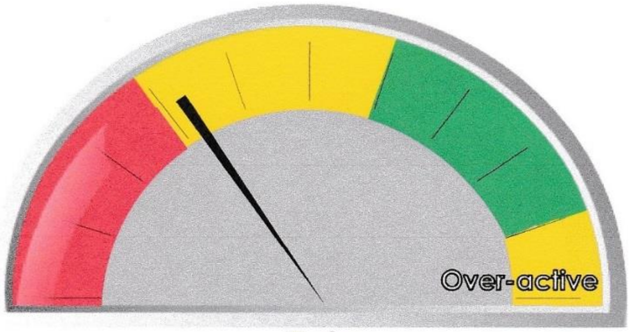
microbiology laboratories australia
agriculture • forestry • environmental

MICROBE ACTIVITY WISE

Apal

Customer	GURRA DOWNS DATE COMPANY	**Agent**	APAL
Sample name	JIREH PALMS	**Crop**	JIREH PALMS
Lab no.	T006	**Date**	17-Feb-15

Microbial Activity Indicator



Data

	Yours	Guide
Microbial activity indicator	27.0	80.0

		Yours	Guide
Soil Basal Respiration (7-28 day)	mg C/kg soil	441.5	1520.0
	mg CO_2/kg soil	1617.6	5569.6
Soil Microbial Biomass C	mg C/kg soil	83.6	463.6

Key

Poor — Fair — Good

Comments

The microbial activity in your sample is poor to fair. This could occur if the soil was very dry when sampled or if microbial activity in your soil has been depleted due to farming practices. It could be increased by adopting management practices that favour microbial activity, for example, those that increase soil carbon. The test is a measurement of total microbial activity which includes both fungus and bacteria levels. As the soil nutrition increases then the level of bacteria increases, examination of the soil analysis can indicate benefits or potential problems.

Explanations

The Microbe Activity Wise test measures activity of soil microbes directly from your sample. It measures the amount of carbon dioxide (CO_2) emitted by microbes over time to calculate Microbial Activity, Soil Basal Respiration (SBR) and Soil Microbial Biomass Carbon (C) (SMBC). Most soil microbes under aerobic conditions (the state your soil should be in) convert carbohydrates into energy and CO_2, which they emit as a waste product, just like animals, plants and humans. This is used to calculate the Microbial Activity Indicator (0 to 100) based on known values for soils. Correlations published in scientific journals are also used to calculate soil basal respiration (SBR, 7-28 day) and soil microbial biomass C (SMBC). Soil Basal Respiration is the normal, steady rate of respiration in a soil. Soil Microbial Biomass C is the amount of C held in the microbial biomass. All three values reflect the quantity and quality of soil carbon, and other microbially assistive nutrients in the soil. CO_2 concentration in the atmosphere surrounding many crops is often a limiting factor to (it is not high enough for) maximal plant production during peak growth. Stomata, the pores plants use to take in CO_2, are located on both sides of the leaf (dicotyledons tend to have more on the underside), which allows plants to use the CO_2 emitted by soil microbes as it rises from the soil. Having a good level of microbial activity in your soil not only helps soil processes, but can also help to improve crop growth. Always compare your results with a control sample. Guide values are included as a help, but because a large number of factors affect microbiology the guide levels may not be optimal for your specific conditions. Visit www.microbelabs.com.au for more information.

Disclaimer

Analysis by Microbiology Laboratories Australia Pty Ltd ACN 145 073 481. The information in this report should be used under consideration of particular production conditions. The guide levels are derived from published data and ongoing research carried out by Microbiology Laboratories Australia. They are intended as a general guide only and do not take into account your specific conditions. Comparison of results with those obtained using other methods may be inaccurate, as accurate interpretation relies on specific sampling and analysis methods. Microbiology Laboratories Australia and APAL, and their employees or agents will not be liable for any loss or damage arising from the use of the information supplied in this report. Please seek specific guidance and recommendations from a qualified agriculture professional.

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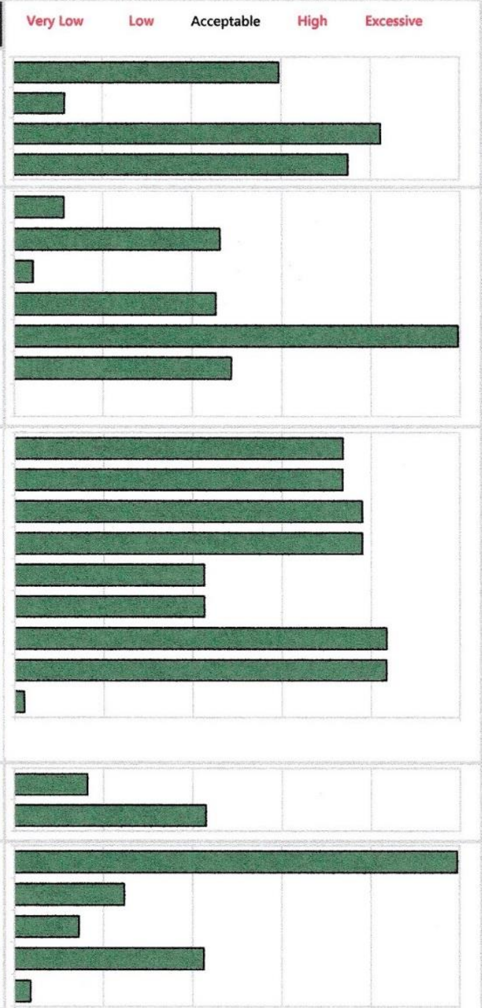
APPENDIX F
Soil analysis

CS2 Complete Soil Analysis

Apal

Customer: DAVE REILLY
Agent: APAL
Sample Name: JIREH PALMS
Crop: PALM TREE
Control 11818
Lab No.: T006
Date: 16-Feb-15

		Unit	Desired Level	Level Found
	ECEC	c.mol/kg	12 - 25	27.7
	Organic Carbon (W&B)	%	>2.0	0.54
	pH 1:5 (Water)		6.0 - 7.0	9.48
	pH 1:5 (CaCl2)		5.5 - 6.5	8.25
Exchangeable N-P-K-S	Nitrate - N	ppm	20 - 50	5.3
	Ammonium - N	ppm	1 - 5	2.6
	Colwell Phosphorus	ppm	50 - 60	5
	PBI + ColP		<100	56
	DGT P	ug/L	-	6
	Colwell K	ppm	>200	240
	MCP Sulfur (S)	ppm	10 - 20	11.7
Exchangeable cations	Calcium (Ca)	ppm	> 1550	4205
		c.mol/kg		20.98
	Magnesium (Mg)	ppm	> 250	574
		c.mol/kg		4.72
	Potassium (K)	ppm	> 250	231
		c.mol/kg		0.59
	Sodium (Na)	ppm	< 160	304
		c.mol/kg		1.32
	Exch. Aluminium (Al)	c.mol/kg	< 0.5	<0.02
	Exch. Hydrogen	c.mol/kg	-	<0.02
Salt	Chlorides (Cl)	ppm	<300	58
	Salinity EC 1:5	dS/m	< 2.0	0.20
Trace Elements	Boron (B)	ppm	1.0 - 2.0	5.98
	DTPA Iron (Fe)	ppm	10 - 70	6
	DTPA Manganese (Mn)	ppm	10 - 20	3.4
	DTPA Copper (Cu)	ppm	0.5 - 5.0	0.61
	DTPA Zinc (Zn)	ppm	4.0 - 5.0	0.33
Exchangeable Cation %	Ca:Mg RATIO		2 - 8	4.45
	K:Mg Ratio		< 0.5	0.13
	Calcium	% Ca	60 - 75	75.8
	Magnesium	% Mg	10 - 20	17.0
	Potassium	% K	3 - 8	2.1
	Sodium	% Na	<5	4.8
	Exch. Aluminium	% Al	<5	0.0
	Exch. Hydrogen	% H	>0	0.0



Notes

Analysis by APAL, PO Box 327, 489 The Parade. Magill SA 5072
Tel.: 08 8332 0199 Fax: 08 83612715 Email: info@apal.com.au Website: www.apal.com.au

ASPAC

NR Test not requested

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APPENDIX G
Drainage water sample

PO Box 1751
Adelaide SA 5001
250 Victoria Square/
Tarntanyangga
Adelaide SA 5000
Tel : 1300 653 366
Fax : 1300 883 171
Internet : www.awqc.com.au
Email : awqc@sawater.com.au

Australian Water Quality Centre

FINAL REPORT: 152886

Report Information

Project Name	AWQC-90730
Customer	DEWNR
CSR_ID	123673-2015-CSR-1

Analytical Results

Customer Sample Description	Irrigation water
Sampling Point	90995-DEWNR
Sampled Date	13/03/2015 12:00:00AM
Sample Received Date	13/03/2015 11:52:57AM
Sample ID	*2015-001-8730
Status	Endorsed
Collection Type	Customer Collected

Inorganic Chemistry - Metals	LOR	Result
Sample temperature at time of receipt 17.8°C		
Boron - Soluble TIC-006 W09-023		
Boron - Soluble	0.020	6.87 mg/L
Calcium TIC-004 W09-023		
Calcium	0.1	24.2 mg/L
Langelier Index W09-023		
Langelier Index		0.57
Magnesium TIC-004 W09-023		
Magnesium	0.05	42.8 mg/L
Potassium TIC-004 W09-023		
Potassium	0.05	12.5 mg/L
Sodium Adsorption Ratio W09-023		
Sodium Adsorption Ratio - Calculation		10.4
Sodium TIC-004 W09-023		
Sodium	0.1	368 mg/L
Sulphur TIC-004 W09-023		
Sulphate	1.5	154 mg/L

Inorganic Chemistry - Nutrients	LOR	Result
Sample temperature at time of receipt 17.8°C		
Chloride T0104-02 W09-023		
Chloride	4.0	208 mg/L
Nitrate + Nitrite as N T0161-01 W09-023		
Nitrate + Nitrite as N	0.003	15.0 mg/L
Nitrate as N W09-023		
Nitrate as Nitrogen	0.005	15.0 mg/L
Nitrite as N T0107-01 W09-023		
Nitrite as Nitrogen	0.003	<0.003 mg/L

NATA WORLD RECOGNISED ACCREDITATION

Corporate Accreditation No.1115 Chemical and Biological Testing
Accredited for compliance with ISO/IEC 17025

Notes
1. The last figure of the result value is a significant figure.
2. Samples are analysed as received.
3. # determination of the component is not covered by NATA Accreditation.
4. ^ indicates result is out of specification according to the reference Guideline. Refer to Report footer.
5. * indicates incident have been recorded against the sample. Refer to Report footer.
6. & Indicates the results have changed since the last issued report.
7. The Limit of Reporting (LOR) is the lowest concentration of analyte which is reported at the AWQC and is based on the LOQ rounded up to a more readily used value. The Limit of Quantitation (LOQ) is the lowest concentration of analyte for which quantitative results may be obtained within a specified degree of confidence.
8. Where collection type is AWQC Collect, NATA has confirmed that due to a robust system in place for maintaining the temperature integrity for samples collected by AWQC's Field Laboratory Services, the recording of temperature when samples arrive at the AWQC is out of scope.
9. Where applicable Measurement of Uncertainty is available upon request

ABN 69336525019 A business unit of the South Australian Water Corporation

PO Box 1751
Adelaide SA 5001

250 Victoria Square/
Tarntanyangga
Adelaide SA 5000

Tel : 1300 653 366
Fax : 1300 883 171

Internet : www.awqc.com.au
Email : awqc@sawater.com.au

FINAL REPORT: 152886

Analytical Results

Customer Sample Description	Irrigation water
Sampling Point	90995-DEWNR
Sampled Date	13/03/2015 12:00:00AM
Sample Received Date	13/03/2015 11:52:57AM
Sample ID	*2015-001-8730
Status	Endorsed
Collection Type	Customer Collected

Nitrogen - Total W09-023		
Nitrogen - Total	0.06	16.0 mg/L
Phosphorus - Filterable Reactive as P T0108-01 W09-023		
Phosphorus - Filterable Reactive as P	0.003	0.011 mg/L
Phosphorus - Total T0109-01 W09-023		
Phosphorus - Total	0.005	0.009 mg/L
TKN as N T0112-01 W09-023		
TKN as Nitrogen	0.05	0.96 mg/L

Inorganic Chemistry - Physical	LOR	Result
Sample temperature at time of receipt 17.8°C		
Alkalinity Carbonate Bicarbonate and Hydroxide T0101-01 W09-023		
Alkalinity as Calcium Carbonate		601 mg/L
Bicarbonate		733 mg/L
Carbonate		0 mg/L
Hydroxide		0 mg/L
Conductivity & Total Dissolved Solids T0016-01 W09-023		
Conductivity	1	2100 µScm
Total Dissolved Solids (by EC)	1.0	1200 mg/L
pH T0010-01 W09-023		
pH		8.0 pH units

Inorganic Chemistry - Waste Water	LOR	Result
Sample temperature at time of receipt 17.8°C		
Suspended Solids T0160-01 W09-023		
Suspended Solids	1.0	<1 mg/L

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9. Where applicable Measurement of Uncertainty is available upon request

P

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Tel : 1300 653 366
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Internet : www.awqc.com.au
Email : awqc@sawater.com.au

Australian Water Quality Centre

FINAL REPORT: 152886

Incidents

Sample ID	S.Point	Description	Sampled Date	Analysis (where Applicable)	Incident Description
2015-001-8730	90995	Irrigation water	13/03/2015	Phosphorus - Total	Dependent results are within acceptable analytical uncertainty

Analytical Method

Analytical Method Code	Description	Reference Method
T0010-01	Determination of pH	APHA 4500-H B
T0016-01	Determination of Conductivity	APHA 2510 B
T0101-01	Alkalinity - Automated Acidimetric Titration	APHA 2320 B
T0104-02	Chloride - Discrete Analyser	APHA 4500-Cl- E
T0107-01	Nitrite - Automated Flow Colorimetry	APHA 4500-NO3-I
T0108-01	Filterable Reactive Phosphorus - Automated Flow Colorimetry	APHA 4500-P G
T0109-01	Phosphorus - total by discrete analyser	APHA 4500-P F
T0112-01	Nitrogen- Total Kjeldahl by discrete analyser	APHA 4500-N org A
T0160-01	Suspended Solids	APHA 4500
T0161-01	Nitrate + Nitrate (NOx) - Automated Flow Colorimetry	APHA 4500-NO3-I
TIC-004	Determination of Metals - ICP Spectrometry by ICP2	APHA 3120
TIC-006	Elemental Analysis By ICP- MS	EPA method 200.8
W-052	Preparation of Samples for Metal Analysis	APHA 3030A to 3030D

Laboratory Information

Laboratory	NATA accreditation ID
Inorganic Chemistry - Metals	1115
Inorganic Chemistry - Nutrients	1115
Inorganic Chemistry - Physical	1115
Inorganic Chemistry - Waste Water	1115

NATA
WORLD RECOGNISED ACCREDITATION

Corporate Accreditation No.1115 Chemical and Biological Testing
Accredited for compliance with ISO/IEC 17025

Notes

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8. Where collection type is AWQC Collect, NATA has confirmed that due to a robust system in place for maintaining the temperature integrity for samples collected by AWQC's Field Laboratory Services, the recording of temperature when samples arrive at the AWQC is out of scope.
9. Where applicable Measurement of Uncertainty is available upon request

Pa

ABN 69336525019

A business unit of the South Australian Water Corporation

APPENDIX H
River Murray comparative water analysis

SA Water

Government of South Australia

Water Quality Data

Thank you for your enquiry, below is the requested data the period of 02/10/2014 to 02/10/2015.

Sampling Point Description	Component	Unit	Min	Max	Average
River Murray Berri Sample Pump	Alkalinity as Calcium Carbonate	mg/L	26	70	42
	Bicarbonate	mg/L	31	86	51
	Carbonate	mg/L	0	0	0
	Conductivity	µScm	161	421	286
	Hydroxide	mg/L	0	0	0
	pH	pH units	7.1	8	7.6
	Total Dissolved Solids (by EC)	mg/L	88	230	157
	Turbidity	NTU	15	89	40

Sampling Point Description	Component	Unit	Min	Max	Average
River Murray Loxton Sample Pump	Conductivity	µScm	168	430	291
	Nitrate + Nitrite as N	mg/L	0.003	0.173	0.02
	Nitrate + Nitrite as NO3	mg/L	0.005	0.77	0.077
	Nitrate as Nitrogen	mg/L	0.005	0.166	0.016
	Nitrite as Nitrogen	mg/L	0.003	0.011	0.0048
	pH	pH units	7.3	8.5	7.9
	Phosphorus - Filterable Reactive as P	mg/L	0.003	0.198	0.031
	Phosphorus - Total	mg/L	0.03	0.313	0.11
	TKN as Nitrogen	mg/L	0.34	1.71	0.76
	Total Dissolved Solids (by EC)	mg/L	92	240	160
	Turbidity	NTU	11	80	37

Sampling Point Description	Component	Unit	Min	Max	Average
River Murray Renmark Sample Pump	Alkalinity as Calcium Carbonate	mg/L	26	65	40
	Bicarbonate	mg/L	32	79	49
	Boron - Soluble	mg/L	0.02	0.02	0.02
	Calcium	mg/L	4.8	12.1	7.7
	Carbonate	mg/L	0	0	0
	Chloride	mg/L	25	67	44
	Conductivity	µScm	146	384	247
	Hydroxide	mg/L	0	0	0
	Magnesium	mg/L	3.51	7.81	5.80
	Magnesium Hardness as CaCO3	mg/L	14	32	24
	Nitrate + Nitrite as N	mg/L	0.003	0.068	0.015
	Nitrate + Nitrite as NO3	mg/L	0.02	0.3	0.07
	Nitrate as Nitrogen	mg/L	0.005	0.064	0.013
	Nitrite as Nitrogen	mg/L	0.003	0.015	0.0048
	pH	pH units	6.4	8.1	7.5
	Phosphorus - Filterable Reactive as P	mg/L	0.003	0.134	0.029
	Phosphorus - Total	mg/L	0.012	0.238	0.111
	Potassium	mg/L	2.07	4.59	2.68
	Sodium	mg/L	15.8	44.4	27.7
	Sodium Adsorption Ratio - Calculation	(blank)	1.34	2.63	1.82
	Sulphate	mg/L	6.3	15.9	9.8
	TKN as Nitrogen	mg/L	0.21	1.73	0.83
	Total Dissolved Solids (by EC)	mg/L	80	210	136
	Turbidity	NTU	17	88	41

Sampling Point Description	Component	Unit	Min	Max	Average
River Murray Morgan Sample Pump	Langelier Index	(blank)	-2	-0.4	-1.14

APPENDIX I
Leaf tissue analysis

Apal

Date palm

PLANT TISSUE ANALYSIS

Agent:	**APAL**	Date Received:	**11/06/2015**
		Date Reported :	**15/06/2015**
Client Name:	**GURRA DOWNS**	Plant/Product :	**Date palm**
Sample Identification:	**JIREH LEAF**	Plant Part:	
Analytical Number:	**C007**	Growth Stage:	**Vegetative**
Batch Number :	**1478**	Actual Growth Stage:	**Not Specified**

Nutrient target levels shown are for Phoenix roebelenii (miniature date palm).
Nutrient target levels are for middle leaflet from most recently matured frond, minus petiole.

NUTRIENT ELEMENT BALANCE CHART

		Result		Deficiency	Below Normal	Normal	Above Normal	Excess	Target	
Nitrogen	N	1.28	%	■■■■■■■■■■■	■■■				2.60	%
Nitrate NO_3	-N	<113	ppm						#	ppm
Sulphur	S	0.14	%	■■■■■■■■■■■					0.35	%
Phosphorus	P	0.09	%	■■■■■■■■■■■	■■■■				0.34	%
Potassium	K	1.4	%	■■■■■■■■■■■	■■■■■■■■■■■	■■			2.18	%
Magnesium	Mg	0.11	%	■■■■■■■■■■■	■■■■				0.27	%
Calcium	Ca	0.15	%	■■■■■■■■					1.28	%
Sodium	Na	0.006	%						#	%
Chloride	Cl	0.83	%						#	%
Iron	Fe	36	ppm	■■■■■■■■■■■	■■■■■■				163	ppm
Aluminium	Al	22	ppm						#	ppm
Manganese	Mn	14	ppm	■■■■■■■■■■■	■■■				156.3	ppm
Boron	B	11	ppm	■■■■■■■■■■■	■■■■■■				26.5	ppm
Copper	Cu	5.6	ppm	■■■■■■■■■■■	■■■■■■■■■■■				16.5	ppm
Zinc	Zn	12	ppm	■■■■■■■■■■■	■				101.3	ppm
Cobalt	Co	<0.06	ppm						#	ppm
Molybdenum	Mo	0.23	ppm						#	ppm
Selenium	Se		ppm						#	ppm

* Source references for graphing are available on request NT = Not Tested IS= Insufficient Sampl #-Target levels are not available
* The Normal Range levels may be altered without notification if new information becomes available.
* All due care has been taken in the analysis and reporting of this sample. However APAL takes no responsibility for the adequacy or accuracy of sample collection and submission or the subsequent use of these results.

ASPAC

Analysis by APAL, PO Box 327, 489 The Parade. Magill SA 5072
Tel.: 08 8332 0199 Fax: 08 83612715 Email: info@apal.com.au Website: www.apal.com.au

APPENDIX J
Soil analysis

CS2 Complete Soil Analysis

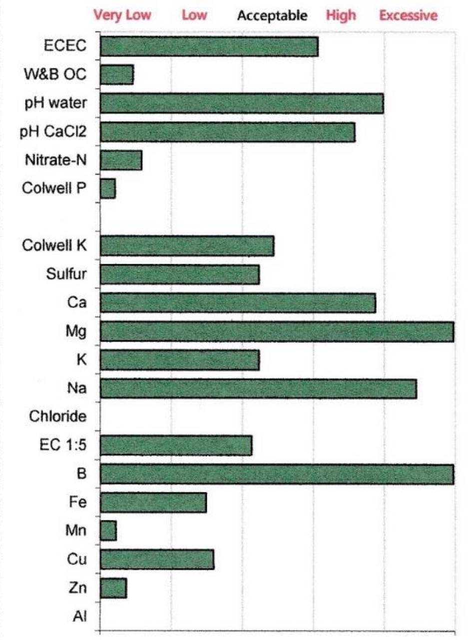
Apal

Customer: GURRA DOWNS
Sample Name: JIREH
Lab No.: G118

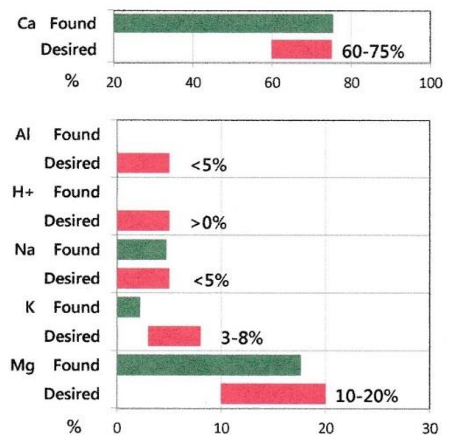
Agent: APAL
Crop: PALM TREE
Date: 25-Jun-15

Control 13916

		Unit	Desired Level	Level Found
	ECEC	c.mol/kg	5 - 25	29.9
	Organic Carbon (W&B)	%	>2.0	0.44
	pH 1:5 (Water)		6.0 - 7.0	9.22
	pH 1:5 (CaCl2)		5.5 - 6.5	7.91
Exchangeable N-P-K-S	Nitrate - N	ppm	20 - 50	5.5
	Ammonium - N	ppm	-	1.1
	Colwell Phosphorus	ppm	50 - 60	5
	DGT-P	µg/L	-	NR
	PBI + ColP		<100	61
	Colwell K	ppm	>200	241
	MCP Sulfur (S)	ppm	10 - 20	13.8
Exchangeable cations	Calcium (Ca)	ppm	> 1550	4528
	Magnesium (Mg)	ppm	> 250	642
	Potassium (K)	ppm	> 250	256
	Sodium (Na)	ppm	< 160	326
	Exch. Aluminium (Al)	c.mol/kg	< 0.5	NT
	Exch. Hydrogen	c.mol/kg	-	NT
Salt	Chlorides (Cl)	ppm	<300	NR
	Salinity EC 1:5	dS/m	< 2.0	0.18
Trace Elements	Boron (B)	ppm	1.0 - 2.0	5.42
	DTPA Iron (Fe)	ppm	10 - 70	7
	DTPA Manganese (Mn)	ppm	10 - 20	1.1
	DTPA Copper (Cu)	ppm	0.5 - 5.0	0.45
	DTPA Zinc (Zn)	ppm	4.0 - 5.0	0.69
Ratios	Ca:Mg RATIO		2 - 8	4.28
	K:Mg Ratio		< 0.5	0.12
Exchangeable Cation %	Calcium	% Ca	60 - 75	75.4
	Magnesium	% Mg	10 - 20	17.6
	Potassium	% K	3 - 8	2.2
	Sodium	% Na	<5	4.7
	Exch. Aluminium	% Al	<5	NT
	Exch. Hydrogen	% H	>0	NT



Exchangeable cation % (eCEC)



Analysis by APAL, PO Box 327, 489 The Parade, Magill SA 5072
Tel.: 08 8332 0199 Fax: 08 83612715 Email: info@apal.com.au Website: www.apal.com.au

ASPAC

NR Test not requested

NT Not tested. Exchangeable hydrogen/aluminium test valid for acid soils only.

F (R)-006, Version 1 Page 1 of 2

CS2 Complete Soil Analysis

Apal

Customer:
GURRA DOWNS

Sample Name:
JIREH

Agent:
APAL

Crop:
PALM TREE

Control 13916

Lab No.: G118

Date: 25-Jun-15

		Unit	Desired	Level
Phosphorus	Total Phosphorus	ppm	-	NR
	Olsen Phosphorus	ppm	-	NR
Traces	Cobalt	ppm	-	NR
	Molybdenum	ppm	-	NR
OTHER TESTS				

Analysis by APAL, PO Box 327, 489 The Parade. Magill SA 5072
Tel.: 08 8332 0199 Fax: 08 83612715 Email: info@apal.com.au Website: www.apal.com.au

ASPAC

NR Test not requested

F (R)-006, Version 1 Page 2 of 2

APPENDIX K
Fruit analysis

DTS FOOD LABORATORIES
YOUR TRUSTED PARTNERS IN QUALITY
INCORPORATING FACTA
FOOD ALLERGEN CONTROL TRAINING ANALYSIS

Dairy Technical Services Ltd
ABN 30 004 319 171
Corporate Office
3/63–71 Boundary Road
North Melbourne VIC
Australia 3051
www.dtsfoodlabs.com.au
Tel: +61 (3) 8371 7600
Fax: +61 (3) 9372 2013

Postal Address
PO Box 81
Flemington VIC 3031
Microbiology
Laboratory NSW
Unit 3 Gateway Business Park
63–79 Parramatta Road
Silverwater NSW 2128
Tel: +61 (2) 8007 7447

Microbiology, FACTA and
MAS Laboratories VIC
5/352 Macaulay Road
Kensington VIC 3031
Chemistry Laboratory
52–58 Mark Street
North Melbourne
VIC 3051

Microbiology and
FACTA Allergen
Laboratory QLD
Unit 1–3/148 Tennyson
Memorial Avenue
Tennyson QLD 4105
Tel: +61 (7) 3426 9750
Fax: +61 (7) 3392 8495

LABORATORY REPORT
on
DATES

Date: 07/08/2015
Our Ref: DTS15057436
Report No: 1590715
Final

FOR: GURRA DOWNS DATE COMPANY PTY LTD

521 Gordon Road
Gurra Downs SA 5341

Dave Reilly

Date received: 30/07/2015
Origin:
Code/Ref: JIREH DATE FRUIT

Order Number: 001
No of samples: 1
Package Type:
Temperature on receipt: Ambient

30JUL15/7625041
Client ID: JIREH DATE FRUIT

TEST	RESULTS	METHOD N
Salt	0.3 % m/m	SALT 07 08.07
Calcium	31 mg/100g	MICP 01 04.06
Magnesium	60 mg/100g	MICP 01 04.06
Sodium	0.79 mg/100g	MICP 01 04.06
Potassium	684 mg/100g	MICP 01 04.06
Phosphorus	51 mg/100g	MICP 01 04.06
Iron	0.71 mg/100g	MICP 01 04.06

Wendy Zheng
Chemist

Page 1 of 1

APPENDIX L
Environment Protection Authority (Water Quality) Policy 2003

Clause 11 states a general obligation to avoid discharge to waters (including to groundwater via land infiltration). EPA guidelines are written to assist in meeting the general environmental duty and in undertaking all reasonable and practicable measures. In this case the WIMP Guideline would still be recommended by the EPA as a guidance document. The principles of the WIMP Guideline (nutrient rich, saline wastewater) are applicable, whilst it is not directly targeted at irrigation drainage wastewater. A basic irrigation management plan should be development and implemented to ensure the sustainability of the activity, if this was not undertaken and harm to waters occurred a contravention of the Policy may result.

For your information the following conditions may be applied to recycled water irrigation activities (under EPA environmental authorisations);

IRRIGATION MANAGEMENT PLAN
The Licensee must:

1. Develop and submit to the EPA by the xxxxx, a Wastewater Irrigation Management Plan (WIMP) to the satisfaction of the EPA for the irrigation activity at the Premises;
2. The WIMP must;
   - 2.1 Determine the appropriate rate of application of water to land for the purpose of irrigation from the wastewater management system.
   - 2.2 Demonstrate the appropriate infiltration rate of each soil type and the allowable leaching fraction
   - 2.3 Demonstrate that the capacity of the soils and vegetation to store and use the nutrients and other chemical constituents of the recycled water is not exceeded.
3. The Licensee must implement the WIMP once approved by the EPA.

NOTE: Guidance on developing a WIMP that meets the standard acceptable to the EPA is provided within the EPA Guidelines document entitled 'Wastewater irrigation management plan (WIMP) - a drafting guide for wastewater irrigators' (updated June 2009).