Audit of Water and Irrigation Use Efficiencies on Farms within the Queensland Dairy Industry

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In Conjunction with

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1. Introduction

Key Points

- *Savings from improved water use efficiency (WUE) are a potential source of water for Queensland*
- *DNR will provide assistance of $41 million over four years to assist the Rural Water Use Efficiency Initiative (RWUE)*
- *The Department of Primary Industries is partnering DNR to implement the program for the Dairy Industry*
- *There will be a range of other benefits that will flow through to the Dairy & Lucerne industries from this initiative.*

Queensland, like the rest of Australia, faces increasing competitive demands for its finite water supply. Over recent years considerable effort has been undertaken to ascertain current supplies and future demands for water. However, there has only been limited assessment of water use efficiency and those efforts have often been on an *ad hoc* and micro basis. The Queensland government has recognised there are three potential sources of additional water for Queensland, which are listed below.

- Savings from improved water use efficiency.
- Reuse of wastewater.
- Additional water supplies through new infrastructure development.

The first of these sources is the focus of the "Rural Water Use Efficiency Initiative" launched by the Queensland Government. The program is a partnership between government and the four main rural industries that use water, dairy, cotton, horticulture and sugarcane.

Forty one million dollars will be spent on this initiative over a four year period. Twenty three million dollars will be spent on adoption (extension) programs to improve water use efficiency on farms, with the balance directed towards the other areas of focus.

The Department of Primary Industries (DPI) has agreed to form a partnership with the Department of Natural Resources (DNR) in implementing the dairy program. This report represents the first stage of this partnership - the evaluation of the dairy industry's current performance with respect to water use efficiency.

In addition to the establishment of extension programs, this project will yield a range of other benefits for DPI and its stakeholders. These include the following.

- A greater and more comprehensive understanding of the industry.
- An opportunity to appropriately value water for use in dairy farming enabling farmers to make informed and profitable decisions for the purchase or sale of water.
- Environmental benefits from reduced drainage and deep percolation through water use efficiency.
- The development of closer links with DNR and the other irrigation industries with regard to water management.

- An opportunity for improved identification, management and maintenance of industry information.
- Empirical evidence of current irrigation performance which, along with future improvements, can be used for industry based lobbying for infrastructure development.

Further to this, these are challenging times for the Queensland dairy industry with deregulation just around the corner. Hence, the development of efficient low cost production systems is going to be important in maintaining a competitive industry. Irrigation and water use efficiency is likely to play a key role in increasing production while at the same time lowering costs. The 1998-99 QDAS statistical report states that "low cost farms produce up to 70 percent of their milk from pastures. Pastures are, and will remain, the most economic source of feed.

The industry is likely to see structural changes as a result of increased competition. For example, increased seasonal production counter-cyclic the south's is probable. This may well create water availability in the "off season" enabling dairy farmers to diversify into other irrigated enterprises.

2. Project Methodology & Deliverables

Key Points

- *Stage 1 – Survey development, Dairy Extension Officer training and completion of surveys*
- *Stage 2 – Ten on-farm case studies critically assessing water use efficiency and irrigation effectiveness*
- *Stage 3 – Development of Energy and Water Use Model*
- *Stage 4 – Database construction and analysis*
- *Stage 5 – Report*
- *Stage 6 – In-region presentation of the report and findings*

There are six major stages to the project, which are presented in the following sections.

2.1 Stage 1 – Survey Development and Surveyor Training

Objective

To develop a survey, train surveyors and collate the completed surveys.

Process

1. Project Inception
2. Development of survey structure and content
3. Development pre Survey Training
4. Training conducted

   The training course covered:

   - Water use efficiency concepts
   - Assessment of water use
   - Irrigation practices
   - Technology of Irrigation Systems
   - The improvement process
   - Lessons from experiences
5. Assistance with the Survey Process
   - Review of survey structure and timetable
   - Review of completed surveys to ensure integrity of results

Outcome

132 dairy surveys completed and collated.

2.2 Stage 2 – Case Studies

Objective

Ten on-farm case studies of approximately two farms in each region have been completed.

Process

1. Develop case study structure
2. Conduct on-farm case studies
3. Collate and analyse data.

Outcome

Ten case studies have been undertaken highlighting current practice water use efficiency and irrigation effectiveness within each region.

2.3 Stage 3 – Energy and Water Use Model

Objective

A completed "desktop" audit accessing climate data for 1998 and a theoretical year representative of 75 percent of years. Development of a model and complete a theoretical estimate of water use in each region.

The model has assessed information available from QDAS and other research projects on feed value and production.

Process

1. Develop theoretical water use for 1998 and 75 percent of years for inclusion in Case Studies and the Energy and Water Use Model.
2. Develop a theoretical model of water use in each region
   - Utilising Rustic software package and FAO 56 crop requirements
   - Desktop search of benchmark data
3. Develop Energy and Water Use Model.
   - Herd energy demand formula will be researched and included.
   - Benchmarks for the water use, production and economic value gained from water use for a representative range of pasture species and feeds will be developed.
   - Outcomes relating an energy balance between demand and supply, water use and cost of feed and energy supply.

Outcome

The model will be a useable on farm tool for assessment of energy demand and supply, water requirements and the most economic supply of that energy given the specific farmers production system.

2.4 Stage 4 – Database Construction and Analysis

Objective

Analysis utilises a database with all available information. The database has been developed in Microsoft Excel and Access format. It has been constructed and documented so that it can be presented, maintained and updated by users on an ongoing basis.

Process

1. Data retrieve and consolidate from existing Australian and international information including:
    - Australian Bureau of Statistics (ABS)
    - Queensland Department of Natural Resources (DNR)
    - Queensland Department of Primary Industries (QDPI)
    - Relevant departments in other states
2. Database Development

    A database has been developed very similar to the development of the QFVG Horticultural Industry database. The database has been primarily developed in Microsoft Excel, which has been exported to Microsoft Access for analysis of industry structure.

Outcome

Four databases that provide:

- An overview of the structure of the industry and water management practices
- An audit of the current industry on a regional basis
- Analysis of best practice
- An assessment of opportunities for improvement by region.

2.5 Stage 5 - Report

Objective

This report includes the developed databases, conclusions and specific recommendations to the industry as well as a WUE target.

The project utilises similar methods of analysis and report structure as developed for QFVG water use efficiency project.

Process

1. Consolidate information obtained during Stages 1 through 4.
2. Develop draft report identifying opportunities for improvement and formulating recommendations to industry.
3. Development of a final report.

Outcome

The report is based on desktop research and the industry participant surveys and provides:

- a comprehensive database of water use and irrigation use efficiency for the major Dairy Industry regions;
- analysis of the water use and irrigation use efficiency of the major Queensland dairy farmers and illustrates the current efficiency patterns for these farms by region;
- analysis the different types of irrigation technology used identifying best practice technologies and the impact of regional issues on the technologies;
- comparisons of the efficiency of Queensland practices across crops and regions;
- identified opportunities for improvement; and
- recommendations to industry for improved performance.

2.6 Stage 6 – Regional Presentations

Objective

Visits to Regional Centre during March 2000 to present and discuss the report with Extension Officers and Farmers in group meetings. The briefing process and information sharing will support the DPI's Continuous Improvement and Innovation Approach. It is assumed that two days on-site in each region will be required.

Process

1. Presentations at appropriate regional centres.

3. Key Measures of Irrigation Efficiency

Key Points

Key measures of efficiency investigated in the project are as follows.

- *Water Use – ML/ha*
- *Engineering Efficiency – ML used/ML input*
- *Agronomic Water Use Index – Yield/ML input*
- *Economic Water Use Index – Gross revenue/ML input*

This project uses three key measures to assess water use efficiency, Engineering Efficiency (or hydraulic efficiency), Agronomic Water Use Index and Economic Water Use Index. Within a systems context these measures can be used to link performance to practice, and practice to improvement.

Assessment and improvement of water use efficiency requires three stages

- an audit of current practices
- calculation of efficiency measures and indices
- application of efficiency measures and indices to the audit.

This enables determination of the current standard of water use efficiency in the industry, performance gaps, pathways to improvement and the benefits or goals to be achieved from improvement.

3.1 Water Use Audit

An audit requires an assessment of current industry structure including scale, water usage and economic parameters. A matrix of key parameters (hectares, megalitres, Litres) collected in the audit process is shown below.

Indices	**Ha**	**ML**	**Litres**	**$**
Ha	Total			
ML	ML/Ha	Total		
Litres	T/Ha	T/ML	Total	
$	$/Ha	$/ML	$/T	Total

3.2 Engineering Efficiency

Engineering Efficiency simply refers to:

> *"How much water was input to a given area compared to how much water the plants in that given area actually used."*

Engineering Efficiency (EE) = ***ML Used/ ML Input***

Where:

ML Used = Crop Evapotranspiration + Evaporation + Percolation (a minimum leaching requirement)

ML Input = Irrigation Water + Rainfall +/- change in Soil Moisture Balance

The engineering efficiency is expressed as a percentage with higher values representing better performance.

3.3 Agronomic Water Use Index

Agronomic Water Use Index simply refers to:

> *"How much production is achieved given the amount of water input"*

It is noted that crop production also depends on a number of inputs other than water input, however, for the purpose of this initial study, these were treated as constant.

Agronomic Water Use Index (AI) = ***Yield / ML Input***

CWUI = *Yield / ML Used*

Where:

Yield = Total litres of milk produced from irrigated forage or pasture. Ideally AI would be calculated in the two steps that represent irrigated milk production, KgDM/ML Input and Litres/ML Input. However, feed production is predominately unrecorded and so this step has been omitted. It is important to note that Litres/ML Input can be influenced by feed utilisation through stocking rates.

ML Input = Irrigation Water + Rainfall +/- change in Soil Moisture Balance

ML Used = Crop Evapotranspiration + Evaporation + Percolation (a minimum leaching requirement)

3.4 Economic Water Use Index

Economic Water Use Index simply refers to:

"What is the value of production given the amount of water input"

Economic Water Use Index (EcI) = Gross Revenue / ML Input

Where:

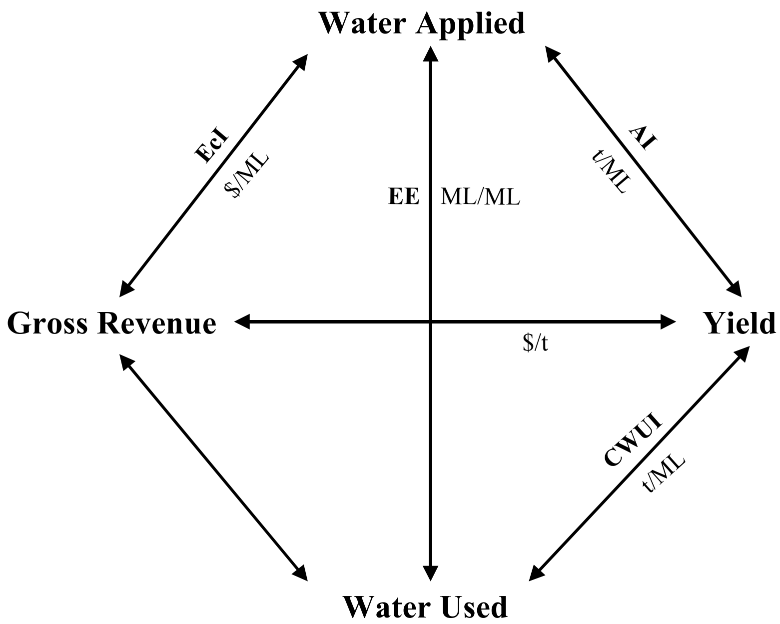
Gross Revenue = Tonnes produced * Dollars per Litre (gross dollars at farm gate)

ML Input = Irrigation Water + Rainfall +/- change in Soil Moisture Balance

Economic Water Use Index is expressed in dollars. Gross revenue has been chosen for two reasons - firstly, to remove management bias influencing input and marketing costs and, secondly, not to unnecessarily delve into the private business performance of irrigators. If revenue increases without any other changes there will be an increase in profitability, which is the key measure for all growers.

Figure 3, following, depicts the interaction between the inputs and outputs of production being considered and where in that relationship the performance measures can be applied.

Figure 1 Relationship between Key Measures of Efficiency



4. Industry Structure

Key Points

- *Total Number of Dairy Producers – 1,735*
- *Total Number of Dairy Producers Surveyed– 132*
- *Total Winter Irrigated Dairy Area – 44,206 Ha*
- *Total Summer Irrigated Dairy Area – 40,153 Ha*
- *Total Water Use – 491,636 ML*
- *Total Production – 513,961,259 Lts*
- *Total Value – $210,724,116*
- *Bores and regulated rivers make up 65 percent of water sources (bores 32% and regulated rivers 33%)*
- *64 percent of respondents have adequate water supplies currently while only 43 percent predict adequate supplies in the future*
- *The irrigation technique most commonly used by producers is the soft hose winch at 47 percent, followed by the hand shift at 26%*
- *81 percent of respondents do not schedule irrigation*
- *Irrigation advisers are used by 7 percent of respondents*
- *The main factor likely to encourage irrigators to become more efficient is the cost of water and its application cost.*
- *66 percent of respondents believe that there is potential to improve irrigation scheduling*
- *44 percent of respondents believe that there is potential to improve irrigation infrastructure on farm*

4.1 Regional Production & Water Stocktake

A database has been developed using ABS production statistics (1997) applied to dairy water use benchmarks using regional breakdowns. These benchmarks have been derived from grower surveys. Megalitre usage is based on irrigation applied and therefore is net of rainfall. A summary of the results is included in Table 1.

Table 1 Summary of Production and Water Audit

Summary Statistics	
Total Area Winter (Ha)	44,206
Total Area Summer (Ha)	40,153
Total Volume (ML)	491,636
Total Production (Lts)	513,961,259
Total Value ($)	210,724,116

Water Use by Region	**ML %**	**Cumulative %**
South Burnett	39.1%	39%
Darling Downs	19.7%	59%
Beaudesert	11.4%	70%
Atherton	9.6%	80%
North Coast	6.8%	87%
Mackay	2.8%	89%
Monto	2.7%	92%
Bundaberg	2.6%	95%
Lockyer Valley	2.3%	97%
Brisbane Valley	1.7%	99%
Rockhampton	1.2%	100%

The table above shows that the South Burnett region is the largest user, followed by Darling Downs using fifty nine percent of the state's dairy water. Beaudesert and Atherton are the next biggest users followed by North Coast. These main regions make up 87 percent of the water used.

Table 2, following, summarises production and water use by regions for the state of Queensland in 1997. This summary is an aggregation of different water use to build an overview of water use for the Queensland dairy industry.

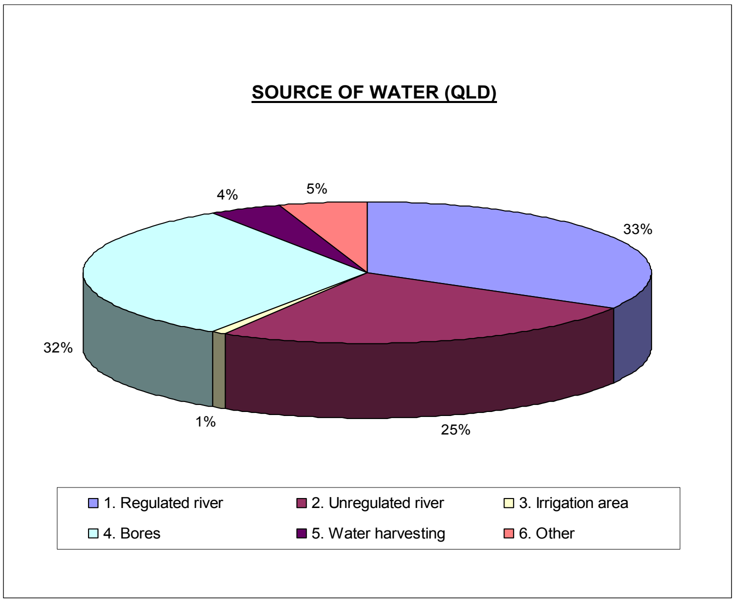
Table 2 Production and Water Stocktake by Region – 1997

SHIRE	TOTAL Irrig. Ha WINTER	TOTAL Irrig. Ha SUMMER	TOTAL ML WINTER	TOTAL ML SUMMER	TOTAL ML	AVERAGE ML/Ha WINTER	AVERAGE ML/Ha SUMMER	TOTAL $ WINTER (1997)	TOTAL $ SUMMER (1997)	TOTAL $ (1997)	AVERAGE $/ML
Atherton	3,842	3,214	27,910	19,092	47,002	7.3	5.9	$16,526,143	$12,634,124	$29,160,268	$620
Bundaberg	1,248	1,248	5,874	7,061	12,934	4.7	5.7	$2,350,608	$1,661,552	$4,012,160	$310
Mackay	1,000	1,236	6,051	7,635	13,686	6.1	6.2	$3,755,409	$4,832,185	$8,587,594	$627
Monto	1,242	1,561	4,555	8,830	13,384	3.7	5.7	$4,607,183	$3,979,160	$8,586,342	$642
Rockhampton	544	473	3,140	2,606	5,746	5.8	5.5	$1,903,809	$1,270,129	$3,173,938	$552
South Burnett	16,797	14,618	88,900	103,513	192,413	5.3	7.1	$37,536,527	$30,802,557	$68,339,084	$355
Beaudesert	6,077	6,303	21,023	35,050	56,073	3.5	5.6	$13,960,972	$16,750,791	$30,711,763	$548
Brisbane Valley	1,074	996	3,714	4,732	8,446	3.5	4.8	$1,980,653	$1,177,236	$3,157,889	$374
Lockyer Valley	1,440	720	7,172	4,071	11,243	5.0	5.7	$3,008,118	$1,362,591	$4,370,709	$389
North Coast	2,937	2,966	15,746	17,902	33,648	5.4	6.0	$6,135,761	$5,614,274	$11,750,035	$349
Darling Downs	8,006	6,817	50,404	46,656	97,060	6.3	6.8	$20,361,573	$18,512,761	$38,874,334	$401
OVERALL	**44,207**	**40,152**	**234,489**	**257,148**	**491,635**	**5.3**	**6.4**	**$112,126,756**	**$98,597,360**	**$210,724,116**	**$429**

SHIRE	TOTAL PROD. WINTER (Lts)	TOTAL PROD. SUMMER (Lts)	TOTAL PROD. (Lts)	AVERAGE Lts/Ha WINTER	AVERAGE Lts/Ha SUMMER	AVERAGE $/Ha WINTER	AVERAGE $/Ha SUMMER	TOTAL GROWERS (ABS)	TOTAL GRS SURVEYED
Atherton	40,307,667	30,814,938	71,122,604	10,491	9,588	$4,301	$3,931	217	22
Bundaberg	5,733,189	4,052,566	9,785,755	4,594	3,247	$1,884	$1,331	45	1
Mackay	9,159,535	11,785,817	20,945,352	9,160	9,535	$3,755	$3,910	44	10
Monto	11,237,031	9,705,268	20,942,299	9,048	6,217	$3,709	$2,549	64	10
Rockhampton	4,643,436	3,097,877	7,741,313	8,536	6,549	$3,500	$2,685	45	6
South Burnett	91,552,506	75,128,188	166,680,694	5,451	5,139	$2,235	$2,107	441	15
Beaudesert	34,051,152	40,855,587	74,906,739	5,603	6,482	$2,297	$2,658	171	10
Brisbane Valley	4,830,860	2,871,308	7,702,168	4,498	2,883	$1,844	$1,182	49	4
Lockyer Valley	7,336,872	3,323,393	10,660,265	5,095	4,616	$2,089	$1,892	106	1
North Coast	14,965,271	13,693,351	28,658,622	5,095	4,617	$2,089	$1,893	112	35
Darling Downs	49,662,373	45,153,076	94,815,449	6,203	6,624	$2,543	$2,716	441	18
OVERALL	**273,479,892**	**240,481,369**	**513,961,259**	**6,186**	**5,989**	**$2,536**	**$2,456**	**1,735**	**132**

4.2 Water Sources

Figure 2 Sources of Water



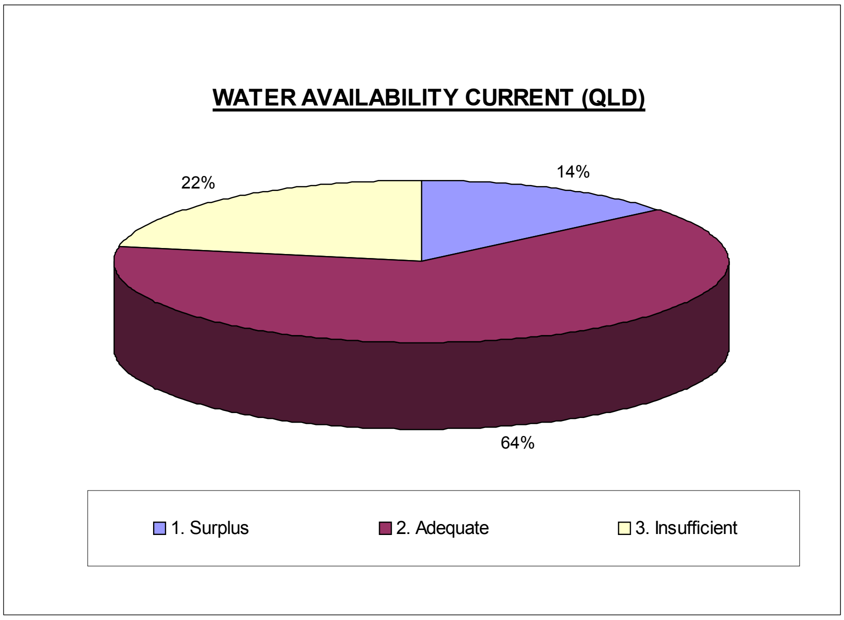
The percentages ascribed in Figure 1 are representative of the survey results. Regulated water sources comprised regulated streams and irrigation areas and supplied 34 percent of growers. Bores supplied 32 percent of growers and unregulated streams provided a water source to 25 percent of growers. Water harvesting and other miscellaneous methods delivered the remaining 9 percent.

Table 3 Regional Sources of Water

	Regulated Water	Unregulated Water	Irrigation Area	Bores	Water Harvesting	Other
Atherton	9%	77%		9%		5%
Beaudesert	20%	30%		30%		20%
Brisbane Valley		50%		25%	25%	
Bundaberg	100%					
Darling Downs	5%	9%		55%		32%
Lockyer Valley				100%		
Mackay	20%			80%		
Monto	60%			20%		20%
North Coast	57%	14%	3%	6%	11%	9%
Rockhampton	33%	17%		17%		33%
South Burnett	33%	7%		47%		13%
Overall	33%	25%	1%	32%	4%	5%

Table 3 shows that those growers surveyed in the Bundaberg, Monto, North Coast and Rockhampton regions utilise regulated river supplies as their first choice for irrigation. Growers surveyed within the Atherton and Brisbane Valley regions irrigate from unregulated river supplies. Bores are the primary source of irrigation in the Darling Downs, Lockyer Valley, Mackay and South Burnett regions. In the Beaudesert region surveyed dairy farmers use both unregulated rivers and bores.

Figure 3 Current Water Availability



When asked to rate their current availability of water, see Figure 2, 64 percent of growers believed they had adequate water availability currently, where as 22 percent believed they had insufficient water availability and 14 percent believed they had a surplus.

Figure 3 Regional Current Water Availability

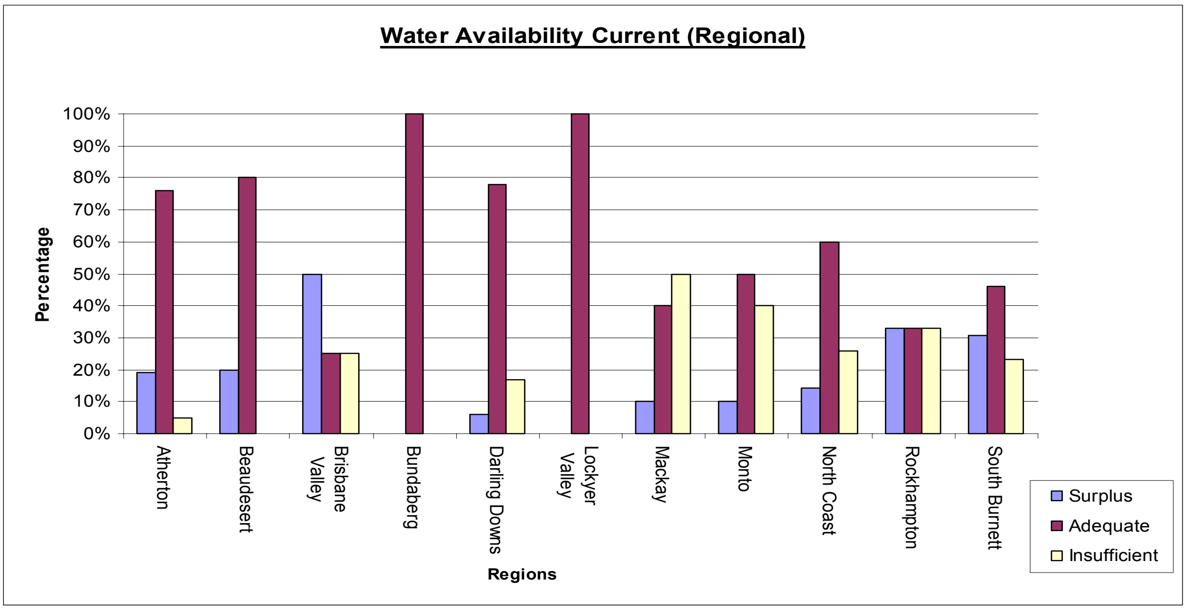
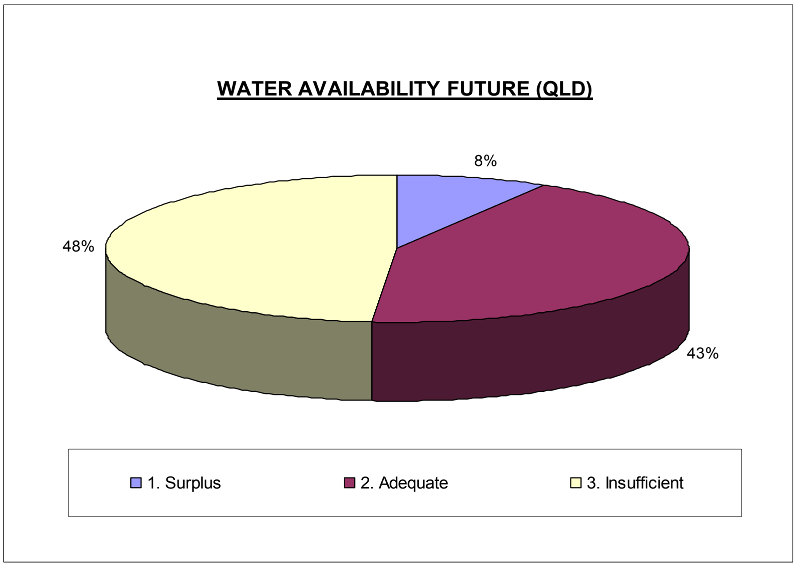


Figure 3 highlights that the majority of growers surveyed within the Atherton, Beaudesert, Bundaberg, Darling Downs, Lockyer Valley, Monto, North Coast and South Burnett regions believe that they have adequate water availability in the current environment. However, it is important to note that this small sample set may not be representative of regions. For example, it is well recognised that areas o f the Lockyer Valley have water availability issues. The majority of growers in Mackay region believe that they currently have insufficient water availability. On the other hand growers in the Brisbane Valley region believe they have a surplus of water. Survey participants within Rockhampton viewed the current situation as an equal combination of adequate, insufficient and surplus water supplies.

Figure 4 Projected Water Availability



In Figure 4, growers were asked to rate their projected water availability. All regions expect a reduction in water availability from their current status. Forty eight percent of growers believed that they would have insufficient water in the future compared to 22 percent currently. Forty three percent of growers believe that they will have adequate water in the future, down 21 percent from 64 percent of growers believing they had adequate water currently. In the future 8 percent of growers believe they will have surplus water, a reduction from 14 percent who believe they have surplus water currently.

Figure 5 Regional Water Availability

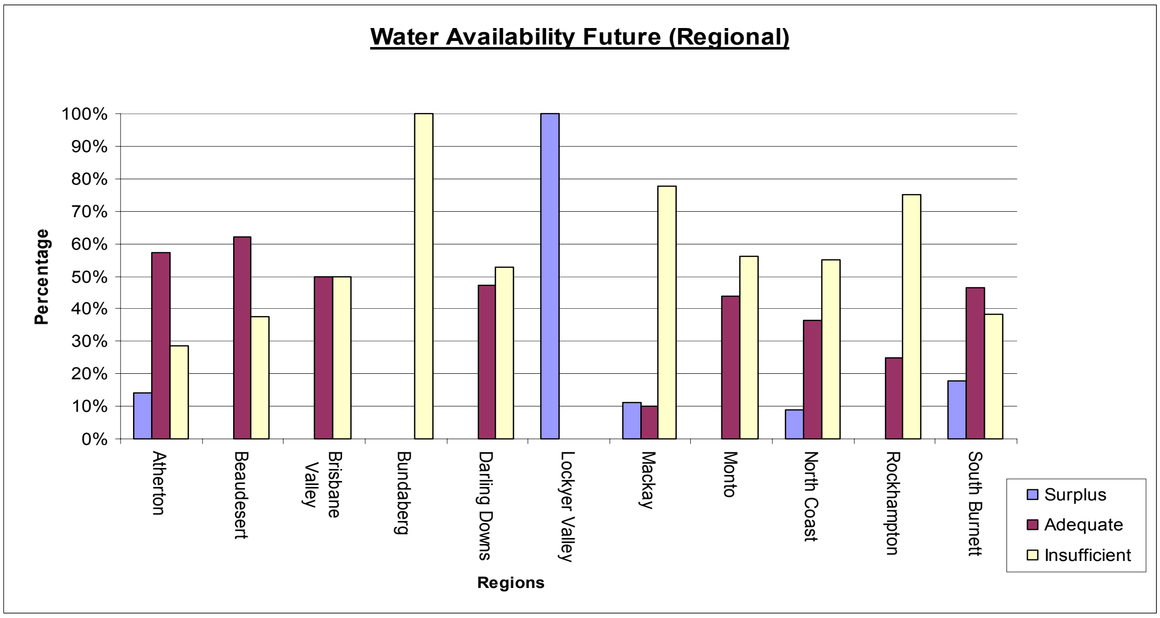
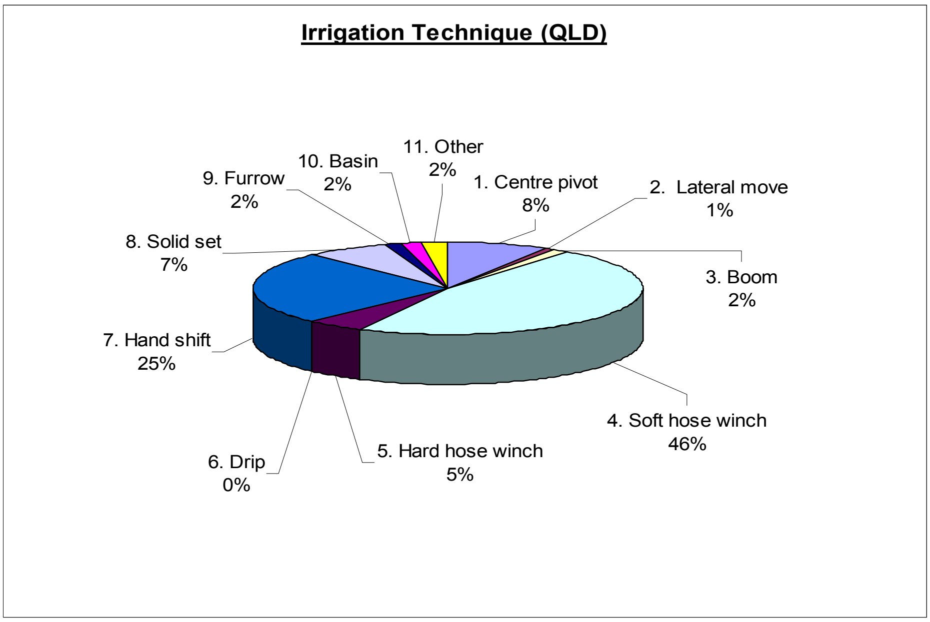


Figure 5 highlights that the majority of growers within the Atherton, Beaudesert and South Burnett regions believe that they will have adequate water availability in the future. Although, all of the growers in Bundaberg and the majority of growers in Darling Downs, Mackay, Monto and Rockhampton believe they will have insufficient water availability in the future. Half of the survey participants within Brisbane Valley believed they had adequate future water and the other half believed the future projection were for insufficient water. Again, this data must be read as survey results and, therefore, is not necessarily representative of all regions.

4.3 Irrigation Infrastructure

Figure 6 Irrigation Technique (QLD)



Survey data in Figure 6 illustrates that the most commonly used irrigation technique is the soft hose winch with 46 percent of respondents, followed by the hand shift at 25 percent.

On a statewide basis: 36 percent of growers use low pressure systems, that is hand shift at 25 percent, boom at 2 percent, lateral move at 1 percent and centre pivot at 8 percent. Fifty one percent of growers use high-pressure systems involving, soft hose winch at 46 percent and hard hose winch (or travelling irrigators) at 5 percent. Solid set irrigation technique is used by 7 percent of growers followed by drip, furrow or flood based systems, basin and other at less than 2 percent each.

Table 4 Regional Irrigation Technique

Regions	%Use Soft Hose Winch	Hand Shift	Centre Pivot	Solid Set	Hard Hose Winch	Lateral Move	Boom	Drip	Furrow	Other	Total
Atherton	37%		37%	26%							100%
Beaudesert	88%				12%						100%
Brisbane Valley	67%									33%	100%
Bundaberg	100%										100%
Darling Downs	6%	56%	13%		13%	6%	6%				100%
Lockyer Valley	100%										100%
Mackay	20%	50%	10%		10%					10%	100%
Monto	88%								12%		100%
North Coast	67%	27%		6%							100%
Rockhampton	50%	25%					25%				100%
South Burnett	25%	50%	8%	8%	8%					1%	100%

Table 6 highlights that producers in the Atherton, Beaudesert, Brisbane Valley, Bundaberg, Lockyer Valley, Monto, North Coast and Rockhampton are most likely to use the soft hose winch for irrigation. Where as producers in the Darling Downs Mackay and South Burnett regions are likely to use the hand shift technique.

Figure 7 Potential to Improve Irrigation Infrastructure

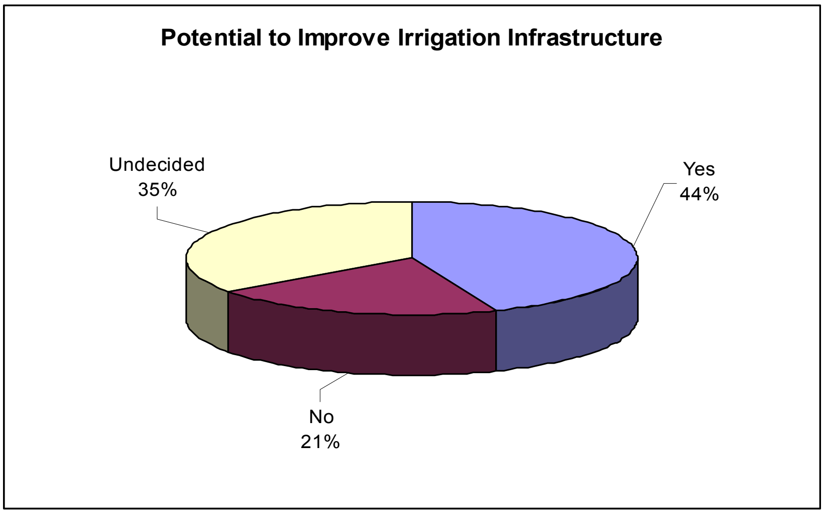
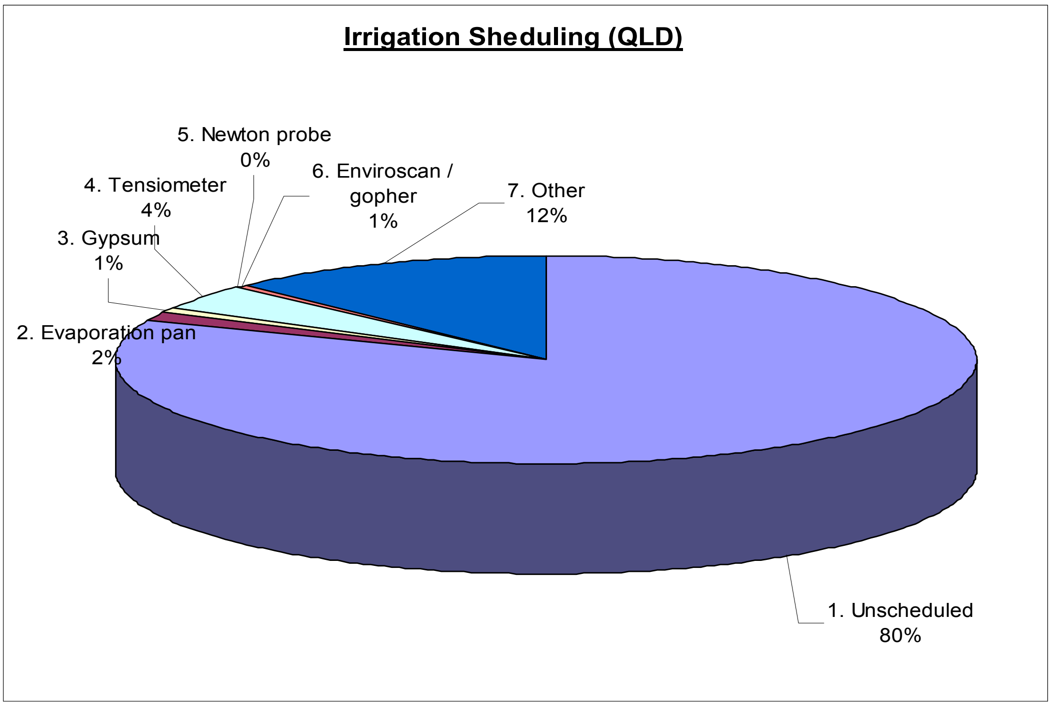


Figure 7 summarises that 44 percent of dairy farmers believe that there is potential to improve irrigation infrastructure. This may be less than half but represents the greatest majority of the voting. A group totaling 21 percent of growers does not believe that there is potential to improve irrigation infrastructure and 35 percent did not comment.

4.4 Management Practices

Figure 8 Irrigation Scheduling



The majority of Dairy farmers in Queensland do not schedule irrigation. Figure 8 shows that 80 percent of surveyed growers do not schedule for irrigation. Technology is used by only 5 percent of growers to support irrigation scheduling. This involves the use of tensiometers, Newton probes and enviroscans. The remaining farmers use gypsum and other miscellaneous methods.

Table 5 Regional Irrigation Scheduling

Regions	% Use Unsheduled	Evaporation Pan	Gypsum	Tensiometer	Newton Probe	Enviroscan/ Gropher	Other	Total
Atherton	78%	10%	6%	6%				100%
Beaudesert	100%							
Brisbane Valley	100%							100%
Bundaberg				100%				100%
Darling Downs	94%						6%	100%
Lockyer Valley	100%							100%
Mackay	90%			10%				100%
Monto	44%						56%	100%
North Coast	80%				3%		17%	100%
Rockhampton	100%							100%
South Burnett	69%			8%			23%	100%
Overall State	**81%**	**2%**	**1%**	**4%**		**1%**	**11%**	**100%**

Table 7 highlights that dairy farmers in Queensland are not likely to schedule irrigation. The majority of growers in the Atherton, Beaudesert, Brisbane Valley, Darling Downs, Lockyer

Valley, Mackay, North Coast, Rockhampton, South Burnett and Monto regions do not schedule irrigation. Please note that there was only one survey respondent in the Bundaberg region.

Figure 9 Potential to Improve Irrigation Scheduling

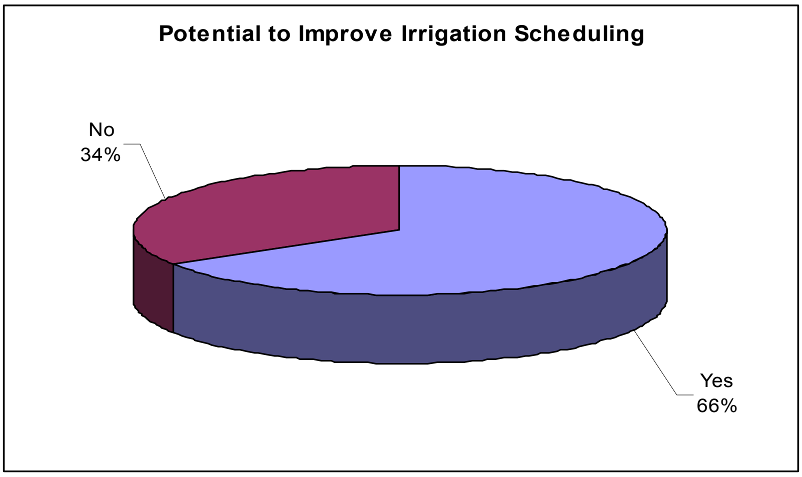


Figure 9 shows that 66 percent of dairy farmers believe that there is potential to improve irrigation infrastructure. Only 34 percent of growers believed that there was no potential to improve irrigation scheduling.

Table 6 Management Practices

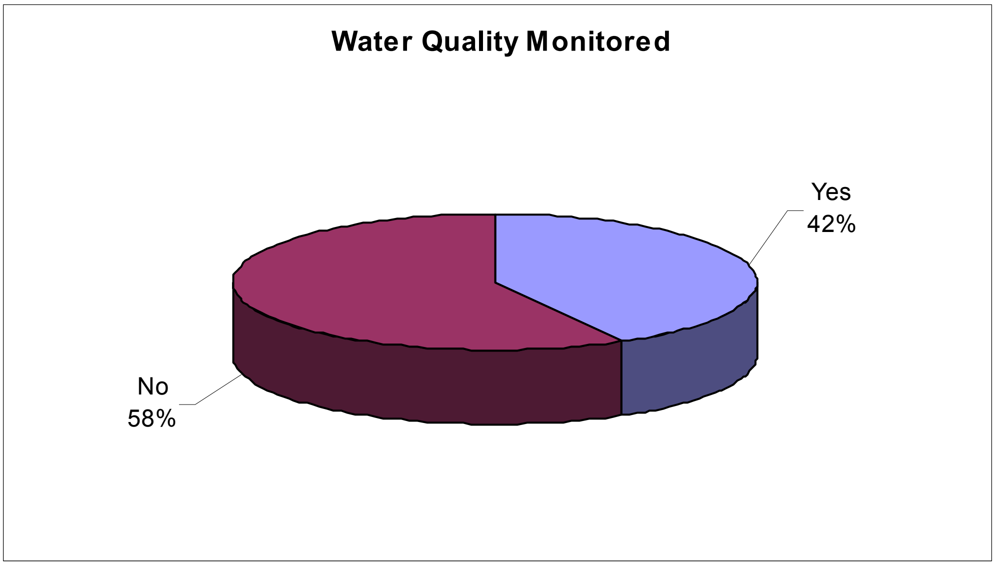
Management Practices Table	Yes	No
Measure & Record Irrigation Applications	21%	79%
Calculate Water Use Per Hectare	19%	81%
Vary Irrigation Practices for Different Soils	46%	54%

Table 8 identifies that only 21 percent of dairy farmers measure and record irrigation applications as part of managing their irrigation scheduling. Of that 21 percent only 19 percent actually calculate water use per hectare.

Soil management, by varying irrigation practices for different soils, is only practiced by 46 percent dairy farmers.

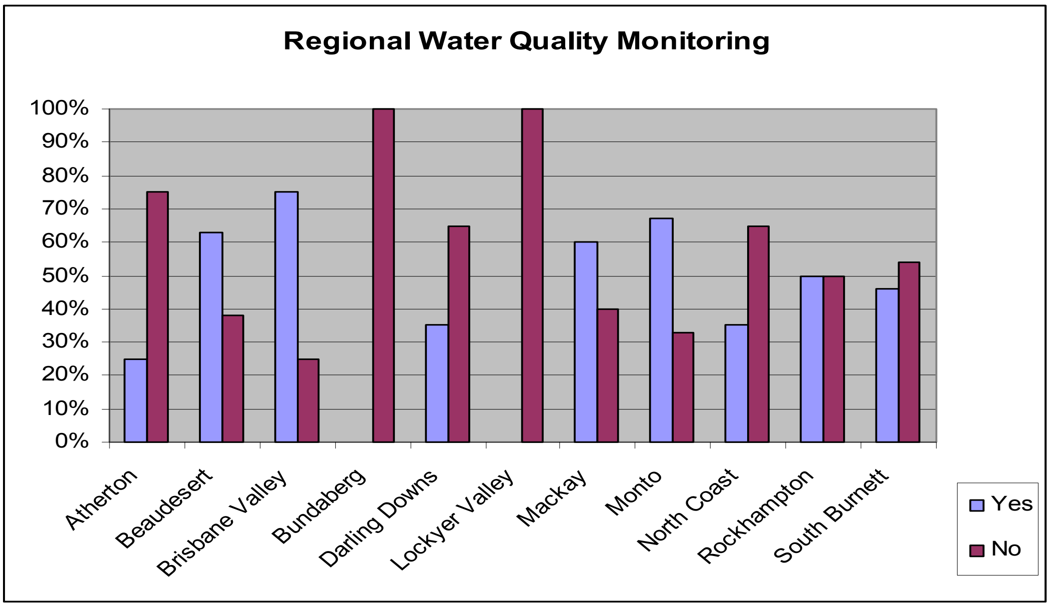
4.5 Water Quality

Figure 10 Water Quality Monitored



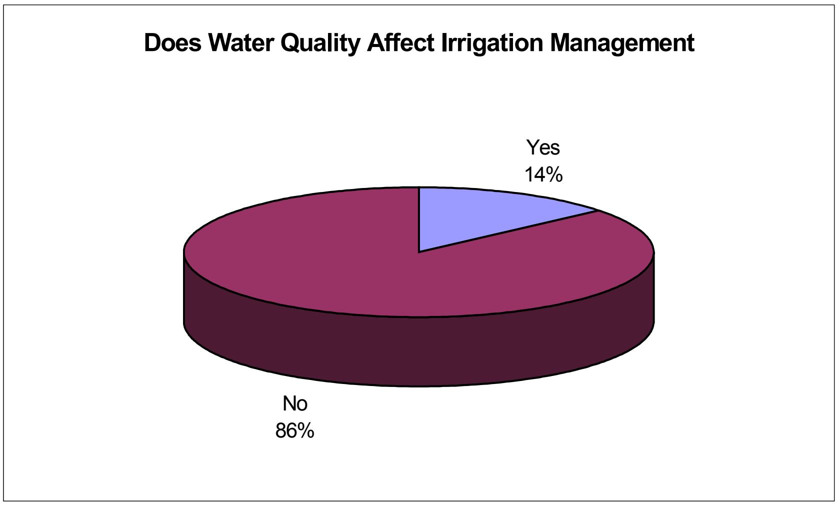
The survey data presented in Figure 10 highlights that 42 percent of dairy farmers monitored the quality of water used for irrigation and 58 percent do not.

Figure 11 Regional Water Quality Monitoring



The majority of growers in the Atherton, Bundaberg, Darling Downs, Lockyer Valley, North Coast and South Burnett regions do not monitor water quality. The majority of growers surveyed within the Beaudesert, Brisbane Valley, Mackay and Monto regions do monitor the quality of water used for irrigation. Half of those surveyed in Rockhampton monitor water quality.

Figure 12 Does Water Quality Affect Irrigation Management



Overall dairy farmers in Queensland do not believe that water quality affects the efficiency of irrigation management. Only 14 percent of growers said that water quality does effect irrigation management and the remaining 86 percent were not concerned about this issue.

4.6 Professional Advice

Table 7 Professional Advice

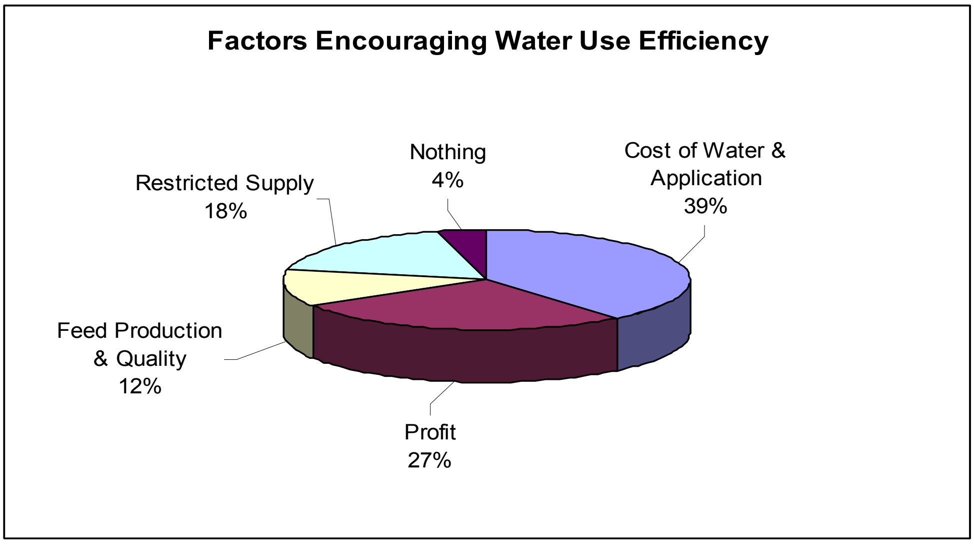
		Yes %
1	Farm Business Adviser	30
2	Agronomic Adviser	51
3	Irrigation Adviser	7

There is a greater use of agronomic advisers amongst dairy farmers than the use of farm business advisers or irrigation advisers. 51 percent of producers have used an agronomic adviser, 30 percent use farm business advisers and seven percent using irrigation experts.

4.7 Attitudes and Perceptions

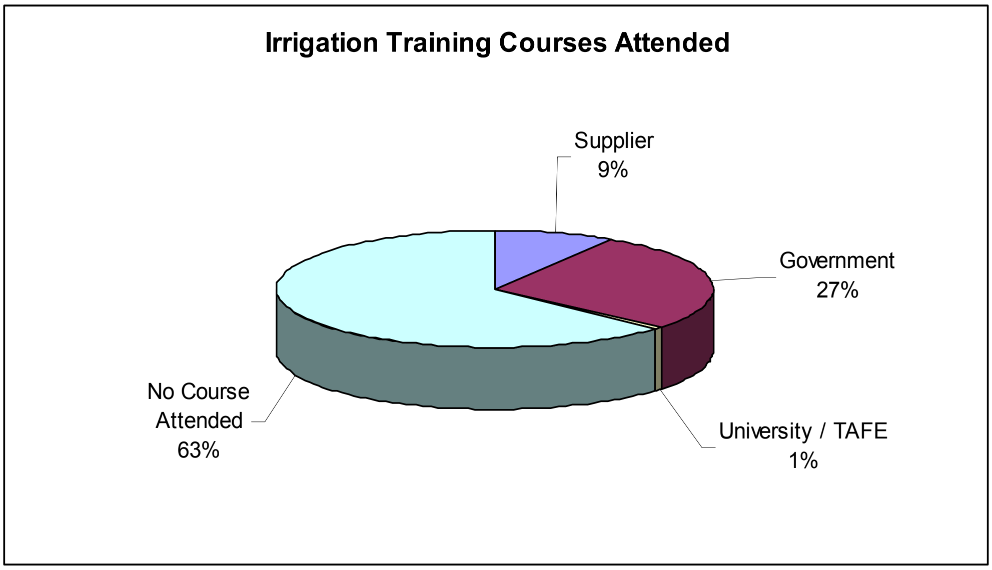
The majority of growers would be encouraged to improve water efficiency if the cost of water and its application where to rise.

Figure 13 Factors Encouraging Water Use Efficiency



Profit and productive benefits resulting from better water use efficiency would be encouraging to 39 percent of respondents (Feed Production & Quality and Profit). The fact that Feed Production & Quality would encourage 12 percent may well indicate a lack of understanding of the impacts of water use efficiency on feed production systems.

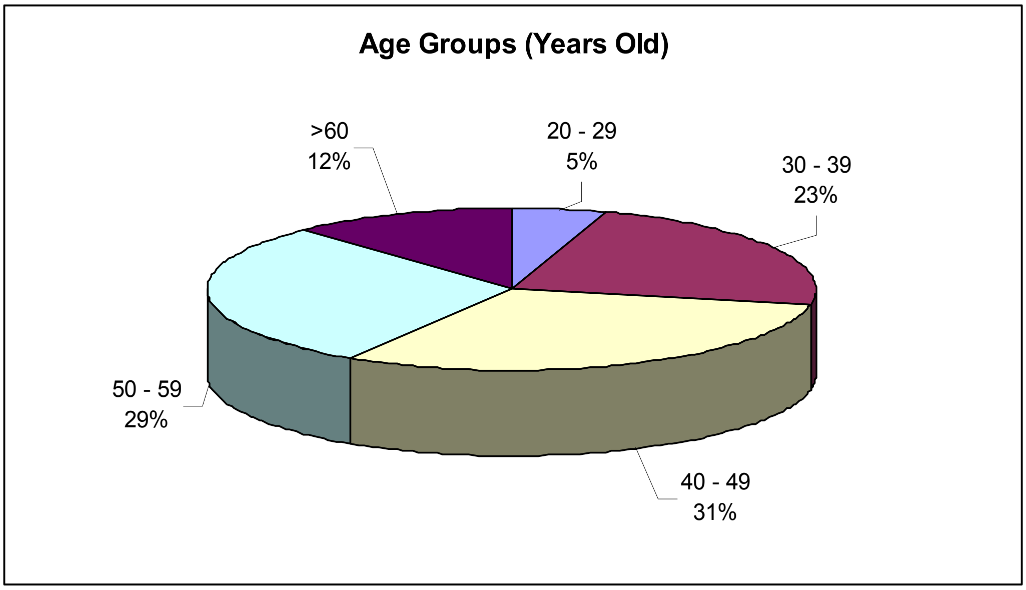
Figure 14 Attended Irrigation Training Courses



Attendance at irrigation training courses is relatively low considering that 66 percent of growers believe that they could improve their irrigation scheduling.

4.8 Demographics

Figure 15 Age Group



Figures 15, shows 60 percent of growers are between the ages of 40 and 60 years. 27 percent are less than 40 and twelve percent are greater than 60 years.

Figure 16 Education

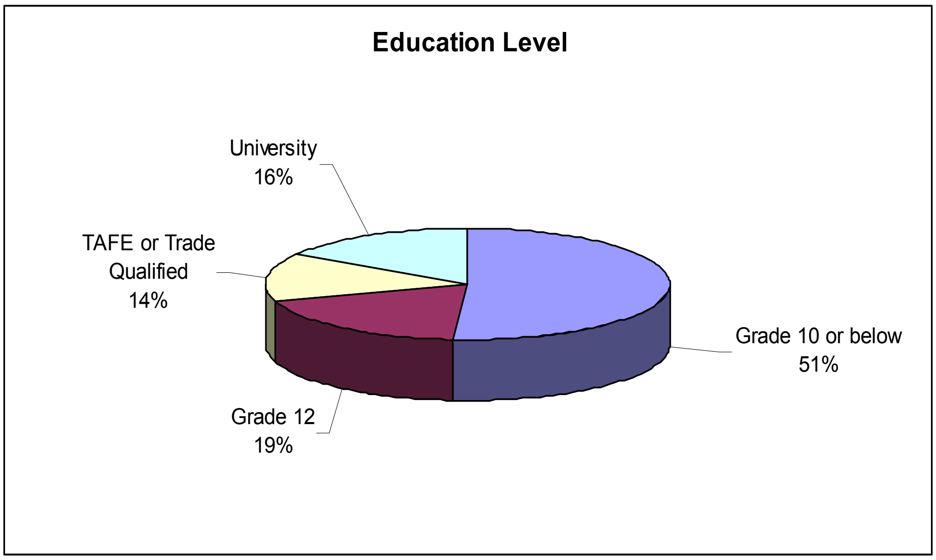


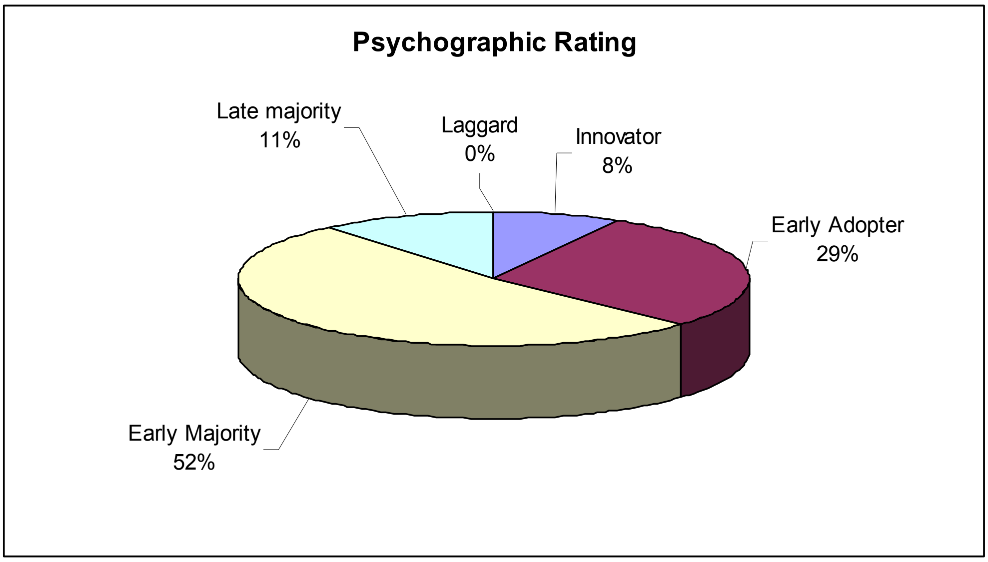
Figure 16 shows that the majority of growers have been educated to grade 10. Higher educated has been received by 30 percent of growers with 14 percent reaching TAFE or trade qualification and 16 percent completing university.

4.9 Psychographic Segments

Psychographic segmentation is a technique to segregate groups based on their behavior towards the adoption of new technologies. The expected proportions in agriculture are: innovator, 3 percent; early adopter, 13 percent; early majority 32 percent; late majority, 32 percent; and laggards 20 percent.

Dairy Extension Officers were asked to rate the growers surveyed. The results are extremely positive showing Queensland Dairy farmers to be progressive and quick to adopt new technologies once they have been proven.

Figure 17 Psychographic Rating



The majority of dairy farmers are in the early majority group (52 %). While 37 percent fall within Innovators and Early Adopter segments. Therefore 89 percent of Dairy farmers were rated as being in an "early" psychographic segment, compared with approximately 48 percent for agriculture on average.

5. Case Studies

Key Points

- *Case studies have been carried out on 10 dairy farms in each of the five main regions*
- *These studies are more in-depth than the surveys and have evaluated water use efficiency and irrigation effectiveness on each of the farms*
- *These studies have enabled the development of a case study template for ongoing use as a service to farmers during the adoption program*
- *A common finding on several of the case study farms was that they have inadequate water availability which is leading to under watering*

Ten case studies, two in each of the main diary regions, have been carried out as part of the project. The goal of the case studies has been to undertake a more in depth analysis of dairy farm irrigation systems than has been possible during the surveys. The outcome has been the development of a case study model for on-going use by extension officers. The case study approach analyses water use, water use efficiency and irrigation effectiveness for individual dairy farms and will be available as a service to farmers during the RWUE adoption program. A benefit of the case studies is that they can be used by extension officers as a pragmatic tool providing an incentive for farmer involvement, as well as being a medium for developing a deeper understanding of the issues facing irrigated dairy farms.

The ten case studies undertaken are provided in the appendices. Individual identities have been omitted for privacy reasons. The approach taken in the case studies is provided in the following section.

5.1 Case Study Approach

The aim of the case studies has been to evaluate the irrigation system water use efficiency and the irrigation effectiveness. Several values have been considered when evaluating these two attributes of an irrigation system, which are detailed below.

5.1.1 Crop Water Requirements

Both irrigation efficiency and effectiveness require an understanding of the crop water use requirements of the production system. This has been calculated using the Rustic software model, which is net of rainfall. The model makes a theoretical assessment of the irrigation requirement for the crop after accounting for effective rainfall for the year(s) being investigated. This can be expressed as follows.

Irrigation Requirement (IR) = Crop Water Use Requirement - Effective Rainfall

Where Rustic calculates crop water requirement as:

$ET_{crop} = K_c\, ET_o$

Where:

ET_{cro} = *Crop evapotranspiration*

$K_c\, ET_o$ = *Crop factor (K_c) which is applied to account for the crop water requirements during its differing stages of development by the potential evaporation of the environment (ET_o).*

Two types of seasons have been assessed, 1998 and a dry year (irrigation requirement to meet water demand in 75% of years).

5.1.2 Actual Irrigation Applied (ML input)

The actual water use of an irrigation system can be calculated by three methods (detailed below). These methods are the best available without actually metering water in the individual irrigators and/or paddocks. This case has used 1998 pump power consumption details and grower estimation for a dry year for assessments of the irrigation applied.

DNR meter readings

If the system is regulated through the Department of Natural Resources (DNR) then a system of regular water meter readings is typically taken. This information can be sourced from the DNR databases.

Farmer estimates

The volume of irrigation applied to the farm can be estimated from a calculation based on the application depths (mm) per irrigation, the number of irrigation's throughout the season or year and the area of irrigation. If using this method, the values for millimeters per irrigation must be based on a good understanding of the design and operation of the system. In this case study this estimate was strengthened by on-farm measurement of the discharge and application rates of the sprinklers. Several methods were used including a timed volume (using container and stopwatch) and pressure at the nozzle measurement (using pressure discharge relationship for specified nozzle sizes).

Pump power consumption.

The pump power consumption is well recorded by the energy provider meter readings (in kW hours). The power required (in kW) to move water using a pump is a function of the flowrate (Q), pressure (H) and the pumping efficiency (η). If these values are known then the average operating power (kW) required for pumping under these conditions can be calculated by the equation:

$$\text{Pump Power Consumption} = \frac{9.81\,Q\,H}{\eta}$$

Given the range of operating pressures and flowrates an average operating pressure and flowrate can be assumed to calculate the average kW that the pump is drawing. Dividing the kW hours by the average kW power gives an estimate of the number of hours the pump is used for in a given period. At the average pumping flowrate an estimate of the total volume of water applied for that period can be made.

5.1.3 Water Use Efficiency

There are three key measures of efficiency.

Engineering Efficiency as a percentage (often termed volumetric or irrigation efficiency) is the ratio of irrigation water required by the crop as calculated theoretically to the total volume of irrigation water applied (ML required/ML input).

Agronomic Efficiency is the feed production per megalitre (ML) applied. This measure has not been calculated in this study due to limited data for feed production (t/ML input).

Economic Efficiency is the dollars of milk sales generated per ML applied ($/ML).

5.1.4 System Effectiveness

Irrigation effectiveness is a measure of the ability of the irrigation system to meet the crop water requirements of the pasture production system. Effectiveness focuses on peak demand to assess two critical design requirements, namely:

1. the peak system flowrate, and
2. the total irrigation system capacity required to irrigate the whole farm in the most critical period

Key measures of effectiveness include the following.

Peak Irrigation Requirement - Calculated from crop/pasture peak water requirement (or demand) period, which is typically the hottest (or most evaporative) month of the year and assumes that for this period no rainfall is available to supplement the pasture. The complete system (including pumps, pipe and irrigators) should be designed to deliver a flow rate that meets the peak irrigation requirement to be effective.

Pump Capacity – assessment of the pumps capacity flow rate.

Application Discharge Capacity – assessment of discharge capacity for each irrigation system used. This value includes both the physical system and labour constants of the application system. This assessment was conducted from physical pressure and discharge measurements at the sprinkler nozzles.

Distribution System Pressure Losses – assessment of pressure losses due to friction and elevation in the system. This determines whether an optimum or deficit pressure is achieved at the application system. Both a physical measurement approach (from pressure measurements at the pump and sprinklers) and theoretical calculation (from pipe friction loss specifications) were used in this assessment.

5.2 Case Study Conclusions

Besides the specific findings of each of the cases, there were also some common conclusions that could be drawn.

Water Availability and Under-watering

The most common issue found was that many dairy farms have a water supply inadequate to meet the demands of the production system they are watering. These farms compensate for this problem by under-watering. This issue has most likely developed in an evolutionary manner with farmers expanding their irrigation area in the knowledge that under-watered irrigated pasture is likely to be more productive that dryland pasture.

A major conclusion is that there is a real opportunity for farms to lift productivity by better supplying their existing developed irrigation area.

Irrigation Effectiveness

Queensland dairy farms have a relative high proportion of older irrigation systems, being one of the original irrigation industries. Many of these systems have an inability to supply crop water requirements in peak demand periods. This is a direct cause of lost production.

Scheduling

The use of scheduling systems and technologies is scarce. There is an opportunity to increase productivity through improved scheduling, once water availability and irrigation effectiveness issues have been overcome.

6. Energy and Water Management Model

Key Points

- The model is a tool that assesses the match of energy demand to supply, considering water requirements and cost
- It enables farmers to vary their available feed inputs to discover their optimal mix
- The model is designed so that it can be upgraded over time as better or more current information becomes available

An Energy and Water Management Model has been developed as part of the project. The model is designed as a tool that can be taken on farm to assess:

- Energy demand
- Energy supply
- Water requirement
- Cost of energy supply
- Gross profit margin.

The model allows extension officers and farmers to vary their available feed inputs in order to discover the optimum mix given the following constraints:

- Energy demand
- Water availability
- Area
- Cost
- Personal preferences.

It also immediately assesses feed utilisation levels of current and possible energy production systems. The model is designed so that over time it can be upgraded or customised as better information becomes available.

The Energy and Water Management model has been supplied with this report in Microsoft Excel format. A printout of the layout is also provided in the appendices.

6.1 Energy Demand

The formula used to estimate the energy demand of a cow herd during a lactation is that developed from the research project "Estimating Energy Requirements for Grazing Dairy Cows" (Kerr et al, 1996). This project was conducted on fourteen dairy farms in south-east Queensland. Liveweight and milk production data was obtained for each cow of predominately Holstein-Friesian.

The model was developed firstly to estimate the energy requirements for maintenance (15,728 MJME + 0.5 x litres milk produced per lactation). Adjustment factors, following, are then be applied to the base figure.

- ***Energy requirement to produce milk***.

  These values of MJ ME/L vary according to the fat content of the milk as shown in the table below. The energy value is then multiplied by the litres produced to provide the energy requirement of milk production.

Fat %	3.0	3.5	4.0	4.5	5.0	5.5
ME MJ/L	4.34	4.67	5.03	5.36	5.68	6.01

- ***Energy requirement for pregnancy***

  This is estimated to be 30 percent of the energy required for maintenance. This is then adjusted given the average calving interval of the herd (days) to calculate the percentage of the herd pregnant at any one time. The resulting factor is added to one and multiplied to the maintenance requirement.

- ***Energy requirement for walking***

  Walking requires 600 MJ ME per cow per lactation for every kilometre walked in a day.

- ***Energy requirement for weight gain***

  The energy requirement for any weight gain (increasing condition score or increasing frame size) is 500 MJ ME per cow per lactation for every 10 kilograms gained.

6.2 Energy Supply

This component of the model has two sections, dry matter production and energy values for the dry matter produced.

- ***Dry matter production***

  This information has been sourced from the program Q-Feed, which has been developed in south-east Queensland and remains unadjusted for the statewide model.

- ***Energy Values***

  Energy values have been sourced from the ATDI Rumnut Feed Library (Martin, 1999). They assume optimal inputs and grazing management, which affect energy values through palatability and digestibility.

- ***Feed Cost***

  Feed costs have been included at their opportunity cost if sold as fodder or at purchase price.

6.3 Water Requirement

Water requirements have been calculated for a range of winter and summer pasture and crop species using Rustic. The regional climatic index developed for survey analysis is then applied to adjust water requirements according to the region selected in the model.

6.4 Outcomes of the Model

The model enables the discovery of the optimal energy supply mix given certain constraints, as discussed. It also enables analysis of the following.

Energy Utilisation – how well the feed supplied is utilised by the cow herd

Water Management – ML and ML/Ha required, the cost of water and energy supplied per ML required.

Energy Cost – the cost of the feeds produced, watered and purchased to enable analysis of dollars per MJ ME

Revenue – revenue of dollars per MJ ME for feed produced, therefore accounting for the value of utilisation

Gross Margin – dollars per MJ ME supplied.

There are considerable opportunities to develop this model over time. Dry matter and energy value data can be developed to incorporate regional differences. Energy values could also be adjusted for stages of growth and grazing. Water use requirements requires ongoing research and the results of this research can be used to update the accuracy of the information, as well as the regional climatic differences. Finally, costs will need to be maintained to values at the time.

7. Database Analysis

Key Points

- *Survey results have been compiled to ascertain the relationship between high performance and average practice*
- *High performance is the intersection of best practice water use (less than average) with above average yield*
- *Analysis of the graphs that plot this relationship indicate the opportunity to improve average performance towards high performance and also there is also an opportunity to target improving high performance over time*
- *Some trends were indicated as to the best practice management processes which lead to improved performance, however, the survey data could not quantify these trends*
- *There is a need to develop research programs to quantify the benefits of best practice processes*

7.1 Water Use and Production Analysis

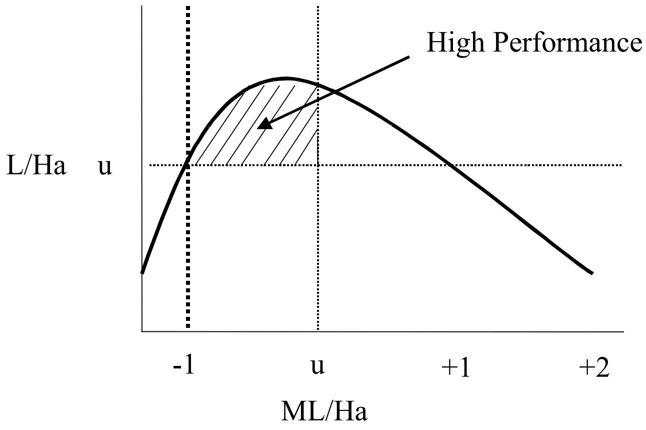
Analysis has been undertaken by averaging the performance of respondents, excepting outliers, for water use (ML input/ha), measures of agronomic water use index (Litres/ML) and ($/ML) economic water use index. Outliers are considered to be water use or production that fall outside a standard deviation range of –1 to +3 of average (u). Details of assumptions are provided in the appendices.

The surveys asked respondents two water use questions, "how much water did you use in 1998" and "how much water would you use in a dry year". As indicated in the Industry Structure analysis, the majority of growers do not record water application of volumes or frequency. Consequently, surveyors asked respondents to estimate how much water they would normally apply at each irrigation event and how often they would normally irrigate, for both 1998 and a "dry year". Analysis of the 1998 water use data showed high variability due to above average rainfall and so for the purpose of the analysis the more consistent data set of the" dry year" has been used. Correlation of grower estimates of a "dry year" and rustic analysis indicate this to be equivalent to the water required to water a pasture in 75 percent of years.

Milk production has been taken from the 1998 QDAS statistical analysis for each of the farmers surveyed. The milk production figure "Milk Produced from Forage Grazed" has been used and adjusted by grower estimates of what proportion of milk production came from irrigated grazing versus dryland.

The high performance sub set has been determined using a two step process, which is illustrated in Figure 18 below. The first step involved identifying growers within less than one standard deviation (-1) of average water use. Within this data set, those growers with above average yields were then selected as "high performance". This approach has not been able to identify best management practice, which needs to be a priority research area in the adoption program.

Figure 18 Determination of High Performance



The large numbers of regions covered by the 132 surveys provides for only a small data set in each region. In order to increase the sample size to gain greater statistical certainty, a system of aggregating the responses across regions has been developed. The survey results for water use have been standardised using a relativity index for environmental differences across the regions surveyed. This is appropriate for water use, as water requirements are directly proportional to regional pan evaporation rates less effective rainfall. Production remains unadjusted, as there are no consistent differences across the regions assessed. Differences in soil type and species have not been accounted for, for the same reason.

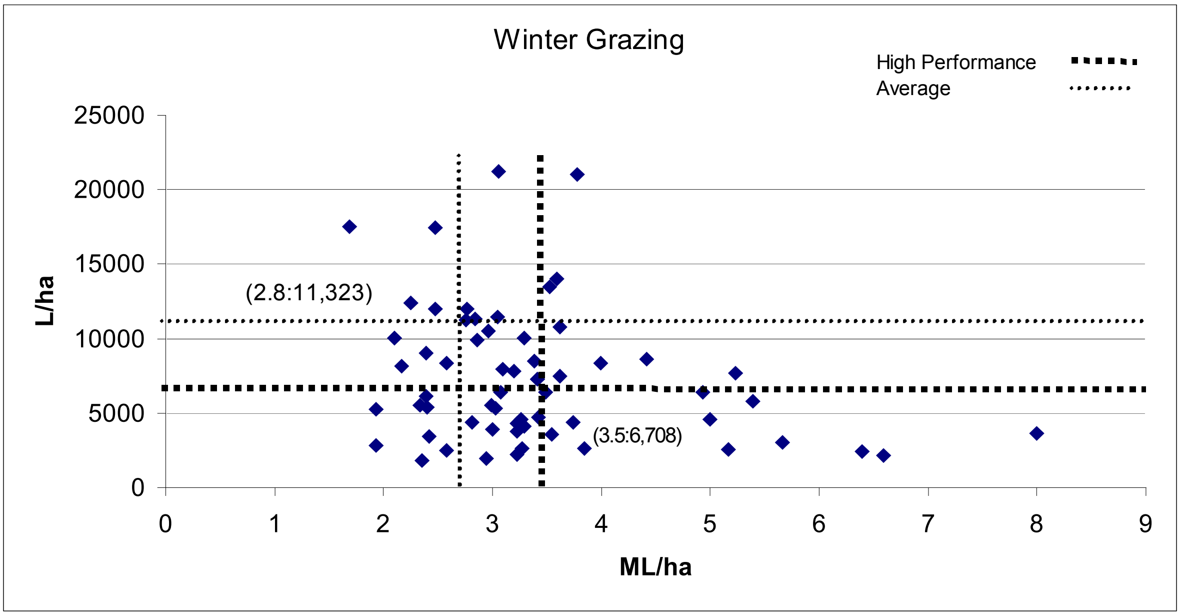
The analysis of the standardised data considered two simple production systems. Winter grazing and summer grazing. A more detailed analysis of specific species has been undertaken in the case studies and is available for ongoing use with the Energy and Water Management Model.

The data supplied in Figures 19 and 20 include standardised average practice water use, which is compared to a subset, standardised high performance water use. However, in this data the average practice measures that mix water, production and dollars have been taken directly from the regionally developed industry audit, which has not been standardised. Consequently, the ML/ha average practice figures in the matrices over the page cannot be related to the other average practice figures provided there. The figures are converged to common units in the opportunities database.

Figures 19 and 20 clearly show the variability in the available data. This is most probably driven by two key factors. Firstly, there are a number of non-water controllable and uncontrollable variables that influence productivity and, secondly, the key water use data is reliant on farmer best estimates in most cases.

However, this information could be used to clearly dissect differences in performance. The only significant difference between winter and summer opportunities is water use. There is little difference in productivity and, therefore value. The water difference is purely driven by the higher summer usage allowing for a greater range of performance.

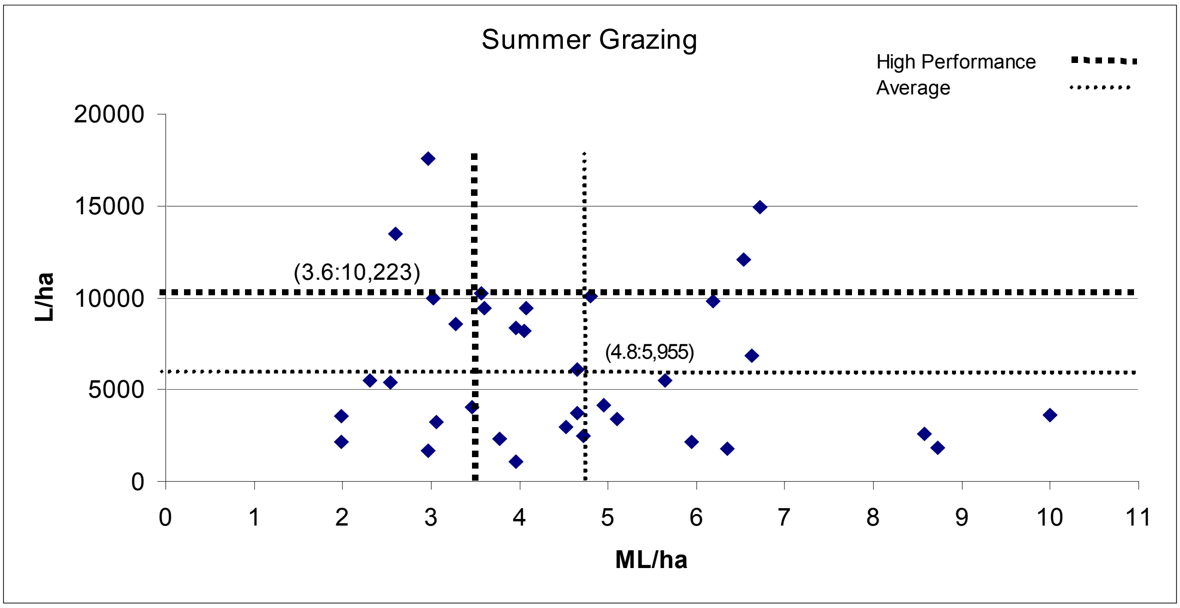
Figure 19 Winter Grazing - High Performance Analysis



	Std ML/ha	L/Ha	Ha/Cow	L/ML	$/L*	$/ha	$/ML
Average"	3.5	6708	0.28	1344	0.415	2441	558
High Performance	2.8	11323	0.18	3989	0.415	4699	1655
Opportunity	-0.6	4615	-0.10	2645	0.233	2258	616

Note: ** Opportunity calculated at manufacturing milk price*
" Average data taken from Audit Database

Figure 20 Summer Grazing – High Performance Analysis



	Std ML/ha	L/Ha	Ha/Cow	L/ML	$/L*	$/ha	$/ML
Average"	4.8	5955	0.27	1006	0.415	2441	417
High Performance	3.6	10223	0.26	2866	0.415	4243	1190
Opportunity	-1.2	4268	-0.01	1860	0.233	1802	433

Note: ** Opportunity calculated at manufacturing milk price*
" Average data taken from Audit Database

7.2 Best Practice Processes

Significant research has proven the benefits of best practice processes for improved water use. These include low pressure application systems such as centre pivots and lateral moves, which minimise evaporation losses, inaccurate application and soil compaction while also enabling more accurate and timely fertigation. Monitoring technology assists grower's irrigation scheduling through meeting plant water requirements while minimising drainage and deep percolation losses.

While having the technology is one aspect, recording and management systems are needed to support this technology. Best practice support is professional advice that links crop husbandry to water management. This level of advice can be supplied from within staff or families of horticultural businesses if supported by appropriate levels of training or experience. The overall system needs to be underpinned by a "quality control" type system that enables management to record, monitor and react to changes in the process in order to maintain optimal performance.

The most widely recognised benefits of improved WUE are reduced application and water costs. The link between WUE and improved production has not received the same levels of research. Specific research projects have provided evidence that these profit related benefits could be more significant than those of a cost saving nature.

In the implementation stage there is a need to undertake greater research to quantify the practical benefits of best practice. Two avenues are indicated by the findings of this project. Firstly, monitor the management processes of those growers who are in the high performance category, where they were willing to participate. Secondly, undertake controlled research studies, where research projects utilising hypothesised best practice are run in parallel to normal grower management comparing of the performance of each. A further important avenue is to monitor the progress of growers over time.

8. Opportunities

8.1 Quantified Opportunities

Quantified opportunities for ML savings, production increases and increased returns are provided for each of the main production regions in Table 8, following. These are theoretical opportunities and assume complete attainment. However, in reality only a proportion of these can be targeted which is discussed in the next section. The complete opportunities database is provided in the appendices.

Table 8 Total ML Opportunities

REGION	ABS Irrigated HA Winter	ABS Irrigated HA Summer	AP ML/Ha Winter	AP ML/Ha Summer	BP ML/Ha Winter	BP ML/Ha Summer	Total AP ML	Total BP ML	TOTAL OPP ML
Atherton	3,842	3,214	7.26	5.94	5.88	4.50	47,002	37,053	9,949
Bundaberg	1,248	1,248	4.70	5.66	3.81	4.28	12,934	10,103	2,832
Mackay	1,000	1,236	6.05	6.18	4.90	4.68	13,686	10,681	3,005
Monto	1,242	1,561	3.67	5.66	2.97	4.28	13,384	10,375	3,009
Rockhampton	544	473	5.78	5.51	4.68	4.18	5,746	4,516	1,230
South Burnett	16,797	14,618	5.29	7.08	4.28	5.36	192,413	150,369	42,044
Beaudesert	6,077	6,303	3.46	5.56	2.80	4.21	56,073	43,567	12,506
Brisbane Valley	1,074	996	3.46	4.75	2.80	3.60	8,446	6,591	1,855
Lockyer Valley	1,440	720	4.98	5.66	4.03	4.28	11,243	8,889	2,354
North Coast	2,937	2,966	5.36	6.04	4.34	4.57	33,648	26,306	7,342
Darling Downs	8,006	6,817	6.30	6.84	5.10	5.18	97,060	76,140	20,920
Totals	**44,205**	**40,152**	**5.30**	**6.40**	**4.29**	**4.85**	**491,628**	**384,583**	**107,045**

Figure 21 Total Litres Opportunity

REGION	ABS Irrigated HA Winter	ABS Irrigated HA Summer	AP L/Ha Winter	AP L/Ha Summer	BP L/Ha Winter	BP L/Ha Summer	Total AP Litres	Total BP Litres	TOTAL OPP L
Atherton	3,842	3,214	10,491	9,588	17,710	16,461	71,122,604	120,945,086	49,822,482
Bundaberg	1,248	1,248	4,592	3,246	7,752	5,573	9,785,755	16,635,454	6,849,699
Mackay	1,000	1,236	9,163	9,537	15,468	16,374	20,945,352	35,695,683	14,750,331
Monto	1,242	1,561	9,046	6,216	15,271	10,672	20,942,299	35,630,829	14,688,530
Rockhampton	544	473	8,543	6,553	14,421	11,250	7,741,313	13,156,871	5,415,559
South Burnett	16,797	14,618	5,451	5,139	9,201	8,823	166,680,694	283,526,631	116,845,937
Beaudesert	6,077	6,303	5,603	6,481	9,458	11,127	74,906,739	127,621,134	52,714,394
Brisbane Valley	1,074	996	4,500	2,884	7,596	4,951	7,702,168	13,084,290	5,382,122
Lockyer Valley	1,440	720	5,096	4,617	8,602	7,926	10,660,265	18,090,776	7,430,511
North Coast	2,937	2,966	5,096	4,617	8,602	7,926	28,658,622	48,771,059	20,112,438
Darling Downs	8,006	6,817	6,203	6,623	10,471	11,370	94,815,449	161,352,004	66,536,555
Totals	**44,205**	**40,152**	**5,910**	**6,061**	**10,443**	**10,282**	**513,961,259**	**874,509,819**	**360,548,560**

Figure 22 Value of Total ML Opportunity

REGION	ABS Irrigated HA Winter	ABS Irrigated HA Summer	Total AP ML	Total BP ML	TOTAL OPP ML	Opportunity $/ML Manu. Price	Value ML Opportunity
Atherton	3,842	3,214	47,002	37,053	9,949	$363	$3,613,061
Bundaberg	1,248	1,248	12,934	10,103	2,832	$182	$514,157
Mackay	1,000	1,236	13,686	10,681	3,005	$367	$1,103,615
Monto	1,242	1,561	13,384	10,375	3,009	$376	$1,130,037
Rockhampton	544	473	5,746	4,516	1,230	$323	$397,829
South Burnett	16,797	14,618	192,413	150,369	42,044	$208	$8,741,176
Beaudesert	6,077	6,303	56,073	43,567	12,506	$321	$4,009,616
Brisbane Valley	1,074	996	8,446	6,591	1,855	$219	$406,062
Lockyer Valley	1,440	720	11,243	8,889	2,354	$228	$535,689
North Coast	2,937	2,966	33,648	26,306	7,342	$204	$1,500,815
Darling Downs	8,006	6,817	97,060	76,140	20,920	$234	$4,904,690
Totals	**44,205**	**40,152**	**491,628**	**384,583**	**107,045**	**$251**	**$26,857,886**

Figure 23 Value of Total Litres Opportunity

REGION	ABS Irrigated HA Winter	ABS Irrigated HA Summer	Ave $/L	AP Total Litres	Current Value	OPP L Winter	OPP L Summer	Total L Opportunity	$/L Manfactured Price (Ma.P)	TOTAL $ OPP Ma.P
Atherton	3,842	3,214	0.41	71,122,604	29,160,268	27,735,022	22,087,460	49,822,482	0.24	11,957,396
Bundaberg	1,248	1,248	0.41	9,785,755	4,012,160	3,944,910	2,904,789	6,849,699	0.24	1,643,928
Mackay	1,000	1,236	0.41	20,945,352	8,587,594	6,302,521	8,447,811	14,750,331	0.24	3,540,080
Monto	1,242	1,561	0.41	20,942,299	8,586,342	7,732,011	6,956,519	14,688,530	0.24	3,525,247
Rockhampton	544	473	0.41	7,741,313	3,173,938	3,195,070	2,220,489	5,415,559	0.24	1,299,734
South Burnett	16,797	14,618	0.41	166,680,694	68,339,084	62,995,728	53,850,210	116,845,937	0.24	28,043,025
Beaudesert	6,077	6,303	0.41	74,906,739	30,711,763	23,430,021	29,284,374	52,714,394	0.24	12,651,455
Brisbane Valley	1,074	996	0.41	7,702,168	3,157,889	3,324,033	2,058,089	5,382,122	0.24	1,291,709
Lockyer Valley	1,440	720	0.41	10,660,265	4,370,709	5,048,378	2,382,134	7,430,511	0.24	1,783,323
North Coast	2,937	2,966	0.41	28,658,622	11,750,035	10,297,349	9,815,088	20,112,438	0.24	4,826,985
Darling Downs	8,006	6,817	0.41	94,815,449	38,874,334	34,171,837	32,364,718	66,536,555	0.24	15,968,773
Totals	**44,205**	**40,152**	**0.41**	**513,961,259**	**210,724,116**	**188,176,879**	**172,371,681**	**360,548,560**	**0.24**	**86,531,654**

8.2 Target Opportunities

Key Points

- *Opportunities are assessed as water savings, production improvement and increased revenue generated by moving from average to high performance*
- *Targeting a proportion of opportunities establishes an 12 percent improvement in WUE*
- *Target opportunities equate to 17,127 ML and 43,265,827 Litres*
- *The value of these target opportunities is $10,383,799 from direct yield increases and $4,778,492 from the opportunity cost of the water savings, providing a combined economic benefit of $15,162,290*
- *Regions where the greatest improvement opportunities exist are South Burnett, Darling Downs, Beaudesert, Atherton and the North Coast*

The following table has been used to calculate water use efficiency goals from the opportunities in Section 8.1. The goals developed indicate realistic water savings of 17,127 ML as well as an increase in production of 43,265,827 litres, which at average price (extra production is valued at manufacturing milk price) per litre can be valued at $10,383,799. The value of the water saved is its opportunity cost (again at manufacturing value) through increased productivity, which is $4,778,492. Thus the combined economic benefit from the achievement of these goals is likely to be in the order of $15,162,290.

The approach used to arrive at these goals uses the statewide opportunities identified by moving from current performance to high performance. Of this opportunity set only forty percent of growers can be predicted to respond. The remaining growers are likely to be either unwilling to change, afford minimal impact or are already at high performance. Experience in process improvement across a number of industries has consistently proven this forty- percent figure.

The next step applies a stretch target to this response percentage. Experience says that forty percent is again the most realistic number. This provides enough of a "stretch" to motivate and encourage innovation while still appearing achievable. The application of these figures (opportunity, response and stretch) provides the goal for improvement in water use.

However, it has been necessary to moderate the stretch target for productivity improvement (litres) to 30 percent for the diary program. This has been necessary to reflect the more complex and less controllable two-stage process of production, feed production and milk conversion.

Table 9 Water Use Efficiency Goal

Input/Output	Current Performance	Opportunity	Response %	Stretch Target %	Goal	Goal %	Goal Value
ML	491,628	107,045	40%	40%	17,127	3.5%	$4,778,492
Litres	513,961,259	360,548,560	40%	30%	43,265,827	8.4%	$10,383,799
Water Use Efficiency Goal						***11.9%***	
Value of Water Use Efficiency Goal							***$15,162,290***

The addition of the two components of megalitres and litres, in their common unit of litres per megalitre, establishes the Water Use Efficiency Goal of twelve percent. This accepts that a decrease in water is an increase in litres per megalitre, as is an increase in litres. Growers are likely to make gains in one or the other or in smaller components of both. The Water Use Efficiency Goal takes this into account.

The approach of combining the two potential areas of gain ensures that the means of improvement is not prescribed. This enables growers and regions to individually seek and implement improvement in the way most appropriate to their situation. This accepts that there are opportunities to make gains in all regions.

Table 10, below, converts the opportunities to goals for each of the regions.

Table 10 Goals by Region

REGION	Total OPP ML	ML Goal	ML Goal %	Total OPP L	Litre Goal	Litre Goal %
Atherton	9,949	1,592	3.4%	49,822,482	5,978,698	8.4%
Bundaberg	2,832	453	3.5%	6,849,699	821,964	8.4%
Mackay	3,005	481	3.5%	14,750,331	1,770,040	8.5%
Monto	3,009	481	3.6%	14,688,530	1,762,624	8.4%
Rockhampton	1,230	197	3.4%	5,415,559	649,867	8.4%
South Burnett	42,044	6,727	3.5%	116,845,937	14,021,512	8.4%
Beaudesert	12,506	2,001	3.6%	52,714,394	6,325,727	8.4%
Brisbane Valley	1,855	297	3.5%	5,382,122	645,855	8.4%
Lockyer Valley	2,354	377	3.4%	7,430,511	891,661	8.4%
North Coast	7,342	1,175	3.5%	20,112,438	2,413,493	8.4%
Darling Downs	20,920	3,347	3.4%	66,536,555	7,984,387	8.4%
Totals	**107,045**	**17,127**	**3.5%**	**360,548,560**	**43,265,827**	**8.4%**

9. Key Outcomes

Key Points

- *The five main production regions use 87 percent of the irrigation to produce the majority of the states irrigated milk*
- *Current water use is 5.1 and 5.9 ML/Ha for winter and summer production respectively*
- *48 percent of respondents predict future water shortages*
- *51 percent of those surveyed use less than ideal application systems*
- *80 percent do not use technology to assist in irrigation scheduling*
- *63 percent of those surveyed have never attended an irrigation training course*
- *39 percent of farmers could be encouraged to become more water use efficient through profit drivers*
- *there is a need to undertake future research into pasture and crop production, best management practices and on-farm management systems*

The key outcomes reviews the survey findings of the structure of the Queensland Dairy Industry, targets and areas recommended for future research.

9.1 Industry Structure

Scale

There are approximately 44,000 hectares of irrigated winter pasture and crop for dairying as well as 40,000 hectares for summer production. This area produces approximately 514 million litres valued at $211 million dollars. The main production areas, in descending order are:

- South Burnett
- Darling Downs
- Beaudesert
- Atherton
- North Coast.

Water Use Efficiency

There are currently 492,000 ML of water used for irrigated dairying. The current measures of water use efficiency and the opportunities for improvement at high performance are included in the Tables 11 and 12, below.

Table 11 Current Measures of Water Use Efficiency

Efficiency Measure	
Water Use - Winter	5.12 ML/Ha
Water Use - Summer	5.90 ML/Ha
Agronomic Water Use Index - Winter	1,344 L/ML
Agronomic Water Use Index - Summer	1,006 L/ML
Economic Water Use Index - Winter	$551 $/ML
Economic Water Use Index - Summer	$412 $/ML

Table 12 High Performance Measures of Water Use Efficiency

Efficiency Measure	
Water Use - Winter	4.29 ML/Ha
Water Use - Summer	4.85 ML/Ha
Agronomic Water Use Index - Winter	2,432 L/ML
Agronomic Water Use Index - Summer	2,120 L/ML
Economic Water Use Index - Winter *	$789 $/ML
Economic Water Use Index - Summer *	$625 $/ML

Note: * *equals opportunity at manufacturing price plus current performance at average price.*

Water Sources

Water supply for growers surveyed was mainly from unregulated sources, 57 percent. 33 percent of growers source water from regulated systems. While 64 percent of respondents currently have adequate water, 48 percent predict future shortages.

Application Systems

On a statewide basis 43 percent of respondents use low pressure systems, with 51 percent using less ideal high pressure systems. Furrow was used by 2 percent. 44 percent of those surveyed considered there is potential to improve their irrigation infrastructure.

Irrigation Scheduling

The large majority, 80 percent of respondents, do not use any form of objective measurement to assist with irrigation scheduling. However, 66 percent believe there is potential to improve their scheduling techniques.

Management

Only 21 percent of those surveyed measure and record their irrigation applications, of which 19 percent calculate water use per hectare.

Dairy farmers are strong users of agronomic advisors with 51 percent of those interviewed using an agronomist. 30 percent use a business advisor and only 7 percent seek professional irrigation assistance.

63 percent of dairy farmers surveyed have not attended any form of irrigation training course while all of those surveyed undertake irrigation.

Attitude towards Water Use Efficiency

The major incentive to encourage water use efficiency was believed to be the cost of water and its application, 37 percent. However, the profit drivers of revenue (27 %) and feed production and quality (12%) would encourage 39 percent.

Demographics

60 percent of dairy farmers surveyed are between 40 and 60 years of age. The majority of dairy farmers have been educated up to and including grade 10, 51 percent. A further 19 percent went on to grade 12 with the remaining 20 percent pursuing tertiary education.

9.2 Targets

Targets have been set at a WUE saving of 12 percent, either from decreased water use or increased production or a combination of both.

Regions

While it is important that the RWUE adoption program provide extension assistance to the Queensland industry as a whole, there are significant production regions that will generate the majority of the gains. The five regions of South Burnett, Darling Downs, Beaudesert, Atherton Tablelands and the North Coast make up 87 percent of the current water use. These same regions are naturally the biggest producers of milk from irrigated pasture.

Issues and Limitations

The case studies have highlighted that many farmers do not have an allocation large enough to meet their current irrigation requirements. In these cases it is therefore most likely that potential gains will come from improved productivity, through increased water use and management of their current resources.

Fifty one percent of those surveyed have older less efficient high pressure application systems. The cost to upgrade irrigation systems, especially in a climate of increased competition through deregulation, will be a barrier to improvement. Therefore, the biggest gains are likely to be made from better managing the current systems through improved scheduling and management.

It is significant that 80 percent of growers do not use technology to assist in irrigation scheduling and, thus, this is a major area for improvement.

9.3 Future Research

Pasture and Crop Research

While this project has established high performance through analysis of survey data, there is a need to verify specific pastures and crops in each of the regions. There remains a need to identify and quantify the linkages between water management and high quality yields. This is especially important given that a significant motivator for growers to improve water use efficiency was profit and improved feed production (39 percent of respondents).

Current theoretical water use models rely heavily on crop factor data, however, the theory and derivation behind these crop factors is quite arbitrary and imprecise. There is a real need to develop this data if engineering water use index goals are to be set and managed.

Best Management Practices

There is a need to undertake greater research to quantify the practical benefits of best practice. Two avenues are indicated as a result of the case studies undertaken. Firstly, monitor the management processes of those growers who are in the high performance category, where they're willing to participate. Secondly, undertake controlled research studies, where research projects utilising hypothesised best practice are run in parallel to normal grower management comparing of the performance of each. A further important avenue is to monitor the progress of growers over time.

Management Systems

There is a need to integrate water management with farm management. Many growers and consultants have managed water in isolation. There is an opportunity to manage irrigation as part of a whole farm system and therefore add value to other farm practices. Consequently, there is a need to identify and/or develop appropriate systems.

10. Adoption Program Objectives

Key Points

- *Development of the adoption program needs to be a consultative approach involving all stakeholders*
- *The adoption program needs to establish water use benchmarks and define pathways for improvement*
- *The extension program needs to be tailored to match the pshycographic segments of the farmers involved*
- *The program needs to motivate increased returns*
- *There needs to be a defined management plan that focuses on the 12 percent goal, establishes key performance indicators, undertakes regular reviews and responds when necessary*

Adoption objectives need to be developed in conjunction with growers, local area groups, dairy extension officers and irrigation extension officers. The following approach is suggested to initiate the setting of objectives.

1. Establish water use requirements
   - Benchmarks by region
   - Understand actual water use given crop husbandry requirements
   - Establish the impact of water and other farm management practices on quality and quantity of production
2. Define clear pathways towards improved water use
   - Best farm and water management practices
   - Provide the motivation to improve
   - Provide support for the use of technology in terms of measuring and responding
   - Get involved at a farm level – micro measure and manage the process
3. Manage extension and communication
   - Extension approach needs to be developed to add value for best practice growers, improve the early majority and create awareness amongst the late majority in WUE efficiency
   - Establish paths of information dissemination
   - Create a breadth of approach amongst service providers
   - Incorporate and encourage a movement to private sector led solutions.

4. Motivate increased returns for water inputs

    - Improve existing performance

    - Understand the true cost value of irrigation water to dairying to enable fair valuation and better decision making regarding alternatives uses or sale

5. Manage the overall program

    - Focus and champion the 12 percent WUE goal

    - Establish implementation plans and progress targets

    - Establish key performance targets for regions and key personnel

    - Review, monitor and respond to progress

11. Evaluation of Value & Accuracy of Information

Key Points

- ABS Statistics are the most accurate data set available on a statewide basis however the accuracy of this data is limited by a time lag from collection and the accuracy of information supplied by growers
- Survey information is of high value but is inherently variable due to a high anecdotal component in responses
- QDAS milk production information is moderately accurate source of information on milk from grazing information. This accuracy is lowered by grower estimates as to the proportion of that feed produced from irrigated sources
- Theoretical modeling has been undertaken using Rustic software. The results of this modeling are limited by the quality of input data. Crop factors, a sensitive input to the model, are not well known or understood

The analysis compiled in this report provides value-added outcomes in line with the project goals using key data of high value but variable accuracy. The key data sources have been ABS statistics, DNR customer databases, international and national literature searches, grower surveys, theoretical modeling and regional advisory information. The value and accuracy of this information is discussed in the following sections.

Readers will note minor variations in some data reported which are due to rounding differences.

ABS Statistics

This is the most comprehensive data set available. However, it provides data for the period of 1997, which means there is a time lag to current production. The other key driver of variability in this information is the level of quality control at source. Information is collated from statistical surveys sent to growers. The accuracy of the input information has been questioned on the basis of growers either wanting to maintain their confidentiality or from being careless in forming responses.

ABS statistics have been used in the industry audit to establish production area, yields and returns for the dairy Industry in Queensland. The production area component has then been used in the development of opportunities, which have been applied to survey results. The ABS census data has now been replaced by sample data collection, which will reduce its reliability in the future.

Farmer Surveys

Extension officers and temporary employees, under the management of DPI, have conducted the farmer surveys. As indicated in the Industry Structure analysis, the majority of growers do not record water application of volumes or frequency. Consequently, surveyors asked respondents to estimate how much water they would normally apply. As a result, grower survey data is of high value but of variable accuracy. However, the impact of inaccurate data has been minimised by excluding outliers.

Survey results of water use, yields and returns have been applied to the production area, derived from the ABS databases, to establish the industry audit and opportunities.

QDAS Database

Milk production has been taken from the 1998 Queensland Dairy Accounting Scheme (QDAS) statistical analysis for each of the farmers surveyed. This is an annual benchmarking program run in by DPI. Milk production records are used and adjusted according to varying feed sources given the quantities of each used and their respective milk conversion ratios.

The QDAS milk production figure "Milk Produced from Forage Grazed" has been used and adjusted by grower estimates of what proportion of milk production came from irrigated grazing versus dryland. This adjustment factor is subjective and may lead to some inaccuracy in the final figures.

Theoretical Modeling

Theoretical modeling has been undertaken using the DNR developed software package Rustic. Rustic was used to calculate theoretical crop water requirements for a winter and summer pasture in each region and assumed no conveyance, drainage or deep percolation losses, with a goal to calculate Engineering Water Use Index. Rustic, however, consistently returned higher crop water requirements than was observed in high performance growers. Potential causes are an inability in the Rustic model to account for drought conditions artificially induced for crop husbandry purposes, and inaccurate input information for crop factors. Crop factors have been taken from the latest FAO publication 56. Rustic is highly sensitive to changes in these crop factors, however, crop factors are not well known, nor have they been thoroughly researched. Future research is required in this area of Engineering Water Use Index is to be well understood and managed.

Rustic was also used to establish theoretical crop water requirements for specific species grown by the case study participants.

12. References

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13. Appendices

13.1 Assumptions

- $/L have been held at a constant ($0.41) which has been derived from the average prices in Northern, Central and South Eastern Queensland

- There is no addition of the summer and winter Ha as the two areas overlap

- Standard deviation calculations have been undertaken to eliminate outliers from the data and were calculated as follows:
  -1 Stdev - to eliminate outliers significantly under the mean
  +4 Stdev - to eliminate outliers significantly above the mean.
  Using these boundaries the following standardised ML/Ha were calculated for both the actual and dry year models:

- Winter ML/Ha

Before Stdev – Average =	3.37	After Stdev – Average =	3.51
Stdev =	1.69	Stdev =	1.26 .
-1 =	1.68		
+1 =	5.06		
+2 =	6.75		
+3 =	8.44		
+4 =	10.13	Removed – 5 entries	

- Summer ML/Ha

Before Stdev – Average =	3.97	After Stdev – Average =	4.15
Stdev =	2.38	Stdev =	2.34 .
-1 =	1.59		
+1 =	6.35		
+2 =	8.73		
+3 =	11.11		
+4 =	13.49	Removed - 5 entries	

- A similar process was used to determine the L/Ha, using the range –1 to +3 standard deviations. The results were as follows:

- Winter L/Ha

Before Stdev – Average =	7243	After Stdev – Average =	7208
Stdev =	5487	Stdev =	4581
-1 =	1756		
+1 =	12729		
+2 =	18216		
+3 =	23703	Removed - 5 entries	

- Summer L/Ha
  Before Stdev – Average =6033 After Stdev – Average = 6150
  Stdev = 4935 Stdev = 4453
  -1= 1098
  +1 = 10968
  +2 = 15903
  +3 = 20838 Removed - 5 entries

- ABS area data has been manipulated to arrive at irrigated dairy area. The three-step iteration is as follows.

  1. QDAS No Cows in Milk (84%) + QDAS No Dry Cows (16%) = Total QDAS Cows (100%)

  2. Total QDAS Cows x 84% = ABS Total No Milk Cows

  3. ABS Total No Milk Cows x QDAS Ha/Cow = ABS No Hectares

  4. ABS No Hectares x Survey Proportion of Irrigated Pasture = ABS No Irrigated Hectares

13.2 Databases

Printouts of the Dairy Industry Audit Database and Dairy Opportunities Database are provided in the following pages. They are also available in "soft copy" in Microsoft Excel, as are the survey results, which are in Microsoft Access.

13.3 Energy and Water Management Model

A print out of the Energy and Water Management Model follows the above databases. This printout is a blank copy of the model, which is also provided Microsoft Excel format.