SRDC Research Project
Final Report

Improving harvest efficiency in the Mossman Central Mill area

MAS002

Mossman Agricultural Services

Principal Investigators: Allan Rudd
(07) 40982286
armossag@bigpond.net.au
Alan Stafford
(07) 40982286

Daryl Parker
(07) 40982286
dpmossag@bigpond.net.au

Australian Government
Sugar Research and Development Corporation

Mossman Agricultural Services wish to acknowledge receipt of project funding from the Australian Government and the Australian Sugarcane Industry as provided by the Sugar Research and Development Corporation.

Executive Summary:

The Mossman sugar industry in 2004 was characterised by small farms and small blocks, an excessive kilometer/tonne transport ratio, an aging transport infrastructure with a bin fleet of limited capacity, a decreasing area of supply and a harvest window limited by topography.

A project to improve the overall efficiency of the harvest and transport sector of the Mossman sugar industry commenced in 2005. Changes to improve the efficiency were developed through a series of workshops with representatives from the Mossman Central Mill, Mossman CANEGROWERS, the Queensland branch of the Mechanical Cane Harvesters Association and Mossman Agricultural Services. This group looked at a range of payment and harvest management issues.

The project was managed through two broad work programs; industry consultation looking at payment options and monitoring of a group of harvesters. The payment options covered:

- A payment process that will allow for equitable fortnightly payments to all growers. The system for this was developed and agreed to in-principal by all industry partners. However, it was not implemented because of financial issues surrounding the management of the process and a reduction in the number of harvest rounds in 2005. This reduced the imperative for the proposed payment arrangements.
- A payment option for grower cane payments to be based on a Cane Quality Index. The CQI utilised NIR readings for Pol, ash and fibre and established cane value as a combination of these factors. This system overcame some of the problems with the traditional ccs based payment system not sending accurate market signals. The system was developed and analysed using data from 2005 but not implemented. It is currently under consideration again and 2008 data will be analysed at the end of the season.
- Payment options for harvesting. In 2005 all harvesting payments in Mossman were based on a flat rate per tonne of cane delivered. Several options were considered with a number of growers and harvest contractors basing payments on a flat rate plus fuel system in 2008.

A group of six cane harvesters had data-loggers fitted to monitor in-field progress and performance. This provided valuable data for growers, harvesters and the mill to establish current practices and costs in relation to yield and cane quality. The system chosen was from Bigmate, a commercial service provider based in Townsville specialising in remote vehicle monitoring.

Data was periodically downloaded from the monitoring units via a CDMA phone link or through direct cable access to a Laptop computer when mobile service was unavailable. The system presented the project team with considerable data management issues primarily because of incompatible GIS data sets. Despite this valuable information was collected on a range of harvesting performance indicators for the group of Mossman harvesters.

This showed that most in the group were operating within Harvest Best Practice guidelines for a number of performance indicators. In addition benchmarks for the Mossman industry were established in 2005. The Performance Indicators and Benchmarks are in the table below.

Performance Indicator	Current Range	Benchmark Value	
Ground speed	5.2 to 8.5		km/hr
Yield	72 to 78	90	tonnes/ha
Pour rate	65 to 89	90	tonnes/hr
Operating rate	43 to 68	70	tonnes/hr
Field efficiency	66 to 78	75	%
Operating efficiency	60 to 78	75	%
Harvesting cost	$5.92 to $9.24	$6.00	/tonne
CCS	12.3 to 13.4		
Fibre	13.6 to 14.9		
Ash	1.92 to 2.86	Less than 2	
CQI	0.54 to 0.70		

Difficulties with the data analysis precluded the monitoring to be used for harvest management in 2005. Two of the original harvester groups had Agguide monitors fitted in 2007 with one of the units being connected to the differential GPS used for steering guidance. This provided much simpler integration of data and routines for data management and analysis were developed locally. This has meant that remote harvest management in the Mossman area can be undertaken with existing resources without major investment in alternative software.

The 2007 monitoring results compared with the 2005 results for the same groups showed improved pour rates and operating rates and a reduction in calculated harvesting cost. Much of this improvement was attributed to increased yield.

The project team recommended continuation of the monitoring in 2008 so that a full assessment of the costs and benefits of remote harvest monitoring can be undertaken. The incorporation of the data logger with the differential GPS also provides an opportunity for capturing accurate elevation data which can be used for producing block contour maps or cut and fill plans for laser levelling. A yield monitor could also be added for minimal cost as an upgrade.

The project team considered that a significant outcome of this project was the formation and continuing activity of the *Vision 2010 Working Group.* This has developed as a strategic planning group for harvest and transport reform in the Mossman area. The group has representatives from all sectors of the Mossman sugar industry and was a forum used extensively in this project for industry consultation and endorsement of change.

TABLE OF CONTENTS

Background:

This project was developed in 2004. A number of competing factors affecting the different sectors of the Mossman cane industry were impacting on the ability of the industry as a whole to improve the efficiency of capture of sugar from the paddock to the mill. The cane supply area was also decreasing. Deregulation of the sugar industry allowed more flexible supply arrangements for growers and as a result the supply of cane from the Mareeba Irrigation area ceased in 2005. The available cane area was also decreasing in the Mossman coastal area as development eroded the agricultural area.

The project was developed to effect change to two particular aspects of the industry; the economic signals from the system of payment for cane and the efficiency of the harvesting and transport operation.

Over the last 40 years in Mossman:

- Productivity of sugar cane (as measured by tonnes ccs/ha) had not changed. There had been a weak yield increase but a trend decrease in ccs levels. Industry growth was initially achieved through increased utilisation of assignment areas and more recently expansion of areas planted to cane in both the Mossman coastal/Julatten area and in the Mareeba area.
- Improvements in technology associated with production (varieties, plant nutrition and fertiliser placement, green cane harvesting and trash blanketing and improvements to drainage) had not resulted in increases in productivity.
- Replanting as a means to increase production had seen a decrease in the area of fallow and significant increase in average ratoon length. These combined with the full adoption of mechanical harvesting were considered the main factors negating the effects of changes in production technology.

The Mossman sugar industry recognised the need to improve productivity to survive and thrive and that change would be driven by economic forces. To this end it was seen as essential that the payment systems to growers and harvesters send the right market signals to encourage practices that would improve productivity. These changes were considered from two aspects; distribution of payments within the season and the payment formula. It was felt that evening out the cash flow to suppliers would allow harvesting contractors and their grower clients more flexibility to capture efficiency gains.

The pattern of cash-flow to individual growers drives the equity system within groups and limits some mill area efficiencies. The equity system in 2004 for most harvest groups was based on five rounds with fixed proportions of cane cut on each farm in each round and an established processional order of movement between farms. This resulted in harvesters often moving between farms because of the equity system. The alternative was for positioning of harvesters within the landscape being determined by transport and field efficiency parameters. A change to the system of payment which drove the equity arrangement was seen as an important issue to be addressed in improving the overall efficiency of capture of the available sugar from the paddock to the mill.

For individual farms harvest timing was also determined by the requirements for replanting. Reducing the proportion of replant blocks and increasing the proportion of managed fallow blocks was a priority within the existing Mossman Agricultural Services extension program.

Deficiencies were also seen in the traditional cane payment system based on relative ccs with an approximate 2/3 split of monies to the growers. This system encouraged the growing and milling sector to separately gain in the division of money from the sale of sugar. The mill did not get any benefit from improved ccs levels in cane and the growing sector did not benefit from gains in the efficiency of extracting the sugar from the cane. In consequence the growers were focussed on ccs and the mill was focussed on coefficient of work. The concern was that if sectors did not equally share in gains, one or the other would tend to block change. In addition the traditional system sent conflicting or inaccurate market/price signals to sectors.

Changes considered to the payment system were based on the constant division of sugar monies to the grower and miller and the payment to growers related to Pol and Cane Quality Index (CQI).

MAS002 project was developed to consider:

- Changes for the distribution of payments to growers and harvesters considered for implementation for the 2005 crushing season.
- Changes to the payment system defined and monitored for the 2005 crushing season and considered for implementation for the 2006 crushing season.

The Mossman sugar industry agreed to consider the changes outlined above and work through a group with representatives of the Mossman Central Mill, Mossman CANEGROWERS, the Mossman branch of the Queensland Mechanical Cane Harvesters Association and Mossman Agricultural Services.

The Mossman sugar industry is based on small farms and small blocks with is seen as resulting in an excessive kilometre/tonne transport ratio. Many of the blocks are bounded by hills and/or watercourses. Many cane blocks are also in close proximity to housing developments. Growers and harvest operators generally felt that the topography and adjoining residential developments had a limiting effect on the daily harvest window.

Transport infrastructure consisted of a rail network for the delivery of all cane to the mill with road transport moving cane to transfer sidings from outlying areas not serviced by the rail network. This occurred principally from the Daintree, Julatten and coastal Mowbray areas. This transfer was enabled through a bin transfer system between rail bogies and road trailers. The transport infrastructure was aging and limited in capacity with financial constraints militating against either replacement of unserviceable units or the introduction of new units to the system.

In order to address some aspects of efficiency, this project was developed to collect data from a group of harvesters in the Mossman area. Both positional and machine function data would be collected so that harvest efficiency indicators could be calculated for use in supporting the process of change in the harvest and transport sector.

The project was seen as complementary to the MAS001 project which had commenced in 2003 and was focussed on improving the sustainability of the Mossman sugar industry.

Objectives:

This project was developed to achieve a number of objectives covering the various issues facing the harvest and transport sector of the Mossman sugar industry.

1. *Implement a new payment system for growers and harvesters that equalised payments over the season for the 2005 harvest.*

The payment system was developed and endorsed by all partners but not implemented because of financial and legal considerations.

2. *Benchmark Cane Quality Index (CQI), harvester performance and harvest costs for the 2005 harvest.*

Cane Quality Index (CQI), harvester performance and derived harvest costs were established for the monitored group in 2005. Benchmarks were then established against these figures. This data is summarised in Table 1.

Table 1. Mossman harvest operations Performance Indicators and Benchmarks 2005.

Performance Indicator	Current Range	Benchmark Value	
Ground speed	5.2 to 8.5		km/hr
Yield	72 to 78	90	tonnes/ha
Pour rate	65 to 89	90	tonnes/hr
Operating rate	43 to 68	70	tonnes/hr
Field efficiency	66 to 78	75	%
Operating efficiency	60 to 78	75	%
Harvesting cost	\$5.92 to \$9.24	\$6.00	/tonne
CCS	12.3 to 13.4		
Fibre	13.6 to 14.9		
Ash	1.92 to 2.86	Less than 2	
CQI	0.54 to 0.70		

Additional monitoring was undertaken in 2007 with the monitoring of two harvesters from the six in the original group. However, data was only collected for the latter part of the season. Analysed data gave results for Pour Rate, Operating Rate and Field Efficiency similar to 2005.

3. *Fewer harvester movements in 2005 compared with 2004.*

The proposed payment system was seen as a tool to improving the efficiency of the harvest operation and reducing the number of harvest movements by overcoming some of the equity issues within groups which were driving some harvester movements. Hence this objective was seen as an outcome objective rather than an output objective. The payment system was not introduced in 2005 and the output objective (Objective 1 above) was not achieved.

The loss of cane from the Tablelands for the 2005 season resulted in a recommendation from the Harvest Working Group to reduce the number of rounds from 5 to 4 as a consequence of the shorter season. This was adopted by industry in 2005 and this had the effect of reducing the number of harvester movements.

4. *Generate CQI figures for cane harvested in 2005 that would allow analysis at a block, farm, district, harvest group and mill area level on a variety and class basis.*

This objective was achieved. CQI figures for the 2005 season were generated and analysed from all cane deliveries to Mossman mill for the 2005 season. Calculations were based on the standard formula developed by Steve Staunton from BSES. An analysis of these results led to the following observations:

- CQI change is closely correlated to variations in CCS (R^2 = 0.6817) but less strongly correlated with ash levels (R^2 = 0.4435) and fibre levels (R^2 = 0.4495).
- Over the season the variation in CQI from week to week was less than the variation in CCS.
- CQI is more sensitive to class than CCS. CCS decreases by 1.0% with each ratoon but CQI decreases by 1.6%.
- CQI and CCS are both closely related to variety but the varieties with the highest CCS do not necessarily have the highest CQI.
- CQI and CCS variations between districts follow similar patterns.
- Some harvester groups appear to achieving good CQI levels compared to CCS particularly at the higher CQI levels. Conversely some groups appear to be under achieving.

5. *Undertake a comparison between payments based on cane quality and the current cane price formula for the 2005 harvest.*

A comparison between cane payments based on cane quality and the current Relative D formula was undertaken for the 2005 season. This comparison showed considerable variation with some growers significantly advantaged by the CQI system; the most extreme cases were with the most advantaged being in the order of $7.30 per tonne of cane and the most disadvantaged being in the order of $7.03 per tonne of cane.

A system based on CQI was considered to send good market signals but growers would need time to adopt to adopt different farming practices to take advantage of the changes to the payment system. A hybrid of the two systems was proposed as an interim step. This would reduce the magnitude of the winners and losers while still sending clear signals of the need to change.

6. *Quantify costs and benefits of remote harvester monitoring in the Mossman area.*

This objective has not been achieved. The analysis of the monitoring data from 2005 season presented some major problems for the project team. The issues centred around incompatibility of GPS data sets and inconsistencies with elements from the monitored data. The bulk of the data was analysed but some data could not be used. This difficulty with analysis precluded using the data collected for remote monitoring of harvest progress.

The project was extended to the 2007 season to allow for further monitoring to address some of the data analysis issues. Only two harvesters were monitored in 2007 compared with the six groups in 2005 and data was only collected from the latter part of the season because of late installation of the monitoring units. Analysis of this data was simpler with the monitored data using the same GPS datum as the Mossman cane datasets.

The mill cane receival system was changed for 2007 to accommodate the changed transport arrangements. Only the elements essential for cane receival were functional for the season because of time and financial constraints. This did not include all the reporting and access functions necessary for harvest monitoring. Hence no remote monitoring of harvest progress was undertaken in the 2007 year.

The final two objectives are outcome objectives intended to reflect the achievement of Objective 1. They were intended to result from changes to harvester scheduling and movements as a result of changes to the system of grower payments. The project team believed that changing the pattern of grower payments during the season would overcome some of the inefficient harvester movements driven by equity issues. As such these movements could be made to reflect achieving efficiency in the harvest and transport system and for capturing maximum available sugar from the paddock to the mill. However, as the payment system was not implemented these two objectives were not been achieved

7. *Improvements to transport efficiency through maximising quantities of cane delivery within geographic zones.*

8. *Maximise sugar production within groups and individual farms through more efficient scheduling.*

Methodology:

The project broadly covered two major activity areas:
- Industry consultation and planning through a representative group of stakeholders.
- Monitoring of a group of harvesters. The monitoring of this group generated the data for consideration of aspects of harvesting efficiency in the Mossman area.

Industry Consultation:

A harvest management working group had been established under the MAS001 project dealing with sustainability of the Mossman Sugar Industry. The group was formed with representatives from the Mossman Central Mill, Mossman CANEGROWERS, the Mossman branch of the Queensland Mechanical Cane Harvesters Association and Mossman Agricultural Services. The working group meetings were intended to broadly consider the following aspects of the project:

- Overall project objectives and management of the various aspects of the project
- Consideration of the payment system to equalise payments to growers over the season.
- Consideration of a payment formula based on CQI rather than the current Relative CCS system.
- Define parameters for harvest management for the 2005 season.
- Harvester monitoring results and implications for the Mossman Sugar Industry

2. *Harvest Working Group Meetings*

Four meetings of this group were held between December 2004 and April 2005. These meetings considered the following:

2.1. 9/12/2004 Meeting. This was the first meeting and served to set the background for the aspects to be considered by the group. The harvester monitoring and various aspects of this project were outlined and the bulk of the meeting concentrated on what the group would be doing and the proposed in-principal agreement on changes to the cane payment arrangements.

2.2. 13/1/2005 Meeting. At the meeting the main items discussed were:
Proposed payment system. Steve Staunton was invited to the following meeting to talk about different payment systems based on cane quality parameters.
A proposal to use transport zones based on time of loco runs from the mill. This was the preferred basis for defining the transport system put forward by MCM. The aim was to have constant proportions of the crop coming from each of the transport zones throughout the harvest.
Consideration of general issues affecting harvest and transport management including harvesting hours, daily bin quotas, size of the bin fleet, season length, operating hours per week, Mareeba cane supply and number of rounds and sequences.
Harvester payments and incentives for harvest best practice. The meeting also discussed the planned trip to Ingham and Mackay and the harvester monitoring aspect of this project.

The main intention with this meeting was to give MCM, harvesters and growers and MAS a forum in which to raise issues with transport and harvest arrangements from their individual perspectives. In addition the meeting served to start setting timelines for developing harvest schedules and the payment system.

2.3. 3/2/2005 Meeting. The main focus of this meeting was the presentation from Steve Staunton on payment options. The current Relative D payment system was not sending appropriate market signals to encourage the changes necessary to maximise sugar recovery from the paddock or to reward for more efficient growing and harvesting practices. Changes considered for the Mackay district were discussed.

Other items discussed were:

- Payment systems including the proposed timetable for the signing of the new individual cane supply agreements and steps to take in implementing the changes to the timing of grower payments.
- Harvest and transport arrangements including the transport zone proposal, harvesting hours, bin fleet and season length.

The main intention of this meeting was to provide information for growers about changing the payment system and to develop timelines and action plans for managing changes to the harvest arrangements and payment systems.

2.4. 1/3/2005 Meeting. The main focus of this meeting was on developing the timelines for progressing changes to the payment system and developing the harvest and transport program for 2005.

In late 2005 the focus for this group changed to a broader more strategic consideration of harvest and transport efficiency. The group agreed to consider developing an optimum model for harvest and transport in Mossman for the year 2010 and was renamed the *Vision 2010 Working Group*. Details of the deliberations of this group are covered in the MAS001 report.

2. *Mackay Field Trip*

In addition to the meetings of this group a field trip was organised to Ingham, the Burdekin and Mackay regions between the 14th and 17th February 2005. A group of 17 growers accompanied by two MAS staff visited a number of sites to consider a range of cane farming and management practices. At Mackay the focus was on harvest, transport and payment issues:

- Discussions with Mackay Sugar management relating to the proposed changes to the payment arrangements for cane based on a constant split of income from all sources (sugar, molasses and power generation).
- Discussions with Mackay Sugar relating to communication and traffic arrangements covering areas of electronic consignment, harvester monitoring, communications, traffic and harvest coordination.
- Discussions with representatives of several harvest groups who had been involved with changes to harvest and group arrangements made at the direction of Mackay Sugar. This included issues such as amalgamations, managing their own harvest equity and movements between farms within the groups.

3. *Northern Rivers Field Trip*

A group of seven representatives from the Vision 2010 Working Group travelled to NSW to meet with Northern Rivers sugar industry representatives over the 21st to 23rd November 2005. This included meetings with members of a number of harvesting groups and alternative payment systems for harvesting were included in these discussions. At a meeting of the Vision 2010 group after this trip these alternatives were again discussed and considered in the Mossman context.

4. *Cane Quality Index*

The CQI developed by Steve Staunton from BSES was used for analysis during this project. Data was collected by NIR analysis at the Mossman Central Mill with measures of Pol. in juice, Fibre and Ash. The Cane Quality Index was based on cane quality being determined as a function of measured sucrose, impurities, fibre, ash, and dry matter in the cane juice.

CQI = 0.5 + a*(ratio of sucrose to fibre) + b*(cane purity) –c*(ratio of inorganic to organic solids)

The quality relationship was based on the following:

- Milling train efficiency/profitability is dependent on the ratio of sucrose to fibre, (Pc/F)
- Sugar recovery is dependant on cane purity, (Pc/Bxc)
- The ratio of inorganic to organic solids shows the fraction of solids processed that contained no sucrose, (A/(DM - A)).
- Inorganic solids are measured by ash.
- Organic solids are defined by - (dry matter - ash).
- Sucrose is only present in organic solids
- The functions 'a', 'b' and 'c' can be varied to reflect the differential value (or cost) of the sucrose, fibre and inorganic portion of the cane.

The specific equation used in this analysis was:

$$CQI = 0.5 + 0.738*(Pc/F) – 0.659*(Pc/Bxc) – 0.638*(A/(DM - A))$$

Under this CQI system the range of calculated values varies between 0 and 1. The range of possible values for CQI and the component fractions are given in Table 2. These are approximate figures only and intended as a guide to the expected levels of the component fractions at given CQI values.

Table 2. Approximate CQI values and component fractions.
(Adopted from a presentation given by Steve Staunton)

Cane Quality	**CQI**	**Ratio of Sucrose to Fibre**	**Cane Purity**	**Ratio of Inorganic to Organic Solids**
Premium cane	1.00	1.50	0.95	0.01
Standard cane	0.50	0.80	0.80	0.10
Sub-standard cane	0.00	0.20	0.65	0.50

Harvester Monitoring

1. *2005*

1.1. *Monitoring Units*

A group of six harvesters from the 17 harvest operators in the Mossman area were offered the chance of participating in this pilot program. In selecting this group a number of factors that all impact on harvest operations were considered with the aim of giving a diverse picture of harvest conditions in the Mossman area. The selection reflected:

- The geographic range across the Mossman area. Cane is grown in the coastal strip from south of Port Douglas, north to the Daintree River and west to the Julatten area.
- Type of machines used. Most of the machines are Austoft manufacture with only two Cameco. Half of the machines are wheeled and half are tracked.
- Size of harvest group. Harvest groups range in size from less than 5k tonne for the smallest single unit operations to over 50k tonne for the largest contractor.
- Nature of harvesting group. In the Mossman area the harvest sector consists of:
    1. Farmers cutting their own cane;
    2. Farmer contractors;
    3. Farmer co-operatives; and
    4. Harvester contractors.

All harvesting groups selected for the pilot were harvesting over 30,000 tonnes with a single farming unit operation cutting only their own cane, two contract only harvesters and three farmer contractors. All were cutting in more than one area and all geographic areas within the mill supply area were covered. Five harvesters were Austoft and one Cameco with three wheeled machines and three tracked.

Three alternative monitoring systems were considered for the pilot with the BIGmate monitoring system selected. The project team considered this system the most cost effective and functional. BIGmate is a Townsville based company specialising in remote monitoring and reporting of mobile or stationary items of plant and equipment. They were involved in harvester and locomotive monitoring projects with CSR and Mackay Sugar.

This hardware consisted of a GPS unit, data logger capable of monitoring a range of engine and machine functions, and a unit that can be set up to transfer data live via a CMDA, GSM or satellite link. In addition suitable sensors were installed on the machine to collect temperature, pressure and speed functions.

The machine functions monitored were:
- Base cutter pressure
- Extractor fan speed
- Elevator on/off
- A range of engine functions including engine RPM, oil pressure, coolant temperature, hydraulic oil pressure and engine oil monitoring.

These functions were monitored at 30 sec intervals.

Data was downloaded via mobile link with CDMA being the preferred option in this area. Some parts of the MCM cane area, and particularly in the Daintree and Julatten districts, did not have suitable coverage. In this case the data was stored on-board until the unit was in mobile coverage, or a laptop with download software installed was directly connected to the monitoring unit.

The data was transmitted and stored on the BIGmate server. It was then post-processed and displayed in both graphical and table format on the host website to which the operators had password protected access. In the original proposal the spatial data was to have been displayed against a background of the Mossman cane layer to give live access to current and historic data for harvest operators as well as other members of the project team with access rights.

Batches of data were made available through email to the project team for import into the GPS cane layer maintained by MAS. Secondary derived data was then generated with the combined datasets.

The BIGmate monitoring was based around a monthly subscription covering the capital cost of the monitoring units, the data hosting on the website and email of datasets. For this project a quote of $10,500 ($350/unit/month) was obtained based on a one year subscription and hosting and collecting data from six units for five months. Communication costs were on top of this and estimated at approximately $10/unit/month with a once per day transmission of data rather than real-time logging.

1.2. *Data Management*

This raw data was sent to BIGmate where it was calibrated for display on the BIGmate website. The project team was able to monitor the six Harvesters via the BIGmate web site and peruse up to four data values for periods from one day to a full week. Individual harvest operators had access to the website to monitor their individual units. Data files were periodically emailed to MAS for further interpretation and integration with other mill area productivity and quality data sets.

At the outset of this project some problems with integration of datasets were considered and a decision was made to undertake this process with resident capacity at MAS. However the task proved to be more difficult that originally thought.

The major steps involved in this process were:

1.2.1. Data verification. Data was processed for individual harvesters on a weekly basis to match the mill data. This step involved ensuring that the dataset included all data for an individual harvester for the working week and did not include any duplicate data.

1.2.2. Format data for import into ArcGIS. ArcGIS data rules required that the first two columns of data contained the latitude and longitude data and the timestamp must be formatted as a number to avoid truncating the number. This prepared the dataset for thematic display in ArcGIS and further analysis.

1.2.3. Intersect dataset in ArcGIS. Dataset from the harvest monitoring unit was intersected with the mill area dataset in ArcGIS. This step allowed for the assignment of farm and block identifiers to the BIGmate dataset for analysis with mill area yield and quality data.

1.2.4. Data analysis for consignment anomolies. This involved qualifying the BIGmate dataset with the mill area dataset in ArcGIS.

1.2.5. Validation of BIGmate dataset against cane receival data. This proved to be the most difficult and time consuming part of the data analysis process. This step defined times that harvesters were working and pouring in individual cane blocks and matched the times and positions against the yield and quality data from the mill.

The data was then stepped through line by line to define times that harvesters were working and pouring. This data was reconciled against the farm and cane receival block data so that yield and quality information could be matched with harvester positions.

1.2.6. Data analysis. Harvesting groups were analysed with efficiency indicators calculated and relationships established between measured harvester parameters and cane quality information.

In the analysis of data for this project the following definitions were used:

- Operating Efficiency. This was considered to be a measure of time efficiency during the working day; measuring the time that the machine was productively engaged in harvesting cane compared with the total time spent in the field during the operating day. All *non-operating* time during the working day included time spent waiting for bins, time spent servicing or repairing the machines and all meal and other breaks during the working day.

  Harvesters were considered to be *operating* when they were running at high engine revs with the machine engaged. Hence *operating efficiency* was calculated as the ratio (expressed as a percentage) of time that the machine was *operating* against the total elapsed time during the working day from when the machine was first started until final shut down.

- Field Efficiency. This was considered a measure of the efficiency of the harvesting operation when the machine was operating, measuring the proportion of the time that the harvester was delivering cane from the elevator *(pouring)* compared with the total time that the machine was *operating*. All *operating* time when the harvester was *not pouring* included time turning on the headlands and time waiting for a haul-out unit with the machine operating.

  Harvesters were considered to be pouring when the harvester was *operating* and the elevator was *on*. Hence *field efficiency* was calculated as the ratio (expressed as a percentage) of the time the machine was *pouring* compared with the time the machine was *operating*.

2. 2007

Two harvesters from the group monitored in 2005 were fitted with AgGuide monitoring units in 2007. However, late installation of the hardware meant no data was collected for the first six weeks of harvest. In addition some data was lost from both units covering week 10 and part of week 11.

One of the harvesters had been fitted with a GPS steering guidance system working to an accuracy of 2cm and the monitoring unit used the same GPS. The second unit had a dedicated GPS and worked to sub-metre accuracy. Data elements were collected at 10 second intervals. The same range of parameters was monitored as in 2005 although the fan speed monitor on one unit did not work.

Data was collected in the same datum as the field mapping and this ensured compatibility of datasets which overcame some of the initial analysis issues with the Bigmate monitoring. Data was stored on SD data cards in the monitoring units and this data was collected weekly from both units.

Interrogation and analysis of the data followed the same basic steps as with the 2005 monitoring. However, dataset compatibility eliminated the need to step through the data line-by-line to validate position and operating status. The higher order positional accuracy and using a common datum across datasets allowed for this process to be undertaken through routines locally developed in MS Access.

The same efficiency measures were calculated using the same analysis protocols. In 2007 MCM experienced some difficulties collecting NIR data particularly during the early part of the season. Only CCS data was available to the project team for analysis and hence no CQI analysis was undertaken.

Outputs:

Payment Systems

1. *Equalising grower payments across the season*

In the initial discussion through the working group MCM had some basics concerns with the proposal. Under their finance facility they were not able to make an advance to an individual grower before they had actually received cane for processing from that grower. In effect they would have been making a loan to the grower before they received his cane.

This then meant that the payment process could only occur through a third party acting as an agent for the grower. This third party would receive the payment from MCM on behalf of the growers and then distribute funds to the growers based on the equal fortnightly payment principal. This arrangement would then need to be reflected in the cane supply agreement between the individual grower and MCM. The working group suggested that MAS be the third party for this payment system.

In summary the payment system would mean that for growers:

- All growers would receive fortnightly payments irrespective of actual harvest
- Each payment would include a deduction for harvesting
- Payments would be based on percentage of estimate for each individual grower calculated on a 'year-to-date' basis across the season
- Adjustments would be made to payments during season when estimates change
- CCS calculations – individual grower's relative CCS for the last 5 yrs will be used for calculating payments to growers and there would be an adjustment with the end of season payment

The payment system relied on estimates for initial grower payments. As a result these estimates must be reliable to prevent overpayment during the early part of the season for an individual grower before he has cut cane. Some of the rules considered for the estimates are:

- Estimates deemed inappropriate would be referred to the Harvest Equity Committee and this needs to be included in the Cane Supply Agreement
- No adjustment would be made for + or – 5% until the end of season payment
- Estimates during the season would be dynamic and the system of payments to individual growers need to reflect this

For harvesters payments would be as normal based on actual tonnes harvested for individual growers during each fortnight period. Under the proposal for harvesters:

- Payments based on actual tonnes harvested each period
- MCM to continue to make payments to harvesters on behalf of growers
- Harvest payments to be taken from grower funds and the balance deposited in the third party trust account held by MAS for distribution to growers

How the payments would be processed:

- Mossman Agricultural Services will act as a third party agent to receive grower payments from MCM
- MCM would forward grower payments (less harvesting charges) as a lump sum to MAS
- Money would be deposited in a trust fund for grower payments
- MCM to calculate payments and advise MAS
- MAS would distribute funds to growers

Mossman Agricultural Services was considered as the preferred third party agent for this process as it is a private company owned by Mossman Central Mill and the cane farmers who supply the mill. As such it has an equal interest in both sectors of the local industry for the benefit of the overall industry and is seen as a separate unbiased entity to administer this payment system. However there were a number of issues to be considered from the MAS perspective:

- Liability of directors for grower's money; may need an individual agreement between each grower and MAS as their agent
- Cost of setting up the payment system within MAS accounting system
- Cost of administering the system – increased number of funds transfers to attract fees and charges.
- MAS received no net return from this payment system
- MAS suffered no net cost with this system

The issue of GST accountability was also raised by MCM. Under the law relating to the Goods and Services Tax a tax liability is incurred when MCM pays a grower for cane received. MCM must also raise a Tax Invoice for the grower payments and this raises the issue of incurring a tax liability ahead of actually processing cane.

Implementation

McCullough Robertson Lawyers were asked by MAS for an issues paper offering a legal opinion on the proposal. This paper raised several significant issues:

- Operating this payment system from within the MAS business structure exposed the directors and the assets of MAS to claims made by either growers or the mill. They suggested a Special Purpose Vehicle (SPV) as a wholly owned subsidiary of MAS be established with the exclusive role of managing the payments. The SPV would receive a lump sum from MCM deposited into a trust account and distribute payments to growers based on a payment schedule provided by MCM. This would quarantine the risk away from the assets and core business of MAS. However the major disadvantage with this arrangement would be in the time and cost involved in establishing and operating this SPV.
- The proposed payment arrangement would need to be documented in a more complex manner by creation of suitable separate agreements between MCM and the growers, MCM and MAS, and the growers and MAS. This again raised the question of the cost involved in establishing the documentation.
- Security of the growers would be ensured with the establishment of the SPV and a separate trust account established with the sole purpose of receiving and distributing payments under this proposed payment system.
- Overpayments and recovery of monies advanced in the event of a farm sale, grower leaving the industry or being declared bankrupt.
- Taxation issues relating to GST liability and timing of GST liability. The paper suggested that this was a complex issue that would require further consideration.
- The liability of MAS in the situation of the bankers of MCM seizing payments from QSL before it was paid to the growers.

It was suggested that these issues were not insurmountable but most required more time and cost to fully explore and develop workable solutions for the payment system to progress for the 2005 crushing season.

The proposal and issues paper were presented to a full MAS Board meeting for consideration. The meeting decided to not proceed with the proposal for the 2005 crushing season, the main concern being the time and legal costs that would be involved in getting a more detailed consideration of the legal and financial considerations. The opinion was also put at the meeting that the short season (16 weeks) and only 4 harvest rounds both reduced the cash-flow impacts to growers.

This decision was taken to the next Harvest Working Group meeting where it was decided that it was not possible to implement the payment system for the 2005 crushing season. The meeting agreed that the concept was worthy of further consideration as circumstances, particularly at the mill, changed in the future.

2. Paying for Cane Utilising a Quality Index

An options paper '*Paying for Cane Utilising a Quality Index*' (Appendix 1) was prepared which discussed the issue and implications of basing the payment to growers for their cane on quality and not on CCS as in the current payment system. Under the current formula based on a constant division of the sugar money gains are not equally shared between growers and the mill. It was argued in the options paper that sharing the returns from sugar between the growers and the mill based on a CQI would send better market signals with the long term effect of growing the 'size of the cake'.

The various parameters affecting cane quality and the strength of these relationships are discussed in detail in the options paper. CCS, ash and fibre levels are all used in the CQI calculation. However, CQI is more closely correlated with CCS than with either ash or fibre. These correlations are a reflection of the relative weightings of the three components in the CQI formula.

Ash is considered a good indicator of soil in the cane supply and for several years prior to 2005 Mossman Central Mill conducted a "..poorly understood payment system based on ash." The options paper suggests that using CQI would obviate the need for a separate payment system based on cane quality.

Fibre from the cane has both positive and negative implications. High fibre is of benefit particularly early in the season when MCM has in recent years been struggling to maintain a fuel supply. However, high fibre also slows crushing rate and has an adverse effect of sucrose extraction.

The proposed CQI system would preclude the need for a separate element to the payment system based on impurities or non-sucrose portions of the cane supply. Fine tuning of payments to growers to reflect the value to the mill and the industry of the different portions of the cane supply was also possible through a CQI based payment system.

The detailed analysis of CQI and CCS found that:

- CQI varied less than CCs from week to week over the harvest season. This suggests that a CQI payment system would not need to have a weekly relativity component.
- CQI and CCs both decrease with older ratoons but CQI is more sensitive to class. A very strong relationship was found between class and ash with ash increasing with age of ratoon. This result may be a reflection of condition of the cane stool with younger ratoons generally having a better (higher) row profile. A payment system based on CQI would favour younger ratoons.

- CQI and CCS are closely related but the highest CCS varieties do not necessarily have the highest CQI. This result may in part be a reflection of CQI favouring younger ratoons.
- CQI and CCS rate similarly in a comparison across districts
- Some harvester groups appear to be achieving good CQI levels compared with the CCS levels and some appear to be underachieving.   The paper suggested that this result was primarily due to varying ash and to a lesser extent fibre levels between groups.

An analysis was undertaken of cane payments based on the CQI data compared with payments made under the existing Relative D cane payment formula for the 2005 season. This showed that some growers would have been considerably advantaged by the CQI formula and some would have been significantly disadvantaged. It was suggested that growers would need some time to adapt their management practices to take advantage of the changes to the payment system. As an interim measure it was suggested that a hybrid of the CCS and CQI based payment systems be used.

The analysis also indicated that some harvesters were achieving better CQI results than others. This was mainly attributed to lower ash levels as a result of lower levels of soil or other extraneous matter in the cane supply. Minimising trash and tops from the cane without applying the principals of harvesting best practice could result in significant sucrose loss in the field. Harvest operators can have little direct effect on parameters other than ash used in calculating CQI. As a result it was suggested in the options paper that any quality incentive included in harvester payments should be based solely on ash levels rather than on CQI.

3. *Harvester payments*

The current payment system for harvesting cane in the Mossman area is based on a flat rate per tonne of cane. The analysis of the data in this project highlighted the differences in harvesting productivity, efficiency and cost between blocks and farms. It also supported the conclusion that the current payment system offers no incentive for positive change. The harvest sector generally recognised the need to encourage farming practices that improved harvest efficiency and reduced or at least contained the real cost of harvesting.

This project was intended to provide data that could highlight areas for change and to provide information in support of alternative payment systems. It was also intended that the information generated would be used in support of a process to facilitate change.

The different pricing mechanisms and their relative merits were extensively discussed in BSS261 report of August 2005. The project report detail seven possible alternatives to the current flat rate per tonne of cane system. Following the trialling of a number of these systems in the Mackay, Burdekin and Maryborough areas in 2004, three alternatives to the current system were short-listed at a project meeting in February 2005.

These were:

- Base rate plus fuel
- Delivery rate/hourly rate
- Sliding scale based on crop yield plus haulage.

The base rate plus fuel was reported as the method most favoured by those harvest groups across industry looking at alternatives.

Discussions as a result of the tours to Mackay and Northern Rivers indicated support for the base rate plus fuel option. It appeared to be a relatively simple system to implement and operate to the satisfaction of both growers and harvesters.

These discussions generally revealed that harvest operators, who in Mossman are mainly contractors or grower/contractors, recognise the deficiencies with the current system. However, in these discussions some harvest operators expressed a concern that if they, as an individual contractor, were to change they may lose clients to other contractors still operating on the current flat-rate per tonne system.

Harvester monitoring

1. <u>2005 Monitoring</u>

From the outset collecting meaningful data of engine speed from all Austoft machines was problematic and a complete resolution of this issue was not achieved. A resolution was vigorously pursued by both the electrical contractor and BIGmate and the problem appeared to be with signal interpretation of the datalogger.

In addition Extractor Fan speed was not collected from three of the units. The problem with these three units was not isolated and may have been an installation issue at the individual machine level rather than an issue with the data-logger.

The full analysis of the data collected from the harvest monitors is included as Appendix 2. The monitoring and resulting analysis established the performance of the group of harvesters in 2005 against a series of performance indicators. The summarised data for all groups has been included as Table 1. The table showed the range of values against each performance indicator across the monitored group. The benchmark values were targets set across industry for the next five years. As such they form an important element in identifying and monitoring areas for change.

The summary data has been presented here in two tables for discussion. A summary of the whole of season average data for each of the monitored harvest groups is shown in Table 3. Table 4 shows the data summarised on a block basis for each of the harvesting groups over the season. The results shown were the median values across blocks for each harvesting group for each parameter.

<u>Table 3. Harvest monitoring group performance summary – Seasonal average values.</u>

Harvester	Speed	Pour Rate	Field Efficiency	Operating Rate	Operating Efficiency	Cost	CCS	Fibre	Ash	CQI
A	5.2	69	67	47	76	$ 8.57	12.6	14.3	2.26	0.62
B	7.0	87	68	59	60	$ 6.83	12.4	14.7	2.79	0.57
C	6.6	85	77	66	67	$ 6.07	12.9	14.0	2.08	0.65
D	5.3	69	72	50	69	N/A	13.0	14.0	2.13	0.65
E	5.3	76	72	54	76	$ 7.35	12.5	13.6	2.38	0.63
F	6.4	81	67	55	78	$ 7.33	13.4	13.3	2.02	0.72

Table 4. Harvest monitoring group performance summary – Block level median values.

Harvester	Speed	Pour Rate	Field Efficiency	Operating Rate	Cost	Yield	CCS	Fibre	Ash	CQI
A	5.2	65	67	43	$ 9.24	72.0	12.8	14.9	2.00	0.60
B	7.0	89	66	59	$ 6.81	73.3	12.3	14.7	2.86	0.54
C	6.5	88	78	68	$ 5.92	78.5	12.9	14.0	1.92	0.64
E	5.2	71	73	49	$ 8.08	77.1	12.3	13.8	2.36	0.63
F	8.5	82	69	52	$ 7.71	72.2	13.4	13.6	1.94	0.70

Operating efficiency is not reported in Table 4 because it can not be calculated at a block basis from the data available. In addition the data from group D was not suitable for analysis at this level. Median values at the block level were used rather than average values to minimise the differences in the number of blocks analysed between groups. Block yield was included in the analysis.

1.1. Ground Speed, Yield and Pour Rate

As discussed in Harvester Best Practice (HBP) Manual (Sandell and Agnew, 2002) ground speed needs to be considered in relation to pour rate and crop yield. The ranges of values for these indicators in the Mossman area were well within guidelines for harvesting best practice for cane loss and extraneous matter. In general terms the yield and pour rates were at the lower end of the range quoted in the HBP manual and the ground speeds are correspondingly higher in the range. The low yield is of particular concern to the industry.

Groups A and E could safely look at increasing speed and pour rates in an attempt to reduce their harvesting costs given the current block yields.

It was felt by the project team that it was not appropriate to set a benchmark target for ground speed because of the relationships discussed above. However, it was considered important for the industry to look at significantly improving yields (90 tonnes her hectare rolling five year average by the year 2010) and this has been targeted through productivity initiatives across the district (MAS001).

The target for pour rate was set in recognition of the need to improve (reduce) harvesting costs through higher pour rates which will largely be achieved as a result of the higher yields. A target of 90 tonnes per hour average has been set by the project team as a guide for the harvest operators.

1.2. Operating Rate

This measure was calculated from total operating hours in this project. As such, time spent moving between blocks and no-haul transport was not included. This was different to the calculation of Engine Hours Pour Rate in the HBP manual. Operating rate was also used to calculate field efficiency.

In this project operating rate was a measure of the speed at which cane was delivered to the sidings when bins were available. As such it is a combination of the rate at which cane is being processed through the machine while accounting for field factors which affect time spent operating in the paddock without processing cane.

Operating rate is a factor that is relatively easy for operators to monitor without sophisticated record keeping or monitoring equipment. It fairly closely approximates to siding delivery rate during normal harvest operations. The suggested target was at least 70 tonnes cane per hour.

1.3. Field Efficiency

The Field Efficiency indicator used in this report did not include time spent servicing or waiting for bins as was the case for Harvester Field Efficiency in Sandall and Agnew. The Field Efficiency only looks at the factors within a block or particularly on row length and headland width which are associated with how often harvesting equipment needs to turn and how quickly the equipment can be turned.

The relationship between field efficiency and harvesting costs was weak; just over 32% of the variation in harvesting costs could be accounted for by variations in field efficiency across all groups. Group C had the best field efficiency and also the lowest harvesting costs. This value could be used as a target for other groups to improve their efficiency and reduce costs. However the price signals sent through payment for harvesting would need to improve to induce changes at farm level to improve harvesting field efficiency. The benchmark target for average field efficiency was set at 75% or greater.

1.4. Operating Efficiency

This was calculated on a daily basis and, as such, measured both the farm based and external transport and mill factors that were impacting on harvesting operations. As such high operating efficiency indicated that a large proportion of the total harvesting hours were spent in operating as compared with time spent waiting for bins, servicing or maintenance. Conversely, a low operating efficiency meant that a smaller proportion of the working day was spent cutting cane. Generally the higher the operating efficiency the better. However, all of the above indicators need to be considered in relation to one another.

Group F had the highest operating efficiency but had relatively low operating rate and field efficiency while pour rate and ground speed were near the top of the ranges of the groups monitored. This suggested that the harvester was processing cane relatively quickly but other time with the harvester operating and not processing cane was also relatively high. The total time during the day when the machine was operating was also relatively high compared with other groups.

Group B had the lowest operating efficiency but the highest pour rate and ground speed while field efficiency was relatively low with operating rate above the median value for the monitored groups. This indicates that the harvester was processing cane relatively quickly but had a relatively high proportion of the operating time when the harvester was not processing cane and a relatively high proportion of the total working hours with the machine not operating.

Operating efficiency is largely a measure of the efficiency of the transport system to deliver empty bins to the sidings. This in turn is a function of the transport capacity and the mill and transport reliability. It can also be strongly influenced by machine reliability and weather conditions. Operating efficiency thus tends to be a measure of overall efficiency of the harvest and transport system and logistics. For the Mossman area the project team suggested a target of at least 75% average operating efficiency for groups.

1.5. Harvesting Cost

The harvesting cost calculation was purely based on operating hours. As such the costs associated with down time when the machine was not operating were not taken into account. The cost of harvesting associated with inefficiencies in the transport or mill sector have also not been taken into account. Non-operational time during any working day is still a cost to the harvest operator irrespective of the reasons for this non-operational time.

The harvesting cost was based on a return of $400 per operating hour to the harvest operator which was quoted as the rate required to cover costs including a return on labour and capital to the contractor in 2005. The limitation with this as a calculation was that it did not directly take account of haul distance and the cost associated with transport of cane from the paddock to the siding. Some previous work had been done in the Mossman area with the CSIRO team using the harvest-haul model. Individual harvest operators were generally aware of the circumstances when it was economic to bring a third haul-out into service and affected operators managed accordingly.

This project did not monitor fuel usage as have other monitoring projects and systems. As such this project only reported on a derived harvesting cost in contrast to other projects. However, other system did not have the GPS capability and relied on the harvest operator inputting farm and block details.

A target of $6.00/tonne average harvesting costs calculated from operating hours was suggested by the project team in 2005. This would be achieved through changes considered above to improve operating rate or changes to reduce the hourly rate for a return to the harvest sector. The real challenge is to contain these costs in the face of spiralling fuel prices while maintaining a viable harvest sector.

1.6. CQI Parameters

The analysis of the monitoring data suggested that ground speed and pour rates were within best practice guidelines. The almost total absence of fan speed data was of some concern. However, discussions with the cooperating harvester operators during the season indicated that all were aware of the best practice recommendations for fan speed and operated accordingly.

Ash is the main factor of cane quality that is of concern to the Mossman industry and can be strongly influenced by harvester operation. As such it is the only factor for which the project team set a target. This target is for average ash levels of less than 2%.

The performance indicators and benchmarks are only useful in measuring change and do not of themselves lead to changes without targeted programs.

2. 2007 Monitoring

A comparison of the 2005 and 2007 efficiency measures are presented in Table 5 as average values over the monitored period for the two monitored harvester groups and in Table 6 as median block values for each harvester group.

Table 5. Average data for the harvester groups over the monitored period – 2005 and 2007.

Harvester	Speed	Calculated Speed	Pour Rate	Field Efficiency	Operating Rate	Operating Efficiency	Cost	CCS
B 2005	7.0	7.6	87	68	59	60	$ 6.83	12.4
B 2007	6.3	8.6	102	66	67	69	$ 5.96	13.1
F 2005	6.4	7.3	81	67	55	78	$ 7.33	13.4
F 2007	6.0	7.2	93	73	68	78	$ 5.91	14.0

Table 6. Median block level data for monitored harvesters – 2005 and 2007.

Harvester	Speed	Calculated Speed	Pour Rate	Field Efficiency	Operating Rate	Cost	Yield	CCS
B 2005	7.0	7.7	89	66	59	$ 6.81	73.3	12.3
B 2007	6.3	7.4	95	63	63	$ 6.42	81.9	13.3
F 2005	6.3	7.2	82	69	52	$ 7.71	72.2	13.4
F 2007	5.8	7.0	90	74	65	$ 5.87	82.3	13.8

The project team felt that some care was required in drawing conclusions from the two sets of monitoring data for the following reasons:

- Only the last ten weeks of the 2007 season were monitored. Harvesting conditions change during the season as the harvester moves from first round plough-out cane into the main crop and then into the final fallow round.
- Different equipment was used in the two seasons with different data collection intervals and different GPS accuracy.
- Slightly different analysis protocols were employed in the two seasons because of the different characteristics of the monitored datasets generated.
- A different operator was in Harvester B for the 2007 season.

The project team noted greater consistency of results between the average values and the median values for group F. The monitor in the group B harvester used the GPS from the steering unit for logging position in 2007 and this did not always function due to technical issues with the equipment. Hence a small amount of data was intermittently lost during the collection period. This meant that for intermittent periods during data logging no data was collected when the machine was actually operating or pouring.

Total pouring hours were used in calculating the pour rate (pouring hours divided by tonnes of cane for each block) and similarly total operating hours were used in calculating the operating rate. Missing data would tend to inflate these figures. Harvesting costs were also calculated from pour rate.

The following discussion uses the median block level data rather than the average data. It was felt that this may remove some of the bias associated with the missing data particularly evident in the case of group B's apparently inflated average pour rate.

The most striking difference between the two years was reflected in the yield differences; both harvesting groups had higher yields and CCS levels in 2007 compared with 2005. Both groups had higher operating and pouring rates and worked at lower ground speeds all of which were still within Harvester Best Practice guidelines. It was also felt by the project team that the reduction in the cost of harvesting was principally a result of the higher pour rates associated with the improved yields.

Ground speed values are established by GPS positional change over time. The project team was concerned that this may give an under estimate of ground speed when the direction is regularly changing through 180 degrees. The normal practice of “cutting in” on the ends may have compounded this effect. Indeed the harvest operators were surprised how slow the speeds were in 2005.

Calculation of ground speed from pour rate and yield for a given row spacing was considered by the project team to give a better estimate of ground speed than the reported GPS generated data. This has been reported as “Calculated Speed” in both Tables 5 and 6 and the figures are consistently above the GPS estimates.

In 2007 Group B had a higher pour rate and slightly slower ground speed but despite this result a slight reduction in field efficiency occurred. This may have been due to a less experienced operator controlling the machine. The operating efficiency improved indicating a more regular bin supply or better matching of harvest to transport.

Group F achieved a 5% improvement in field efficiency in 2007. One factor in this would have been the slight reduction in harvester ground speed resulting in higher ratio of pouring time to turning time. Despite the slower ground speed, good pour rates were achieved in the higher yielding crop. This resulted in a reduction in harvesting costs as estimated. The operating efficiency of 78% was maintained indicting the group’s expertise in matching harvest and transport.

In general terms both groups have reduced calculated harvesting costs. In real terms the cost of harvesting would have risen between 2005 and 2007 mainly due to increased fuel prices.

Environmental and Social Impacts:

There are no direct environmental or social impacts resulting from this project.

Expected Outcomes:

Payment Systems.

The proposed system of regular grower payments over the season was adopted in principal by the Mossman Sugar Industry through the harvest working group. However, the idea was not adopted because of financial management and practical implementation issues. The Vision 2010 group felt that the imperative for such a system was reduced since the 2005 season with the shorter crushing season and fewer harvesting rounds.

Similarly the payment system based on CQI was considered in depth by the industry working group but not adopted. The Mossman sugar industry is suffering from poor productivity largely as a result of older ratoons through low levels of cane planting over the last five years. At the time of preparing this final report the industry is again considering adopting a CQI system recognising that such a system favours younger ratoons.

The Mossman sugar industry considers that a crop of at least 600,000 tonne is required for long term sustainability. This would require an increase of at least 50,000 tonnes of cane or an improvement in productivity of at least 7 tonne/ha over the 8,000 ha of available cane land. Productivity achieved for 2007 harvest was 71 tonnes cane per hectare (tcph) with the target being 80 tcph. This extra cane would be worth an extra $1.5m to the Mossman sugar industry based on $30/tonne of cane. The project team and the Vision 2010 group feel that this increase is achievable.

It is difficult to assess the full impact of changing the payment system. Improving the productivity in Mossman through increased levels of planting will be accomplished through an integrated series of mechanisms including a revised payment system that sends better market signals. In many mill areas direct grower payments are made to support planting as direct short term incentives. An improved payment system is seen as a medium to long term incentive.

The formation of the Harvest Working Group was a tangible successful outcome for this project. This group represented all sectors of the Mossman industry and provided a structured forum for consideration of industry issues in the harvest/transport sector. The use of this group as a forum for discussion of the various outputs from this project was important to facilitating wider industry discussion of the payment options in particular. While these were not adopted by industry within the timeframes of this project, there is still ongoing consideration of cane payments based on CQI.

In late 2005 the working group was given a wider industry role as the Vision 2010 Working Group. This group has an ongoing role as a forum for discussion of industry issues.

In 2006 a number of growers and harvest contractors negotiated payment arrangements based on the flat rate plus fuel system. It was extended in 2007 and now at least one harvest group uses this system for all harvest contracts.

Harvester Monitoring Data.

The outputs from this project supported discussions with the different sectors on improving efficiency in the harvest and transport system. Collated results were presented to the cooperating harvest groups as part of the interpretation and analysis of the data, an overview of the data was presented to the Vision 2010 working group and some of the detailed group data and analysis was presented to the individual harvest operators.

Presentation to the Project Group of Harvest Operators - 2005

All cooperating harvest operators were invited to attend a meeting where the preliminary results of this project were presented. The issues involved with the collection and analysis of the data were presented and discussed with the group. The spatial analysis was prepared for individual groups as a result of this discussion.

At the outset the project team felt that the monitoring function on the BIGmate website functioned adequately. However, comment from involved harvesting contractors was mainly neutral to negative. Most felt that they could not obtain sufficient detail here to act as an aid to harvester performance.

Collated results of all the monitored groups were presented anonymously to the whole group. Individuals were also given their own summarised results so that groups knew individually which set of data was theirs but not which set of data belonged to other individuals. Table 1 is similar to the collated results presented and some of the graphs in the series from Graph 1 to Graph 14 were also presented at this meeting.

Discussion centred on differences between the groups and the reasons for the differences in the performance of the different parameters measured or calculated. The initial harvesting cost calculated using the figure of $285/hour for operating costs caused some confusion. It also tended to divert attention from the intended purpose of highlighting the differences in real harvesting costs that existed between block. The main discussion was around the justification of this figure. Following this meeting the harvesting costs were calculated at $400/hour and this was used in the subsequent analysis of the data.

The situation of Group B was discussed openly where the group had the highest ground speed and pour rates but the lowest operating efficiency and was in the lower part of the range for field efficiency. The suggestion was that his group tended to fill bins quickly when they were available and would then not be involved in harvesting operations (doing other jobs) when bins were not available. This compared with other groups who would tend to more ‘pace’ themselves so that they did not have so much non-harvesting time. Group B only harvests their own cane and it was suggested that the crew were sometimes involved in other farming operations when bins were not available. In addition Group B used several delivery points when on road transport in the Daintree. This meant longer haul distances and consequently delays waiting for the haul-out from some blocks.

This discussion further led to discussions on the unreliable bin supply faced by the operators when on road transport compared with rail. The Julatten and Bamboo/Daintree as well as some of the southern areas of Mowbray are serviced by road transport. Operators felt that when in these areas the bin supply was less reliable than when on rail alone. The road transport contractor did not provide sufficient capacity to maintain a constant flow of bins to the harvesters. The main concern of the transport contractor was that his vehicles were not waiting for bins (either fulls or empties) and for significant periods during harvester operating hours it meant an interrupted bin supply for harvesters.

Further discussion occurred on the general bin supply where all operators experienced some delays. This was in a large measure due to the reduced bin supply and the reduction in the number of available rail shifts as a consequence of the mill's financial difficulties.

Group B operator also noted the significantly higher ash levels for his group. A significant proportion of the cane from this group was from the higher rainfall Daintree area where ash levels tend to be higher. However, this did not appear to explain all the differences as some of the other operators in this project also harvested cane from the Daintree area.

Subsequent to this meeting the more detailed spatial analysis was undertaken to attempt to identify some of the contributing factors to the recorded differences. Some of this later analysis was discussed in greater depth with the individual groups.

The presentation of data to this group did not progress to identifying ways of addressing some of the inefficiencies at block or farm level. Changes also need to be considered in the wider Mossman harvest and transport context.

Presentation to the Vision 2010 working group - 2005

The same data was presented to this group. Here the discussions were in relation to the size of the harvest sector (number of groups and harvesters) in 2010. The group had considered that ten harvesters should be a target for that time based on an anticipated area production of 700,000 tonnes.

During the 2006 off-season two changes of significance occurred within harvesting groups:

- One harvest operator sold his equipment and contract to another existing contractor in the Mossman area which effectively reduced the number of harvester groups by one without reducing the number of harvesters. The two contracts could not have been comfortably handled as a single shift operation.
- Another existing contractor purchased a second machine to operate in conjunction with his existing machine. This second machine will be mainly used as a plant cutter for the contract planting side of his business but will also be used for cutting some of their own grown cane. The size of the existing contract was difficult to handle with a single shift operation but was not large enough for a two shift operation.

The net effect for the local industry is a reduction in the number of harvesting groups but an increase in the number of harvesters. Some discussion then occurred around the ability of the transport sector to service the harvesters.

Current pour rates are constrained by the ability of the transport system to provide a continuous supply of bins. Capacity is limited in the number and timing of loco shifts to move bins to and from the mill and in the size of the sidings (ie the number of bins that can be located in a siding). Higher pour rates can only be achieved with more transport capacity; more siding capacity, more transport movements and/or more bins. In effect the deficiencies in the transport sector are having a negative effect on the ability of the harvesting sector to improve efficiencies.

The road transport contractor was changed after the 2005 season and many of the capacity issues in this part of the transport sector were addressed for the 2006 crush.

The opinion of the Vision 2010 working group in 2005 was that the transport system needs to be reformed before any significant change could be achieved in the harvest sector. The real value of working with this group is that the whole system is being considered in a holistic manner rather than individual elements considered in isolation.

In line with this the project team decided to defer any further presentations of the outputs of this project at an industry level until after some of the greater transport issues had been resolved. It was further intended that the Vision 2010 working group consider this material before it is presented to the wider growing sector.

Presentation to individual Harvest Operators from the Project Group - 2005

This more detailed information was prepared for presentation to the individual harvest operators. The project team felt that the more detailed information was not suitable for presentation to all groups together as individual farms and blocks and associated productivity information were identified. However this information was seen as valuable for defining areas for change to operations that need to be made at the farm level to improve harvest efficiency. The team also believed it could help individual harvesters improve the efficiency of their operations and would support the need for alternative payment systems that are needed to drive changes to farm layout to improve harvest efficiency.

The more detailed spatial analysis was presented to only two of the cooperating harvest operators. Of the other four groups:

- Missing data elements for one group meant that there was not sufficient data for the more detailed analysis.
- One of the groups felt that they would not make any changes to their operations as a result of the data as they did not believe they could improve their operational efficiency with the constraints of the transport system.
- One harvest operator retired at the end of the 2005 season and sold his equipment to another existing harvest contractor.
- One harvest operator was unavailable during the lead up to the 2006 harvest when the project team tried to give the presentations.

Individual data was presented to groups B and F. Group B was most concerned with their high ash levels and was keen to reduce the extraneous matter with changes to their harvester operations. Both groups are harvesting mostly (group F) or exclusively (group B) their own cane and are making changes to their block layout and farming operations to improve their harvest efficiency. They are also the two groups which have continued monitoring.

The unavailability of data for calculating CQI in 2007 was disappointing for the project team. Group B had the highest ash levels in 2005 and this was the cause of some concern to the group. A new harvester operator drove the machine in 2007 and the project team and the group were keen to see if this change had an effect on the ash levels.

The project team felt that the major contributing factor to the long term cost reduction would be due to a change in row spacing. As a consequence of the adoption of MAS001 productivity initiatives in excess of 75% of the total area planted in 2006 and 2007 was at a row spacing of 1.6m or greater. Although this has had little effect on the 2007 harvest it is expected that there will be a flow on effect in improving harvest efficiencies.

Monitoring in 2007 and 2008

Data was collected in 2007 only during the latter part of the season using different equipment to the Bigmate units and unfortunately the cane quality data was not available. The project team was unable to give any information back to group B on their ash levels.

However, the monitoring will continue for the whole season in 2008 and it is expected that the full range of quality data will be available. The project team expects that data analysis will be undertaken during the season and fed back to the groups.

The data collected will also be used for monitoring harvest progress during the season. Having the monitored data in a format compatible with the field and productivity data has allowed for easier analysis and interpretation protocols to be developed. This will allow for block harvest details (part cut, areas/tonnages left in blocks and blocks finished) to be established from the monitored data as an aid to the field harvest management operations.

Quantifying benefits.

It is difficult to quantify the full benefits of this project. The impact of improving yield has been discussed as has the role of changing the payment system in that context. The harvester monitoring has established benchmarks for the harvesting efficiency parameters of pour rate, operating rate, field efficiency and operating efficiency and the impact of these measures on harvesting costs have already been discussed. It was also interesting to note that the harvest operator who sold out after the 2005 season was the one from the monitoring group with the lowest operating rate and the highest calculated harvesting cost.

Field efficiency is mainly a function of farm block characteristics; length of row, width of headland and haul distance. As mentioned in the background, Mossman is characterized by many small blocks with natural boundaries that restrict size and shape. However, these small blocks still contribute significantly to the overall cane throughput of the Mossman mill. As such retaining these blocks as part of the productive cane land is important for the long term viability of the mill.

Changes to block layout to improve harvest field efficiency are a cost to the farmer. Until the payment system for harvesting is changed to reflect the real cost of harvesting, farmers will be reluctant to change block layout. Growers who do their own harvesting are the exception and indeed both groups B and F are changing row spacing and block layouts. This will give benefits through improved harvest field efficiency. Some other grower/harvesting contractors are also doing the same on their own properties. However, because of the low correlation between field efficiency and harvesting costs it is difficult to directly quantify benefits.

Operating efficiency is a largely a function of the ability of the transport system to meet harvesting requirements. The local industry believes that changing the road transport arrangements in 2006 and 2007 gave benefits to the whole of the industry and not just the harvest operators on road transport. Effectively the size of the transport fleet was increased by 20% in 2006 (from 3,400 tonnes to 4,100 tonnes total capacity) and another 15% in 2007. However, these changes were developed and endorsed by the Vision 2010 group outside this project.

Mossman is one of the few districts in the sugar industry using the ArcGIS platform for spatial data interpretation and analysis. Most other areas are using ArcInfo. This has meant that it was not simply a case of using software and other routines developed for other districts of the sugar industry to undertake the data interpretation and analysis. The alternative to developing the tools locally was to migrate all Mossman data to the ArcInfo platform which would also have presented some cost and data transformation issues. This project has enabled the development of the local resources for remote harvest management.

The project was originally developed as a pilot for remote harvest management and to consider and implement changes to the payment system. The data ant other outputs generated in the project will support change in the Mossman area

Future Research Needs:

Payment Systems

The project team does not see any future research needs for this area of the project. The cane payment system based on CQI as developed by Steve Staunton has direct application in all other cane areas. The introduction of the system into Mossman will depend on continuing the work undertaken to date. At the time of preparing this report the system is again under consideration for introduction. MCM management has given in-principal support for the system and an analysis will be undertaken from the 2008 harvest of payments made based on the CQI system compared with the existing Relative D cane payment formula.

No further action required for system of equalising payments during the season. The principals for implementing this system have been developed and all parties are in-principal in agreement to the system as defined. The implementation through a third party has some inherent difficulties but not insurmountable. However, the imperative for the system has been reduced with a reduction in the number of harvesting rounds. At this stage the system could be modified to suit prevailing conditions without major refinement should the industry decide to reconsider implementation of this payment system.

Payments for harvesting has now changed for some farmers and harvesting groups. The industry will move further in this direction over time as the benefits of alternative payment arrangements are more widely accepted by the industry. If a cane payment system based on CQI is implemented then the issue of including ash in the harvest payment formula should be reinvestigated.

Harvest Monitoring

The unit fitted to group B harvester operated using a differential GPS receiver which allows for data with a GPS accuracy of 2cm horizontal and 10cm vertical (elevation) accuracy to be collected. Elevation data to 10cm accuracy is suitable for determining levels for laser grading. Thus it is possible in the future to use this data for block drainage work or even to produce accurate contour maps of blocks and farms for broader drainage design work.

This project has established suitable equipment and analysis protocols for harvester monitoring in Mossman. This data can be used as a tool for improving the efficiency of harvest operations within a group and between groups and remote monitoring of harvest. The units are modestly priced and routines for data analysis have been developed locally hence specialist interpretation and analysis software or software routines are not required. The functional range of data elements collected can be expanded and the same units could be used for yield monitoring in addition to the current data elements collected.

There are three logical extensions to this part of the current project:

1. *Monitoring a larger number of harvesters.*

Units could be installed on other harvesters within the Mossman harvest fleet. However, the project team feels that the full benefits of the current monitoring need to be quantified before taking this step. The monitoring in 2008 will be undertaken from resources available within Mossman Agricultural Services and this does not stretch to extending beyond the current two units.

2. *Electronic consignment.*

The units do have the potential in use for electronic consignment but the logistics of electronic transmission of data to allow for real time monitoring would need to be addressed. In addition the cane receival system at MCM would need to be tailored for electronic consignment.

These two should be considered together. However, electronic consignment is currently not being considered for the Mossman Sugar Industry.

3. *Extended Monitoring Functionality.*

The monitor fitted to Group B harvester can be easily upgraded with yield monitor sensors which have been developed by Agguide. At this stage the operator is not interested in a yield monitor. The capacity for fully utilising the elevation data collected should to be explored.

Recommendations:

Recommendations to the local industry are:

1. Continue analysis of CQI options using 2008 harvest data with the view to implementing a CQI base payment system in 2009.
2. Continue harvest monitoring with the two installed units in 2008 including an assessment of the use for remote monitoring of harvest and evaluation of cost/benefit from this data.
3. Analyse results from monitoring including 2008 season data and set a program including a timetable and funding options for extending harvester monitoring and electronic consignment.
4. Investigate options for utilising collected elevation data for generating contour maps of cane blocks and plans for laser levelling.
5. Continue with Vision 2010 group for industry strategic planning of harvest and transport.

List of Publications:

No papers published but Options Paper “Paying for Cane Utilising a Quality Index” prepared for discussions and included as Appendix 1. Analysis of monitoring data from 2005 is included as Appendix 2.

Appendix 1. Options Paper

Paying for Cane Utilising a Quality Index

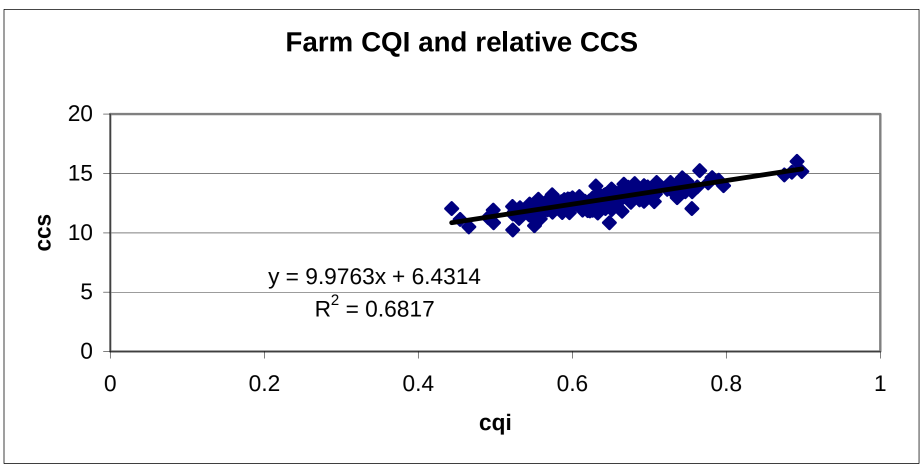
With Mossman Central Mill opting for independence in marketing of its products, an alternative system for paying growers for cane will need to be devised. This paper looks at alternative systems primarily based on a quality index. It does not discuss the division of income between growers and miller but looks at payment to growers so that the clearer market signals are sent to this sector. All data is based on the 2005 season.

Cane Quality Index (CQI)

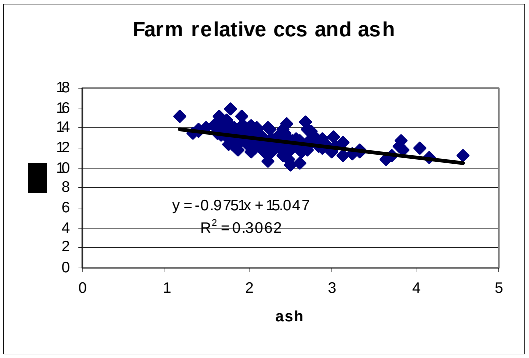
A cane quality index developed by Steve Staunton was used in this exercise. It is based on NIR data collected by MCM. Any payment based on CQI will depend on MCM continuing to collect quality data necessary for the calculations. CQI is calculated using the following formula

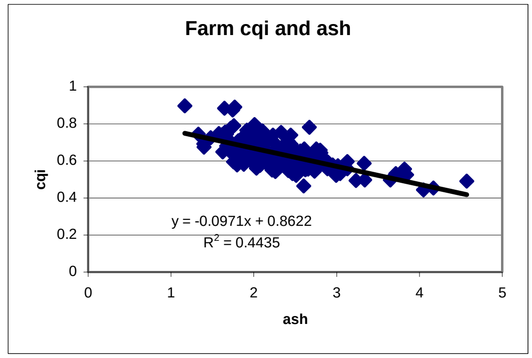
CQI=0.5+0.738*(([NIR POL_J]*(100-([NIR FIB]+5))/100)/[NIR FIB])-0.659*(([NIR POL_J]*(100-([NIR FIB]+5))/100)/([NIR BX_J]*(100-([NIR FIB]+3))/100))-0.638*([NIR ASH]/([NIR DRY]-[NIR ASH])). It is believed that CQI will give a greatly improved measure of the value to the mill of sugar cane consignments than CCS.

CQI is closely correlated to CCS as illustrated in the following graph but is also more sensitive to other quality factors

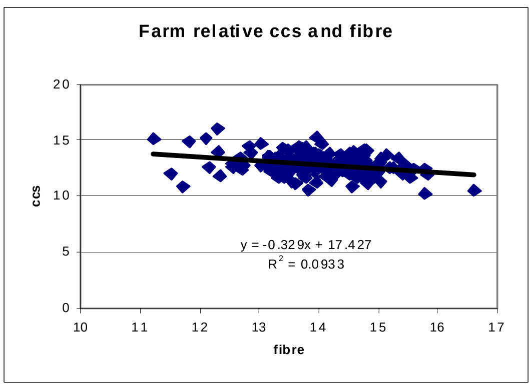


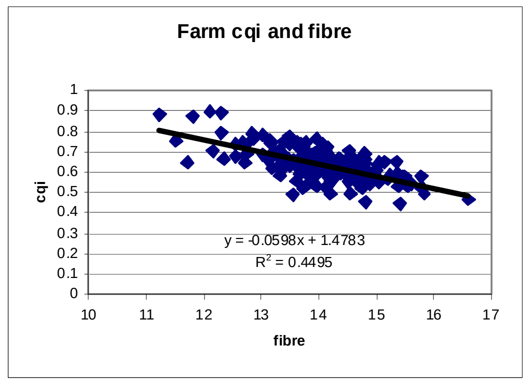
CQI is more closely correlated to CCS than ash. R^2 = 0.6817 compared to R^2 = 0.4435 and more sensitive to change. The trend is for CQI to decrease 11.35% with each 1% increase in ash compared with 6.5% for CCS. Ash is considered to be a good indicator measurement for soil in the cane supply and MCM have for several years conducted a poorly understood quality system based on ash. A payment system based on CQI would obviate the need for a separate cane quality scheme.





High fibre, despite its use as a fuel, is considered undesirable because it slows crushing rate and has deleterious effect on extraction of sucrose. Fibre is very weakly correlated with ccs and much stronger relation is evident with CQI. The value of fibre versus its deleterious effects may need to be more closely considered in the future and adjustments made to the CQI formula if fuel supply continues to be an issue early in the season.

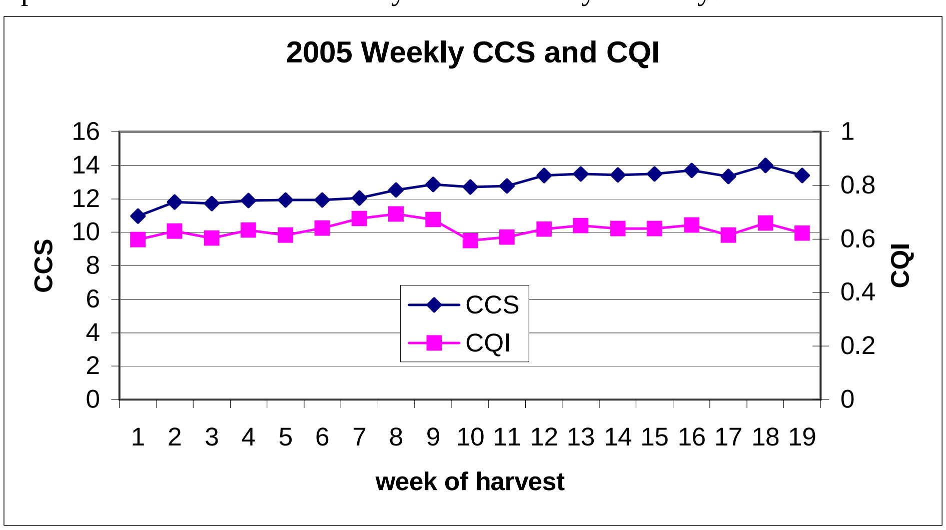




CQI and CCS Comparisons

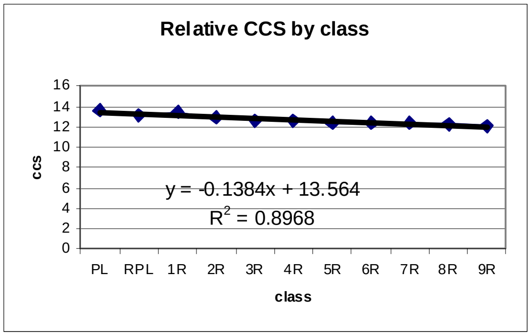
By week of harvest

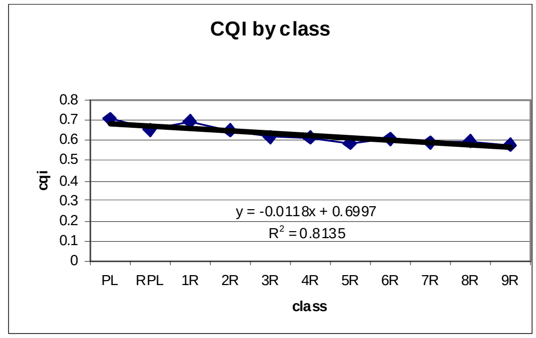
CQI varies much less than ccs from week to week through the harvest season. If CQI is used for payment purposes it should not be necessary to have weekly relativity.

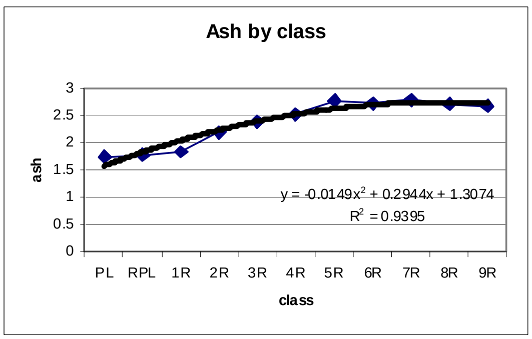


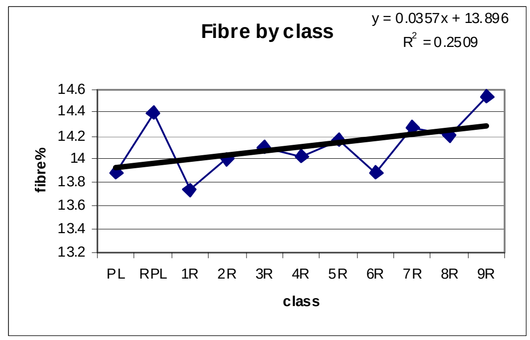
By Crop Class

Both CCS and CQI decrease in older ratoons but CQI is more sensitive to class. CCS decreased by 1.0% with each ratoon while the CQI decreased by 1.6%. The reason for this is due to the increased sensitivity of CQI to Ash and fibre levels both of which are higher in older ratoons.



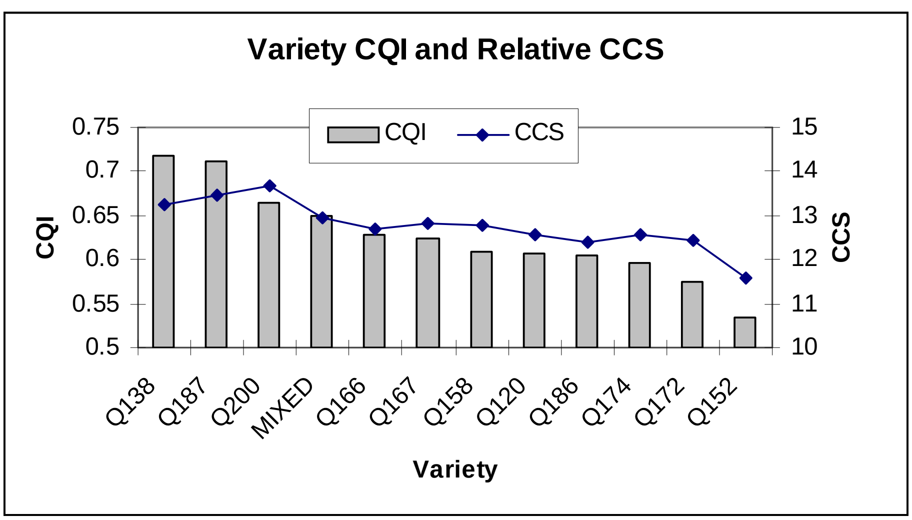






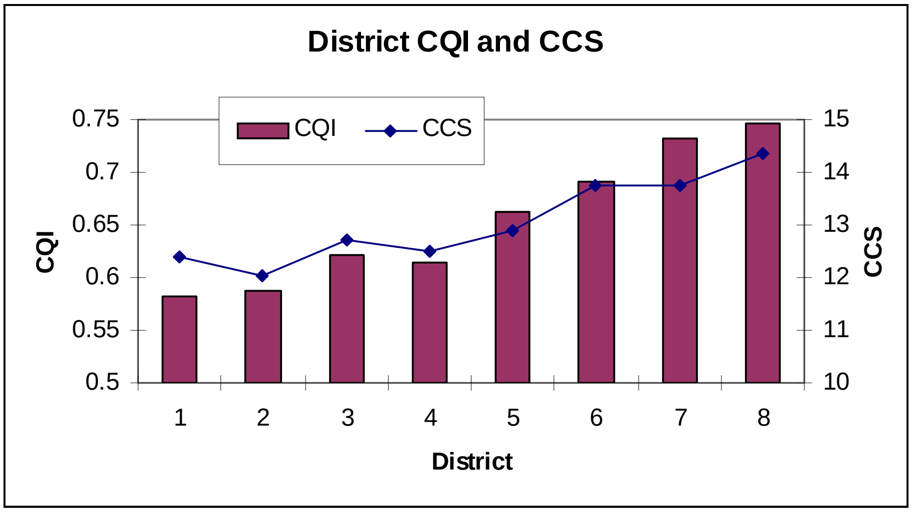
By Variety

Although CCS and CQI are closely related varieties with the highest CCS do not necessarily have the highest CQI. The following graph with varieties arranged in descending order of CQI illustrates this point. Note that the vast majority of the Q138 came from the high ccs Julatten area.



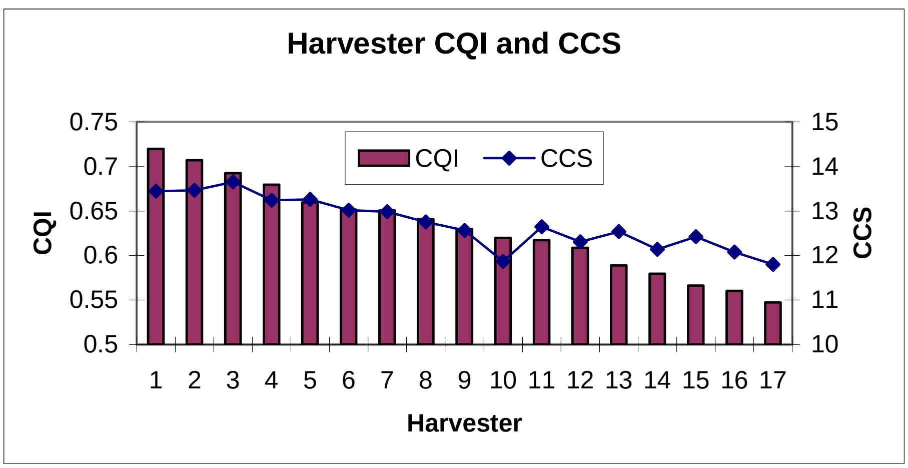
By District

CQI and CCS rate districts similarly although the relative positions of the two lowest districts are reversed in this instance

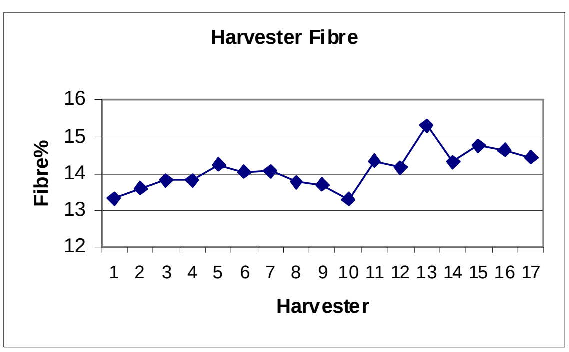


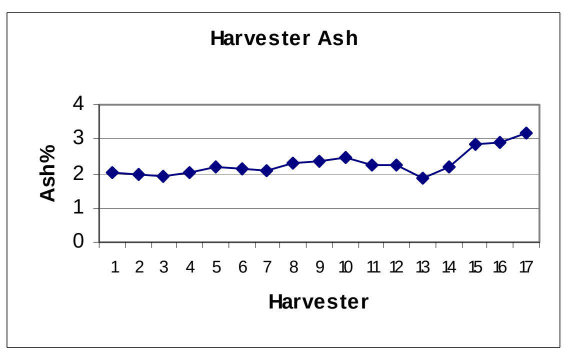
By Harvester

Some harvester groups appear to achieving good CQI levels compared to CCS particularly at the higher CQI levels. Conversely some groups appear to be under achieving.



These variations are primarily due to varying ash and lesser extent fibre being achieved by groups.





Payment Systems

Growers

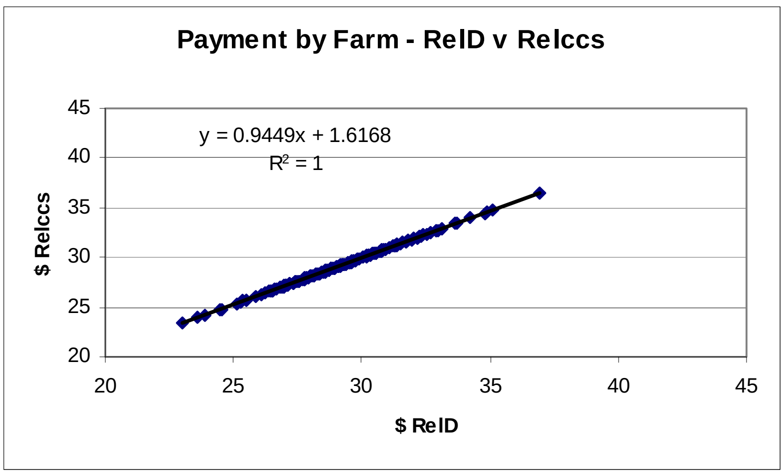
With the cane price formula no longer being valid an alternative system for distribution of payments needs to be agreed to. For the purpose of this paper the total amount that will available for distribution to growers in 2005 based on a sugar price of $315/tonne was used as the basis for comparing different distribution options**.** This amounts to $15,462,068 for 528,950 tonnes of cane

Although not the concern of this paper, how the amount for distribution is arrived at in future, if this is the way distributions are to be made, needs to be resolved promptly.

System A Payment based entirely on relative ccs

Establish Average Price
Average Price for tonne cane =Total $ available divided by total tonnes
=15,462,068 divided by 528,950
=$29.23
Grower price = Average price x $\frac{\text{grower relative ccs}}{\text{average ccs}}$

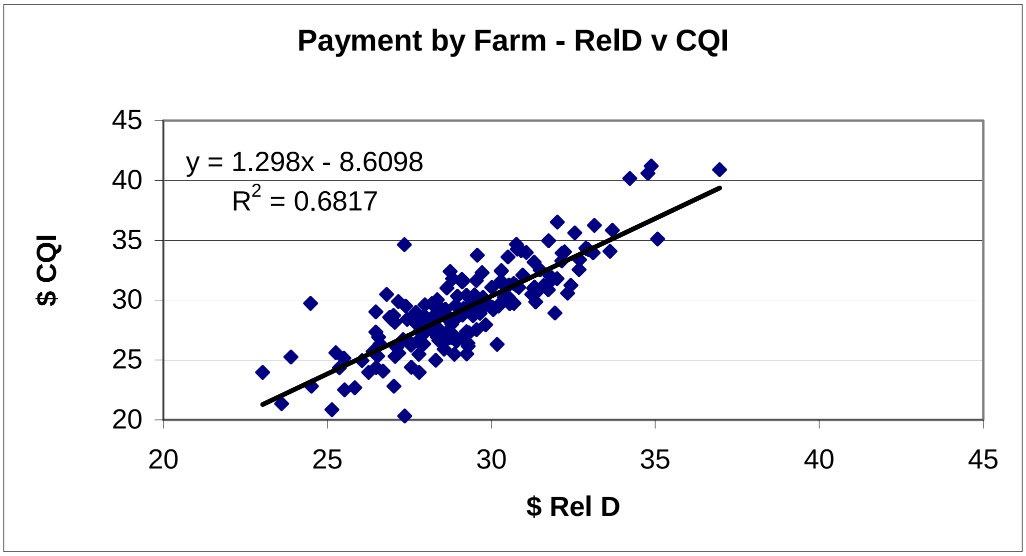
Virtually the same as present system.



System B Payment based entirely on CQI

Establish average price as above
=$29.23
Grower price= Average price x $\frac{\text{Grower CQI}}{\text{Average CQI}}$

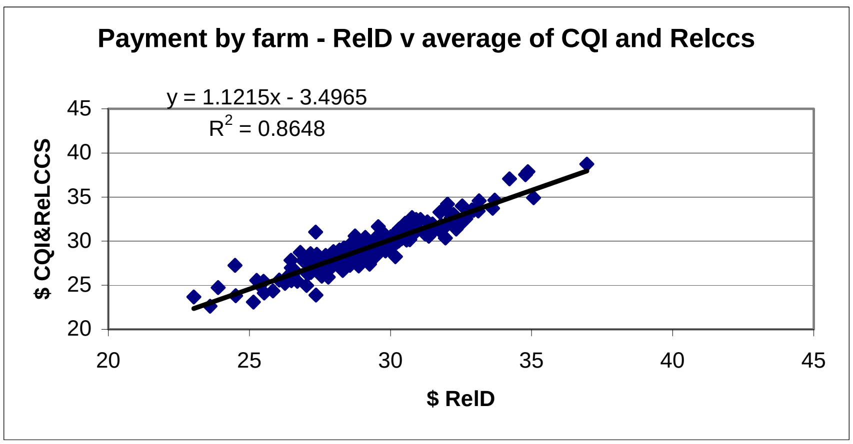
A CQI based payment system whilst sending good market signals would result in major overs and unders compared to present system. Growers would need time to adopt different farming practices to take advantage of the change in payment system.



System C Hybrids of the above two systems

To soften the change from CCS to CPI a hybrid or hybrids of the 2 systems should be considered. Hybrids such as the average of System A and System B ie $\frac{A+B}{2}$

would reduce the magnitude of the "winners" and "losers" while still sending clear signals of the need to change.



Other hybrids such as $\frac{2A+B}{3}$ or $\frac{A+2B}{3}$ may also be considered as interim systems.

Harvester Payment

In the above harvester section there is an indication that some harvesters are achieving better CQI results than others. This is probably being achieved by minimising the amount of soil or other extraneous being included in the product.

It is considered desirable that harvesters through their operating procedure minimise soil in the product. Procedures that minimise trash, tops etc may, if not done using best practice, result in substantial cane losses. Harvester operators can have little direct effect on the other parameters included in CQI. Consequently if any quality incentive is included in harvester payments it should be based solely on ash levels rather than CQI.

Recommendations

1. MCM is encouraged to continue to collect good quality NIR data necessary for the reliable calculation of CQI
2. Industry to debate basis for split of sugar proceeds between grower/miller
3. Grower sector to debate adoption of a quality based system that will send good market signals aimed at increasing the “size of the cake”.
4. Close consideration be given to phasing in CQI utilising hybrids of CQI and CCS.

Appendix 2. Extract from MAS002 Milestone 4 Report – *Data Analysis*.

The primary dataset used for the analysis over the season had some obvious outlier elements. The primary data elements calculated when the Bigmate data was integrated with the rake file data from MCM were pour rate and operating rate. These were calculated on a block level based on pouring and operating hours respectively when the harvester was deemed to be in a particular block against tonnages assigned against a particular block. All assignment of harvester positions to blocks and subsequently to assigned tonnages was through interrogation of the datasets line by line.

Two possible sources of error from this step in the analysis are:

- Harvesters may have been incorrectly assigned to blocks because of errors in the positional data
- Cane may have been incorrectly assigned to blocks.

The situation was compounded where harvesters cut through more than one block and cane was subsequently assigned on an arbitrary basis to one of several blocks.

Some missing data would have also been from cane that was not consigned but used for planting. This may have resulted in complete blocks without consigned cane or lower tonnages from some blocks. The Bigmate data was the only data collected on harvest operations. In the data analysis, cane harvested but not consigned would have resulted in lower pour and operating rates with resultant effects on field and operating efficiencies and harvest costs. Conversely positioning inaccuracies which indicated harvesters were not in blocks or in blocks from which there was no record of cane being consigned would have resulted in higher pour and operating rates.

The above inaccuracies produced a number of data outliers that were removed from the final analysis. The selection of outliers was based on pour rate with data elements of less than 40 tonnes cane per hour or greater than 130 tonnes of cane per hour culled from the final analysis. In adopting this selection criterion the project team recognised that some invalid data elements may still be included in the analysed dataset and that some valid data may have been excluded from the analysed dataset. The results of harvester performance and cane productivity at a block or farm level included in this report are based on this dataset.

The complete set of rake file data was used for the time based summaries of cane quality characteristics reported on a weekly or seasonal basis. This means that these summaries are from an analysis of the larger data set that includes blocks where there is no harvester performance information. This dataset was used complete without any interrogation of the data for outliers.

The definitions of the reported characteristics were detailed in MR3 and are summarised in Appendix 1 of this report. A cost figure has been calculated on a cost/tonne basis using a standard hourly operating cost to enable comparison between groups. The original figure used was $285/hour (see MR3). An initial meeting with the cooperating harvest operators suggested this should be $400/hour (see Criteria 5) and this figure has now been adopted as the standard operating cost.

The data analysis includes:

- Farm and block summaries of CQI parameters, pour and operating rates and field efficiency for each harvester
- Harvester summaries for CQI parameters, pour and operating rates and field and operating efficiencies on a daily, weekly and seasonal basis
- Harvesting costs on a farm, block and group basis
- An analysis of the relationships between reported parameters.

In preparing this milestone report the results will be presented as time based reports of performance of the harvester groups (ie seasonal, weekly and daily summaries) and group based reports (ie group, farm and block summaries).

Results over the whole season

Table 1 shows the average values for performance and cane quality characteristics for each harvester group over the whole crushing season.

Table 1 Group Performance Summary

Harvester	Speed	Pour Rate	Field Efficiency	Operating Rate	Operating Efficiency	Cost	CCS	Fibre	Ash	CQI
A	5.2	69	67	47	76	$ 8.57	12.6	14.3	2.26	0.62
B	7.0	87	68	59	60	$ 6.83	12.4	14.7	2.79	0.57
C	6.6	85	77	66	67	$ 6.07	12.9	14.0	2.08	0.65
D	5.3	69	72	50	69	N/A	13.0	14.0	2.13	0.65
E	5.3	76	72	54	76	$ 7.35	12.5	13.6	2.38	0.63
F	6.4	81	67	55	78	$ 7.33	13.4	13.3	2.02	0.72

Group A has the lowest average ground speed, pour rate, operating rate and field efficiency but is in the upper group with respect to operating efficiency. It has the highest overall calculated operating cost. Conversely Group B has the highest average ground speed and pour rate and second highest average operating rate, however field and operating efficiencies are among the lowest. Harvesting cost is the second lowest in the monitored group. Group C has the lowest calculated harvesting cost. It also has the highest operating rate and field efficiency, second highest average pour rate and ground speed but second lowest operating efficiency. The remaining three groups are intermediate in all characteristics.

Cane Quality Index (CQI) and its relationship to CCS, Ash and Fibre are defined and discussed in detail in Criteria 3. Group B has the lowest CQI with correspondingly low CCS and high Ash and Fibre. Group F has the highest CQI and correspondingly high CCS and low Ash and fibre levels. Relationships between cane quality parameters and measured harvester performance parameters are examined later in this analysis. In addition the relationships between cane quality parameters and time of harvest, district, variety and class are discussed in Criteria 3.

Harvesting costs ($/tonne) for this analysis have been calculated from the operating rate (tonnes/hour) and a standard operating cost of $400/hour applied for all groups. In the Mossman area all harvesting is charged on a per tonne basis. However, the actual costs of owning and operating harvesting equipment are incurred and more accurately accounted for on an hourly basis. The cost of harvesting in this report was calculated on a cost per tonne basis using the operating rate to highlight the actual variation in costs of harvesting different blocks of cane due to differences in operating conditions.

Median values for all characteristics considered above showed the same relativity between groups when compared on a weekly or a daily basis. The more detailed comparison of performance between harvesters on a daily or weekly basis across the season is difficult because of the elements of missing data. On any one particular day there is considerable variation amount of data that is available for analysis between harvesters. The different district and transport operating conditions also compound this time based comparison.

The analysis of data at a block or farm level gives a clearer picture of variations between harvesters than the shorter time based analysis.

Farm and Block Level Analysis

Table 2 shows the data summarised on a block basis for each of the harvesting groups over the season. The table show the median values for each parameter. Operating efficiency is not reported in this instance because it can not be calculated at a block basis from the data available. In addition the data from group D was not suitable for analysis at this level. Median values were used for this report rather than average values to minimise the differences in the number of blocks analysed between groups. Block yield has been included in this analysis.

Table 2 Block Group Performance Summary

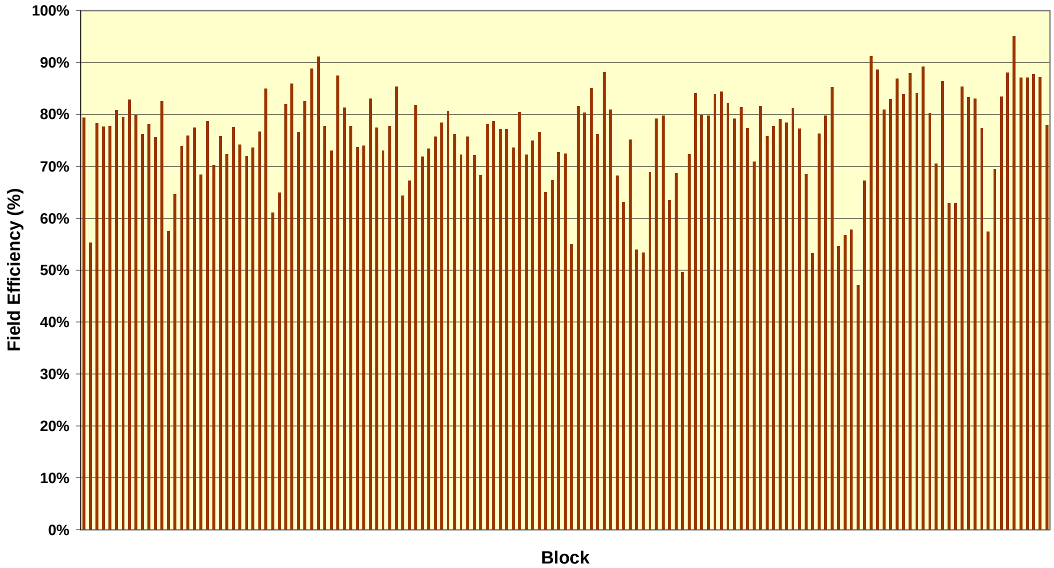
Harvester	Speed	Pour Rate	Field Efficiency	Operating Rate	Cost	Yield	CCS	Fibre	Ash	CQI
A	5.2	65	67	43	$ 9.24	72.0	12.8	14.9	2.00	0.60
B	7.0	89	66	59	$ 6.81	73.3	12.3	14.7	2.86	0.54
C	6.5	88	78	68	$ 5.92	78.5	12.9	14.0	1.92	0.64
E	5.2	71	73	49	$ 8.08	77.1	12.3	13.8	2.36	0.63
F	8.5	82	69	52	$ 7.71	72.2	13.4	13.6	1.94	0.70

The median values show a trend similar to the whole of season data from the time based analysis. All groups were in their same relative positions for each parameter reported but the absolute values differ slightly.

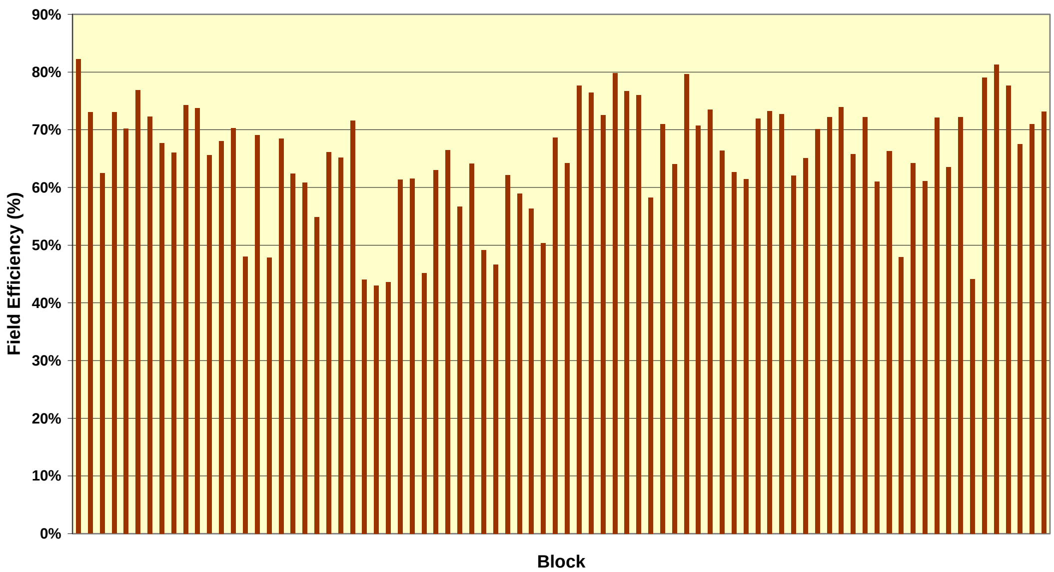
The differences between farms and blocks at a group level are an important consideration in terms of outcomes from this project. To improve efficiencies in the harvest and transport sector the differences need to be examined and strategies developed to address change that will reduce the differences or at least the impact of the differences.

The following graphs illustrate some of the differences between farms and blocks. In each case the group with the relative best and poorest rankings are included for each reported characteristic.

Graph 1 Field Efficiency by Block for Group C



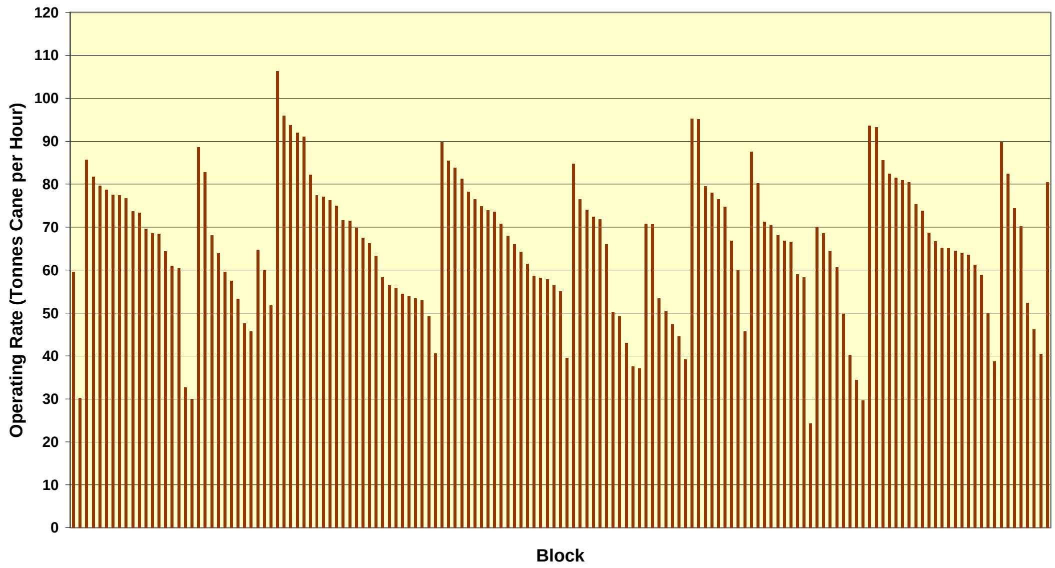
Graph 2 Field Efficiency by Block for Group B



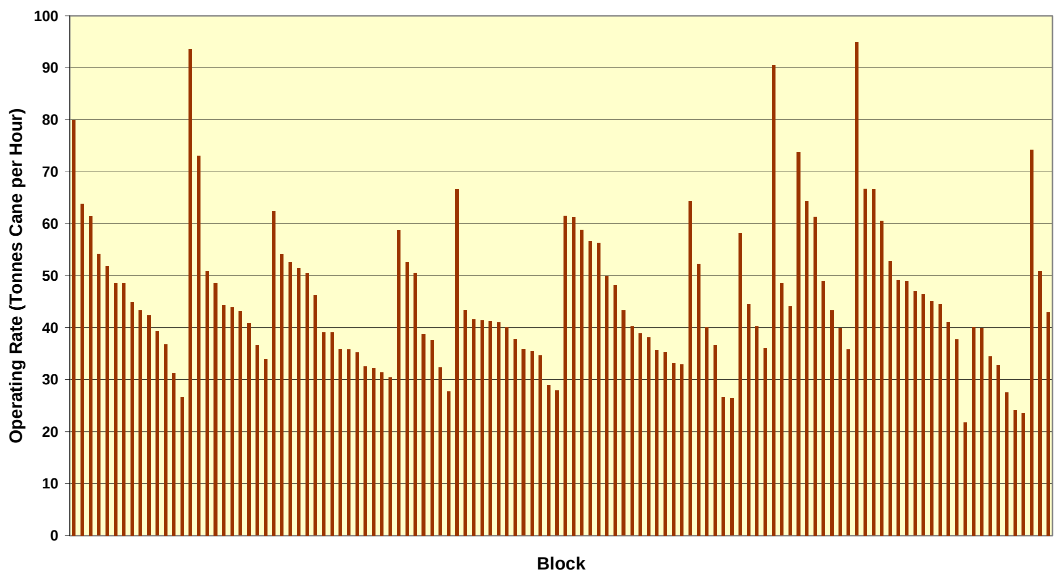
Field efficiency is a measure of the relative proportion of time that a harvester is working (cutting cane) compared with the time it is operating (engine at full revs and machine engaged) in the block. The time difference is due to time spent turning on headlands, reversing in rows and short periods of waiting for haul out units.

From the graphs field efficiency was between 60% and 80% in the vast majority of blocks for group C but for group B the majority were between 50% and 70%.

Graph 3 Operating Rate by Block for Group C



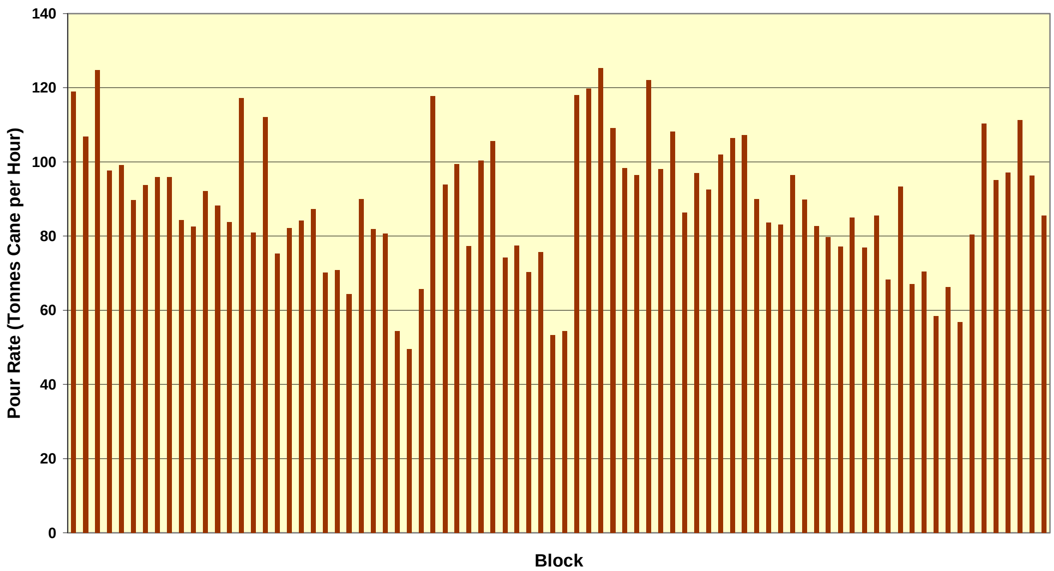
Graph 4 Operating Rate by Block for Group A



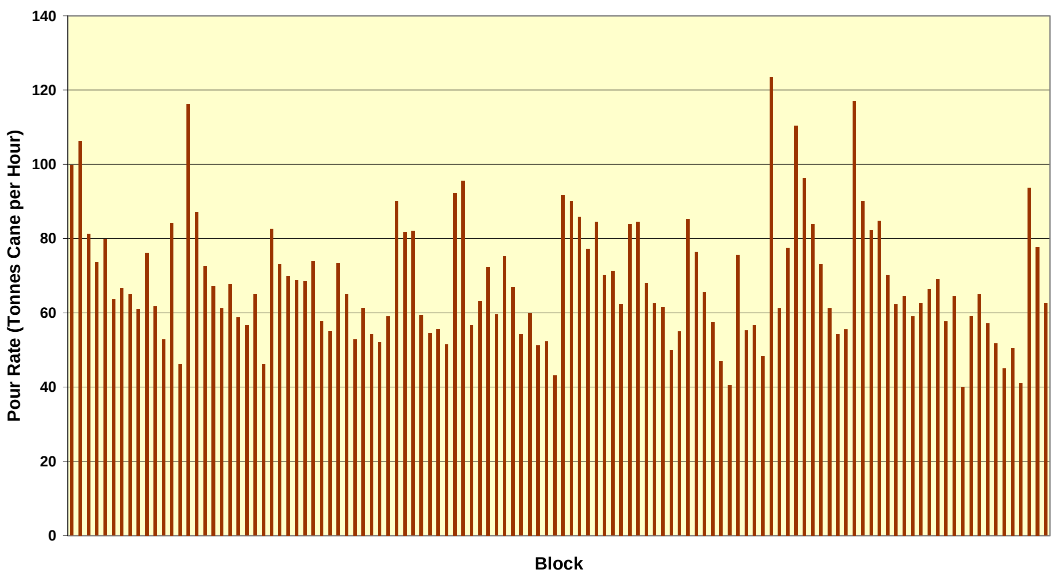
Operating rate is a measure of the rate at which cane was delivered to sidings for transport. The value was calculated by dividing the total tonnes consigned from a block by the operating time in the block.

Group C had the majority of blocks in the range of 40 to 80 tonnes of cane per hour while for group A the majority fell between 30 and 60 tonnes cane per hour.

Graph 5 Pour Rate by Block for Group B



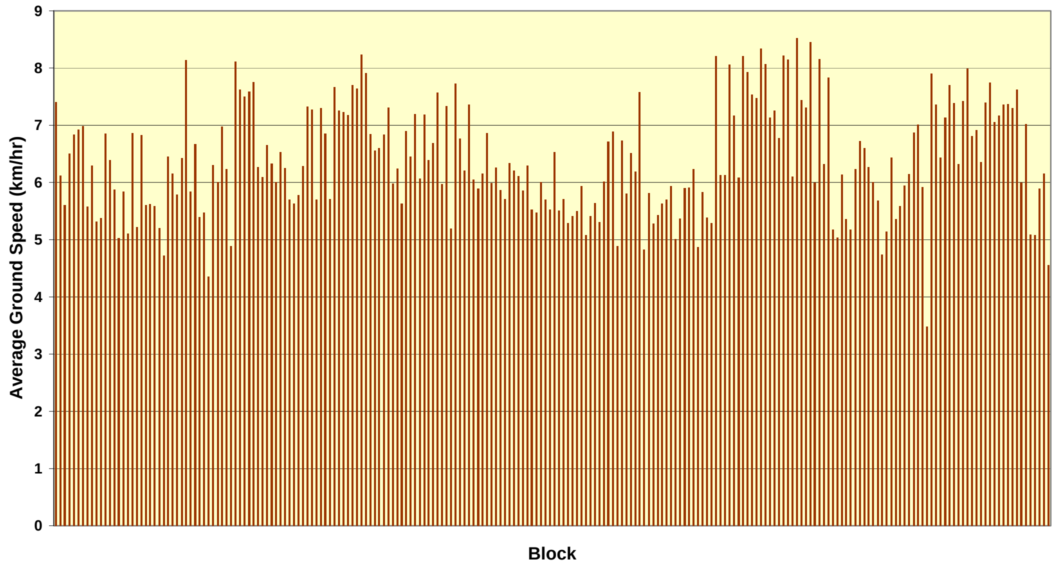
Graph 6 Pour Rate by Block for Group A



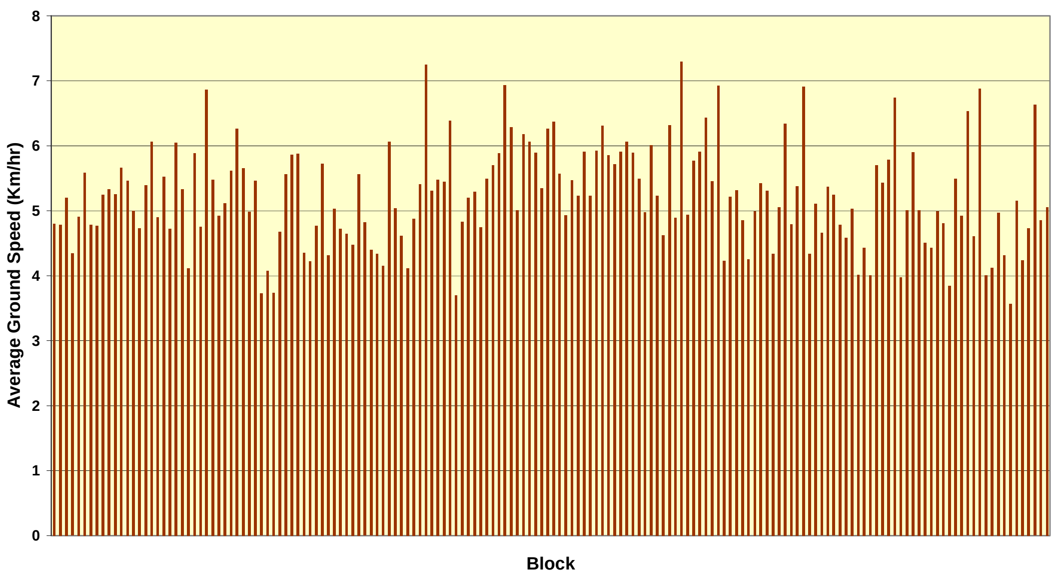
Pour rate is a measure of the rate at which cane is harvested in blocks as compared with the rate at which cane is delivered to the sidings. The rate was calculated by dividing the tonnes consigned from a block by the hours that the harvester was pouring (elevator on) in a block.

Group B had the majority of blocks between 60 and 90 tonnes per hour while Group A has the majority between 50 and 80 tonnes per hour.

Graph 7 Ground Speed by Block for Group F



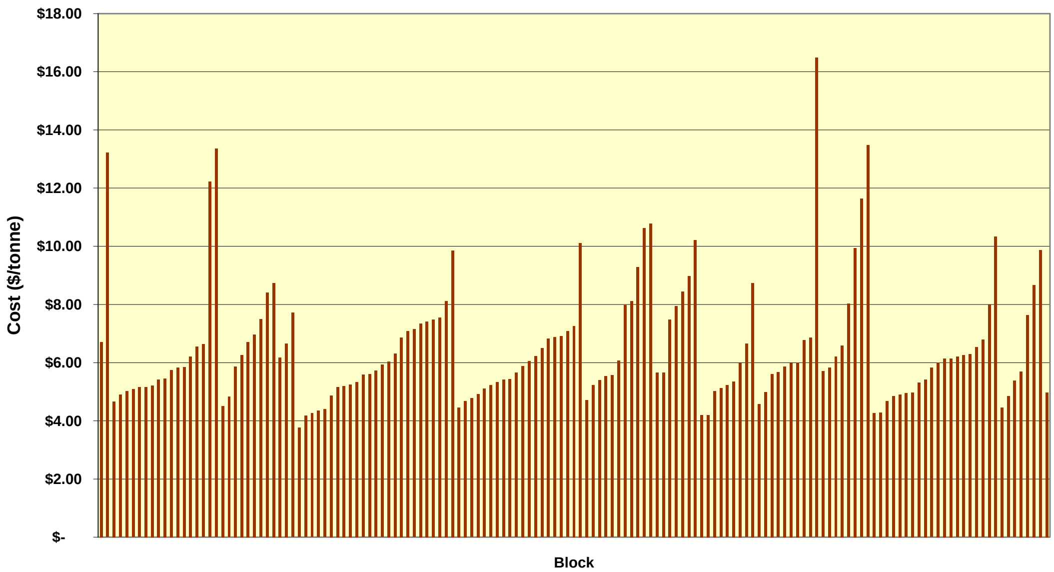
Graph 8 Average Ground Speed by Block for Group E



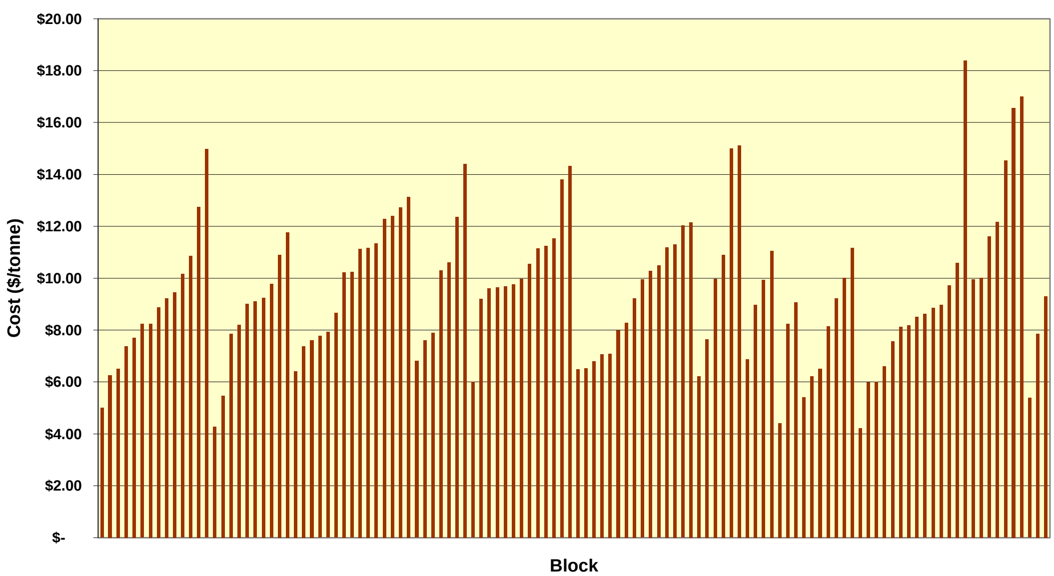
The Bigmate units logged position and other performance parameters at 30 second intervals. The relative change in position over time was interpreted and expressed in the dataset as average speed. The figures used above are the median values of the average speed calculated for each block.

For group F the vast majority of records are in the range of 5 to 6 km/hr while for group E the majority are in the range of 4 to 5 km/hr.

Graph 9 Harvesting Costs by Block for Group C



Graph 10 Harvesting Costs by Block for Group A



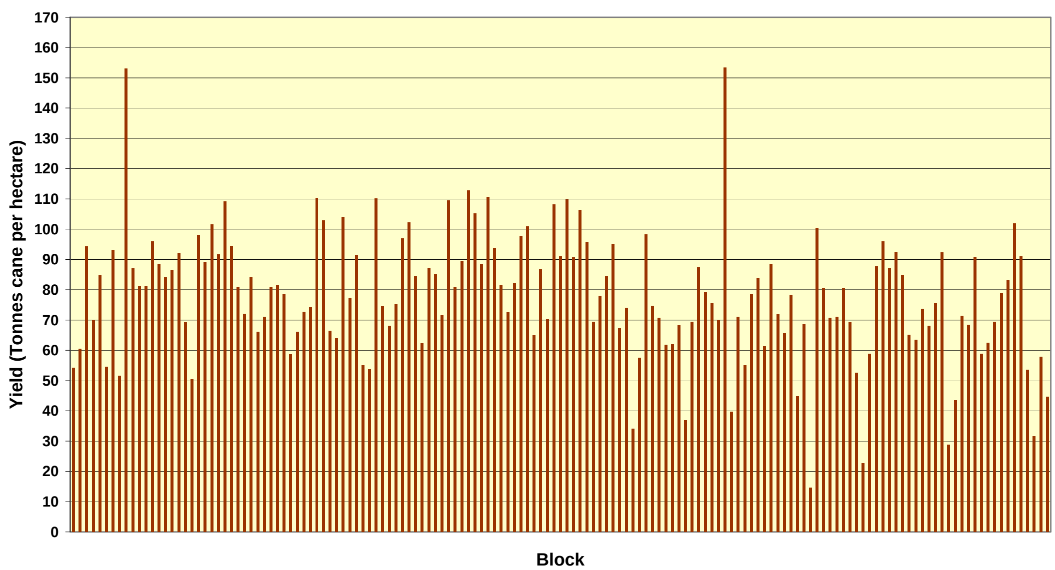
Harvesting cost was calculated directly from operating rate by assigning a value of $400/hour to the operating time in each block analysed. The figures generated then represent the cost per tonne of cane harvested that the operator would need to charge the farmer to get a return of $400/hour from the harvesting operation.

For group C the majority of the figures were in the range of $4.00 to $6.00 per tonne while for group A the majority of figures are in the range of $6.00 to $10.00 per tonne.

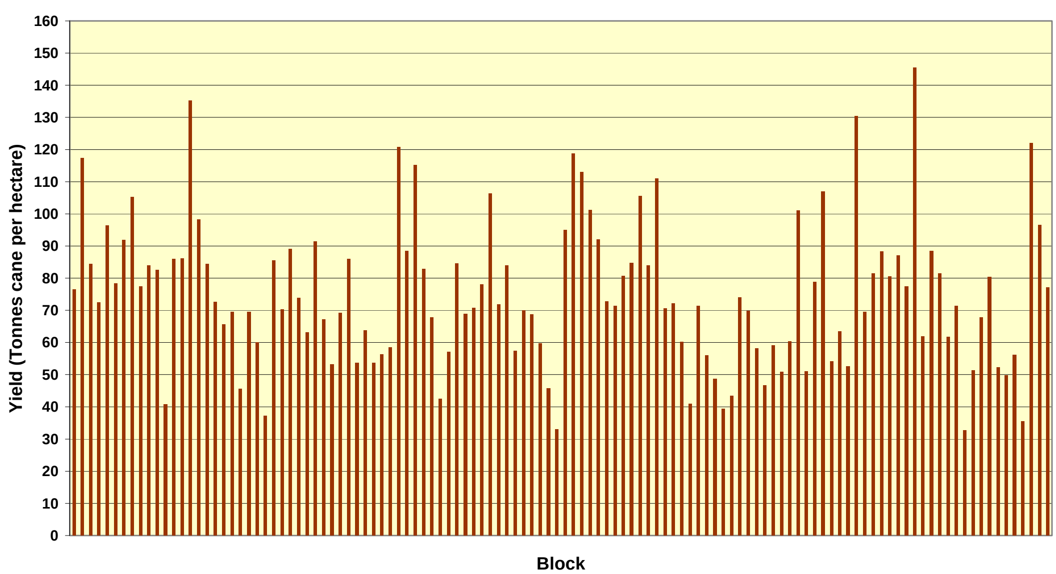
Using operating rate alone in calculating harvesting cost takes no account of the cost of harvesting when the harvester was idling or stopped. As such it does not account for the cost to harvest operators of delays due to waiting for bins. Indeed a harvest operator may have been operating at a moderate operating rate because of the knowledge that there will be interruptions to the bin supply. The situation reflected by Group A where Pour Rate and Operating Rate were low but Operating

Efficiency is relatively high may have been a response to bin supply interruptions. These were some of the issues discussed when the analysis was presented to the cooperating harvest operators.

Graph 11 Yield by Block for Group C



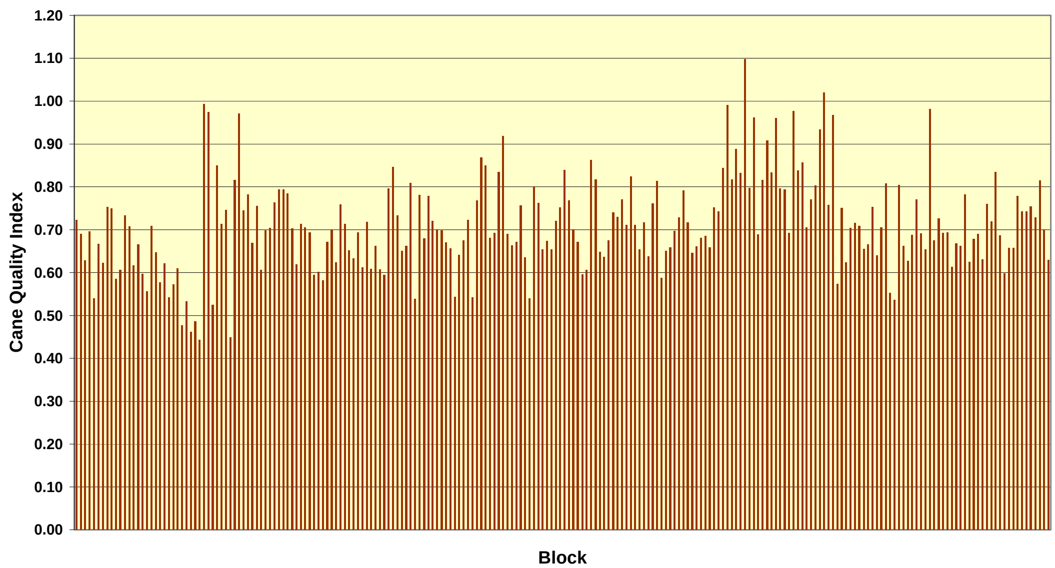
Graph 12 Yield by Block for Group A



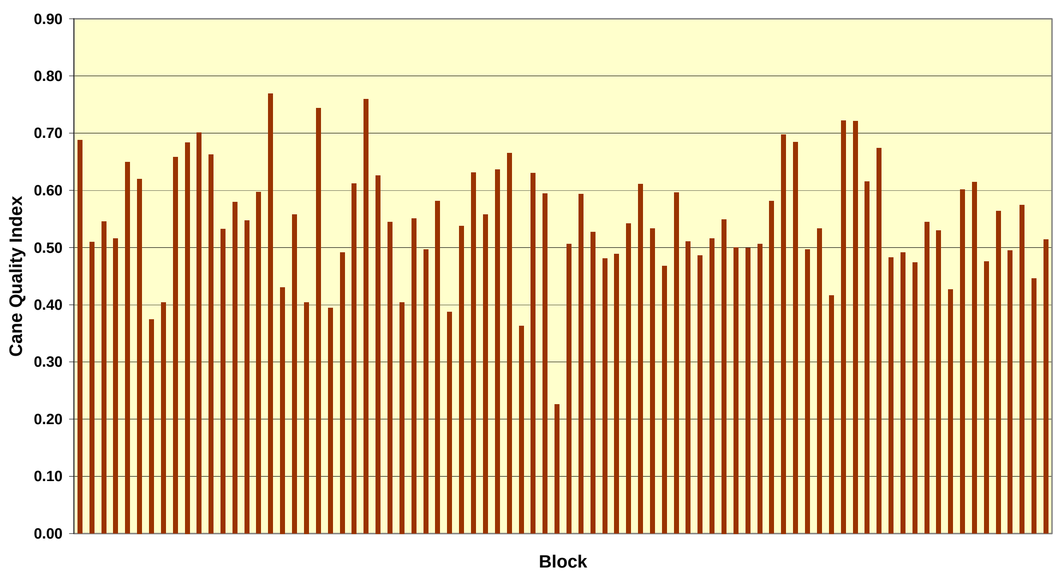
Yield was calculated at the block level using cane consigned against blocks and block areas. The calculated yields for some blocks suggested that some anomalies may have been present in the analysed dataset giving unexpectedly high or low values. No further attempt was made to cull this dataset.

For blocks harvested by group C the majority of block yields were in the range of 50 to 90 tonnes cane per hectare and for group A this range was from 40 to 90 tonnes per hectare. The overall average for the mill area was 73.2 tonnes/ha.

Graph 13 Cane Quality Index by Block for Group F



Graph 14 Cane Quality Index by Block for Group B



The calculation of Cane Quality Index is discussed in detail in Criteria 3. It was included in this analysis as an indicator or harvester practices. In the Harvesting Best Practice Manual (Sandell and Agnew, 2002)the editors discuss how harvester parameters such as pour rates and extractor fan speed can influence cane quality.

For blocks harvested by group F the majority of values are between 0.5 and 0.8 while for group B the majority were between 0.4 and 0.7.

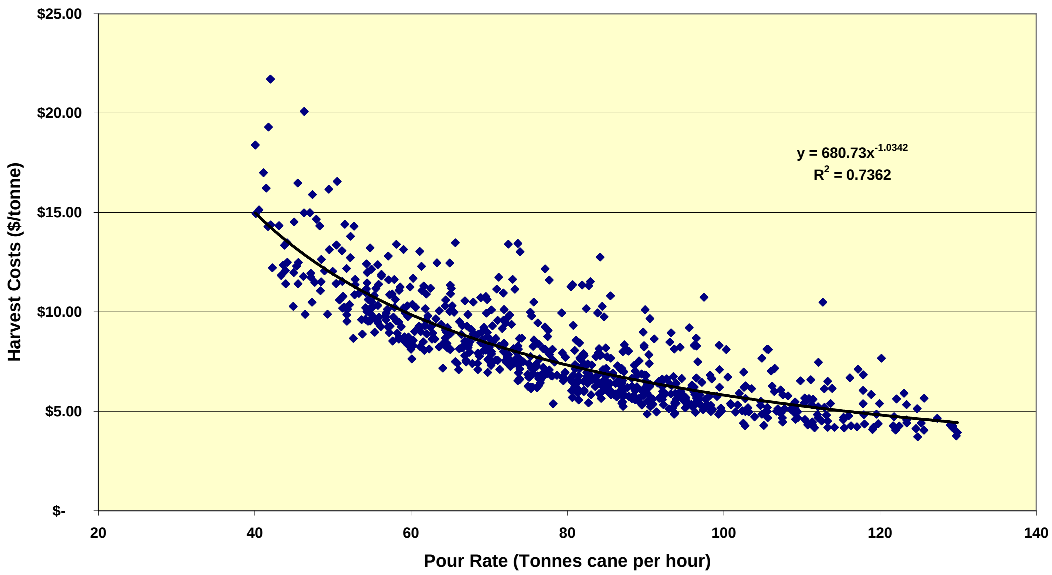
Field Efficiency and Operating Rates were the primary indicators of harvester performance used in this project. The main factors that impact on these were discussed in MR3. These are mainly harvester and farm characteristics. As such improvements in these indicators will be through changes to farm or harvester operating practices and as later discussed will be driven by appropriate pricing mechanisms for harvesting cane.

Regression Analysis

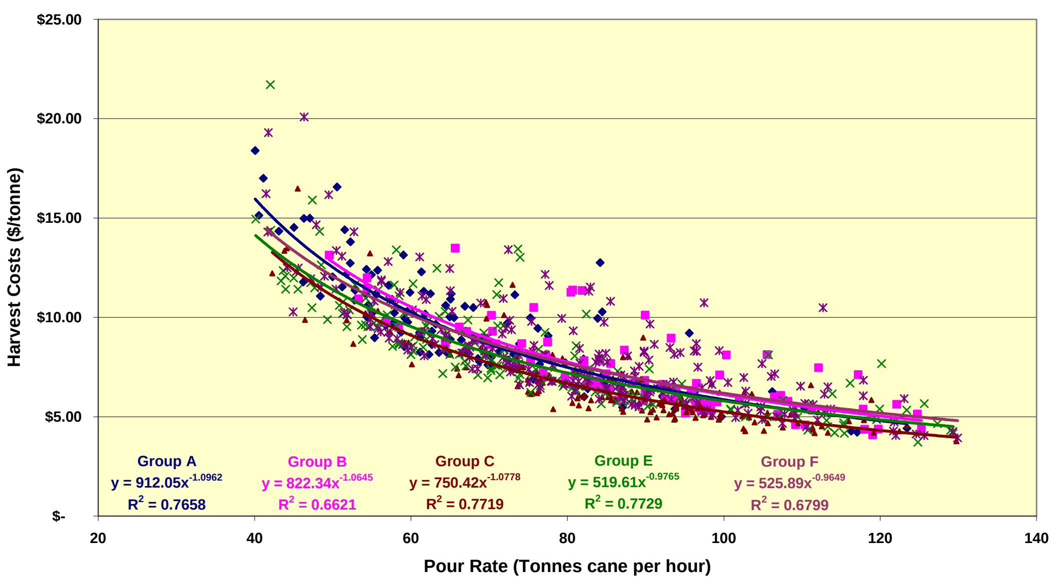
The first stage of the analysis defined the different operating characteristics of the harvesting groups. The next stage looked at possible relationships between measured parameters that could be used to improve the performance indicators of the harvesting groups.

The following analysis used an aggregated dataset from all monitored groups as discussed in the introduction to this section of the report. The data was analysed and graphed in Excel 2003 using regression analysis.

Graph 15 Harvesting Costs and Pour Rate



Graph 16 Harvesting Costs and Pour Rate



Graph 15 looks at the relationship between harvesting costs and pour rate. A reasonable strong relationship was found between harvesting costs and pour rate from an analysis of the complete dataset; nearly 80% of the variation in harvesting cost could be attributed to variations in pour rate. The higher the pour rate the lower the harvesting costs.

Graph 16 looked at the same relationship as in Graph 15 but the dataset was divided into individual harvester groups. All groups reflected the same trend although the strength of the relationship varied between groups.

This analysis indicated that for the 2005 monitored harvester groups, harvesting costs of less than $5.00 per tonne were never achieved when pour rates were less than 90 tonnes cane per hour. However in some cases harvesting costs were still above $5.00 per tonne when pour rates were above 120 tonnes cane per hour. The regression equation gave a predicted average pour rate of 98 tonnes cane per hour required to give a return to the harvest operator of $400 per hour when the rate charged to the grower was $6.50 per tonne.

The regression equation was used to prepare the sensitivity analysis presented in Table 3. Different factors for hourly harvesting operating costs were applied to the dataset to produce a series of regression equations of harvesting costs against pour rate. These regression equations were then used to examine the average pour rates that would need to be achieved to give an operating return of from $300 per hour to $400 per hour at different rates of charging for harvest from $5 per tonne to $10 per tonne.

Table 3 Sensitivity Analysis. Pour Rates at different Harvesting Costs and Hourly Rates

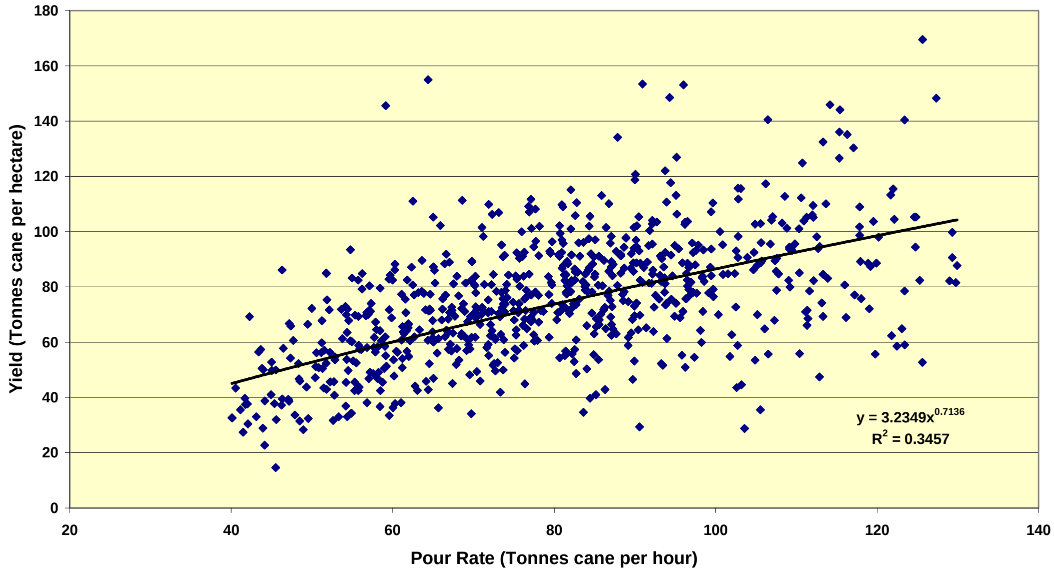
	Harvesting Cost										
	$5.00	$5.50	$6.00	$6.50	$7.00	$7.50	$8.00	$8.50	$9.00	$9.50	$10.00
$400/hr	129	117	107	98	91	85	79	74	70	66	63
$375/hr	121	109	100	92	85	79	74	70	66	62	59
$350/hr	113	102	93	86	80	74	69	65	61	58	55
$325/hr	105	95	87	80	74	69	64	60	57	54	51
$300/hr	97	88	80	74	68	64	59	56	53	50	47

This table gives harvester operators the ability to look at their average pour rates and make an assessment of how much they may need to vary the harvesting price to achieve a defined hourly operating return. Conversely given their known hourly operating costs, what pour rate do they need to be averaging to remain profitable when charging a set rate per tonne of cane harvested.

Once the relationship between harvesting costs and pour rate were established the data was analysed to look for relationships that linked other measured parameters and pour rate. An understanding of how things impacted on pour rate could assist with making changes to improve average pour rate.

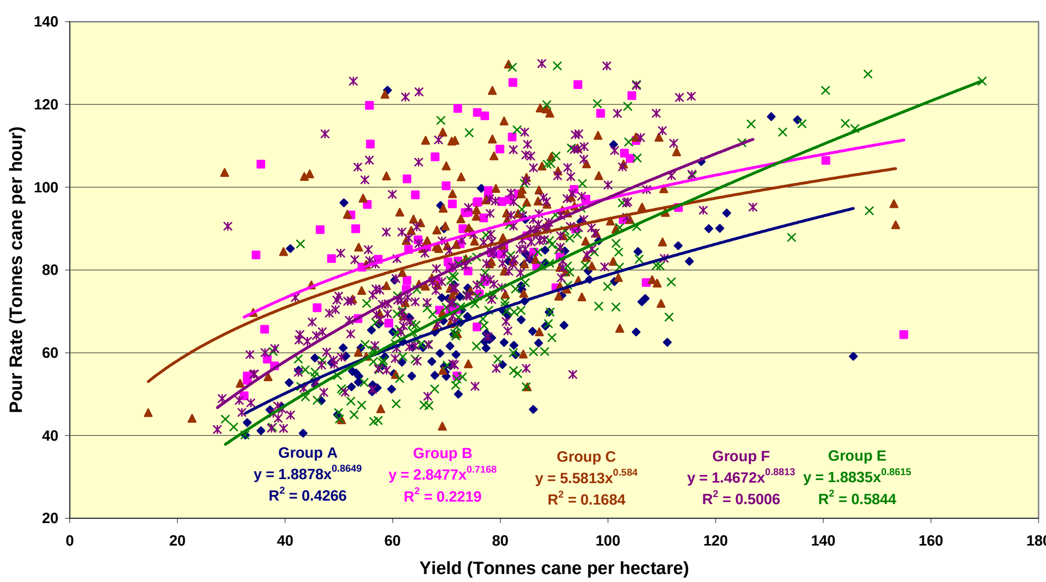
Graph 17 examined the relationship between yield and pour rate. Analysis of this dataset indicated that a weak relationship existed between yield and pour rate with less than 35% of the variation in pour rate being explained by variations in yield. The regression suggests that higher pour rates were achieved in higher yielding crops.

Graph 17 Yield and Pour Rate



When the data is analysed for individual groups a slightly different result was presented (Graph 18). In this case, some of the harvester groups showed much stronger relationships than others: for Group E nearly 60% of the variation in pour rate was attributed to variations in yield while for group C this only accounted for 17% of the variation. This result suggested that for the groups where the relationship was weaker factors other than yield were having a stronger influence on pour rates.

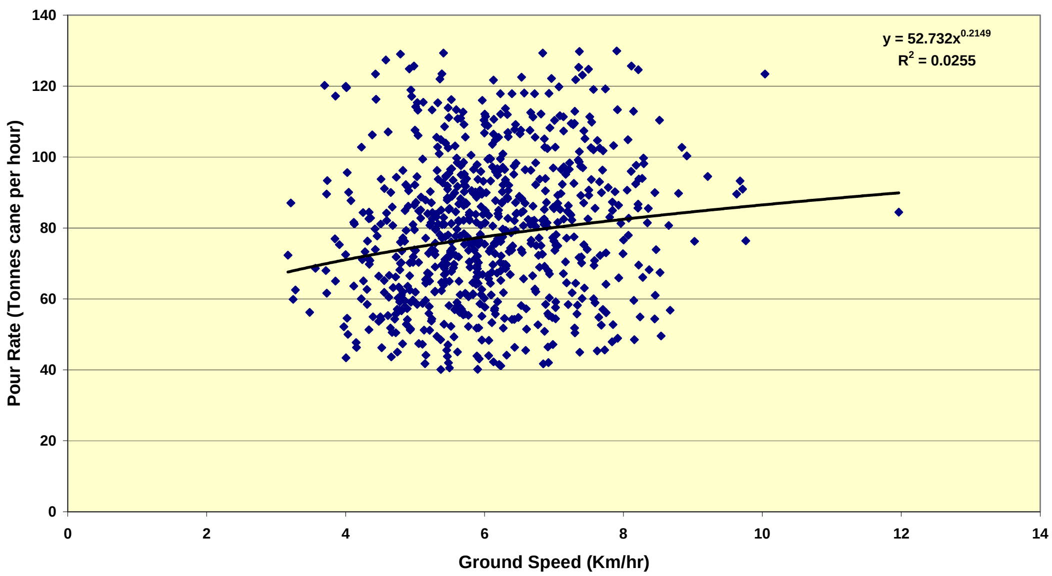
Graph 18 Yield and Pour Rate



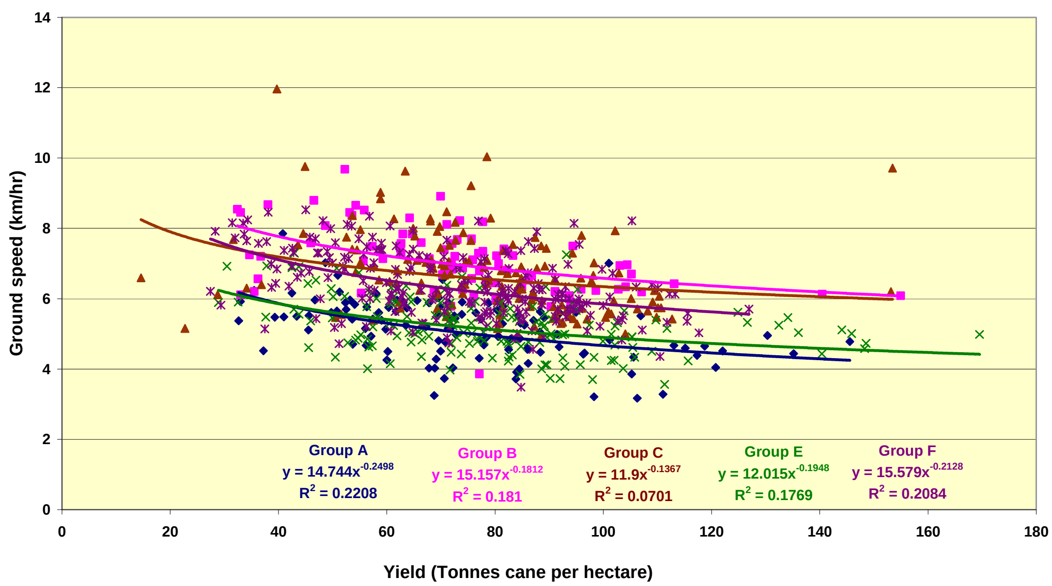
Ground speed was considered as another factor that would have a significant influence on pour rate. The relationship between ground speed and pour rate was analysed and results presented in Graph 19. In this case there was effectively no relationship with variations in average ground speed accounting for less than 3% of the variations in pour rate. The result was similar when groups were analysed individually.

The relationship between ground speed and yield was analysed with less than 13% of the variation in ground speed accounted for by variations in yield for the complete dataset. Individual harvesters did show some differences with the results presented in Graph 20. Group A showed the strongest relationship with 22% of the variation in ground speed accounted for by variations in yield. The trend was for higher yielding crops to be harvested slower than lower yielding crops. The weakest relationship was for group C with only 7%.

Graph 19 Pour Rate and Ground Speed



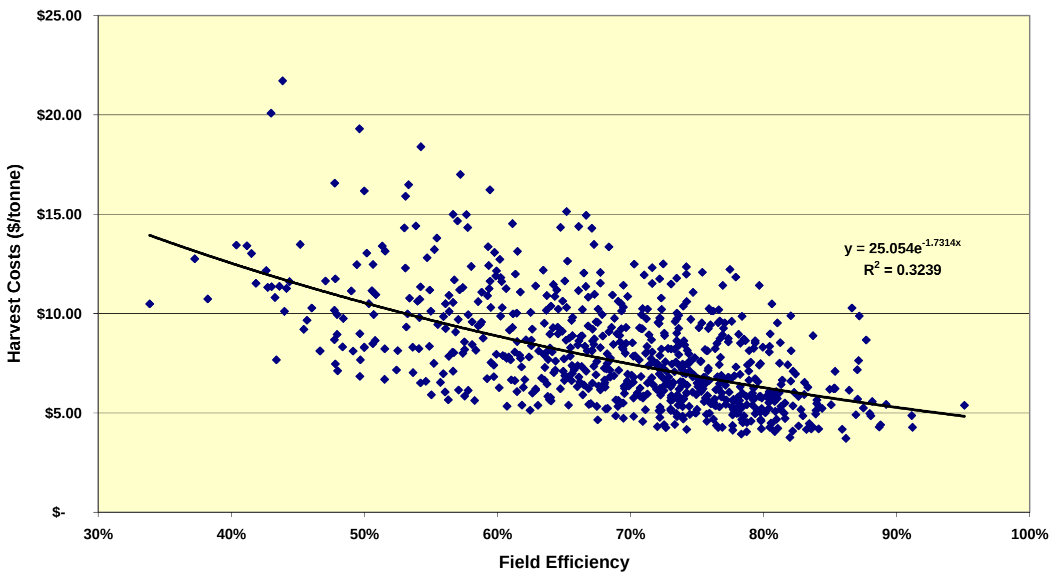
Graph 20 Ground Speed and Yield



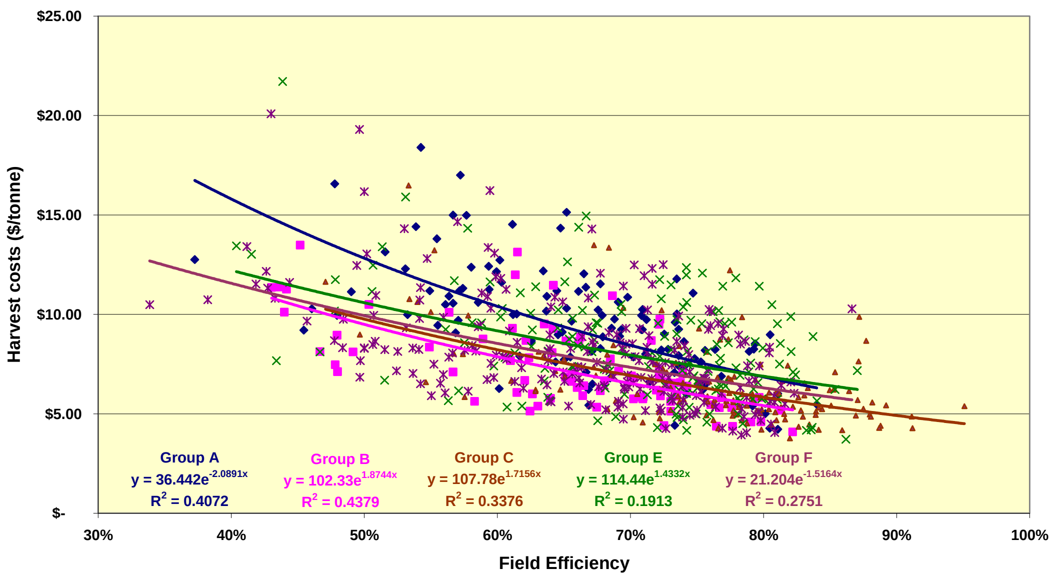
Field efficiency was used as the other primary performance indicator at the block level. The relationship between harvesting cost and field efficiency was analysed and the results are presented in Graph 21 for the complete dataset. This analysis showed that just over 32% of the variations in harvesting costs were accounted for by variations in field efficiency. This result suggested that improving the field efficiency would lead to a reduction in harvesting costs. The dataset also showed that no block that had a field efficiency of less that 68% had a harvesting cost of less than

$5.00. The dataset also showed that some blocks with field efficiencies of more than 70% were still costing up to $12.50 to harvest.

Graph 21 Harvesting Costs and Field Efficiency



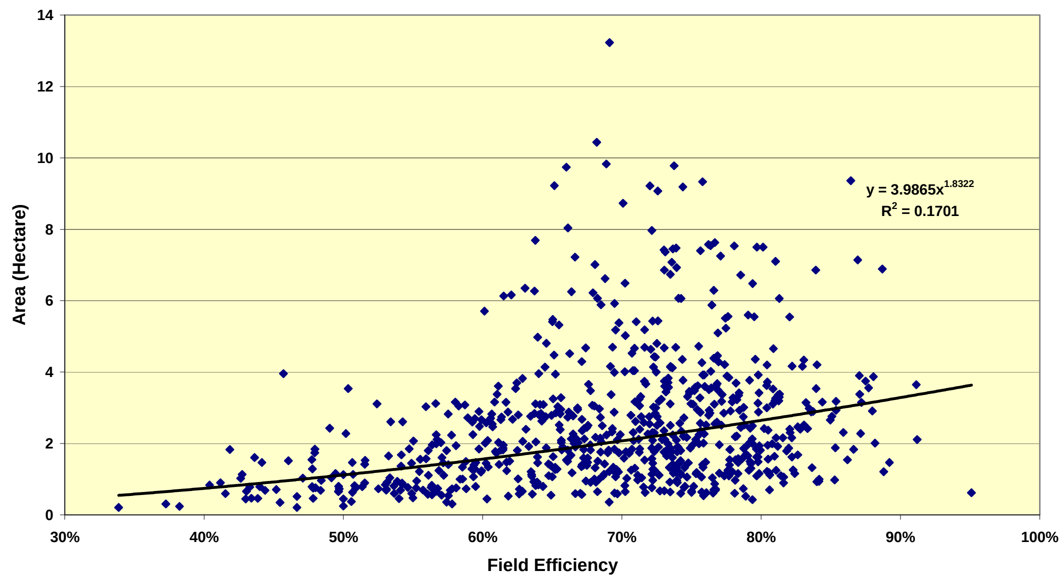
Graph 22 Harvesting Costs and Field Efficiency



Individual group data was analysed and the results are presented in Graph 22. This shows that there was considerable variation between groups with variations in field efficiency accounting for nearly 44% of the variation in harvest cost for group B while group E was at the other end of the spectrum at less than 20%.

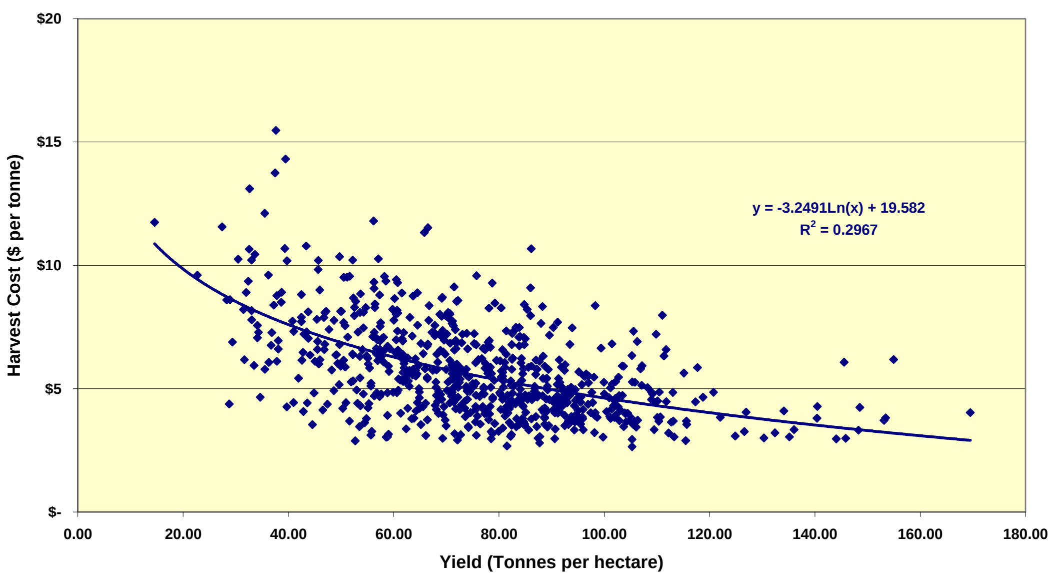
The relationship between block size and field efficiency was analysed. The results are presented in Graph 23 with only a weak relationship established. The factors considered most likely to influence field efficiency were discussed in MR3. Factors such as headland width and condition and row length will strongly influence field efficiency and block area is a poor indicator of these factors.

Graph 23 Area and Field Efficiency



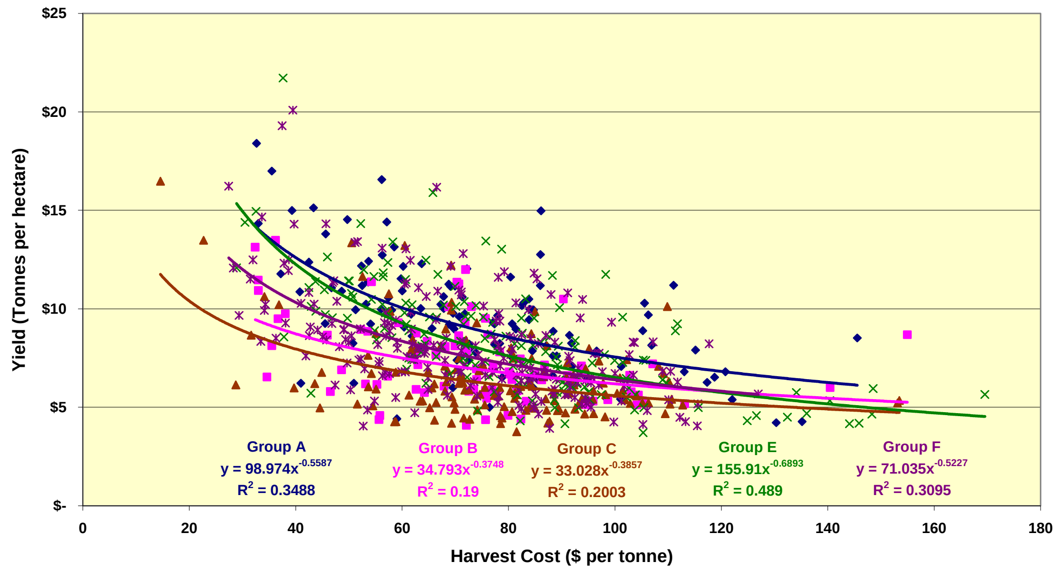
The relationship between harvesting cost and yield for the total dataset is shown in Graph 24. This analysis established that less than 30% of the variation in harvesting costs were accounted for by variations in yield.

Graph 24 Harvesting Costs and Yield



The data for individual harvesters was examined and is presented in Graph 25. In this case individual harvesters varied considerably with less than 20% of the variation in harvesting costs being accounted for by variations in yield for group B and nearly 50% in the case of group E.

Graph 25 Harvesting Cost and Yield



Relationships between cane quality and harvester performance parameters were also considered in the analysis of data from this project. The possible relationships considered were between base cutter pressure and both Ash levels and CQI and between extractor fan speed and both Fibre levels and CQI.

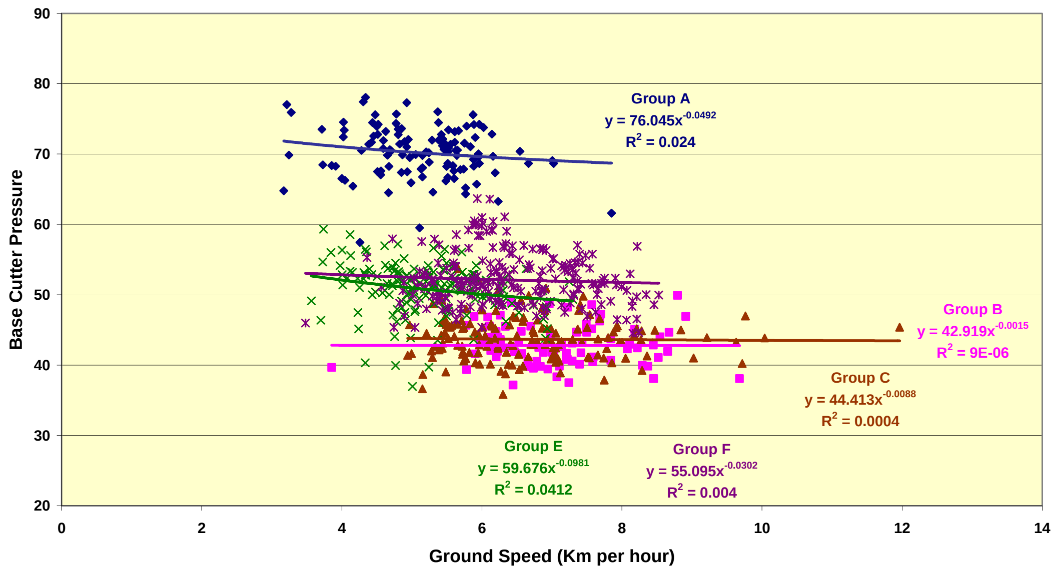
The two different makes of harvesters had different operating characteristics for base cutter pressure. The Cameco operated at a higher pressure than the Austoft machines. The dataset was split on make of harvester and the data analysed separately on base cutter pressure. No meaningful relationships were found with either Ash or CQI for either brand of machine.

The issue of missing data has been discussed in detail in previous reports. Only one harvest group had enough extractor fan speed data for analysis and this did not show any relationship between the measured variables.

As the final part of this stage of the analysis of the data base cutter pressure was analysed against ground speed. Again there was no meaningful relationship established with variations in ground speed accounting for less than 4% of the variation in base cutter pressure for any individual group. This analysis is presented in Graph 26.

Individual harvesters presented discrete clusters of data because of different mechanical characteristics of the machine. This was considered due to differences in models of harvesters (year of manufacture and ground drives), hydraulic performance characteristics and wear. Analysis as a total dataset was not possible.

Graph 26 Base Cutter Pressure and Ground Speed



The analysis of the numerical data indicated that there were relationships between characteristics but these were not simple relationships that could be easily interpreted. Harvesting costs were strongly influenced by pour rate. However the factors that affected pour rate were dependant on both block and harvester operating characteristics. Changes to farm practices and harvester operating characteristics could only occur if the relationships at the block level were better understood. To assist with this process a spatial analysis of the data was undertaken.

In summary, apart from the relatively strong relationship that existed between harvesting costs and pour rates, all other relationships examined showed a degree of variation between groups. Hence a clear picture of cause and effect relationships was not established for the total monitored group in this analysis. Different groups appeared to show different relationships emerging.

This data analysis gave only general indicators of cause and affect relationships with respect to harvesting costs. It appears that a relationship did exist between:

* Pour rate and harvesting costs; the higher the pour rate the lower the harvesting cost.
* Yield and harvesting costs for some groups; the higher the yield the lower the harvesting costs particularly for Groups E and F.
* Field efficiency and harvesting costs for some groups; the higher the field efficiency the lower the harvesting cost particularly for groups A and B.
* Pour rate and yield for some groups; the higher the yield the higher the pour rate particularly for groups A, E and F.

The data analysis was not able to establish any relationships between measured harvester parameters and CQI. Of particular concern was the paucity of available data on extractor fan speed and engine RPM. The base cutter pressure data was extremely useful in establishing machine operating condition but the analysis failed to establish any significant relationship between base cutter pressure and CQI or any of its component factors (ash, ccs or fibre).

The Harvesting Best Practice Manual has set some guidelines for machine operations to maximise the recovery of sugar from cane fields. The median value for extractor fan speed for group B was 1021 RPM which compares well with the harvest best practice recommendations of 1000 RPM.

The pour rate calculated in this project is the same as the Elevator Pour Rate used in the best practice manual. General recommendations in the manual are for “low” pour rates with qualifiers based on yield and ground speed. The Median values for pour rates from the harvesters monitored in this project (Table 2) are all within the suggested range within the manual.

This data analysis gave some understanding of the overall relationships that existed. Further analysis was undertaken to get a better understanding at the block and farm level on how improvements could be effected for individual groups.

Spatial Analysis

The dataset was further analysed at the farm and block level using the ArcGIS suite of programs. The blocks were analysed for field efficiency, yield, pour rates and harvest costs. The information was presented as overlaying layers with different colours and patterns to represent the data elements in each of the layers. Some samples of these maps have been reproduced in this report. Sets of two maps have been included in this report to illustrate the data interpretation. A single map is too complex to visually interpret at this report level.

Diagram 1 shows the layers for field efficiency, yield and pour rates for a section of the harvested cane blocks for Group C. In each case the blocks where there was no data collected are defined. The area highlighted as ‘1’ shows a number of blocks where the field efficiency is greater than 80%, the yields are in the range of 70 to 89 tonnes per hectare and the pour rates in the range of 70 to 89 tonnes per hour.

Diagram 2 shows similar data except that harvest cost is displayed as the base layer. For clarity this layer had not been turned on in Diagram 1. The area highlighted as ‘1’ in this diagram now shows that the harvesting of this section is less than $5.00 per tonne. This data was interpreted as meaning that the area in question had high field efficiency, mid-range values for yield and pour rate and subsequently low harvest cost. Blocks in this area have been laid out for maximum row length and would be considered ‘easy’ cutting.

Diagram 1 Spatial analysis of Group C – Block level data.

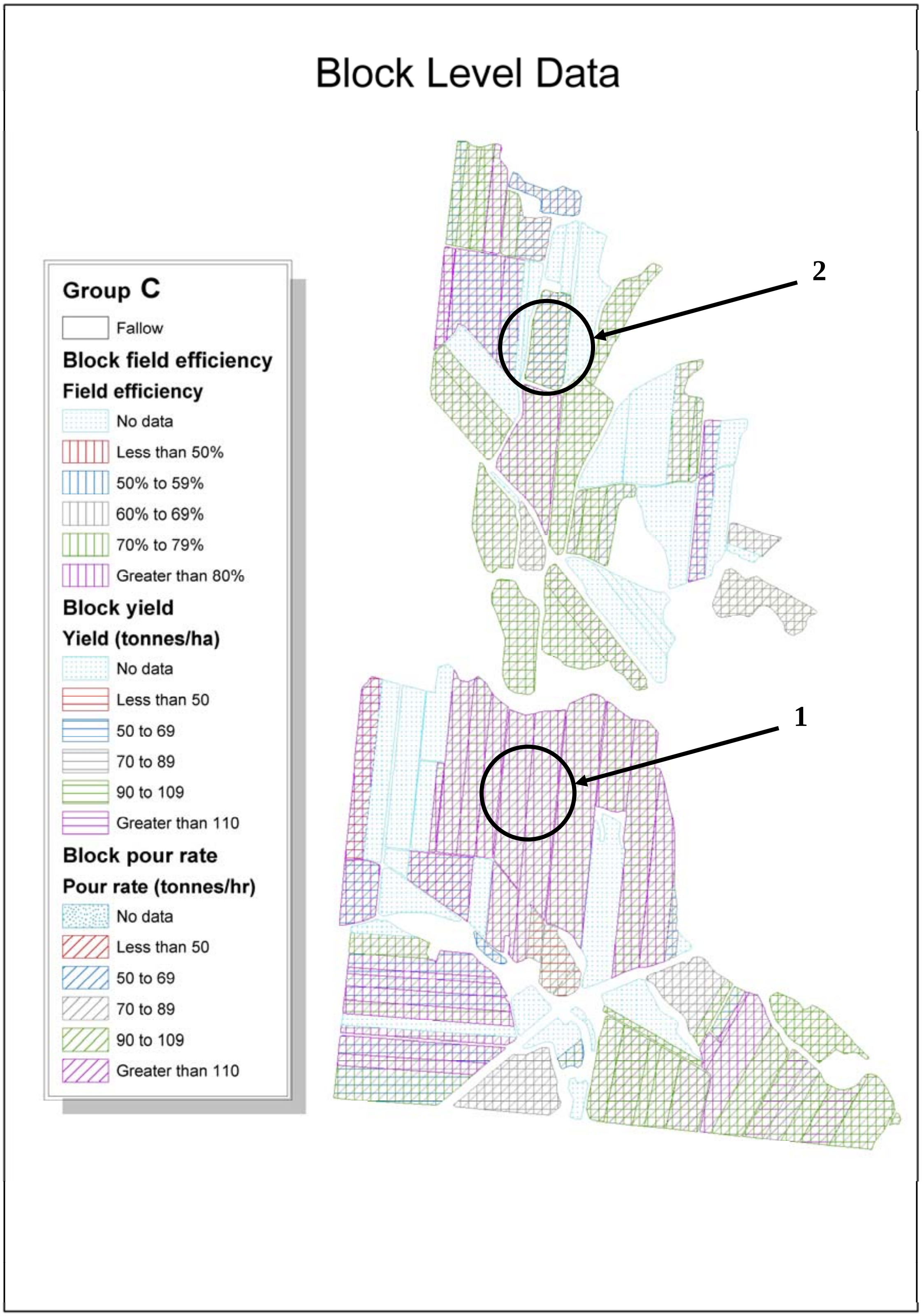


Diagram 2 Spatial analysis of Group C – Block level data including harvest costs.

The area highlighted as ‘2’ in Diagrams 1 and 2 show a block where the field efficiency is reasonable (70% to 79%) the yield is relatively low (50 to 69 tonnes per hectare) and the pour rate is low (less than 50%). Subsequently harvest costs are high (greater than $9.50/tonne). In this example the second block appears to have had a lower pour rate and high harvesting cost because of low yield and factors that contributed to this would need to be addressed to reduce the harvest cost. Other blocks in the group area could be similarly analysed. Group C had the lowest harvest costs in the monitored group.

Diagrams 3 and 4 show a section of the spatial data for Group E. The area ‘3’ highlighted refers to two adjacent blocks. The block on the right hand side had a field efficiency of greater than 80%, a yield of greater than 110 tonnes per hectare and a pour rate of greater than 110 tonnes per hour. Calculated harvesting costs were less than $5 per tonne. The block on the left hand side had a slightly lower field efficiency (70% to 79%) significantly lower yield (50 to 69 tonnes per hectare) and pour rate (less than 50 tonnes per hour) and a significantly higher cost (greater than $9.50 per tonne). The second block had a higher proportion of shorter rows and this may have contributed to the lower field efficiency. The main factor that contributed to the higher cost appears to have been the lower yield contributing to the lower pour rate.

The block on the right hand side of the area highlighted as ‘4’ had a high field efficiency (greater than 80%), yield in the range of 90 to 109 tonnes per hectare, pour rate of greater than 110 tonnes per hour and a calculated harvesting cost of less than $5 per tonne. The left hand block had similar field efficiencies and yield but significantly lower pour rates (50 to 69 tonnes per hour) and higher calculated harvest costs (greater than $9.50 per tonne).

The raw data showed that the average ground speed for the left hand block was 0.5 km per hour slower than for the right hand block. The implication of this is that increasing the average ground speed could have improved (reduced) the harvesting costs, and isolating and addressing the issues that resulted in this lower ground speed could improve the cost outcome. The value of this spatial analysis is in undertaking the more detailed analysis in an attempt to establish cause and affect relationships regarding harvesting costs.

Group E had the lowest median value for ground speed and is at the lower end of the operating rate and the higher end of the harvesting cost spectrum. The implication of the whole analysis of the data is that addressing the issues that are resulting in this lower ground speed should be a priority for this group in an attempt to reduce the real cost of harvesting.

In the first example the differences in harvest costs appeared to be due to differences in yield while in the second case the differences appeared to be due to differences in pour rate. The differences in pour rate were most likely attributed to differences in ground speed.

Diagram 3 Spatial analysis of Group E – Block level data.

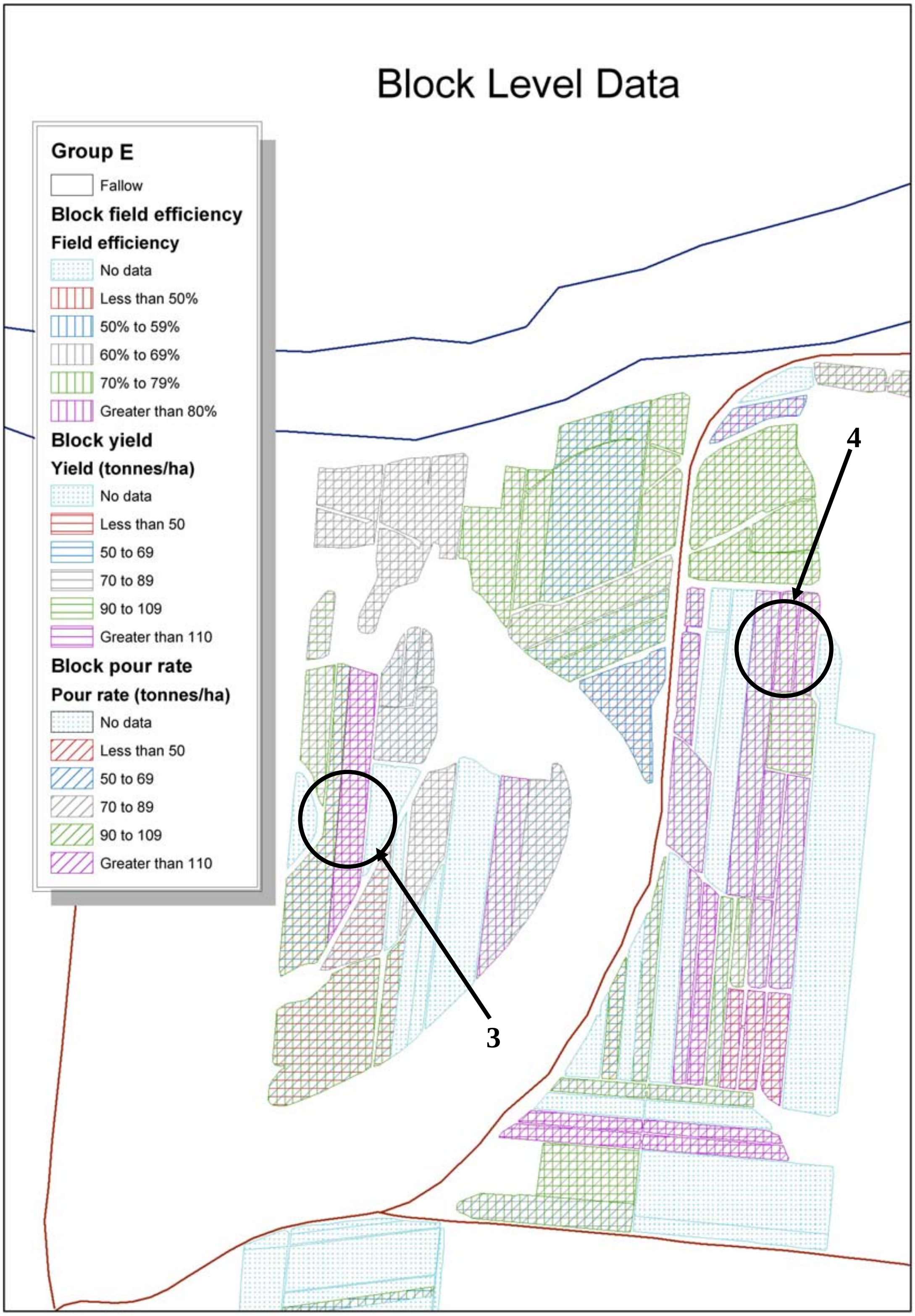
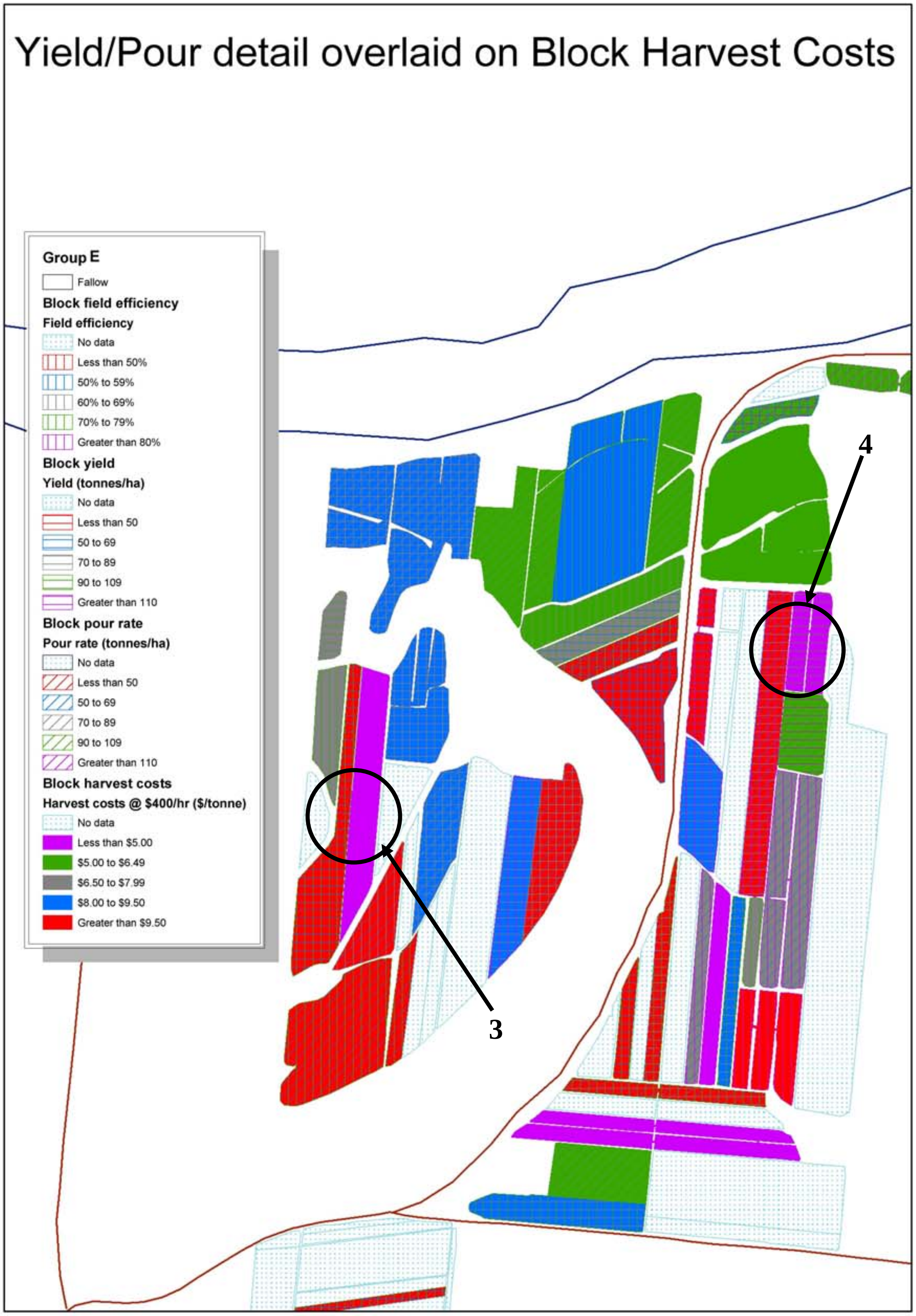


Diagram 4 Spatial analysis of Group E – Block level data including harvest costs.



This illustrates the difficulty with the analysis of this data. The regression analysis showed a reasonably strong relationship between harvest cost and pour rate but it did not adequately qualify the other factors that directly impact on either pour rates or harvest costs. This then made it difficult when presenting the data to the harvest contractor to indicate how they could improve the harvesting costs.

The spatial analysis allows the multiple factors to be looked at together so that more specific cause and effect relationships can be developed at a block level or even a farm level. The current harvest payment system is based on a fixed price per tonne for all cane cut in a harvest group. This system gives no price signals that will induce growers to change their practices to reduce their real harvesting costs. Alternative pricing mechanisms are discussed in Criteria 3 and 4. This project and the data analysis has provided some definitive local information to support the case for a change to the harvest payment system. The next section deals with targets or benchmarks of performance to measure change.