INTEGRATING AND OPTIMISING FARM-TO-MILL DECISIONS TO MAXIMISE INDUSTRY PROFITABILITY

FINAL REPORT

SUGAR RESEARCH AND DEVELOPMENT CORPORATION PROJECT REFERENCE CSE005

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1 Executive Summary:

Late in the 1990's, the Australian sugar industry recognised the need to achieve increased integration across its value chain, so as to reduce costs and increase international competitiveness. Past projects and independent assessments highlighted the harvesting and transport interface as being a high priority due to its current logistical inefficiencies and large potential economic benefits from removing these. The logistical inefficiencies were partly manifested by the social and ownership differences between these sectors. CSE005 aimed to explore and implement multiple opportunities to achieve economic benefits at the harvesting and transport interface of the value chain, using a combined participatory action research and technical modelling approach.

The project used case studies, initially being the Mourilyan, Mossman and Plane Creek regions. Each case study had a local industry working group, to drive the process of building models, validation, and developing pathways to adoption. Mourilyan was the basis for the model development due to the broad range of opportunities that the region was to explore and due to its technical capacity to work closely with the research team. This research team was multi-disciplinary across CSIRO, BSES and Harvesting Solutions due to the broad range of modelling expertise required in harvesting and transport.

One of the first steps with the Mourilyan case study was to conceptualise the value chain in harvesting and transport, which defined the key linkages and drivers across these sectors. This was the basis for formulating a modelling framework which defined the interactions between the industry component models, some of which already existed within the industry. A modelling framework approach was better than building a super-model since it was more transparent to the local industry working groups, more robust and had greater industry ownership. Throughout the life of the Mourilyan case study, the modelling work underwent many revisions (over a one-year timeframe) through the participatory action research process. During this process, the case study regions developed and refined options (or scenarios) for the models. This provided the case study working group with a growing understanding of best-bet options for the local region and the benefits across the participants of the chain.

Opportunities identified across the case study regions collectively fell into the themes of: increased time window of harvest through staggering the start times of harvesters; harvest best practice; improved seasonal logistics; transition to larger harvesting groups; and rationalisation/upgrading of transport infrastructure. Their collective potential benefits from these options was in excess of \$2.00/tc for some case studies. The increased time window of harvest option was adopted immediately in the Mourilyan and Mossman regions due to minimal change management and no capital investment requirements, and continued to be implemented throughout the life and beyond CSE005. Harvest best practice started to be piloted in Mourilyan as a result of CSE005, though its adoption was often hampered by pressure to fill bins and disruptions. Whilst the Mourilyan and Mossman regions agreed the time window of harvest options were beneficial, an evaluation based on factual data was impossible due major changes in the base line evaluation (e.g. changed number of harvesting groups, tonnes crushed at each mill) from 2002 to 2005.

About mid-way through CSE005, the Mourilyan and Plane Creek case studies ended pre-maturely due to reasons beyond the control of the project team. Whilst this was a disappointment for the project team and for many of the participants in the local industry working groups, the Herbert quickly became a replacement case study. Progress was rapid in the Herbert due to the knowledge base already developed with the other case studies. Through producing several options, the Herbert region agreed to pursuing extended time window of harvest, harvester/siding rosters, partnering of harvesting groups, and rationalisation/upgrading the transport network. To implement the latter option, the Herbert working group produced and submitted a proposal (based on the CSE005 analysis) to the federal government for financial assistance to remove 100 sidings and build 72 "state of the art" new sidings. This proposal was successful and the region has already started to spend the \$7.2M on the siding upgrades. A role of CSE005 was to estimate benefits at the block, group and siding level from each rationalisation/upgrade, and to conduct sensitivity analysis for suitable positions for each siding, leading to decisions on exact location for construction. This work and the partnering of harvesters will continue in a follow-up SRDC project in the Herbert. Benefits to harvesting are estimated at \$0.27/tc/yr with benefits to milling in terms of reduced locomotives, shifts and better use of bin fleet. The Herbert and Mossman are preparing for implementation of extended time window of harvest and optimised siding rosters in 2006, which will continue beyond the life of CSE005.

Overall, the project has broken new ground in research and development of complex issues across the harvesting and transport system. It has been well supported by the local industry case studies and has achieved adoption within the life of CSE005. More importantly, further adoption is very likely to occur in the case study regions post CSE005. Other regions, including Sth Johnstone, Babinda, Mulgrave, Maryborough and NSW Sugar have expressed strong interest in adopting the tools of CSE005, and new SRDC projects have been established during the life of CSE005 to achieve adoption in some of these regions.

2 Background

Increased international competitiveness and a rapidly changing Australian sugar industry (through de-regulation, increasing cost-price pressures, expansion and new technology) has rendered the current value chain systems across the growing, harvesting and transport sectors as inefficient or unsustainable. The Independent Assessment of the Australian Sugar Industry, produced by Mr Clive Hildebrand in 2002, emphasised that the harvesting and transport system was a high priority for quantum efficiency gains. The report also noted that it is a difficult task due to social and ownership differences between these sectors.

Prior to CSE005, methodologies for integrating and optimising the farm-to-mill system (particularly the harvesting and transport interface) were very limited in Australia (and other sugar industries as well), despite the opportunities being identified. Research activities prior to CSE005 have addressed components of this farm-to-mill system to increase profitability or reduce costs:

1. CSIRO and CRC Sugar from 1996 to 2002 have examined options for increasing net revenue through optimising the harvest date of individual farm paddocks, exploiting the geographical and crop differences that occur in sugar yield at harvest date. The project showed that average gains in profitability of up to $1.50/tc were possible in the different case study regions of Mackay, Mossman, Maryborough. Tools were also developed to optimise harvester and siding rosters to reduce harvesting and transport costs through a more effective day-to-day utilisation of infrastructure.
2. The BSES have examined options for harvester pour rate, fan speed and billet length for decreased costs of production, cane/sugar losses and impacts on ratoons. Trials in Mackay, Tully and Bundaberg have shown potential gains in industry profitability of $100/ha. BSES had also developed the Harvest Transport Excel spreadsheet model, designed to measure the costs of harvesting individual farm paddocks for a given set of inputs.
3. Sugar North and SRI have developed models to optimise transport schedules at a seasonal and operational level. The number of harvesters, locos, bins and loco shifts were optimised at seasonal level. Savings of up to $2.75/tc were shown to be possible by the combined seasonal and operational models.

These individual research activities (and others) only focused on some specific issues in the farm-to-mill system, and technologies were not developed to consider all drivers across the farm-to-mill system to improve practices. Therefore, on their own they could not consider opportunities for an optimal integrated system that is economically efficient for the future of the Australian sugar industry. Australia's market competitors such as Brazil already have in place a cost effective farm-to-mill system with longer harvest hours, efficient harvest systems (e.g. pour rate), longer season lengths, optimised sugar cane supplies exploiting geographical differences in sugar yield at harvest date and better field design, and typically a single regional profit centre, just to name a few. While the Australian sugar industry value chain is more complex because of multiple ownerships (individual farm and harvester ownerships), the tools and capacity were not available prior to CSE005 to conduct options and sensitivity analysis leading to the adoption of a farm-to-mill system that is optimal when considering the key economic drivers. CSE005 aimed to progress beyond the individual activities listed above to deliver the tools and capacity to identify and exploit opportunities for an integrated and optimal farm-to-mill system minimising costs of production, and consequently increasing industry profitability.

3 Objectives:

The objects stated in the original proposal were:

- Industry/ community issue and its relevance. The Australian sugar industry needs to improve its efficiency to compete in world markets as a supplier of raw sugar, in the face of declining terms of trade. While incremental increases in productivity and technology are likely to continue, significant increases in profitability are possible by implementing changes in harvesting and cane transport. Potential gains of over $100/ha are possible from geographical harvesting to optimise CCS and cane yield within mill areas (CSIRO/CRC), a further $100/ha from reducing cane loss and sugar losses by operating harvesters according to best practice guidelines (BSES), and another $150/ha by optimising transport schedules and the number of harvesters (Sugar North). While these gains may not be additive, harvesting and transport optimisation can significantly increase profitability for the Australian sugar industry.
- How project addresses this issue. The project aims to integrate the components identified above and explore the potential efficiency and profitability gains in a whole-of-system optimisation approach. A biophysical/ economic model of the farm-to-mill system will be constructed from past research, and used in participatory research to explore the economic and social impacts of implementing alternative harvesting and cane transport arrangements in case-study mill areas.
- Likely longer term benefits from this project. All growers should gain financial benefit through harvest and harvester optimisation, by increases in relative CCS, higher cane yields, and reduced cane and sugar losses. Millers and the industry in general will gain by increased sugar production from harvesting to optimise CCS and cane tonnage across mill districts, and by reductions in cane transport costs. Restructuring of harvester payment arrangements may be required to ensure that harvester operators benefit from whole-of-industry gains. There will be environmental benefits from reduced losses of sugar during harvest.
- The project aims to provide the capacity to integrate and optimise the management of the growing, harvesting and cane transport sectors in mill regions across the Australian sugar industry, to decrease costs of sugar production and increase industry profitability.

The last dot point accurately captures the big picture objective in CSE005, which encapsulates the other objectives listed. This objective has been achieved from three key perspectives:

1) *Development of a modeling capability for whole-of-systems optimization across the harvesting and transport sectors.* The participating organizations, CSIRO Sustainable Ecosystems and BSES, entered into CSE005 with various tools/models aimed at reducing costs by addressing specific decisions in harvesting and transport (e.g. harvester speed, siding rosters). Further models were developed in CSE005 that improves other decision activities in harvesting and transport. What CSE005 contributed, that was unique for the industry, was a framework that allowed these individual models to be used collectively to address several big picture options in harvesting and transport. The framework (Figure 1 & 2) provided the capacity to comprehensively address these big picture options (e.g. siding rationalization, increased group size, logistics optimisation) without missing any important knock-on effects associated with simplistic "back-of-the-envelope" approaches. The modelling framework has not ended in CSE005 and has subsequently been (or will be) extended to other sugar regions in Australia.

2) *Implementation of a participatory action research process that provides the capacity for millers, harvesters and growers to collectively develop whole-of-system options for the harvesting and transport sector.* The project also focused on a social capacity for the various sectors of the industry to work together and use the technical modeling work to develop harvesting and transport options for implementation. This was demonstrated in two major case study regions, Mourilyan and the Herbert, though the project also had smaller case studies in Plane Creek and Mossman. In each of the case study regions, working groups comprising of growers, harvesters and millers were formed. Prior to CSE005, the sectors of these case study regions had not worked together collectively to capitalize on the value chain opportunities for the region, and instead used destructive methods aiming at sectoral profit maximization such as competitive bargaining. Their behavior reflected a mistaken belief of industry profitability being a zero-sum game: if one sector gains someone else must lose to the same extent. We believe the case study regions have progressed substantially as a result of the participatory action research in CSE005. This is demonstrated in Mourilyan by members of the original working group taking initiative to develop a new SRDC proposal to extend the options developed in CSE005 to Sth Johnstone and Babinda. In the Herbert it is demonstrated by the development of further value chain projects, and by formerly "cynical" growers/harvesters now taking more initiative for the best interests for the region as a whole.

3) *Adoption of the harvesting and transport options in practice, demonstrating an increase in industry profitability.* The original objectives listed above emphasized that optimizing across harvesting and transport will lead to decreases in costs and greater social benefits. This has been demonstrated through adoption during the life of CSE005. Adoption of options to improve efficiencies at the harvesting/transport interface has been achieved in Mossman, Mourilyan and the Herbert though the options are considerably different than envisaged at the start of CSE005. Industry participants in Mossman and Mourilyan have agreed the options (extended time window of harvest and delivery timetable) implemented have led to improved efficiencies and reduced delays in transport and harvesting, though an evaluation of actual dollar benefits in practice has been impossible.

4 Methodology:

CSE005 was a long project (4 years) with a considerable amount of evolution, learning and experiences throughout its life. We believe this message is best conveyed through presenting the methodology in a chronological order of major project stages. The soft and technical methodologies are separated in to different subsections, with each case study in its own sub-section. Through-out the life of CSE005, a huge amount of results were produced for each case study region. Key results will be shown in this section, with the remainder being contained in the appendices.

4.1 Project Team Building

Since there was minimal familiarity between the researchers from CSIRO and BSES before the project, a facilitated team building workshop was held prior to the start of the project. Within the project workshop, we agreed on how we will operate as a team and defined our individual roles, given that there more than one research organisation involved in the project. During the workshop, we collectively developed criteria for inclusion of a case study in the project, and then used these criteria to identify the following potential case studies: Mossman, Maryborough, Plane Creek, Proserpine, the Herbert, and NSW sugar regions. An action from the workshop was for project members to make contact with these regions and organise a workshop if the region showed interest. The project team agreed that two mill regions would be the ideal number of serious case studies and that it would be too difficult to accommodate any more than three.

4.2 Formation of Case Studies

The first case study to be established was Mourilyan, which already had an established local industry working group through the “Enhanced Cane Supply: Harvesting and Transport” initiative. This was a tough case study to start with due to the long history of distrust between the millers, harvesters and growers. This distrust and friction was evident at the initial workshops, which comprised of about 30 participants. Through the early workshops, the Mourilyan working group was very keen to be a part of CSE005 and for the project team to produce various scenario analyses addressing the key harvesting and transport issues highlighted by working group. Since Mourilyan was the first case study for the project team and given their enthusiasm, it would be the basis for the development of the modelling tools (Section 4.3) for integrated harvesting and transport. The Mourilyan working group would actively participate in the development of the modelling framework for harvesting-transport along with building and validating the sub-models. Because Mourilyan was the first case study, there would be a long iterative process in the development of options for the region to implement in the short and long term.

In the second half of 2002, members from the Plane Creek Regional Industry Board expressed interested in using CSE005 to address opportunities that they had identified in harvesting-transport. A workshop was held with CANEGROWERS, CSR Plane Creek and their Regional Industry Board on August 2002, to explore how the project could add address several issues in the region, including integration of harvesting and transport, season length and best practice. Unlike the Mourilyan case study, Plane Creek were further advanced on a vision of where they would like their region to be in 3 years (three harvesting co-operatives operating 24 hours per day). Early in the case study, four focus groups were formed: Logistics, Best practice, Business Structures and Farm Design. The research team spent time with these newly formed focus groups to develop a plan to move forward to address the issues in Plane Creek.

Mossman Agricultural Services arranged a workshop in September 2002 for the local industry to highlight the issues on local importance and for the project team to explore how they could address these issues.

Mossman had a clear issue that needed to be addressed. At sugar prices and production levels of 2002, the mill was unprofitable and so must reduce its operating costs by $3M in 2003. The scenario put forward by Mossman (for the workshop) to achieve this goal was:

1. 24 hour harvesting
2. 5 day per week crushing with possible overtime crushing during peak CCS periods
3. Present road transport areas to deliver their payload direct to mill
4. Road transport payload(Bdouble) to increase by 6 tonne with lighter bin construction
5. 150,000 tonnes from Arriga area to be toll crushed by Tableland mill (The Maisel & Singh groups)
6. Four supply groups (1 road & 3 rail) to operate on the coast
7. One supply group to operate in the Julatten area
8. Two supply groups to operate in the remainder of the Mareeba area
9. The 3 coastal supply groups would each operate 2 harvesters

Whilst this scenario fit within the scope of the project, the Mossman industry agreed that the industry would not adopt all aspects of it for 2003 and there was a need for the project team to address some of the components of the scenario. As a result of the workshop, the local industry agreed that the most important issue to be addressed for implementation in 2003 was to reduce the number of loco shifts.

Given the resources within the project, Mossman, Mourilyan and Plane Creek were the case studies addressed by the project team in the early stages of CSE005.

4.3 Development of Models for Harvesting and Transport Integration

With the case studies established and a general understanding of the big picture harvesting-transport goals in these regions, the project team needed to develop the modelling capability. The direction we took in the modelling required some careful consideration. The following criteria had to be addressed:

- We needed an integrated set of tools that considered the knock-on effects (or drivers) across the harvesting-transport system. We needed to know the full range of benefits and costs.
- We needed a methodology that was adaptable to the options considered in each case study. We needed to avoid a methodology that could only be used in one case study.
- Short time frames and limited resources was a major issue. The case studies were keen for adoption in 2003/2004 and the project budget was very limited for this time frame. As a result, we had to tailor the methodology towards these limitations rather than develop the “Rolls Royce”.
- Each of the team members brought in skills and existing IP which the project needed to capitalise on effectively.
- We needed an industry champion, with a technical capability, to work closely with the research team in the early stages of the technological development. This champion was found in the Mourilyan case study, through Mr Ian Davies.

The Mourilyan case study was the basis for the modelling work. The first technical task was to conceptually model the harvesting-transport system to obtain an understanding of the key drivers and linkages. Prior to the start of this study, the Mourilyan steering group broke up the harvesting and transport system into 12 components, each of which is easily interpreted from an industry perspective. Through slight modifications and merging of some of these components, the research team was able to formulate seven components (summarised in Figure 1), each of which is tangible from a scientific perspective.

The harvesting and transport sectors of the sugar value chain contain a range of logistical, economic and social links that constitute the system. Trying to improve efficiencies requires accounting for these links. A modelling framework was required to 1) build and link best-practice and optimisation tools; 2) make the complex harvesting and transport system more tangible; 3) account for financial transfers and effective incentives across the system; 4) and explore opportunities for efficiency gains that were previously not thought possible. To construct the framework, the harvesting and transport system needed to be broken down into components that represent activities or major managerial decisions, which are more conducive to being modelled. Figure 1 illustrates the logistics of developing the modelling framework.

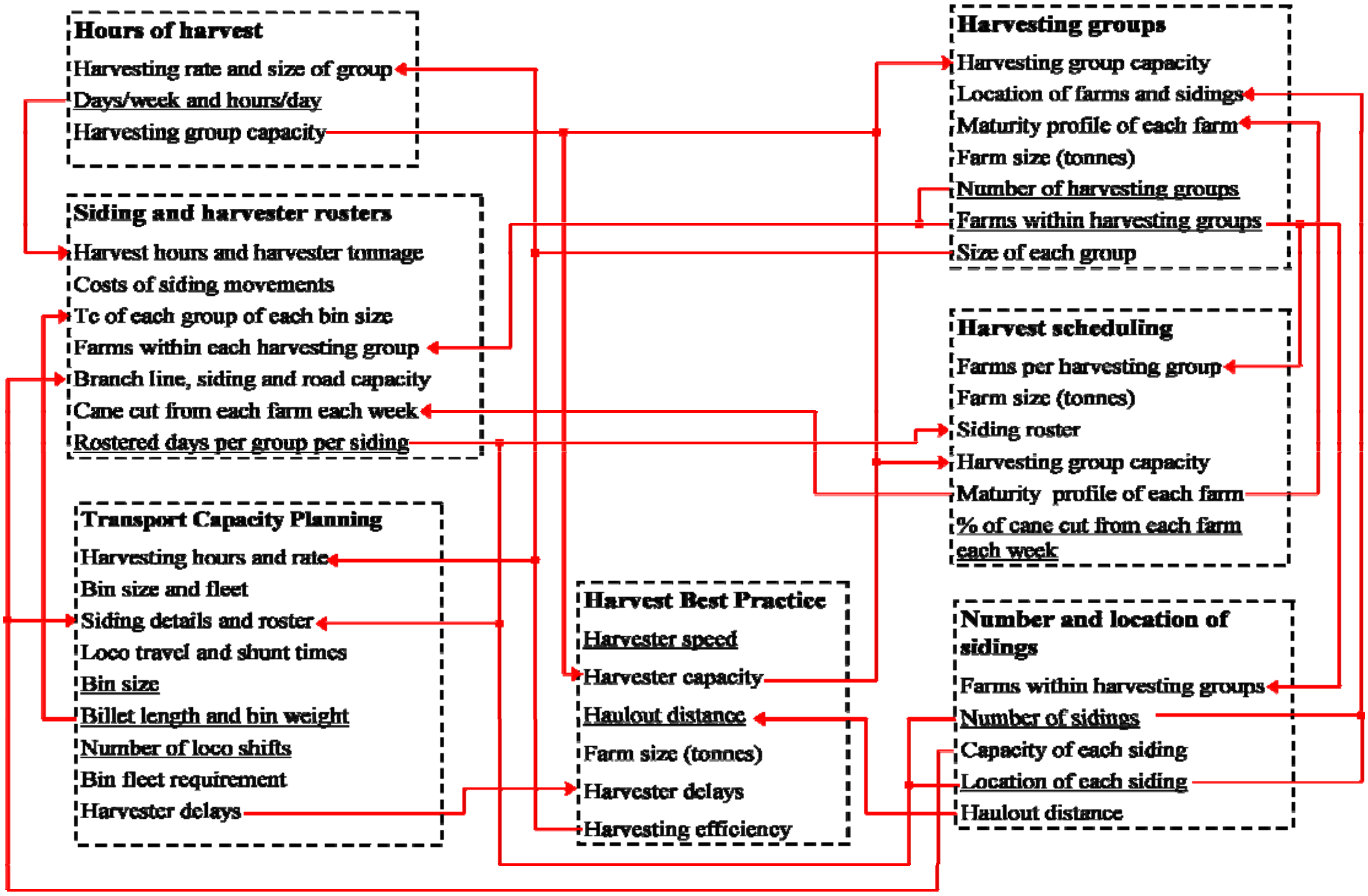


Figure 1. Modelling framework for the harvesting and transport system showing the key links. Key decision variables are underlined.

Figure 1 not only highlights the major components of the harvesting and transport system, but also shows the major inputs/outputs and the key linkages across them. These logistical relations also carry economic or social meanings. Key decision points in Figure 1 are underlined and represent some of the questions that the steering groups want answered when looking for increased efficiencies within the system. It is not practical to build a single 'supermodel' to describe and optimise the whole system in Figure 1. However, it is feasible to model the seven individual components and some have already been done. Once the linkages between system components are implemented as data links between the model components, application of the component models achieves a capability akin to a single model.

Through further development and simplification of the linkages in Figure 1, a modelling framework was developed in the context of the component models developed/used in CSE005. This modelling framework is contained in Figure 2.

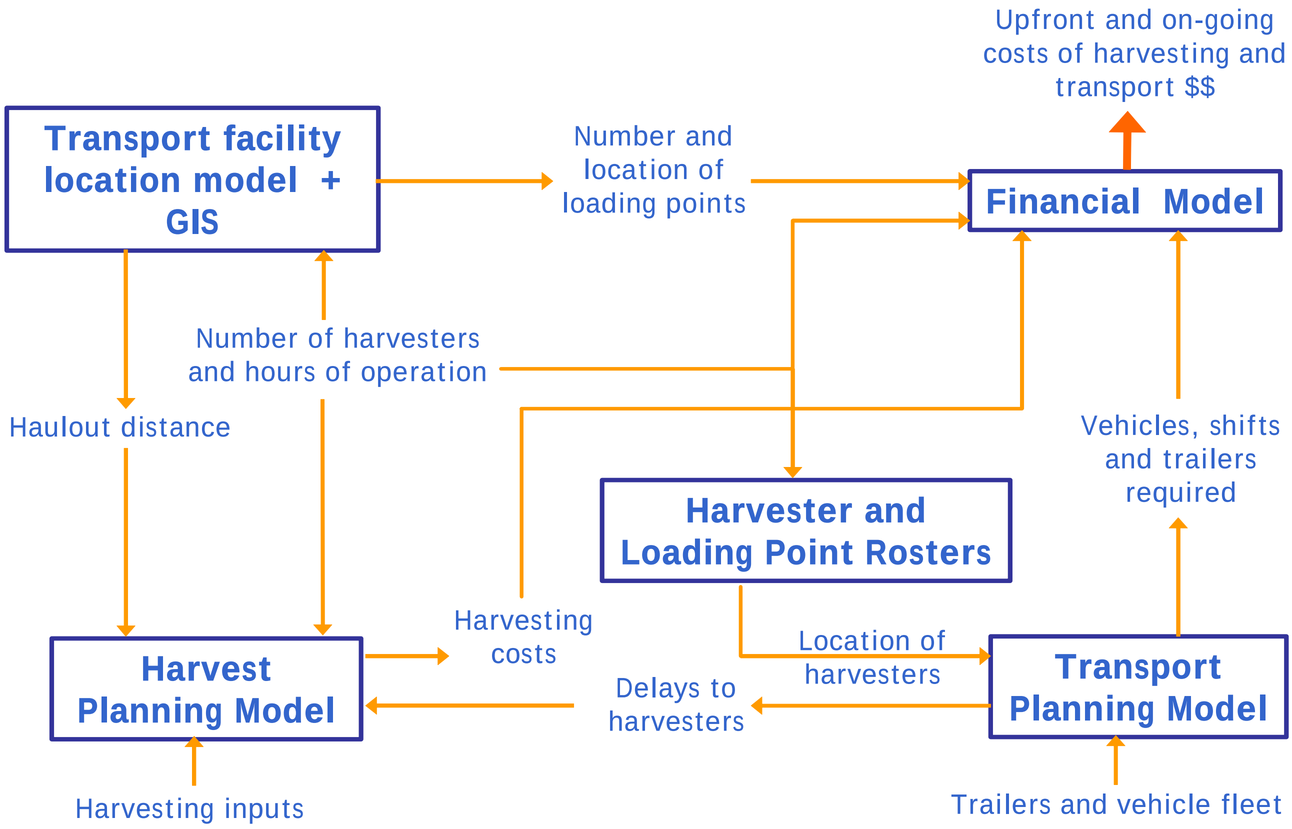


Figure 2. Modelling framework based on key models used/developed in CSE005

The modelling framework of Figure 2 formed the basis of how the harvesting and transport models would be applied to address the options formulated by the case study working groups. As one can see the models are not applied in a serial manner but as a network of linked models. This was one of the biggest scientific developments of CSE005, which was recognised through a journal paper, Higgins et al (2004). It was also validated and accepted by the local industry working group in Mourilyan. An overview of each of the models in Figure 2 is now provided.

4.3.1 Harvest Haul Model (Harvest Planning Model)

The Harvest Haul Model was developed to provide a capability for costing the region-wide performance of harvesting and hauling under a range of scenarios. It calculates the time performance and cost of harvesting each block (or paddock) of sugarcane in a milling region harvested by multiple harvesting groups. It can calculate a base-case scenario then compares alternative scenarios against this.

The model requires specific data about each block such as area, tonnes of cane, average row length, row width and haul-out distance to railway siding or road pick-up points. As gathering region-wide data is an enormous task, different strategies were used. Mill data were used to obtain delivered tonnage, CCS and area for each block. Surveys of harvesting groups were conducted to estimate the type and value of capital equipment used in the region and some assumptions were made from previous research for variables such as unload time for haul-outs and the time to turn at the end of rows.

GIS methods were used to estimate row length and haul-out distance for each block of cane in the region. Row length was assumed to be the length of the longest side of the block polygon. To estimate the haul distance for each block, the siding nearest to (or already assigned to) each farm block was selected. Distances from the centroid of individual blocks on the farm to this siding were then calculated as a straight-line distance and a multiplier of $2\sqrt{2}$ was applied to account for travelling around block boundaries. Manual checking and adjustment was used where a creek or other boundary divided the farm.

The Harvest Haul Model evolved from the BSES Harvest Transport Model, which was developed to cost harvesting a single paddock. This was upgraded to run multiple blocks and groups to calculate regional harvester performance. To derive the cost of harvesting, the Harvest Haul Model calculates the time performance of the harvest then applies costs on an hourly rate. To analyse scenarios, the model is run twice. The first run is the base case and outputs are copied to a 'standard' table. The second run models the scenario representing the changed harvesting practice and copies outputs to a 'scenario' table. A financial model then aggregates block-level results to a regional level and subtracts the base case results from the scenario results to derive the net regional benefit or cost of the scenario. The outputs, such as seasonal average delivery rate, for each group is sent to the Transport Capacity Planning Model. The model also returns the time each group will wait, on average, each day for mill deliveries. Further details of the Harvest Haul Model can be found in Sandell and Prestwidge (2004)

The Harvest Haul Model was initially developed, within the aims of CSE005, as a research tool. However, with the increasing demand for flexibility and new capabilities from contractors, millers and other users there was a need to develop a "front-end" of user-input screens to make the model practical for general use. A user-friendly Harvest Haul Model also would facilitate wider adoption of rationalization of harvesters because modelled results would be applicable to individual circumstances and, importantly, be available.

Since the initial development of the Harvest Haul Model at beginning of CSE005 and subsequently its use within other projects (CSE010, NSC006, BSS261 and others), several versions and adaptations have been developed to suit different scenarios and regions. It was adapted to handle all different scales of analysis, from blocks to farms to harvesting groups. These adaptations and enhancements have given rise to the possibility of it being developed into a flexible and adaptive research tool which could in turn be used by harvesting consultants and contractors. The model is now a more flexible and adaptive tool than the version developed at the start of this project. Several harvesting contractors and extension staff associated with the current project have suggested that the model would be a useful industry tool. Further feedback on requirements from potential users and further testing and development will still be needed to maximise its effectiveness in the industry. To facilitate its adoption by other researchers, extension staff, consultants, etc, a user manual was written, and is contained in Appendix A. The manual contains an overview of the model; an explanation of the data requirements and default values used; an explanation of the functions and processes used; a guide for running the model; an explanation of the types of outputs available; as well as an appendix on the input database structure. In the current version of the Harvest Haul Model, the main screen (Figure 3) shows four tabular pages for: data management; running the model; running batch scenarios; and, reporting the outputs. It is a database application with a front-end database containing all the modelling and processing functions along with back-end databases containing inputs for the different harvesting scenarios. An SRDC proposal was developed in May 2006 to request funding for further development of the model and to link it with CHOMP (Cane Harvesting On-line Monitoring Program).

Figure 3. The main screen of the Harvest Haul Model.

4.3.2 Transport Capacity Planning Model

Modelling transport is a complex discipline with a huge range of methodological approaches available, and whole journals dedicated to it. In choosing a methodology, it was important that:

1) key industry issues in the transport system could be represented without causing excessive complexity;
2) any model developed was still easily integrable with the other components of the modelling framework to reduce demand for computational resources;
3) it had the capability to be adapted to a wide range of scenarios;
4) data required by the model were from existing records and simple enough for mill staff to collate, avoiding the need for time-consuming surveys; and
5) it could be produced within the short time frame of less than one year.

In light of industry requirements, we dismissed scheduling methodologies in favour of tools that measure capacity requirements for a given demand. Despite the Australian sugar industry being totally unfamiliar with capacity planning models at the start of the project, these types of models are commonly used for railroad applications and road applications in developed countries.

The approach we took was to develop a capacity-planning model based on simulation, analytical equations and queuing. A summarised description of the model is as follows:

1) Given the inputs- harvester start times; harvester delivery rates (tonnes of cane per hour); harvester finish times; siding capacity; and maximum train capacity - we can determine the exact times each day that each harvesting group will require empty cane bins at the sidings, along with the number of bins.
2) Given the deliver times of bins thus calculated, we can determine the required locomotive numbers and the time-frame to deliver the bins to the sidings and pick up full bins from the sidings to deliver to the mill.

3) When the locomotives arrive at the mill with full bins, we calculate the waiting time (queue at the mill) for the cane in the bins to be processed. The mill has a limited crushing rate and cannot process the cane straight away if large amounts of cane arrive at the mill within a small time frame.
4) Given the number of bins at the sidings, in transportation, and waiting at the mill to be crushed, we can calculate the number of bins required. A longer waiting time requires more bins and more storage space in the marshalling yard.
5) When an upper limit is introduced on the number of bins and locomotives available, delays occur in 1, 2 and 3 above which can be measured. This imposes delays to the harvester contractor who is forced to wait for empty bins.

The model provides the flexibility to assess the amount of capacity required or the delays imposed upon the system by limited capacity. The model was written in Lahey Fortran 95 and produces a solution requiring less than one second of CPU use on any modern PC. The model was developed closely with Ian Davies (Bundaberg Sugar) whom provided considerable intellectual input on how the model is structured and works. In fact, Ian originally developed a model that measures bin fleet utilisation and queue time at the mill. This original model developed by Ian was used in the Transport Capacity Planning model. The model was later adapted to the Mossman and Plane Creek regions with close interactions with their local skills. The development of the model required several iterations with Ian Davies between September 2002 to March 2003 to arrive at a version that accurately captured the existing Mourilyan rail transport system. Once the Mourilyan region gained confidence with the model, they also gained confidence with its capability to be applied to the alternative scenarios. Application to Plane Creek and Mossman is not 'plug and play' due to the vast differences in infrastructure and operational arrangements. One issue that needed to be considered was the difference between harvesting dominating the transport (Mourilyan) and when the transport dominates the harvesting (Plane Creek).

An additional transport model was developed for the case of road transport. A road transport scheduling model was developed with the Maryborough region, though Maryborough was not a case study in CSE005. The model was a joint development between CSE005 and CSE010. Further details about the model are contained in Appendix B.

4.3.3 Siding Location Optimisation Model (Transport Facility Location Model)

The development of a model to assess the impacts of or position sidings/pads at better locations than currently present, was motivated by the long term goal of the industry to improve capital infrastructure. The existing track infrastructure and siding/pad locations have become inefficient over the past 100 years due to changes in land use, geographical expansion of the industry, and changes in technology of locomotives and rail bin wagons. One of the inefficiencies is that the rail track network was originally built with a large number of short sidings, rather than fewer large sidings that are more easily serviceable by the modern large locomotives.

Reducing the number of rail sidings has conflicting impacts for the harvesting sector and the transport system. Fewer sidings will mean an increase in average haulout distance between the farm paddock and the nearest permissible sidings, which can increase costs to the harvester owner. These increased costs can be minimised by ensuring that the remaining sidings on the track network lead to the minimal average haulout distance. Fewer sidings will mean decreased transport costs, between the sidings and the mill, from having to service fewer sidings each day and reduced shunt time. Sidings have varying costs per tonne of cane for servicing, depending on the location of the siding (e.g. distance from mill) and its condition.

The above issues of number and location of sidings can be formulated as a P-Median problem (Higgins and Laredo 2006), with additional constraints of upper limits on average haulout distances (depending upon the objective), and farm paddocks only being assigned to the nearest permissible siding. The model was coded in Lahey 95 Fortran and is currently in the form of a non user-friendly scientific tool. One of the biggest challenges in applying the model to the case study was obtaining values for distances from the farm paddock to each possible siding/pad. In a region like the Herbert with 15000 farm paddocks and 300 sidings, 4.5M combinations of distances needed to be calculated. This was achieved through using GIS technologies, using MapInfo (for most areas), together with ArcView (for the Herbert) native and customised functions and scripts. The implementation of GIS technologies into this project can be viewed from two angles:

- from a technical point of view, where actual scripts, applications and techniques are used for data manipulation; and,
- from an end-user perspective, where GIS works as an interface between the technical elements of the model and the real-world application of model outputs, providing a spatial context to the data.

To make the distances between sidings and farm paddocks more realistic, geographical features such as rivers, creeks, QR lines and highways needed to be accommodated. This was done through the use of adding penalties to the distances or adding barriers so that farm paddocks can only be hauled to a limited set of sidings.

4.3.4 Harvester and Loading Pad Rosters

In 2000-2001, CSIRO developed mathematical models that generates 1) the optimal RDO combinations for harvesters; and 2) the optimal sequence of sidings that each harvester visits across the days of the harvest season. The objective of these models was to: provide a better balanced cane supply; reduce costs to harvesters by reducing the travel costs between sidings while maintaining grower equity; reduce transport costs; and provide a more reliable service of bins to harvesters which reduced their waiting time for bins. Overall, these models provide the tactical logistics plan at the harvesting-transport interface, and are a key to operationalising the options developed in CSE005. Further information about these tools is found in Higgins (2003) and Higgins and Postma (2003).

4.3.5 Financial Model

The purpose of the financial module is to provide such a common denominator across the individual component models that reflect industry objectives. The purpose of research is to improve financial returns along the value chain, accounting for the possible divergent or conflicting interests of some sectors. The long-term aim is to develop an incentive system that encourages individual sectors to operate in a way that maximizes whole-of-system returns. This is not possible, however, without first identifying the financial implications of proposed changes to the industry system, for each sector and overall: the purpose of this stage of the research.

For this end, individual component models calculate the financial outcomes of harvest-transport scenarios for the sector(s) whose operation is modelled. The way the different sectors derive their earnings varies. Growers and mills share the proceeds from sugar sales. Grower returns are based on the CCS content of their cane or, more precisely, by use of a cane payment formula based on relative CCS.

Harvesting contractors are currently paid a flat amount per tonne of the cane/extraneous matter mix harvested, counted when delivered at the mill. Haulout within paddocks is part of the harvesting operation. Transport from siding to mill is conducted by the mill, and it constitutes a cost item among mill operations.

Sectoral financial returns must be compared with care, as their economic meanings have important differences. There is also a variation in sectoral interests that may conflict with one another and that of the whole industry:

- Growers: By the time of harvesting, growers have incurred all growing costs, and the only outstanding cost item for them is harvesting. Once harvesting costs are deducted, their benefits constitute net, pre-tax profits.
- Harvesting contractors: Detailed costings available for the harvesting sector include direct costs only, ie, those directly associated with the harvesting operation. Gross margins (excluding general business overheads) are calculated and monitored for this sector. However, as small businesses often do, harvesting contractors tend to disregard capital depreciation and their own time as cost items. Hence, the parallel measure of cash operating surplus is also calculated.
- Transport system: Any savings in transport costs add to the pre-tax profits of mills. Hence, the incentive is to minimize transport costs, as long as this does not negatively affect cane deliveries. Reducing the EM content of the material and, thereby total mass, transported would result in such clear-cut savings.

- Mill processing: It is in the mill's interest to increase cane throughput within its physical capacity by, eg, reducing cane lost during harvesting. The value of additional sugar from more cane, and the mill's share of that, are easily calculated. However, this is a gross figure, before processing costs are deducted. A detailed analysis of the mill's overhead and variable costs is needed before mill profits can be identified, and the present work did not extend to this.

In scenario analyses, all of the sector benefits above have been compared to the benchmark scenario (current system), yielding the marginal benefit associated with each. The sector benefits are assumed to be generated in a steady-state operation following systems transformation. As a matter of general approach, costs of transformation were not always included in the benefit estimation at this stage, as a complete coverage is not yet available. For example, the capital requirement of siding upgrade is known, but the cost involved in reducing harvest-group numbers (through buying out or retiring harvesting contractors) is not. Nor was is possible to quantify non-financial costs such as psychological reluctance to change, individual perceptions of risk resulting in preference-weighted amounts different from nominal figures, full opportunity costs of alternative scenarios that, etc. Hence, economic analysis was simplified to financial analysis using only the observable nominal monetary values.

Nevertheless, the consistent financial analytical framework allowed a realistic comparison of sectoral costs and benefits, as well as their aggregation at the regional level. This was essential for demonstrating to stakeholders that regional profitability is not a zero-sum game.

4.4 Summary of Mourilyan Case Study

Initially, the main developments by the local steering group was a list of scenarios they would like to have analysis for, and through the analysis, decide on a scenario to present to the industry for implementation during the 2003 harvest season. A list of these original scenarios formulated is:

Scenario 1 – 10/100 (10 Harvesting Groups / 100 Sidings)
- 10 Harvesters (best) ie. 10 Harvesting Groups
- Harvesting times rostered over 24 hours
- Harvesting - 7/7 days per week
- 100 Sidings (reduced number)

Scenario 2 – 13/100 (13 Harvesting Groups / 100 Sidings)
- 13 Harvesters
- Harvesting times rostered over 18 hours – 3am to 9pm
- Harvesting - 5/7 days per week
- 100 Sidings (reduced number)

Scenario 3 – 13/50 (13 Harvesting Groups / 50 Sidings)
- 13 Harvesters
- Harvesting times rostered over 18 hours – 3am to 9pm
- Harvesting - 5/7 days per week
- 50 Sidings (reduced number)

A summary of benefits is in Figure 4. As the profit-equivalent measures are conceptually compatible, they can be added at the industry level to show overall gains for the local industry. At the same time, the distribution of gains and losses is indicated for each sector.

Figure 4. Total dollar benefits for each scenario vs base case

The results indicate that there is substantial scope for the improvement of the financial position of the industry through harvesting and transport practices developed in this project. At the same time, benefits are unevenly distributed among the sectors, to the extent that harvester operators would suffer a net loss as a consequence of adopting best-practice harvesting. Hence, to realize the opportunities offered by research outputs in this project, the industry itself must take the crucial step of changing the incentive system in a way that compensates harvester operators for their additional costs. Without the cooperation of harvester operators, the whole regional industry would miss out on large benefits.

The original scenarios above were big picture (or long term goals) which the steering group later realised would be difficult to implement in 2003 (or even 2004), particularly the first scenario. However, it did provide a benchmark for other scenarios produced and those adopted in 2003. Other scenarios considered were:

- harvest best practice
- staggered harvesting over 15, 18, 20, 21 and 24 hours
- removing the transport taxi service for harvesters (and 24 hour hauling)
- all 6 tonne bins
- whole of crop harvest
- implementing a Burdekin transport system

As detailed modelling analysis for these scenarios (and others) is found in Appendix C. The steering group agreed upon staggered hours of harvesting and harvest best practice as scenarios to pursue for implementation during the 2003 harvest season. The staggered hours of harvesting was particularly attractive because it can be implemented in small steps at a time. For example, an 18 hour time window could be considered in 2003, and 20 hour in 2004 and so on. In March 2003, the steering group presented and recommended to the local industry, the option of harvest best practice and staggering the hours of harvest to an 18 hour time window. About 80 growers attended the 2 hour session and most agreed to move forwards with the option for the 2003 harvest season. Most concerns were expressed by the harvester contractors who saw potential difficulties with 1) increased harvesting at night; 2) breakdowns for late starting harvesters; 3) policing HBP; and 4) some are already doing HBP. The steering group produced a one-year timeframe for implementation as highlighted in Figure 5. It also shows that on-going research and planning for 2004 is being conducted in parallel to the 2003 implementation.

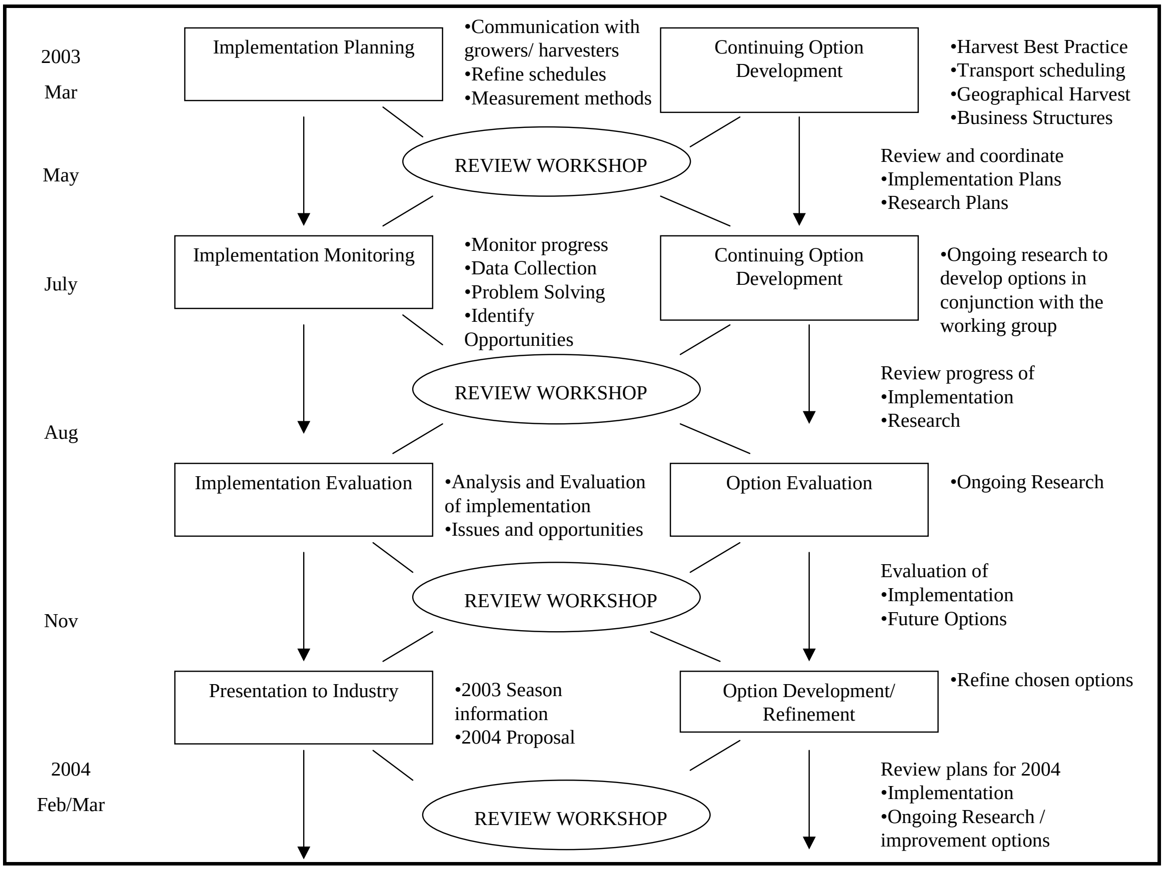


Figure 5. One-year timeframe of implementation, evaluation and planning for the project in the Mourilyan region.

While an extended time window of harvesting may appear to be 'just' a case of changing the starting times of harvesters, implementation was complicated. The issues involved in the implementation were highlighted by the local industry as follows:

1) The mill-owned harvesting group now supplies South Johnstone mill instead, which creates increased pressure on the mill locomotive and bin fleet.
2) Many harvesters voiced concerns about night harvesting or starting too early in the morning and being subjected to dewy cane.
3) Some harvesters simply did not want to change.
4) The mill had issues with ensuring that there is continuous cane supply, thus preventing a mill stoppage at zero hour.
5) Road transport past the hospital (Goondi) had to be conducted within reasonable hours.

The approximate hours of harvest for each harvester during the 2002 harvest season is contained in Figure 6. While there are many harvesters starting early, most finish before 4 pm, thus producing a time window of about 12 hours. Through consultation with the growers and harvesters, the mill initially formulated several possible scenarios for an extended time window, with the one implemented in 2003 shown in Figure 7:

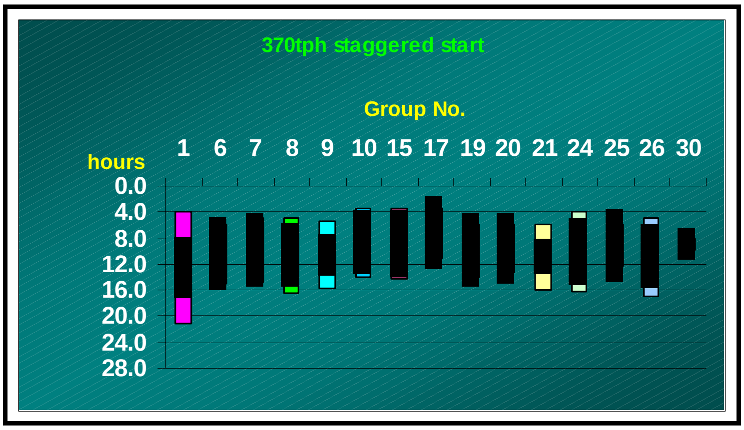


Figure 6. Harvester start and finish times during the 2002 harvest season.

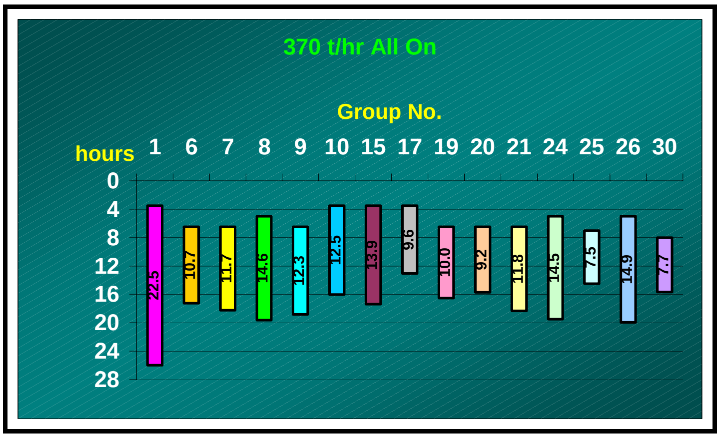


Figure 7. Hours of harvest scenario implemented in 2003.

The Transport Capacity Planning Model was applied using each of the harvesting scenarios and the results are contained in Table 1.

Table 1. Summary of base case and 2003 time window of harvest scenario

Scenario	Number of loco shifts required each day	Total Bins Required	Average cut to crush delay (hrs)	% of time the harvester waits for bins
Base case 2002	15	1516	8.6	14.9
18 hour time window of harvest	15	1483	7.9	3.6

In Table 1, the 18hr time window scenario (Figure 7) would have resulted in some reductions in cut to crush delay and about an 80% reduction in the percentage of total harvesting time that a harvester is spent waiting for bins, compared to the 2002 start times (Figure 6). This was the key selling point for the scenario.

Feedback from the local industry after the harvest season highlighted some teething problems with the implementation of the 18 hour time window in that there were a few weeks of wet weather initially and there was a learning period for the traffic officers to provide transport schedules for the new harvester start times. The grower and harvester representatives agreed there were some teething problems initially which led to some substantial delays to harvesters. By mid-season, Bundaberg Sugar stated that most of the problems were sorted out and that they were benefiting from the 18-hour time window. While the grower and harvester representatives also supported this view, they agreed that the reasons for the problems need to be communicated to the harvesters and growers in Mourilyan to prevent incorrect perceptions. The local steering group agreed that an 18 hour harvesting time window was to be implemented in 2004 if the delays to harvesters were fixed.

Harvesting best practice was also implemented in Mourilyan during the 2003 season, though there were some significant challenges in achieving this. Primarily there were difficulties in getting the harvesting contractors to implement HBP and this stems from the fact the harvester gross margins decreased under HBP even though industry gains increased. Lack of proper communication channels to harvesting contractors was another barrier - how does a contractor implement HBP. To begin to address these issues an industry meeting was held and attended by all contractors in Mourilyan. Information on HBP was presented at this meeting and industry opinion was gathered. It was noted that most contractors were already achieving HBP in many instances. This could not be quantified due to the lack of previous season harvester baseline data.

In early 2004, the steering group suggested the project team look at designing an integrated harvest and transport system for three of the Bundaberg Sugar northern mills, Mourilyan, South Johnson and Babinda. This design will include additional features of allocating farms for mills and integrating the transport systems across the mills. The optimal harvesting and transport designs needed to be produced by about July 2004 so that the local industry can develop a plan for government funding. Such a plan would be implemented in 2005 and beyond. The analysis for the wider region is contained in Appendix C. Also contained in this appendix is the outputs from farm comparison study in the Mourilyan case study, which was aimed at identifying key variables for why productivity varies significantly spatially.

In early 2004, significant difficulties emerged with the Mourilyan case study. Firstly, funding (through SIDAC) for facilitation of the workshops ended. Secondly, two key industry champions, Mr Ian Davies and Mr Richard Rees, moved on. Momentum was lost in the case study as a result and despite attempts by the research team to maintain momentum, the case study ended. Many of the participants of the working group were disappointed with this outcome and felt the project was gaining momentum for implementation of bigger picture options in 2004. An 18 hour time window of harvest did continue to be implemented in 2004 and 2005.

Eighteen months later, former Canegrower and Bundaberg Sugar members of the steering group submitted a proposal to SRDC to extend the work of the Mourilyan case study to Sth Johnstone and Babinda with implementation taking place in 2007. This was a great legacy from the Mourilyan case study and demonstrated a growing industry acceptance and initiative for the value chain research during that 18 month period.

4.5 Summary of Mossman Case Study

Mossman Agricultural Services arranged a workshop in September 2002 for the local industry to highlight the issues on local importance and for the project team to explore how they could address these issues. At current sugar prices and production level, the mill is unprofitable and so must reduce its operating costs by $3M in 2003. Between the September 2002 and March 2003, the emphasis for the research team was to assess hours of harvest options to reduce loco shifts and the number of bins required. While Mossman mill pushed for harvesting across 24 hours/day, the harvesters were not keen, but the harvesters did agree that staggered harvesting from 4am to 8pm could be implemented in 2003. To do this, Mossman Agricultural Services paired up harvesters so that one will start early and one will start late, and the Mossman harvesters agreed to this principle. A meeting was held in February 2003, with the prime purpose of getting the mill on-board and a path forward for implementation during 2003. A summary paper was produced (Appendix D) and delivered in advance to all who were to be present at the meeting. The benefits of different hours of harvest was presented to the milling representatives, along with the potential benefits and logistical strategies for each group to implement the alternative harvest hours. The mill staff responded positively that they were able to remove a loco shift through extending the hours of harvest, and will support the implementation of it.

The Mossman region has implemented a 16-hour time window scenario from 2003 with the start and finish times close to that in Figure 8. The feedback from Mossman Agricultural Services was that the scenario proceeding ahead well. As with Mourilyan, it was difficult to evaluate the outcome of adoption (in terms of delays waiting for bins and cut-to-crush delay) due to two large harvesting groups being toll crushed at the Tableland mill.

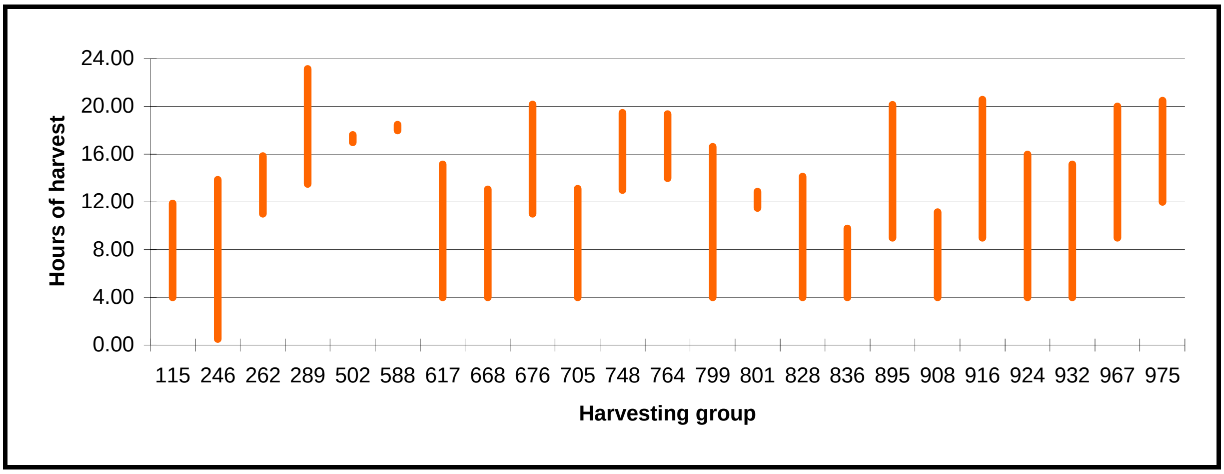


Figure 8. Hours of harvest implemented in Mossman during the 2003 harvest season.

A key focus in Mossman was to reduce locomotive shifts. While extending the time window of harvest has minimal impact on locomotive shifts in Mossman, staff from Mossman Agricultural services and Mossman Central mill saw opportunities to produce a siding roster of movements of harvesters that minimises the number of locomotive shifts to service the harvesters. Prior to the start of the harvest season, the project team and Mossman Agricultural Services worked closely to integrate the Transport Capacity Planning Model with the Siding Rostering Model to do this. The impacts of producing a siding roster to minimise locomotive shifts is shown in Figure 9 for the Mossman case study when applied to the entire harvest season. The most noticeable impact is the reduction in variability from actual to optimised, which would produce a more constant demand on the transport system leading to better utilisation. While there is considerable demonstrated potential from optimising siding rosters, it can interfere with grower equity and farm rotations within a harvesting group. Alan Stafford (Mossman Agricultural Services) spent considerable time fine-tuning the model roster to produce a practical roster from the grower's perspective. Unfortunately it was not implemented in 2003 due to these difficulties.

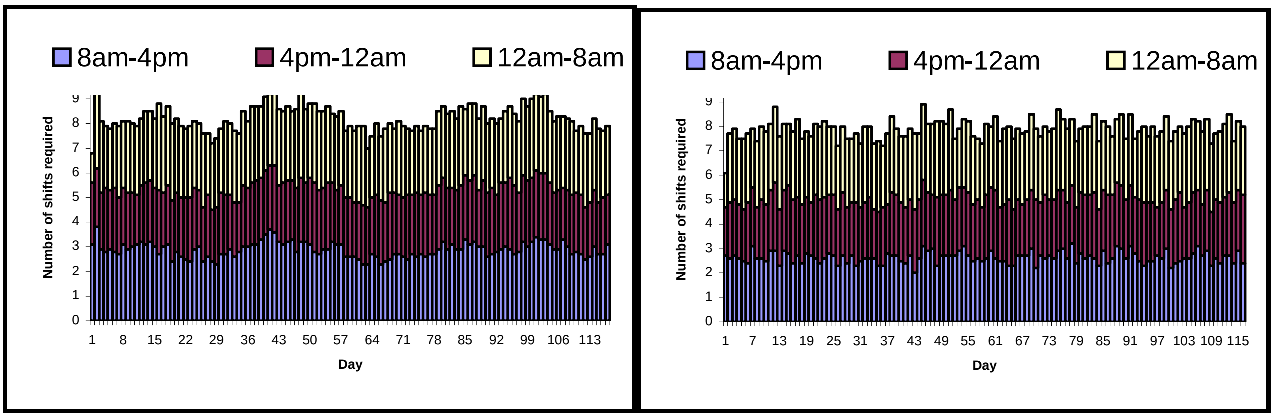


Figure 9. Impact of siding roster to minimise loco shifts, actual 2002 (left), optimised (right).

However, there was strong progress towards overcoming the social barriers for implementation in Mossman in 2005. The scenario would lead to a reduction in locomotive resources required and reduced costs to harvesters. It would also overcome the inflexible aspects of grower equity to increase whole-of-industry profitability. With Mossman Agricultural Services (MAS) having control over the transport planning activities in 2005, the combined 16 hour time window of harvest and siding roster was able to be achieved in 2005, which was a first for the Australian sugar industry. The siding roster was not fully prescriptive and needed to be fine-tuned by MAS throughout the harvest season due to changes in estimates etc. Plans are on track for implementation of a wider time window of harvest (probably 20 hours) and a siding roster in the 2006 harvest season.

4.6 Summary of Plane Creek Case Study

As a result of meetings held in Plane Creek in late 2002 and early 2003, the Plane Creek Regional Industry Board (RIB) agreed that the research team looks at 1) improving farm design (such as different layout of paddocks) to increase harvesting efficiency; 2) harvest best practice; 3) CCS maximisation through optimising the harvest date of cane; 4) minimising the number of harvesting groups; and 5) extending the hours of harvest. The research team adapted the tools developed for Mourilyan to the Plane Creek system and advanced scenarios were presented to the RIB shortly afterwards. The key scenarios are as follows:

a) optimised harvest season start and finish time

b) amalgamation of existing harvesting groups to increase group size and reduce number of harvesting groups to 29.

c) formation of super groups. This is where several harvesting groups work together as a co-operative so it is like one big harvesting group with several machines. The long-term aim is for three super groups of eight machines each. The aim in 2004 is to trial one super group.

d) Harvesting best practice.

In b) above, we showed there was a substantial reduction in waiting time for harvesters and cut-to-crush delay when the number of harvesters was reduced from 70 to 29 (Table 2). The potential efficiency gains that may occur with the super-groups of c) above has helped motivate the Plane Creek steering group.

Table 2. Impact of reducing the number of harvesting groups in Plane Creek.

Scenario	Max bins required	Required loco shifts per day	Av Cut to Crush Delay (hrs)	Waiting time for bins (% of total harvest hours)	Mill stoppages (hrs/day)
1	2600.00	14.90	9.80	19.60	0.70
2	2535.00	14.80	8.80	5.20	1.60
3	2379.00	14.70	7.90	3.70	1.60
4	2335.00	14.20	7.70	3.30	1.60

1 2002 harvest season with the harvesting groups and their start times of 2002
2 29 harvesting groups
3 26 harvesting groups, with the following merges (19,20) (21,22) (24,29)
4 26 harvest groups, with groups 19,20,21,22,24,27 and 29 into one group with 4 machines

After the development of these initial scenarios, the Plane Creek RIB formulated bigger picture scenario for the region, which consists of 3 groups (co-operatives) of 8 machines. Unlike the Mourilyan case study, the Plane Creek region focused on a single scenario formulated by the Regional Industry Board, independently of the steering group. The role of the research team was to fully cost out the scenario and develop operational plans to show how it would work in practice. The results from this scenario are contained in Appendix E.

In late 2003, during the modelling analysis of the 3 groups x 8 machines scenario, the project team ran into major difficulties with the Plane Creek case study. The Plane Creek RIB pursued the scenario with alternative resources instead of the CSE005 project team. As a result, Plane Creek was no longer a case study of CSE005. It was an unfortunate outcome for CSE005, particularly as the region was progressing rapidly. Despite reconciliation efforts by the project team to mend the case study, it was not able to be achieved. The project team are also unaware of the underlying reasons for the outcome.

4.7 Transition to Herbert Case Study

In February 2004, representatives of the Herbert region expressed interest to use the CSE005 research team to explore scenarios of siding rationalisation and optimal harvesting group size across the Herbert sugarcane region. As a result, a workshop was held in February 2004 to explore the scope of the work, resources required and time lines. The research team agreed to take on the Herbert as a case study under the following assumptions: 1) minimal innovative research opportunities though easy to apply existing models; 2) increase the impacts of the CSE005 project, particularly as the Herbert is a large multi-mill region; and 3) the representatives were well organised in terms of availability of data and its supply.

An initial workshop was held in June 2004 (in Townsville) to describe the capability of the research team to the milling and grower representatives of Herbert, and to discuss the following issues:

- Update of RainRisk database/software
- Optimisation of early cane supply schedules based on maximising CCS / sugar yields and minimising the risk of wet weather disruptions and infield stool damage (incorporating soil moisture and trafficability)
- Input into the new SRDC 'optimal season length' project
- Progress on siding rationalisation and issues relevant to the Harvesting & Transport team

The industry and research representatives present at the workshop were: Peter Sheedy, Michael Pisano, Warren Russo, Lawrence DiBella, Paul Giordani, Andrew Higgins, Di Prestwidge, Gary Sandell and Andrew Wood. The industry representatives at the meeting presented a summary to the regional industry board a few days later that collectively agreed to explore harvesting and transport scenarios for the Herbert. The regional industry board particularly wanted to pursue:

i. Develop a Herbert Harvest Group and Siding Location Model - Sept 2004;
ii. Develop a Herbert Harvest Haul Model - Oct 2004;
iii. Develop a Herbert Transport Capacity Model - Oct 2004;
iv. Develop a Herbert Harvest and Siding Roster Model - Oct 2004;
v. Develop a Herbert Financial Model - Nov 2004.

After the meeting in June 2004, there was a very strong on ground commitment by CSR Sugar – Herbert to collate model data and validate initial results. This was reflected by the ability to set up most of the above models and go through one to two iterations with the industry staff prior to the next meeting in September 2004. As a result of the workshop, the local industry was particularly keen to proceed with: implementation of optimal harvester and siding roster in 2004; finetuning the Harvest Haul, Transport Capacity Planning and Siding Location models to produce more accurate scenarios for the next meeting; explore harvest scheduling options to maximise CCS (new project); and to look at the impacts of the crushing season time window accounting for wet weather risk.

A major effort in the Herbert case study was to learn from the experiences from the Mourilyan case study and ensure the research process will have the greatest likelihood of heading towards their desired implementation and regional change. One of the biggest learnings from the Mourilyan and Plane Creek case studies was that the local steering group had to have complete control and ownership of the path forward. In the past case studies that had an external facilitator, the control and ownership was taken away from the local steering group. Once the facilitator was absent (e.g. in between meetings or if the facilitator leaves the scene all together) there wasn't the local capacity and/or drive to continue. This problem went on relatively un-noticed in the first two years of CSE005, since an external facilitator often provided a "feel good" atmosphere within the workshops. This then clouded the true health of the case study, which became apparent when significant events take place, such as members of the steering group leaving. In the Herbert case study, from the start the research team has acted as a resource that technically underpined the scenarios that the Herbert steering group formulated. Of course, the research team did share experiences and scenarios from their other case studies to help the Herbert steering group work out themselves on appropriate scenarios relevant to their own region. The organisation and structure of workshops has been controlled by the CSR, Canegrowers and Mechanical Caneharvesters Association representatives. Conflict resolution and difficulties in moving forward were always managed by them, even if it takes longer to arrive at solutions compared to if a facilitator was present. In the first 12 months, the research team worked hard to obtain a good rapport with members of the Herbert steering group. While developing a good rapport took a long time and required a large number of regular interactions, it was an intangible outcome that led to members of the Herbert steering group increasing their faith in the project and desire to make it work.

In late 2004, the steering group suggested several extended time window of harvest that better utilised the daylight hours of harvest. These scenarios are shown in Table 3 with the hours of harvest for 2004 and a proposed 6pm finish shown in Figures 10 and 11 respectively. Other scenarios were developed and results are contained in Appendix F. While Figure 11 is not the actual proposed harvesting times for each harvester, it does highlight a major change from the hours of 2004. The modelled benefits of the time window is contained in Table 3, which has been verified by CSR through the application of their transport operations tools.

Other time windows of harvest scenarios were considered by the steering group for 2006, which would lead to even bigger benefits (Table 3). The main benefits of a harvesting time window with a 6pm finish is about a 50% reduction in the time spent waiting for bins. The locomotive usage is not reduced. For the 2am to 8pm scenario, the number of locomotive shifts can be reduced by one. There are less locomotives needed due to the more even spread of shifts across the day. There is also a further significant reduction in the average waiting time for bins. For both the 2am-8pm and 2am-10pm scenarios, not all of the bin fleet is needed.

During the workshop on the November 2004, the steering group (about 22 members) agreed that to achieve implementation, we needed much broader industry involvement in the project. As part of obtaining industry acceptance and ownership of the project work in the Herbert, the steering group organised (with input from the research team) a local industry workshop for March 2005. A purpose of the industry workshop was to invite others within the region to be part of the scenario development, validation and gaining acceptance from others. Sixty three harvesters and growers attended. A miller, harvester and grower representative from the steering group facilitated the industry workshop. During the 5 hour workshop, several formal questions were presented to the participants. These questions are listed as follows:

What do you expect to achieve by being here today?

What work remains to be done?

What did today mean for you?

How are you feeling?

Suggestions on how to make this workshop better?

The feedback on some of these questions is contained in Appendix G. Many of the participants came into the workshop cynical about the research and cynical towards other sectors of the industry. It was important that the participants could air their viewpoints before we could move ahead constructively. General notes were taken during the workshop and are contained in Appendix G, which also contains the list of participants at the workshop. One of the outcomes of the workshop was that several participants (20+) volunteered to help with the validation of the Harvest Haul and Transport Capacity Planning Models, to help build wider industry confidence. As a result of the volunteers to help validate the Harvest Haul model, meetings were held to train some members of the Herbert steering group on using the Harvest Haul model, so that they can work closer with the industry participants who volunteered to help validate the model outputs.

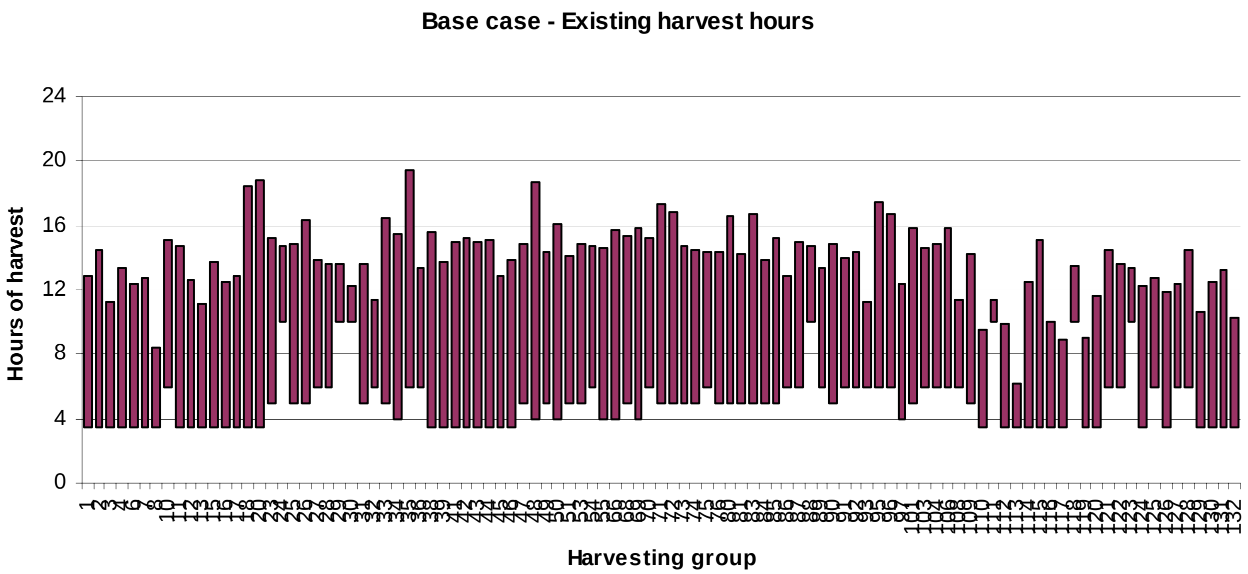


Figure 10. Existing hours of harvest (2004)

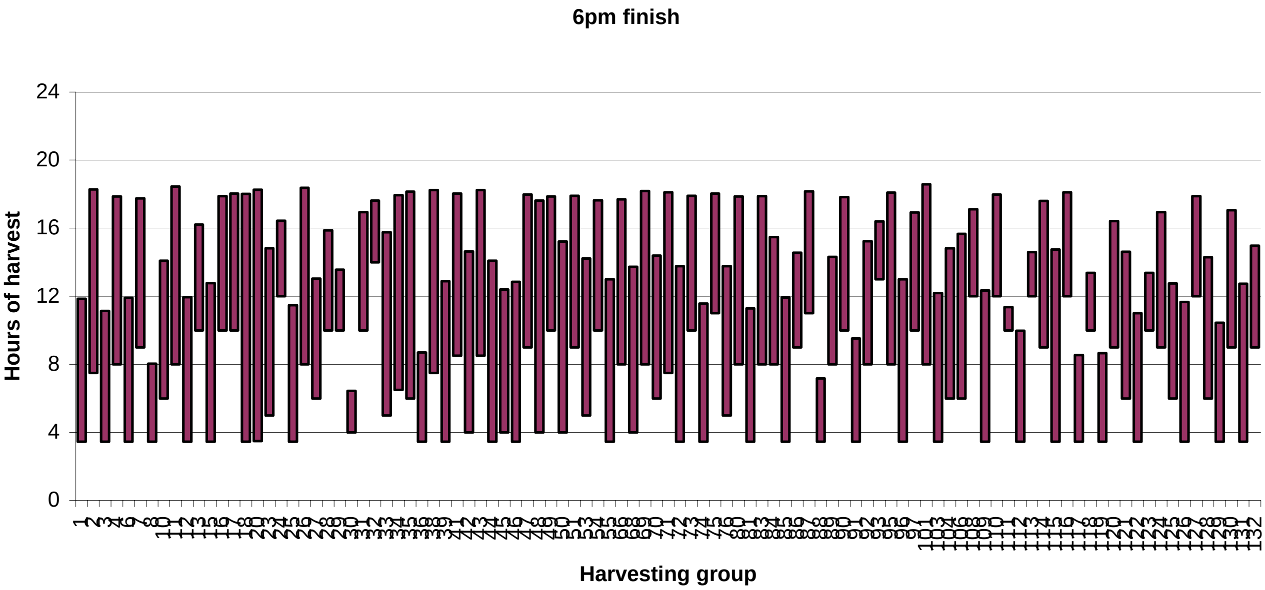


Figure 11. Harvest time window scenario with 6pm finish (14.5 hour time window).

Scenario	Mill	Locomotive shifts: Morning	Afternoon	Night	Cut-to-crush (hrs)	Average Delays to harvesters (% of total harvest hours)
Base	Vic	14.4 (15)	6.7 (7)	8.9 (9)	8.7	33.0
	Mck	6.6 (7)	2.6 (3)	4.3 (5)	10.2	8.9
6pm finish	Vic	14.2 (15)	7.1 (7)	8.3 (9)	8.5	15.5
	Mck	6.3 (7)	3.5 (4)	3.7 (4)	9.8	4.8
8pm finish (7700) bins**)**	Vic	11.9 (12)	8.8 (12)	8 (8)	7.3	7.4
	Mck	5.6 (6)	4.6 (5)	3.5 (4)	8.6	4.4
2am – 8pm (7300 bins)	Vic	11.7 (12)	8.9 (9)	8.5 (9)	6.7	5.2
	Mck	5.5 (6)	4.2 (5)	4.0 (4)	9.0	3.9
2am – 10pm (6900 bins)	Vic	11.3 (11)	9.6 (10)	8.5 (9)	6.0	4.8
	Mck	5.3 (6)	4.6 (5)	3.9 (4)	8.6	3.7

Table 3. Comparison of different time windows of harvest considered by the Herbert steering group.

In 2005, the Herbert steering group agreed with the early siding rationalisation/upgrade analysis developed by the project team, from the perspective of significant efficiency benefits to harvesters and CSR by having fewer but bigger sidings with less shunt time. The analysis developed by CSE005 was used in a regional proposal for federal government funding to remove 100 sidings and build 72 new sidings in the Herbert. The Herbert proposal was successful and there is now $7.2M (including $3.6M from CSR) to build the new sidings. A further role of CSE005 was to accurately measure the cost saving to harvesting and transport through the different options of the 72 new sidings. The Transport Capacity Planning and Harvest Haul Models were applied for performing the cost benefit analysis for the proposed siding rationalisation/upgrade scenario. The objective was to calculate on a harvester by harvester basis, the financial impacts of the siding upgrades and removals. The information would be used to provide a common understanding of the benefits and consider alternative arrangements/compensations if there were dis-benefits. To apply the models, updated 2005 data needed to be obtained and comprehensively error checked so that the analysis is accurate from the regional scale through to the block scale. CSR Herbert and HRIC provided much of this resource.

Alternative haul-out paths between paddocks and sidings needed to be produced by the Herbert for the rationalised/upgraded siding plan. These paths accounted for several geographical obstacles, such as creeks, drains, road access and neighbour co-operation. Using the Transport Capacity Planning Model, the benefits in terms of reductions in locomotive shifts and waiting time for bins is contained in Table 4. In the second column, a "yes" denotes the upgraded/rationalised siding scenario, where an upgraded siding is assumed to have a capacity of 200 bins and a shunt time of 10 minutes. The upgraded/rationalised scenario was performed for three harvesting time window options, the time window of harvest scenario of 2004, an extended time window where some harvesters finish at 6pm (target for 2005 and 2006) and an extended time window where some harvesters finish at 8pm. As seen in Table 4, there were significant locomotive shift savings across both mills under the upgraded/rationalised siding scenario. There was also a significant reduction in waiting time for bins experienced by harvesters, with the benefits increasing with an extended time window of harvest. Feedback from the milling and grower representatives was very positive, particularly towards the increased reliability of the transport service for harvesters.

An analysis of harvesting cost benefits from siding rationalisation has been done in CSE005 for 20 priority (out of the 72) sidings only, due to the huge amount of information required (and needed to be validated) for the Harvest Haul Model. It was a complex analysis due to the precision required at the siding by siding level and ensuring accuracy of blocks allocated to the new sidings. It also needed to be validated on-ground by growers/harvesters supplying each of these priority siding areas. Whilst full details of the analysis is found in Appendix F, the potential savings to harvesting costs (harvesters affected) is up to $0.27/tc when combined with an extended time window of harvest. These priority 20 sidings are currently being built, with a plan for completion by June 2007.

Commitment to construction of sidings needed to be obtained on a branch line basis, with the harvesters and growers agreeing to a location for a new siding and removal of some existing ones. In the Herbert, this process involved about 35 meetings held throughout the district (up until about May 2006). Whilst, CSE005, is a small component of this process, the Harvest Haul Model, Siding Location Optimisation, GIS and Transport Capacity Planning Models were applied to assess changes in harvesting costs resulting from each of the potential siding changes, and considering impacts on a block-by-block basis. This process will continue beyond the life of CSE005 and during the follow-up project FPP109. Transport rationalisation is a strategic option, resulting in a one-off adoption pathway in the Herbert. The learnings from implementation of rationalised sidings in the Herbert can be transferable to other regions considering such an option in the future. However, the learnings will not be available until after CSE005 has been completed, since the Herbert is still in the process of implementation.

Other analysis are contained in Appendix F, which include harvester rosters, impact of number of sidings vs haulout distance, and optimising the use of the different bin fleets in the Herbert.

Table 4. Impacts on transport and waiting time for bins.

			Locomotive shifts				
Scenario	**Siding Upgrade**	**Mill**	**Morning**	**Afternoon**	**Night**	**Cut to crush (hrs)**	**Waiting time for bins (% of total harvest hours)**
Base (Harvest hours of 2004)	No	Vic	14.3	7.1	9.1	9.1	32
		Mck	6.5	2.8	4.2	9.6	11
	Yes	Vic	9.5	6.8	8.5	9.9	23
		Mck	4.7	2.8	3.7	10.1	7
6pm finish	No	Vic	14.8	7.8	8.5	8.4	18
		Mck	6.4	3.6	3.8	9.8	5
	Yes	Vic	10.4	7.2	7.6	9.1	6
		Mck	4.8	3.1	3.2	9.9	2
8pm finish (7500 bins needed)	No	Vic	14.2	9	8.2	7.6	11
		Mck	6	4.5	3.4	9.8	5
(8800 bins needed)	Yes	Vic	10.3	7.9	7.2	8.5	4
		Mck	4.7	3.4	2.9	9.6	1

5 Outputs:

Several soft and hard outputs have been achieved during the life of CSE005, with some outputs unforeseen at the start of the project. The following hard outputs have been achieved.

- A modelling framework that integrates several component models for harvesting and transport, providing a whole-of-system modelling capability for harvesting and transport, whilst being understandable by industry. This framework is not a physical computer model itself but rather a process of necessary inputs/outputs between the models and a strategy for using the models collectively. It is also adaptable to any mill region. The framework is well documented in the paper by Higgins et al (2004), published in Agricultural Systems. The framework was regarded by the reviewers in Agricultural Systems as a major development for agriculture and one that would be widely cited. This was the case as the paper was the 4th most frequently downloaded paper in Agricultural Systems during the second half of 2004.
- Additional component models were developed in CSE005:
    - Harvest Haul Model: A redevelopment of the BSES Harvest Transport Model (paddock level only) to determine harvesting costs aggregated to a regional level. It was also further developed to accommodate implications from such as extra waiting time for bins or increased migration. This provided a capability to model harvesting costs for big picture options such as bigger harvesting groups. The documentation for the Harvest Haul Model is contained in Appendix A, and further information about the model can be found in Sandell and Prestwidge (2004).
    - Transport Capacity Planning Model: This is a simulation model to measure the transport needs (locomotive shifts, bin fleet, wait time for bins) for any given option in harvesting/transport (Higgins and Davies, 2005). It is not a daily scheduling tool like TOTools (developed by SRI), but rather uses simulation to measure capacity requirements at a tactical or seasonal level.
    - Siding Location Optimisation Model: This model optimised the location of sidings on a track network, with objectives such as minimising haulout distance, transport costs or a combination. Further information about the model can be found in Higgins and Laredo (2006).
    - Road Transport Scheduling Model: This model was partially developed under CSE005 (and partially under CSE010) and schedules the daily pick-up and delivery of trailers in a road transport system (Higgins and Downs, 2005).
- Ten publications, four international refereed journal papers and six ASSCT papers. There has also been one article in Australia Canegrower and five radio interviews.

The following soft outputs were achieved in CSE005:

- A participatory action research process for a region to develop and implement value chain opportunities at the harvesting-transport interface. This process evolved throughout the Mourilyan case study (through learnings) and had corporate level input from SRDC, ASMC, CANEGROWERS and QSL. The process was adapted to the Herbert region nearly 2 years after commencing in Mourilyan and the advancements from the Mourilyan case study made the process more efficient in the Herbert.
- Case studies established in Mourilyan, Herbert, Mossman and Plane Creek, with working groups of up to 30 members representing the growing, harvesting and milling sectors. Not all of these working groups were formed completely as a result of CSE005 but they have underpinned progress in CSE005. The working groups have evolved substantially over the past four years with the working groups in Mourilyan and Herbert initiating further projects.
- Pathways to implementation of some options at the harvesting and transport interface. Pathways were developed (at least in draft) for: extended time window of harvest; harvesting group amalgamation; delivery timetable and roster logistics; and siding rationalisation. Whilst pathways are not fully and quantitatively tested for each of these harvest/transport options, there was much greater knowledge base to draw upon now to effectively implement such options, compared to the start of CSE005.

- Greater collaborative capability across R&D organisations servicing value chain projects in the Australian sugar industry. Prior to CSE005, CSIRO and BSES had not collaborated on a value chain project, despite the organisations having complimentary skills. Through some effort being devoted to developing an effective working relationship between CSIRO and BSES (and Harvesting Solutions) for CSE005, it is now a much easier process to develop new collaborative projects with participants fully understanding their roles early in the project. By developing the collaborative capability in CSE005, collaborations with other organisations (e.g. Agtrix, iScape) have been developed without a major effort.
- Greater collaborative capacity between regional stakeholders due to the interaction and learnings associated with project activities.

These actual outputs from CSE005 encapsulate all of the expected outputs listed in the original CSE005 proposal.

6 Intellectual Property:

Both CSIRO and BSES brought intellectual property into the project in terms of: cane supply optimisation, harvester and siding rostering, and the harvest-transport model (BSES). These tools still reside with the host organisations. Several tools were developed as a result of CSE005:

Harvest Haul Model (joint BSES, Harvesting Solutions and CSIRO)
Transport Capacity Planning Model (CSIRO)
Siding Location Optimisation Model (CSIRO)
Road Transport Scheduling Model (CSIRO and partly developed with CSE010)

Some of these tools have been further developed through additional SRDC projects (CSE010, NSC006). The algorithms behind these models are publicly available through the journal and conference publications. The Transport Capacity Planning and Siding Location Optimisation Models are tools that were adapted to other sugar regions through additional SRDC (or other sources) funding. There are no plans for commercialisation or patenting of these tools. The Harvest Haul Model has been developed as a software package, though not on a commercial basis at this stage. It is adapted to other sugar regions and harvesting groups on a fee-for-service basis (through SRDC or other funding sources) to address the issue or develop options. The project investigators may take out a patent on the Harvest Haul Model. The Road Transport Scheduling Model is currently a non-user-friendly scientific tool, which will be further developed through a FREDD user-friendly type interface (through SRDC project FPP111) and adopted in the Maryborough region (and probably other regions as well). It may be commercialised through the FREDD software in the future but are unsure at this stage.

7 Environmental and Social Impacts:

The project has had no known environmental impacts and this is unlikely to change in future outcomes generated by the project. The siding upgrade/rationalisation component of CSE005 in the Herbert contributed to outcome of the construction of new sidings. However, decision by the region on where these sidings are located accommodate potential adverse environmental impacts (e.g. drainage into waterways, loss of tree cover).

There are social benefits from the case studies in Mourilyan and the Herbert. There were social benefits in terms of legacies from the participatory action research process with the local industry working groups, and due to implementation of options produced by the project. We will highlight these in the Expected Outcomes section.

A specific combined socio-environmental impact of the Mourilyan project included restricting rostered harvesting, hence noise pollution due to haulage, near the Goondi hospital to more acceptable day-light hours. This demonstrates how the tools developed can accommodate such social objectives.

8 Expected Outcomes:

The outcomes to date resulting from the project are as follows:

- *Improved collective planning across the growing, harvesting and milling sectors to win-win solutions that also maximise industry profitability.* This has been demonstrated in the later stages of the Mourilyan case study and through their initiative to construct a follow-up SRDC value chain project. It has also been demonstrated in the Herbert with some influential canegrowers and harvester (of the working group) taking initiative with further value chain opportunities in their region (demonstrated by new project proposals FPP108 and FPP109). An evaluation has been conducted with the Herbert region (in conjunction with SRDC project CSE013) with the results available in Appendix H). The evaluation highlights some of the improvements in planning.
- *A greater industry acceptance of value chain research and the use of rigorous methodologies.* Whilst this is difficult to quantify, there are indications in the Herbert evaluation (Appendix H). The outcome is also demonstrated by the adoption of the CSE005 methodologies in additional SRDC projects (CSE010, BSS264, NSC006, FPP108 and FPP109), which many of these are industry led.
- *A greater common understanding across the industry sectors to the impacts of a wide range of value chain opportunities in the combined harvesting and transport sectors* (also highlighted in the evaluation of Appendix H). Prior to CSE005 in all case study region, there was limited opportunities identified as having significant savings in harvesting and transport (e.g. optimised transport scheduling, HBP). CSE005 highlighted several further opportunities and enhanced the understanding across the industry sectors to their potential and how they would work in practice. This outcome is one of the key factors leading factors leading to industry taking more initiative.
- *Adoption of increased time window of harvest (from about 12 hours to 18 hours per day) in Mourilyan from 2003 onwards leading to some reductions in waiting time for bins and improved utilisation of the mill's bin fleet.* Whilst it was impossible to quantitatively assess the actual benefits from adoption due to changes in the baseline between the years, milling and growing representatives indicated it was worthwhile and continued in 2004 onwards.
- *Adoption of increased time window of harvest combined with optimal siding rosters in 2004 onwards, leading to an ability for the Mossman mill to transport the cane to the mill given its declining limited locomotive and bin capacity and no budget for increased capacity*. By 2006, the Mossman region was heading towards a 20 hour time window of harvest.
- *Adoption of CSE005 analysis on benefits for rationalisation/upgrading the transport network, for use in a proposal to the federal government for $3.6M funding to build the proposed upgraded sidings.* The proposal to the federal government was successful, and since its success, a more extensive plan of where the new sidings should be located (and which sidings should be removed) has been developed by the CSE005 research team and adopted by the local region. The sidings are currently being built, with completion of 72 sidings by 2008.
- *Adoption of optimised harvester rosters in both mills of the Herbert region during the 2005 harvest season*. Harvester rosters were developed to improve daily balances of cane supply to each of the mills and along the branch lines.
- *Adoption of methodologies and models developed in CSE005 in other SRDC projects, CSE010, BSS264, NSC006, with anticipated used of outputs from CSE005 in new projects FPP109 and FPP108.* The use of outputs from CSE005 in CSE010, BSS264 and NSC006 is a demonstration of the wider industry importance/uptake and has led to considerable cost savings to SRDC. For example, the cost to SRDC for CSE005 was about $700,000, whilst the cost to SRDC from CSIRO and Harvesting Solutions input into NSC006 (NSW) was about $150,000. Without CSE005, the cost of CSIRO and Harvesting Solutions to achieve the same outputs in NSC006 would have been high higher (estimated at about $300,000) since the models would need to have been build from scratch. In CSE010, the learnings from the participatory action research process in CSE005 was used.
- *Greater trust, transparency and adaptability across the multi-organisational research team.* The Australian sugar industry now has access to a multi-organisational (has included participants from CSIRO, Harvesting Solutions, BSES, AgTrix, CSR) value chain research team that is world class, an honest broker and synergistic. CSE005 has played a major role in providing the industry with this capacity, with does not exist in most other Australian agriculture industries.

We expect following future benefits and legacies as a result of CSE005:

- *Cost savings of at least $2M/year to the Herbert region upon completion of the siding upgrades/rationalisation and extended time window of harvest to 6pm finish.* This outcome is likely to occur from 2008 onwards.
- *Adoption of extended time window of harvest in Sth Johnstone/Babinda and Mulgrave by 2008 leading to reduced waiting time for bins and reduced costs of maintaining bin fleet.* This outcome is anticipated due to local industry initiatives to improve efficiencies at the harvesting-transport interface.
- *Adoption of the Harvest Haul Model in 90% of the sugar regions by 2009 to evaluate various options for reducing costs at the harvesting-transport interface.* The demand for the Harvest Haul Model has increased rapidly across the sugar industry and we expect this to continue as it is further developed and integrated with harvester tracking (CHOMP). The Harvest Haul Model will be used for various options, including harvesting group amalgamation, dual row harvesting, improving efficiency of harvesting businesses and changes to the transport system.
- *Improved regional intersectoral relationships and thereby better regional decision-making.* Especially in Mourilyan, there was a marked change in regional stakeholder interaction from a confrontational to a cooperative approach. Better consideration of others' interests is a precondition of more effective change management and regional decision-making that maximizes regional, rather than sectoral, benefits.

We don't expect CSE005 to significantly benefit other sugar industries, mainly because the tools were developed for an industry with separate ownerships in growing and harvesting, as well as being developed for rail transport.

9 Future Research Needs:

By far the most important future research need is the development of a quantitative evaluation methodology that is effective for value chain research. It will need to accommodate uncertainty in the system as well as an evolving baseline. It will also need to be statistically sound and may be data intensive. It is a research need that is common to the wider agriculture as well.

Evaluation was very difficult in CSE005 because of the lack of (or lack of access to) quality data, and because the harvesting and transport system changed very rapidly (e.g. major fluctuations in cane yield and harvester numbers) across the years. As a result, the research team resorted to a qualitative evaluation based on surveys and interviews. Whilst this qualitative evaluation indicated whether the industry found value in CSE005, it provided no facts on actual benefits. These qualitative benefits are often disputed by cynical industry stakeholders. Whilst there are strong indications that CSE005 is delivering value (e.g. new projects, continued adoption), it would be much more convincing with factual data.

From a modelling perspective, there is minimal "foreseen" further research needed at the harvesting-transport interface. The newer SRDC projects (BSS264, FPP108 and FPP109) are or will address these (and broader) research needs. Some work will always be needed to adapt the tools to different regions, though this process is now quite minimal.

There is still room for improvement in the participatory action research at a value chain level. There were many problems encountered in CSE005 that could be overcome through such improvements. The following issues need to be addressed through social research: overcoming setbacks in the project due to key industry participants moving on or external forces; establishing effective working groups; obtaining commitment from all working group members and without hidden agendas; improved pathways to adoption; and effective communication strategies with the wider industry to maximise sign on. Economic research is needed to refine the current deterministic static financial analysis into a stochastic dynamic economic analysis. This requires the identification and quantification of (a) stakeholders' risk preferences and perceptions, (b) objective risks associated with such system parameters as prices or regional yields and their distribution, (c) non-financial costs and benefits as perceived by stakeholders and the broader community, (d) costs associated with institutional constraints hampering industry transformation, and (e) industry development paths independent from but impacting upon processes examined in the project.

10 Recommendations:

A list of recommendations is as follows:

- The research needs (listed above) in evaluation and participatory action research should be addressed in order for the sugar industry to achieve the full potential from value chain research at harvesting-transport. The extended time window of harvest and amalgamated harvesting groups scenarios may have progressed further in Mourilyan and Plane Creek if these research needs were addressed in the past. Future progress in the Herbert will also be enhanced by addressing the research needs.
- Future value chain projects at the harvesting-transport interface (particularly those primarily based on adoption) need to be designed with adaptability to better accommodate unforeseen events that impact on the project. Because the project deals with options spanning across more than one sector and joint agreement across multiple parties is required for adoption, there is high risk or variability to the type of adoption that takes place. The extended time-window of harvest options in the Herbert is an excellent example of this. Whilst CSR and the Canegrower's leadership were confident of adoption, resistance by some harvesters and a lack of joint commitment to overcome this, led to the option not being implemented in 2005. If the term "adoption" was flexible enough to encapsulate changed attitudes or commitment, which is also a major outcome in itself, it would lower the risk for success. Another example of unforeseen events is in the unfortunate loss of the Plane Creek case study early in the life of CSE005. The case study progressed well in the early stages (particularly compared to Mourilyan) and it was not clear to research team as to why they were locked out of Plane Creek after the end of 2003. CSE005 was flexible enough that the research team could move to a new case study.
- CSE005 delivered options that ranged from very conservative (e.g. extended time window of harvest to 18 hours) to very radical (e.g. combination of 50% reduction of harvesters, harvesting across 24 hours, optimised logistics and overhauled transport system). The different case studies primarily focused on the conservative options due to their easier acceptance, though there was an agreement that the very radical options is where the industry should be. Whilst the very radical options have tended to get lost in the background in the later stages of CSE005, we recommend that they are not lost and the industry is re-reminded that they are the long term goals. With the industry currently enjoying a high sugar price, it is easy to no longer consider the radical options that they once developed. A greater focus on the longer-term "more radical" options will put a better perspective on directions in the shorter term goals.
- The modelling, analysis and data accuracy sometimes needs to be better matched with the options being developed. By better matching these needs there could be considerable savings in R&D transaction costs. An excellent example is in some of the options developed for the Mourilyan case study. The initial draft of the Siding Location Optimisation Model took 2 weeks to develop and was able to accurately show potential benefits/costs (and the trends) from removing or adding sidings. However, at that stage it did not accurately accommodate common constraints such as creek crossings, transport around farm boundaries etc. The view from many in the industry working group was that if the model could not represent the existing system, it could not be reliable for measuring benefits/costs for siding rationalisation. As a result, six extra months was spent on adding detail and complexity in the model so that it accurately modelled the existing system. However, as a result of this effort, there was no significant increase in accuracy to the benefits between the existing system and the options developed. The main point is that in value chain modelling, there is often much less effort required in determining the incremental change in the system (e.g. increased benefits, costs, extra transport requirements) compared to modelling the state of the system. We recommend that future value chain projects should take care in selecting the technical methodologies as this would reduce transaction costs and lead time to implementation. We also recommend that industry participants need to learn more about these technical modelling consideration as well.

List of Publications:

Antony, G., Prestwidge, D., Sandell, G., Archer, A., Thorburn, P. & Higgins, A.J. (2005) Towards farming-systems change from value-chain optimisation in the Australian sugar industry. *Australian Farm Business Management Journal*, **2**, 1-9.

Antony, G., Prestwidge, D., Sandell, G. & Higgins, A.J. (2003) Scope for cost savings from harvesting rationalisation in the Australian sugar industry *Proceedings of the 25th Australian Society of Sugar Cane Technologists*, Townsville, (CD).

Higgins, A., Antony, G., Sandell, G., Davies, I., Prestwidge, D. & Andrew, B. (2004) A framework for integrating a complex harvesting and transport system for sugar production. *Agricultural Systems*, **82**, 99-115.

Higgins, A. & Davies, I. (2005) A simulation model for capacity planning in sugarcane transport. *Computers and Electronics in Agriculture*, **47**, 85-102.

Higgins, A.J. & Davies, I. (2004) Capacity planning in a sugarcane harvesting and transport system using simulation modelling *Proceedings of the 26th Australian Society of Sugar Cane Technologists*, Brisbane, (CD).

Higgins, A.J. & Downs, P. (2005) Optimal scheduling of road vehicles in the Maryborough sugarcane transport system *Proceedings of the 27th Australian Society of Sugar Cane Technologists*, Bundaberg, pp. 32-39.

Higgins, A.J. & Laredo, L. (2006) Improving harvest and transport planning within a sugar mill region. *Journal of the Operational Research Society*, **57**, 367-376.

Higgins A.J., Archer A., Thorburn P.J. and Jakku E. (2006). Value chain research in sugar – lessons from the past and opportunities for the future. *Proceedings of the 28th Australian Society Sugar Cane Technologists*, Mackay, pp. 28-36.

Higgins, A.J., Prestwidge, D., Laredo, L. and Sandell, G. (2006). An integrated harvesting and transport supply chain model. *Proceedings of the 28th Australian Society Sugar Cane Technologists*, Mackay, pp. 606-607.

Sandell, G.R. and Prestwidge, D.B. (2004) Harvest Haul Model – the cost of Harvesting paddocks of sugarcane across a sugar milling region. *Proceedings of the 27th Australian Society of Sugar Cane Technologists*. (CD).

Modelling aims to reduce harvesting and transport costs. *Australian Canegrower*, December 2003, Vol 25, No 24, p16.

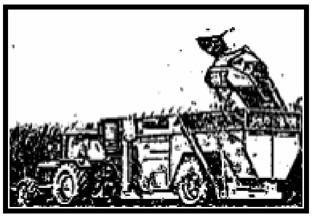
References

Higgins, A.J. (2002) Australian sugar mills optimize harvester rosters to improve production. *Interfaces*, **32**, 15-25.

Higgins, A.J. & Postma, S. (2003) Siding roster optimisation: case studies in the Mackay region *2003 Conference of the Australian Society of Sugar Cane Technologists held at Townsville, Queensland, Australia, 6-9 May 2003*. PK Editorial Services Pty Ltd, Brisbane Australia.

Appendix A   Harvest Haul Model – User Manual

Harvest Haul Model User's Guide



Gary Sandell[1], Di Prestwidge[2] and Luis Laredo[2]
[1] Harvesting Solutions, [2] CSIRO Sustainable Ecosystems

1. **Harvest Haul Model Overview**
2. **Data requirements**
   a. **Data sources**
3. **Model functions and processes**
   a. **Model Functions**
   b. **Running the Model**
      i. **Attaching and Detaching Input Databases**
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      v. **Outputting Reports**
4. **Appendix A1 – Input Variables and Tables**
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6. **Appendix A3 – Output Report Examples**

1. Harvest Haul Model - Overview

Harvest Haul Model estimates time performance and harvesting costs at a block level and aggregates results to the farm or group and regional level. It was developed by Gary Sandell (BSES) and Di Prestwidge (CSIRO CSE) as part of SRDC (Sugar Research and Development Corporation) project CSE005 "Integrating and optimising Farm to Mill decisions to maximise profitability" and is also used in projects CSE010, NSC006 and BSS261.

The model can be used to compare different harvesting scenarios as well as run sensitivity analyses dealing with cost and time performance. It can use actual values from harvesting operations or where actual measurements are not known the model uses default values based on the latest available in harvesting research. Data generated from GPS harvester tracking systems can also be used to determine actual harvesting parameters. GIS techniques have been developed to measure region-wide paddock row-lengths and block to delivery point haul-out distances. Capital equipment value schedules have been developed to estimate capital and salvage values of equipment using age, engine hours and horsepower.

Some of the research issues and industry needs that have lead to the development of the Harvest Haul Model are:-

- Modelling harvesting costs changes for farm re-design ie. changes in paddock (row) configurations.
- Comparison of current harvesting practices to harvest best practice (ie. slowing Elevator pour rates and fan speeds)
- Modelling harvesting costs changes for whole of crop collection for co-generation or other sugarcane trash products
- Harvesting group restructure or amalgamations (ie. more tonnes harvested and re-organisation of harvesting equipment
- Delivery point (siding or pad) location and capacity re-arrangements ie. costs of changing haul-out distances
- Effect on haul costs when changing billet length (ie. bin density).
- Haul-out number optimisation within a group ie. most cost effective number of haul-outs
- Different start and finish times ie. harvesting hours with different waiting times

The database application consists of a main front-end database (currently named “HHModel-v09-Beta.mdb”) that contains the model functions and data processing routines. Data for different harvesting scenarios are held in back-end input databases with a naming convention of “HHM-Inputs……….mdb” where “…….” describes the scenario ie. “–MKD-FullTrash-ExistingHrs”. The input databases contain several input data tables with generic formats:- TBLBlockID, TBLBlockInputs; TBLGroupInputs; TBlGroupCapitalInputs and TBLMill as well as a table used for setting up the model:- TBLPreferences along with two tables where model results are held:- TBLBlockOutputs and TBLGroupOutputs.

2. Harvest Haul Model - Data Requirements

2a – Data Sources:-

The Harvest Haul Model uses data collated from several sources:- Mill block productivity data; block to siding/pad allocations (which siding or pad the cane is delivered to); Geographic Information Systems (GIS) data; mill or region information; harvesting group setup information; as well as harvesting group operating parameters. These are described below in more detail.

Mill productivity data for each block:-

Mill	
Harvesting Group	
Farm number	
Split number	
Block number	
Paddock number	
Tonnes	tonnes
area	hectares
CCS	units
Green/burnt	logical
Class	(optional)
Ratoon	(optional)

Block or Paddock Information

Each block is given an Identifier – which Farm and Harvesting Group is belongs to.

Example of Block ID data:-

BlockID	Mill	Group	Farm	Split	Block	Paddock
xxx-00019-02-A	0	8	19	0	2	1
xxx-00022-13-A	0	8	22	0	13	1
xxx-00022-13-B	0	8	22	0	13	2
xxx-00025-01-A	0	8	25	0	1	1
xxx-00025-02-A	0	8	25	0	2	1
xxx-00025-02-B	0	8	25	0	2	2
xxx-00025-03-A	0	8	25	0	3	1

Block to Siding/Pad Allocations:-

- the Siding Id or Pad Id that each block is hauled to (to calculate Haul distance using GIS methods)

GIS data (Geographical Information Systems):-

- Cane Block boundaries (to calculate average row length using GIS methods)
- Siding/Pad centroids (lat. and long.)

(Note: if actual row length and haul distance data is available these can be included in the model)

Mill or Region information:-

- Days in harvest season
- Cane payment coefficient (eg. 0.009)
- Cane payment adjustment (eg. 0.459)
- Sugar price AUD per tonne

- Harvester pay rate (dollars per tonne.)

Harvesting Group setup information:-

- **Number, Name**
- **Roster days (on and off)**
- **Harvesting capital equipment –**
  - **Harvester;** wheeled or track, make, model, year
  - **Haul unit;** (for each unit), primer mover (truck or tractor) make, model, horsepower (within 10 or so horsepower)
  - **Haulout Bin;** side-tip, elevator or RORO, capacity (in cubic meters or tonnes)
  - **Other** significant capital, service vehicles, track buggies, etc.
- (The HHModel uses current market value, salvage value and current engine hours to calculate costs for depreciation, financing and non-cash (opportunity) capital costs. Look-up schedules have been developed for current and salvage values. Group engine hours are calculated by estimating engine hours per season and multiplying by age of the harvester.)

Harvesting group operating parameters:- (default values used but can be changed for different regions)

Row width	1.53	metres
Cane loss	2.5	%
Elevator pour rate	120	tonnes/hour
Maximum ground speed	9.2	km/hour
Backing speed[#]	0	km/hour
Turning time	60	seconds
Unload time	150	seconds
Cost of diesel	0.50	$/tonne
Harvester idle fuel burn rate	11	litres/hour
Harvester work fuel burn rate	52	litres/hour
haul idle fuel burn rate	7	litres/hour
haul work fuel burn rate	17	litres/hour
Vehicle daily fuel burn rate	9	litres/day
Other equipment 1 fuel burn rate	0	litres/day
Other equipment 2 fuel burn rate	0	litres/day
Harvester wage rate*	14.8955	$/hour
Haul-out wage rate*	14.4276	$/hour
Maximum shift length	24	hours
Wage on-costs*	30	%
Seasonal harvester repairs & maintenance	1.23	$/tonne
Seasonal haul-out repairs & maintenance	0.70	$/tonne
Seasonal overhead costs		$
Seasonal cost of harvester blades	0.07	$/tonne
Interest rate	8	%
% time spent servicing**	8	%
% time spent moving**	4	%
% time spent repairing**	3	%

Assumes that all harvesting occurred two-way.

* Uses award rates with overtime.

* The model estimates cut + turn + wait time for each block then increases this amount by these percentages to account for time to service, move and repair.

3. Model functions and process – how it works

3a Functions

The Harvest Haul Model runs through several functions to model the logistics of harvesting then aggregates block information to a group level. Block harvesting hours are adjusted according to group waiting, repair and service times. Group wages, overheads, repair and maintenance costs are taken into account along with capital, depreciation and fuel costs. Details of this process is as follows:-

1 – Logistics - calculates for each block - yield, number of rows, tonnes per row, number of rows to fill one haul-out, ground speed, EM, time spent cutting, turning, backing and waiting, time spent servicing, moving and repairing, harvest hours, field efficiency, engine hours, delivery rate, tonnes per engine hour, blade factor per engine hour

2 – Aggregates block data to group - calculates the number harvest days for the group, from the block data calculates the total tonnes, total area for the group, the total engine hours for the group, the total blade factor per engine hour for the group

3 – Adjusts harvest hours –for each block converts group wait time to block wait time; checks and adjusts block bin wait time according to block service time; adjusts block harvest hours by adding the adjusted block bin wait time; updates block bin wait time with adjusted bin wait time

4 – Updates group output - for each group

- Wages (harvest hours & shifts) - calculates the harvest hours per day and the number of shifts required. Aggregates block harvest hours to group;
- Overheads - divides gross group overheads by group's seasonal engine hours to give hourly overhead cost;
- Repairs and Maintenance - divides harvest R&M and haulout R&M by group's seasonal engine hours to give hourly R&M cost;
- Capital - calculates cash and non-cash costs for one engine hour for harvester and for haul-outs. Capital costs of Other equipment is split 50/50 harv/haul.;
- Depreciation - calculate depreciation cost per hour. Calculates harvester and haulout depreciation cost to include 50% of other equipment depreciation;
- Fuel - converts Other equipment fuel from daily burn rate to equivalent per engine hour rate.

5 – Costs - for each block

- Fuel - distributes fuel for the harvester and haul-outs on a l/hr basis with rates for idle and working. Adds 50% of Other equipment litre/engine hour fuel to harvester and to haulout. Looks up fuel burn rates and number of haulouts per block. Calculates total litres of fuel used in the block. Multiplies gross litres by cost then divide by tonnes, hours and hectares to derive unit cost.
- Wages – calculates normal time – calculates normal time plus time and a half - if group shift length greater than 11hrs then normal time plus time and a half plus double time. Calculates wage cost on a per tonne, per hour and per ha basis.
- Repairs and Maintenance – harvester and haulout R&M is proportioned by engine hours.
- Blades - A blade factor is added to particular blocks (default = 1) to account for excessive blade use due to rocks. A motivator for growers to reduce rocks in the cane field.
- Overheads - Overheads, such as insurance, telephone and electricity are distributed per engine hour. Only total overhead costs (i.e. harvester overheads + haulout overheads) are calculated as it assumed that overheads are split 50/50 between harvester and haul-outs. Calculates gross overhead cost per block by multiplying by block engine hours.
- Capital - This section is based on block variables. Distributes capital costs by block on a per engine hour basis.
- Depreciation - calculates depreciation cost per hour. Calculates harvester and haulout depreciation cost to include 50% of other equipment depreciation.
- Total costs – per block, Cash and Non-Cash

A financial function can then be incorporated for comparison between sectors.

6 – Financial - Calculates the sharing of proceeds between growers, harvesters and millers. Look up cane and harvester payment variables**.** Look up cane loss and EM by block under standard practice and harvest best practice and block tonnes and CCS under standard practice. Calculates clean cane yield and tonnes sugar per hectare for each block. Calculates harvest best practice yield and CCS. Calculates harvester income, gross margin and net cash for harvest best practice and standard practice. Calculates gross grower income. Calculates grower income net of harvesting. Calculates mill income.

3b Running the Model

The Main screen of the Harvest Haul Model contains section showing the currently attached Input database as well as four tab pages (as shown in Figure A1) for managing input data; running the model in single model and batch mode; and outputting information.

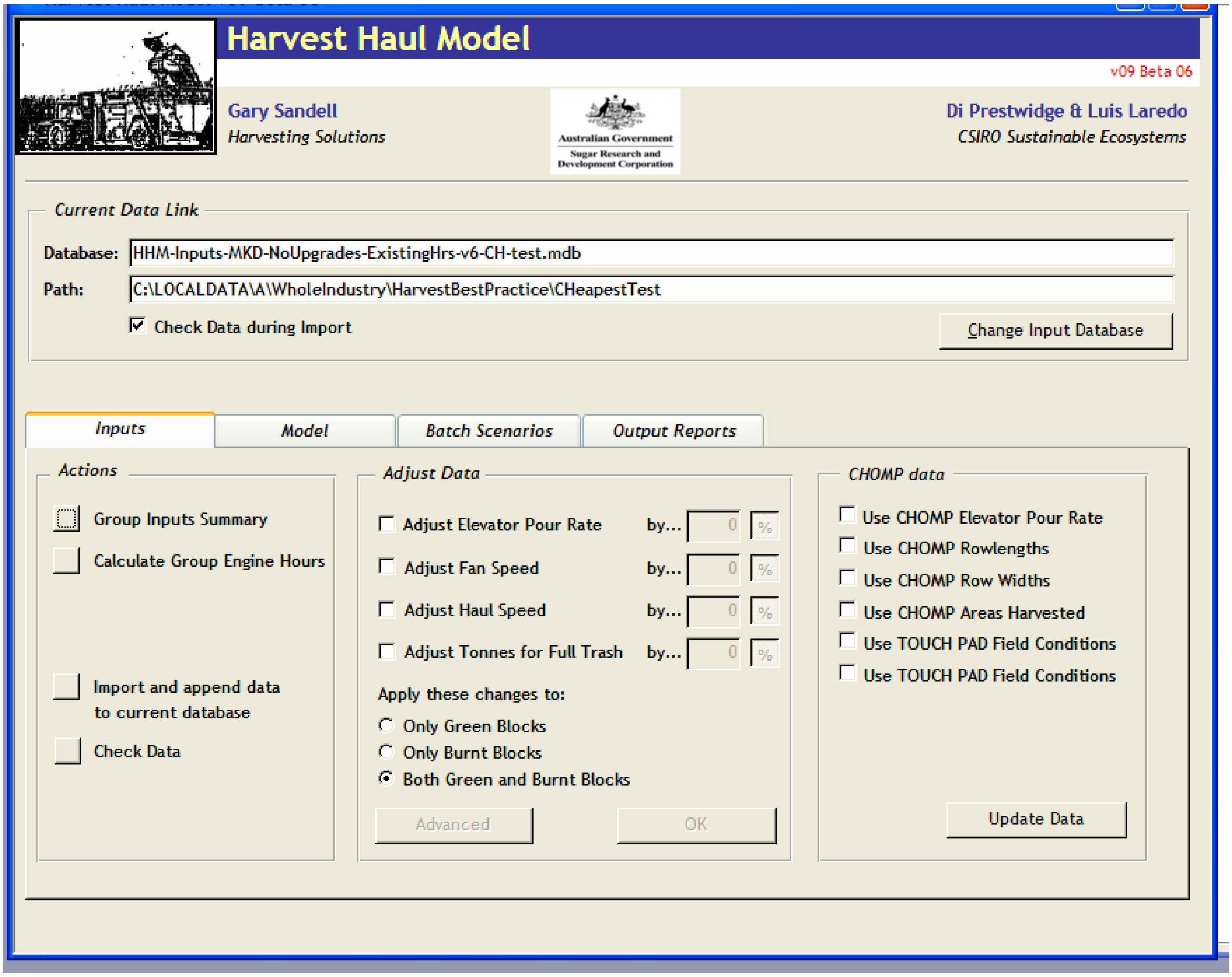


Figure A1 The Main Screen of the Harvest Haul Model showing the four tab pages used in setting up and running the model as well as the Inputs page

There are several process and options available for running the Harvest Haul Model.

i. Attaching and Detaching Input Databases
ii. Inputs
iii. Running the Model in Single mode
iv. Running the Model in Batch mode
v. Outputting Reports

i. Attaching and Detaching Input Databases

The Harvest Haul Model uses data from the Input Database which is currently linked to the front-end database. Input Databases contains five tables to store input variables:- TBLBlockID, TBLBlockInputs; TBLGroupInputs; TBlGroupCapitalInputs and TBLMill. These input variables and tables are described in

Appendix A1. along with the variable names and descriptions, the data types are listed as well as the minimum, maximum and default values. The Input Databases also contain two output tables:- TBLBlockOutputs and TBLGroupOutputs as well as a TBLPreferences tables containing information about the current Input database. These 7 tables the same format in all Input Databases so the model can handle them the same way.

Clicking on the button "Change Input Database" in the "Current Data Link" section of the main screen (shown in Figure A2) detaches the 7 tables for the currently attached Input Database then produces a Dialog box to find another Input Database to attach. Input Database names have the following naming convention:- "HHM-Inputs-MKD-FullTrash-ExistHrs.mdb". The last part of the name summarise the scenario the database represents.
After linking the tables, a checking function can be run on the input data tables, this can be done by either checking the "Check Data during Import" Check Box or using the "Check Data" button on the "Inputs" page.

ii. Inputs

The "Inputs" page has 3 sections:- "Actions", "Adjust Data", and "CHOMP data" as shown in Figure A1 above.

The "Actions" section has the following options:-
- "Group Inputs Summary" button – to produce a summary report of input data for all groups
- "Capital Equipment Schedule" button – used for calculating the capital and salvage values of equipment
- "Calculate Engine Hours" button – used in Capital Equipment Schedule???
- "Import and append data to current Input database" – used to include adjusted data for groups
- "Check Data" button – used to check for missing and out of range input data – produces a report in table "ERRORS????".

The "Adjust Data" section is used for adjusting block input data in the TBLBlockInputs table and has the following options:-
- "Adjust Elevator Pour Rate" by… a Value or a %
- "Adjust Fan Speed" by… a Value or a %
- "Adjust Haul Speed" by… a Value or a %
- "Adjust Tonnes for Full Trash" by… a Value or a %
- Apply these change to:
    - Only Green Blocks
    - Only Burnt Blocks
    - Both Green and Burnt Blocks

The "CHOMP Data" section is used for replacing estimated block data in the TBLBlockInputs table with actual data from the CHOMP (Cane Harvester On-line Monitoring Program) or the Benchmarking Touch Pad data and has the following options:-
- "Use CHOMP Elevator Pour Rate"
- "Use CHOMP Rowlengths"
- "Use CHOMP Row Widths"
- "Use CHOMP Areas Harvested"
- "Use TOUCH PAD Field Conditions"

iii. Running the Model in Single Mode

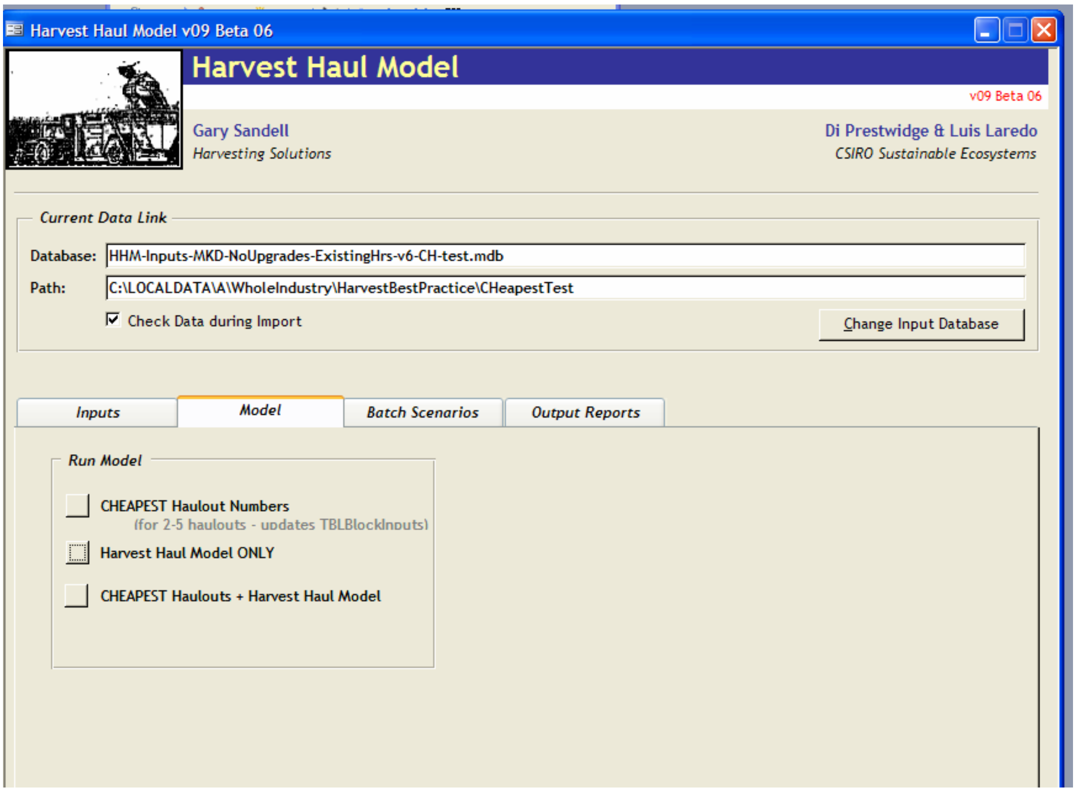


Figure A2 – The “Running the Model in Single mode” screen for the Harvest Haul Model

iv. Running the Model in Batch Mode

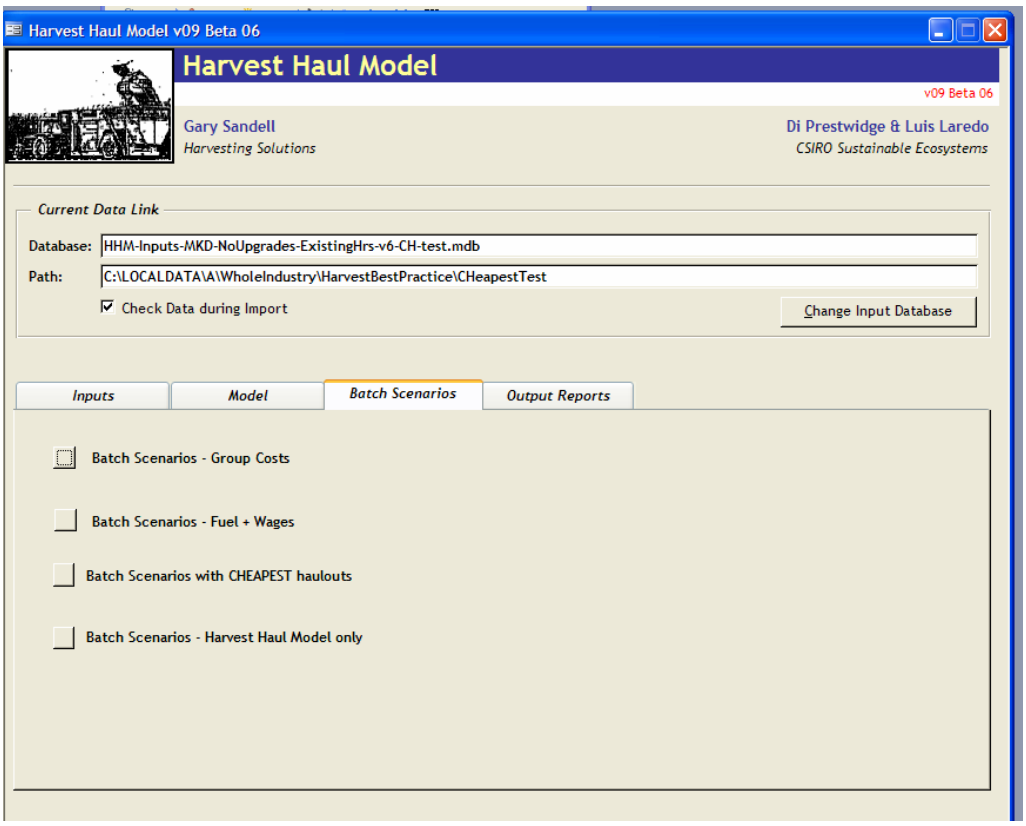


Figure A3 The Model in Batch mode” screen for the Harvest Haul Model

v. Outputting Reports

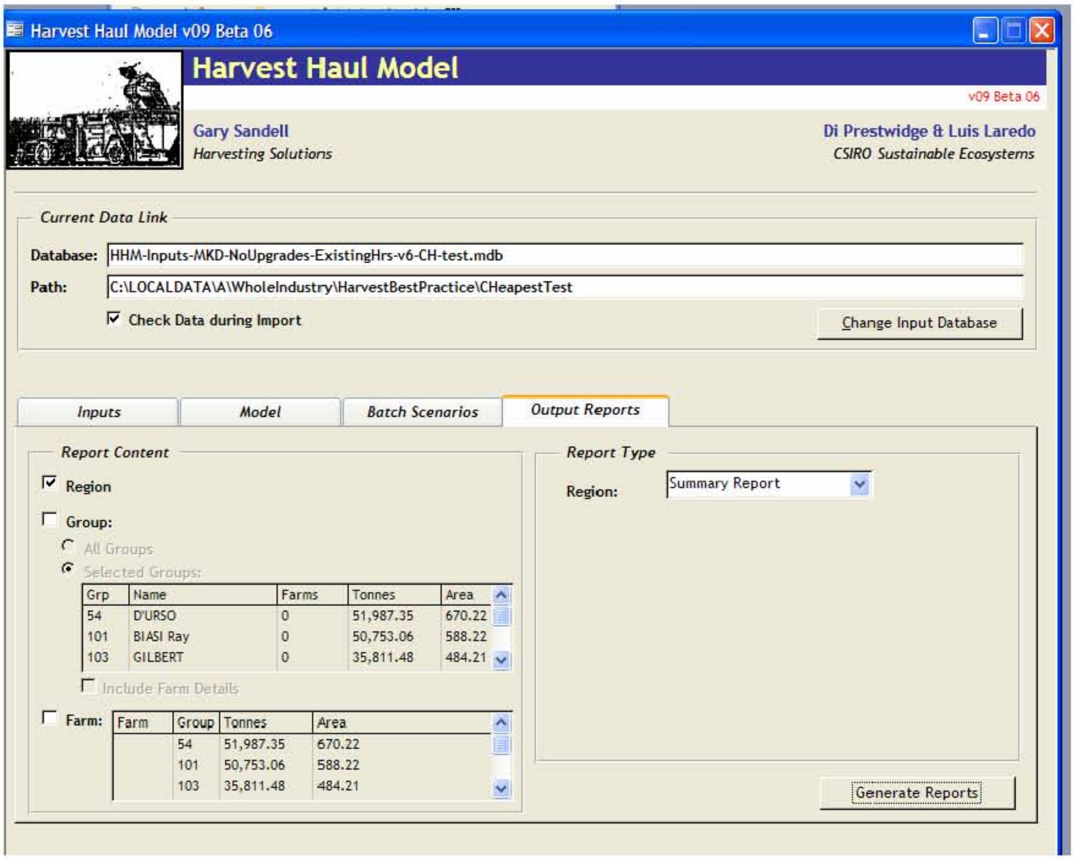


Figure A4 “Outputting Reports” screen for the Harvest Haul Model

Appendix A1 – Input Variables

TBLBlockId

Variable	DataType	Var_Desc	Required
BlockID	Text		Yes
Mill	Long Integer		No
Group	Long Integer		Yes
Farm	Text		No
Split	Text		No
Block	Long Integer		No
Paddock	Long Integer		No

TBLBlockInputs

Variable	DataType	Var_Desc	Required	MinValue	MaxValue	DefaultValue
BlockID	Text		Yes	0	0	0
blk_variety	Text		No	0	0	0
blk_class	Text		No	0	0	0
blk_green	Yes/No	Green(Yes) or Burnt (No)	No	0	0	Green
blk_delivery_pnt	Text	Haulout Delivery Point (Siding or Pad)	No	0	0	0
blk_tonnes	Single	block tonnage after harvest (t)	Yes	0	99999	0
blk_area	Single	block area (hectares)	Yes	0	99999	0
blk_row_length	Single	Av. Row length (m)	Yes	0	0	0
blk_row_width	Single	Av. Row width (m)	Yes	1	3	1.53
blk_haul_dist	Single	Haulout distance (km)	Yes	0	0	0
blk_fan_speed	Single	fan speed (rpm)	Yes	0	0	100
blk_elev_pour_rate	Single	elevator pour rate (tonnes/hr)	Yes	0	0	1100
blk_back_speed	Single	speed when backing (km/hr)	Yes	0	0	0
blk_turn_time	Single	av. Turn time (seconds)	Yes	0	0	60
blk_haul_num	Integer	number of haul-outs	Yes	0	0	0
blk_haul_speed	Integer	av. haul speed (km/hr)	Yes	0	0	20
blk_haul_unload	Integer	haul-out unloading time (seconds)	Yes	0	0	150
blk_blade_factor	Integer	blade factor for block, 1-default to 4	Yes	0	0	1
blk_ccs	Single	mill CCS of the block	No	0	0	0
blk_gs_max	Single	maximum ground speed	Yes	0	0	9.2

TBLGroupInputs

Variable	DataType	Var_Desc	Required	MinValue	MaxValue	DefaultValue
MillId	Long Integer		No	0	0	0
Group	Long Integer		Yes	0	0	0
GroupName	Text		No	0	0	0
grp_dayson	Byte	days harvesting	Yes	0	0	0
grp_daysoff	Byte	days rostered off	Yes	0	0	0
grp_serv_perc	Single	service time (%)	Yes	0	0	0
grp_move_perc	Single	moving time (%)	Yes	0	0	0
grp_repair_perc	Single	repair time (%)	Yes	0	0	0
grp_haul_capacity	Single	haul-out nominal capacity (Tonnes)	Yes	0	0	0
grp_haul_num	Long Integer	total number of haul-outs owned by the group	Yes	0	0	0
grp_fuel_cost	Single	fuel cost after rebate ($/litre)	Yes	0	0	0
grp_harv_fbr_idle	Single	harvester idle fuel burn rate (litre/hr)	Yes	0	0	0
grp_harv_fbr_work	Single	harvester working fuel burn rate (litre/hr)	Yes	0	0	0
grp_haul_fbr_idle	Single	haul-out idle fuel burn rate (litre/hr)	Yes	0	0	0

Variable	DataType	Var_Desc	Required	MinValue	MaxValue	DefaultValue
grp_haul_fbr_work	Single	haul-out working fuel burn rate (litre/hr)	Yes	0	0	0
grp_vehicle_daily_fbr	Single	service vehicle daily fuel burn rate (litre/day)	Yes	0	0	0
grp_other1_daily_fbr	Single	other 1 equipment daily fuel burn rate (litre/day)	Yes	0	0	0
grp_other2_daily_fbr	Single	other 2 equipment daily fuel burn rate (litre/day)	Yes	0	0	0
grp_harv_wage_rate	Single	harvester hourly wage rate incl. on-costs ($/hr)	Yes	0	0	0
grp_haul_wage_rate	Single	haul hourly wage rate incl. on-costs ($/day)	Yes	0	0	0
grp_max_day_length	Single	max working day before 2 shifts start (hrs)	Yes	0	0	0
grp_harv_gross_RM	Single	gross seasonal harvester R&M excluding blades($)	Yes	0	0	0
grp_haul_gross_RM	Single	gross seasonal R&M all haulouts ($)	Yes	0	0	0
grp_gross_blade_cost	Single	gross seasonal cost of blades ($)	Yes	0	0	0
grp_oheads_gross	Single	total overhead cost for the group ($)	Yes	0	0	0
grp_bin_wait	Single	wait time for the group (hrs/day)	Yes	0	0	0
grp_interest_rate	Single	interest rate on capital equipment (%)	Yes	0	0	0
grp_wage_oncosts	Single	% wage on-costs eg super etc. (%)	Yes	0	0	0

TBLGroupCapitalInputs

Variable	DataType	Var_Desc
grp_equip_type		Each piece of equipment owned by the Group – harvester (harv), haul-out tractor1 (haul1), haul-out tractor 2 (haul2),...haul-out bin 1 (bin1), haul-out bin2 (bin2), ..., service vehicle (vehicle), other vehicle 1 (other1), other vehicle 2 (other2) ....
grp_equip_desc		name of equipment
grp_capital		current capital value of equipment
grp_salvage		salvage value of equipment at end of life
grp_equity		% equity in each piece of equipment
grp_start_enghrs		engine hours at start of season
grp_end_enghrs		Calculated in model
grp_anticipated_use		anticipated life of machine in engine hours

TBLGroupCapitalInputs - example

Group	grp_equip_type	grp_equip_desc	grp_capital	grp_salvage	grp_equity	grp_start_enghrs	grp_end_enghrs	grp_anticipated_use
X	bin1	6t side tipper	10000	5000	70	0	0	10000
x	bin2	6t side tipper	10000	5000	70	0	0	10000
x	bin3	6t side tipper	10000	5000	70	0	0	10000
x	harv	Austoft 7700 - 1996	140000	55000	70	0	0	10000
x	haul1	JCB Fastrack	50000	8000	70	0	0	10000
x	haul2	JCB Fastrack	50000	8000	70	0	0	10000
x	haul3	JCB Fastrack	50000	8000	70	0	0	10000
x	other1	other1	90000	7000	60	0	0	10000
x	other2	other2	0	0	0	0	0	10000
x	vehicle	vehicle	20000	5000	70	0	0	10000

TBLMill

Variable	DataType	Var_Desc	Required	MinValue	MaxValue	DefaultValue
Mill	Long Integer		No	0	0	0
season_length	Long Integer	region season length (days)	Yes	0	0	0
mill_efficiency	Single	cane payment formula (0.009)	No	0	0	0
mill_equity_adjustment	Single	cane payment formula (+ 0.459)	No	0	0	0
mill_sugar_price	Single	AUD sugar price AUD $/t	No	0	0	0
mill_harvester_pay_rate	Single	dollars per tonne harvester payment rate $/t	No	0	0	0
mill_net_harvester_grossmargin	Single	mill area change in harvester gross margin under the introduction of hbp	No	0	0	0
mill_net_harvester_netcash	Single	mill area change in harvester net cash under the introduction of hbp	No	0	0	0
mill_net_grower_income	Single	mill area change in grower income under the	No	0	0	0

Variable	DataType	Var_Desc	Required	MinValue	MaxValue	DefaultValue
		introduction of hbp				
mill_net_grower_less_harvesting	Single	mill area change in grower income less harvesting cost under the introduction of hbp	No	0	0	0
mill_net_mill_income	Long Integer	mill area change in mill income under the introduction of hbp	No	0	0	0
mill_net_industry	Single	mill net industry change	No	0	0	0

Appendix A2 – Output Variables:-

TBLBlockOutputs

Variable	DataType	Var_Desc
BlockID	text	
blk_totalcost_gross	Single	total dollars required to harvest the block ($)
blk_totalcost_tonnes	Single	cost of harvest per tonne ($/t)
blk_totalcost_enghrs	Single	cost of harvest per engine hour ($/t)
blk_totalcost_ha	Single	cost of harvest per hectare ($/t)
blk_yield	Single	Crop density (tonnes/ha) = blk_tonnes / blk_area
blk_cane_loss	Single	cane loss (tonnes/hr)
blk_em	Single	extraneous matter (%)
blk_harvest_hrs	Single	total harvest time for block (hrs)
blk_field_eff	Single	cut / shift length (%)
blk_eng_hrs	Single	engine hours (hrs)
blk_deliver_rate	Single	delivery rate (tonnes/hr)
blk_tonne_eng_hr	Single	tonnes per engine hour (tonnes/hr)
blk_gs	Single	ground speed (km/hr)
blk_back	Single	total backing time for block (hrs)
blk_turn	Single	total turning time for block (hrs)
blk_serv	Single	service time for block (hrs)
blk_move	Single	moving time for block (hrs)
blk_repair	Single	repair time for block (hrs)
blk_cut	Single	cutting time for block (hrs)
blk_bin_wait	Single	bin waiting time for block (hrs)
blk_harv_wait	Single	time harvester spends waiting haulout (hrs)
blk_haul_wait	Single	time haul spends waiting harvester (hrs)
blk_totalcost_cash_gross	Single	total cash dollars required to harvest the block ($)
blk_totalcost_cash_tonnes	Single	cash cost of harvest per tonne ($/t)
blk_totalcost_cash_enghrs	Single	cash cost of harvest per engine hour ($/t)
blk_totalcost_cash_ha	Single	cash cost of harvest per hectare ($/t)
blk_totalcost_noncash_gross	Single	total non-cash dollars required to harvest the block ($)
blk_totalcost_noncash_tonnes	Single	non-cash cost of harvest per tonne ($/t)
blk_totalcost_noncash_enghrs	Single	non-cash cost of harvest per engine hour ($/t)
blk_totalcost_noncash_ha	Single	non-cash cost of harvest per hectare ($/t)
blk_harv_dep_tonnes	Single	harvester depreciation cost per tonne ($/tonne)
blk_harv_dep_ha	Single	harvester depreciation cost per ha ($/ha)
blk_harv_fuel_litre_tonnes	Single	harvester gross fuel burnt per tonne (litre/tonne)
blk_haul_fuel_litre_tonnes	Single	haul gross fuel burnt per tonne (litre/tonne)
blk_harv_fuel_cost_gross	Single	($)
blk_harv_fuel_cost_tonnes	Single	($/tonne)
blk_harv_fuel_cost_hrs	Single	($/hr)
blk_harv_fuel_cost_ha	Single	($/ha)
blk_haul_fuel_cost_gross	Single	($)
blk_haul_fuel_cost_tonnes	Single	($/tonne)
blk_haul_fuel_cost_hrs	Single	($/hr)
blk_haul_fuel_cost_ha	Single	($/ha)
blk_total_fuel_litre_tonnes	Single	total fuel burnt per tonne (litre/tonne)
blk_total_fuel_cost_gross	Single	($)
blk_total_fuel_cost_tonnes	Single	($/tonne)
blk_total_fuel_cost_hrs	Single	($/hr)
blk_total_fuel_cost_ha	Single	($/ha)
blk_harv_wage_cost	Single	gross harvester wage cost ($)
blk_harv_wage_tonnes	Single	gross harvester wage cost per tonne ($/tonne)
blk_harv_wage_hrs	Single	harvester wage cost per hour ($/hr)
blk_harv_wage_ha	Single	harvester wage cost per ha ($/ha)
blk_haul_wage_cost	Single	gross haul wage cost ($)
blk_haul_wage_tonnes	Single	gross haul wage cost per tonne ($/tonne)

Variable	DataType	Var_Desc
blk_haul_wage_hrs	Single	haul wage cost per hour ($/hr)
blk_haul_wage_ha	Single	haul wage cost per ha ($/ha)
blk_total_wage_cost	Single	gross wage cost ($)
blk_total_wage_tonnes	Single	gross wage cost per tonne ($/tonne)
blk_total_wage_hrs	Single	gross wage cost per hour ($/hr)
blk_total_wage_ha	Single	gross wage cost per ha ($/ha)
blk_harv_rm_tonnes	Single	harvester R&M per tonne
blk_harv_rm_ha	Single	harvester R&M per hectare ($/ha)
blk_harv_rm_gross	Single	harvester R&M block total ($)
blk_haul_rm_tonnes	Single	haul R&M per tonne
blk_haul_rm_ha	Single	haul R&M per hectare ($/ha)
blk_haul_rm_gross	Single	haul R&M block total ($)
blk_total_rm_tonnes	Single	total R&M per tonne
blk_total_rm_ha	Single	total R&M per hectare ($/ha)
blk_total_rm_gross	Single	total R&M block total ($)
blk_blade_cost	Single	blade cost by block ($)
blk_blade_tonnes	Single	blade cost by block per tonne ($/tonne)
blk_blade_hrs	Single	blade cost by block per engine hour ($/hr)
blk_blade_ha	Single	blade cost by block per ha ($/ha)
blk_bladefactor_by_enghrs	Single	block blade factor multiplied by block engine hours '= blk_blade_factor * blk_eng_hrs
blk_oheads_gross	Single	block gross overhead cost = grp_oheads_eng_hrs * blk_eng_hrs
blk_oheads_tonnes	Single	block overhead cost per tonne ($)
blk_oheads_ha	Single	block overhead cost per hectare ($)
blk_harv_capital_cash_gross	Single	block total havester capital cash cost ($)
blk_harv_capital_noncash_gross	Single	block total havester capital non-cash cost ($)
blk_haul_capital_cash_gross	Single	block total haul capital cash cost ($)
blk_haul_capital_noncash_gross	Single	block total haul capital non-cash cost ($)
blk_harv_capital_cash_tonnes	Single	harvester capital cash cost per tonne ($/tonne)
blk_harv_capital_noncash_tonnes	Single	harvester capital non-cash cost per tonne ($/tonne)
blk_harv_capital_cash_ha	Single	harvester capital cash cost per ha ($/ha)
blk_harv_capital_noncash_ha	Single	harvester capital non-cash cost per ha ($/ha)
blk_haul_capital_cash_tonnes	Single	haul capital cash cost per tonne ($/tonne)
blk_haul_capital_noncash_tonnes	Single	haul capital non-cash cost per tonne ($/tonne)
blk_haul_capital_cash_ha	Single	haul capital cash cost per ha ($/ha)
blk_haul_capital_noncash_ha	Single	haul capital non-cash cost per ha ($/ha)
blk_total_capital_cash_tonnes	Single	total capital cash cost per tonne ($/tonne)
blk_total_capital_noncash_tonnes	Single	total capital non-cash cost per ha ($/ha)
blk_total_capital_cash_ha	Single	block total capital cash cost ($)
blk_total_capital_noncash_ha	Single	block total capital non-cash cost ($)
blk_total_capital_cash_gross	Single	block total capital non-cash cost ($)
blk_total_capital_noncash_gross	Single	block total capital non-cash cost ($)
blk_harv_dep_gross	Single	total harvester depreciation cost for the block ($)
blk_haul_dep_gross	Single	total haul depreciation cost for the block ($)
blk_total_dep_gross	Single	total depreciation cost for the block ($)
blk_haul_dep_tonnes	Single	haul depreciation cost per tonne ($/tonne)
blk_haul_dep_ha	Single	haul depreciation cost per ha ($/ha)
blk_total_dep_tonnes	Single	total depreciation cost per tonne ($/tonne)
blk_total_dep_ha	Single	total depreciation cost per ha ($/ha)

TBLGroupOutputs

Variable	DataType	Var_Desc
Group	Number	Group number
grp_tonnes	Number	Group size (tonnes)
grp_eng_hrs	Number	group engine hrs / season (hrs)
grp_harvest_hrs	Number	total seasonal harvest hours by group (hrs)
grp_area	Number	area harvested by the group (ha)
grp_harvest_hrs_per_day	Number	harvest hours per day (hrs)

grp_harvest_days	Number	cutting days (days)
grp_shift_num	Number	number of shifts per day
grp_shift_length	Number	length of shifts per day (hr)
grp_harv_rm_eng_hrs	Number	harv R&M per engine hour ($/hrs)
grp_haul_rm_eng_hrs	Number	haul R&M per engine hour ($/hrs)
grp_total_rm_eng_hrs	Number	total R&M per engine hour ($/hr)
grp_other_fuel_eng_hrs	Number	group seasonal fuel use for vehicle, other1, other2 per harvester engine hour (l/hr)
grp_bladefactor_by_enghrs	Number	group total of blk_bladefactor_by_enghrs
grp_oheads_eng_hrs	Number	total group overheads divided by group engine hours
grp_harv_capital_cash_enghrs	Number	harvester capital cash cost per engine hour ($/hr)
grp_harv_capital_noncash_enghrs	Number	harvester capital non-cash cost per engine hour ($/hr)
grp_haul_capital_cash_enghrs	Number	haul capital cash cost per engine hour ($/hr)
grp_haul_capital_noncash_enghrs	Number	haul capital non-cash cost per engine hour ($/hr)
grp_total_capital_cash_enghrs	Number	total capital cash cost per engine hour ($/hr)
grp_total_capital_noncash_enghrs	Number	total capital non-cash cost per engine hour ($/hr)
grp_harv_depreciation_enghrs	Number	harvester depreciation cost per engine hour ($/hr)
grp_haul_depreciation_enghrs	Number	haul depreciation cost per engine hour ($/hr)
grp_total_depreciation_enghrs	Number	total depreciation cost per engine hour ($/hr)
grp_paid_hrs_per_shift	Number	total paid hours per shift

Appendix A3 – Output Report examples:-

Example of a Region Summary Report:-

Regional Summary Report

	TOTAL		
	$ / tonne	$ / eng. hr	$
NON-CASH			
Depreciation	#Error	#Error	#Error
Capital	#Error	#Error	#Error
TOTAL NON-CASH	#Error	#Error	#Error
CASH			
Capital	#Error	#Error	#Error
Overheads	#Error	#Error	
Wages	#Error	#Error	#Error
Fuel	#Error	#Error	#Error
R & M	#Error	#Error	#Error
Blades	#Error	#Error	
TOTAL CASH	#Error	#Error	#Error
TOTAL COST	#Error	#Error	#Error

INPUTS

Tonnes	t	Row Length	#Error m	Harvest Hours	hours
Area	ha	Haul distance	#Error km	Shifts / day	
Yield	#Error t/ha	Season Length	days	Shift Length	hours

REPORTED OUTPUTS

Field Efficiency	#Error %	Tonnes per engine hour	#Error t/hr	Harvester fuel	#Error lt
Engine hours	hrs	Tonnes per crew hour	#Error t/hr	Haulout fuel	#Error lt
Elevator pour rate	#Error t/hr			Total fuel	#Error lt

Example of a Group Detailed Report:-

Regional Detailed Report - Harvest Haul Model

Regional Detailed Report

	TOTAL				HARVESTER				HAUL-OUTS			
	$ / tonne	$ / eng. hr	$ / ha	$	$ / tonne	$ / eng. hr	$ / ha	$	$ / tonne	$ / eng. hr	$ / ha	$
NON-CASH												
Depreciation	#Error	#Error	#Error	#Error	#Error	#Error	#Error		#Error	#Error	#Error	
Capital	#Error	#Error	#Error	#Error	#Error	#Error	#Error		#Error	#Error	#Error	
TOTAL NON-CASH	#Error	#Error	#Error	#Error	#Error	#Error	#Error	#Error	#Error	#Error	#Error	#Error
CASH												
Capital	#Error	#Error	#Error	#Error	#Error	#Error	#Error		#Error	#Error	#Error	
Overheads	#Error	#Error	#Error		#Error	#Error	#Error	#Error	#Error	#Error	#Error	#Error
Wages	#Error	#Error	#Error	#Error	#Error	#Error	#Error		#Error	#Error	#Error	
Fuel	#Error	#Error	#Error	#Error	#Error	#Error	#Error		#Error	#Error	#Error	
R & M	#Error	#Error	#Error	#Error	#Error	#Error	#Error		#Error	#Error	#Error	
Blades	#Error	#Error	#Error		#Error	#Error	#Error					
TOTAL CASH	#Error	#Error	#Error	#Error	#Error	#Error	#Error	#Error	#Error	#Error	#Error	#Error
TOTAL COST	#Error	#Error	#Error	#Error	#Error	#Error	#Error	#Error	#Error	#Error	#Error	#Error

Appendix B Maryborough Road Transport

As part of the value chain integration project CSE010, the Maryborough Sugar Region (driven by Maryborough Sugar Factory) have desired a modelling capability to 1) explore the transport impact of co-generation and increased cane from the former Moreton region; 2) reduce transport costs through more efficient scheduling; and 3) increase mill crush rate through a more reliable cane supply. While the scenario analysis is part of CSE010, the model development and solution was achieved under CSE005. Also, CSE010 does not focus on the development of new models and the transport models are integrated into the harvesting and transport modelling framework of CSE005.

Two transport models were developed: 1) a strategic level capacity planning model written in the Vensim modelling package and transformed into Excel; and 2) a tactical/operational level scheduling model to schedule the pick up of trailers from the farms for delivery to the mill. The Vensim diagram of the strategic model is contained in Figure B1. This Vensim model has been converted to an Excel Spreadsheet and validated by Maryborough Sugar Factory.

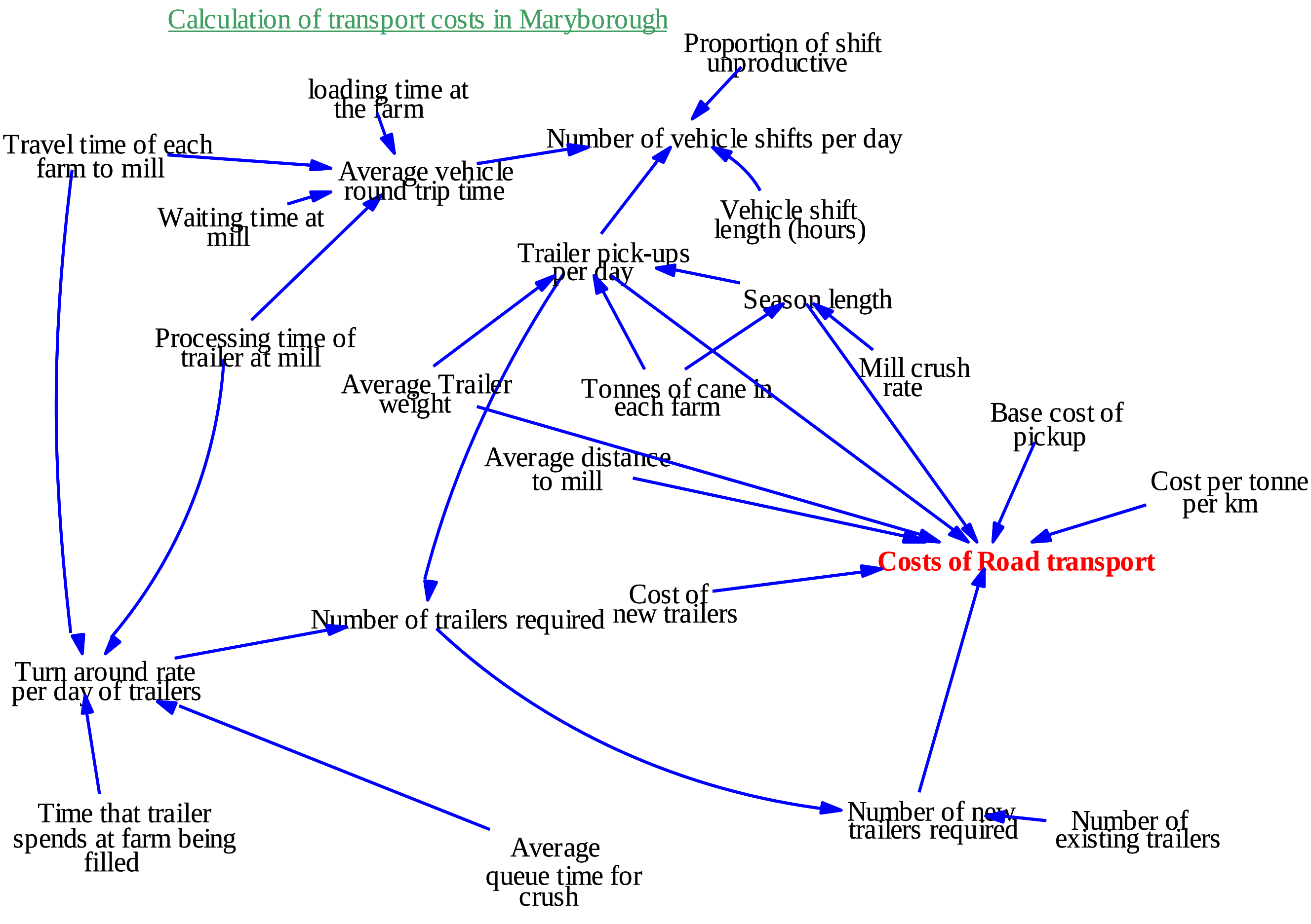


Figure B1. Functional relationships for capacity planning in a road transport system

The tactical/operational planning model is a transport schedule optimisation model coded in a programming language. The credibility of the model has also been validated by the Maryborough Sugar Factory who plan to use the model for its scheduling activities during the 2006/07 harvest seasons. A user-friendly version will be developed through a new SRDC project, FPP111. The model was applied in conjunction with the Maryborough sugar region to assess the transport consequences of the following scenarios:

- Base case - 2 quick hitchers (QH), max of 3 full trailers at loading pads, existing harvester start times
- Harvester start times modified for harvesting over 18 hour time window 5am to 11pm
- Harvester start times modified for harvesting over 24 hour time window
- 15 equally sized harvesting groups harvesting over 18 hour time window, 5am to 11pm
- 60000 tonne group at Yandina coming into the system, starting at 10am
- 60000 tonne group at Yandina coming into the system, starting at 6am

The transport impacts of each scenario is contained in Table B1 which shows substantial reductions in the number of road vehicles and trailers required when moving towards a 24 hour harvesting time window. The total vehicle hours are not substantially reduces which means there better utilisation of vehicles around the clock. The impact of transporting a large harvesting group to from Yandina (formerly went to Moreton) to Maryborough is also shown, with a distance of about 150km. While slightly more trailers are required, the number of vehicles very much depends on the start time of the large group.

Table B1. Transport impacts of each scenario

Scenario	Number of vehicles required	Number of trailers required	Total vehicle hours (including QH)	Total vehicle idle time (h)
Base	17	137	325	13
18 hr window	13	82	315	1
24hr window	11	42	316	4
15 groups over 18 hours	14	92	327	3
Yandina group starting at 10am	19	139	361	1
Yandina group starting at 6am	25	140	376	15

Appendix C Mourilyan Case Study

Detailed Transport Impacts

The tables below show the impact on the transport sector (using the model of Section 4) given the scenarios formulated by the Mourilyan steering group.

Table C1: Impacts of long-term scenarios formulated by the Mourilyan steering group.

	Loco shifts				Bins required					
Scenario	7am-3pm	3pm-11pm	11pm-7am	Total shifts	6t	OB	4t	Av. Cut to crush delay (hrs)	Cost Saving ($/tc)	Saving with 10% I charge on capital
Existing 2002 but with 850kt,360tc/h (base)	6	5	4	15	549	419	450	8.8		
Whole crop harvest (30% EM)	8	6	4	18	759	461	506	7.3	-0.42	-0.67
10 harvesters 24 hr, 100 sidings	4	3	3	11	549	517		5.5	0.44	0.44
10 harvesters 24 hr, 100sidings upgraded	4	3	3	10	549	517		5.5	0.59	0.30
13 harvesters 18 hr, 100 sidings	6	4	2	12	549	517	480	9.2	0.22	0.22
13 harvesters 18 hr, 100 sidings upgraded	6	4	2	11	549	517	420	9.1	0.38	0.09
13 harvesters 18 hr, 50 sidings	6	4	2	12	549	517	480	9.2	0.22	0.22
13 harvesters 18 hr, 50 sidings upgraded	6	4	2	11	540	517	420	9.1	0.38	0.24

In the above table, the required loco shifts are split into the morning, afternoon and night shifts. There are three bin types in Mourilyan, 6t, onion bags (about 4t) and 4t bins. Some scenarios require capital investment and a 10% interest charge is assumed on this investment. All scenarios are compared to 2002 practice.

Table C2: Impacts of staggered hours of harvest and removing the inefficiencies of the current transport system

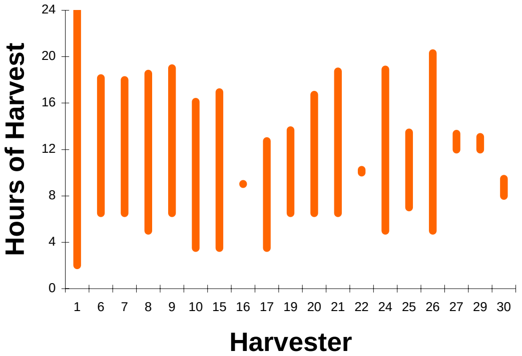
	Loco shifts				Bins required				
Scenario	7am-3pm	3pm-11pm	11pm-7am	Total shifts	6t	OB	4t	Av. Cut to crush delay (hrs)	Cost Saving ($/tc)
Existing 2002 but with 850kt,360tc/h (base)	6	5	4	15	549	419	450	8.76	
Double delivery	6	4	2	13	549	450	460	9.34	0.13
No taxi service	6	4	2	13	549	455	502	9.55	0.14
Harvesting staggered across 15hrs	6	5	4	15	549	382	370	7.65	0.02
Harvesting staggered across 18hrs	6	5	3	14	549	346	333	6.64	0.04
Harvesting staggered across 21hrs	6	5	3	14	549	346	313	6.09	0.05
Harvesting staggered across 23hrs	6	5	4	14	549	284	231	5.37	0.10
Harvesting staggered across 24hrs	6	5	4	14	549	284	190	5.23	0.11
Harvesting staggered across 18 hrs, no taxi	5	4	2	11	549	417	455	7.30	0.30
Harvesting staggered across 24 hrs, no taxi	4	4	3	11	549	352	333	5.97	0.34
Burdekin transport system	1	1	1	3	942			7.23	0.96

Table C3: Impacts of siding upgrades

	Loco shifts				Bins required				
Scenario	7am-3pm	3pm-11pm	11pm-7am	Total shifts	6t	OB	4t	Cost Saving ($/tc)	Saving with 10% I charge on capital
Existing 2002 but with 850kt,360tc/h (base)	6	5	4	15	549	419	450		
5 most utilised sidings upgraded	6	5	4	15	549	419	484	0.02	0.00
10 most utilised sidings upgraded	6	5	4	14	549	390	440	0.04	0.01
15 most utilised sidings upgraded	6	5	3	14	549	390	500	0.05	0.01
20 most utilised sidings upgraded	6	5	3	14	549	390	470	0.06	0.00
25 most utilised sidings upgraded	6	5	3	14	549	390	470	0.07	0.00
30 most utilised sidings upgraded	6	4	3	14	549	434	470	0.08	-0.01
40 most utilised sidings upgraded	6	4	3	13	549	420	470	0.10	-0.02
50 most utilised sidings upgraded	6	4	3	13	549	420	470	0.10	-0.04

Optimising start times of harvesters

The Transport Capacity Planning Model needed to be enhanced so that an optimal 18 hour harvesting time window could be developed, which is an improved version of that implemented in 2003. Figure C1 shows the 18 hour harvesting time window (set by the steering group) implemented in 2003 and the start times produced by the refined transport planning model. Because the hours of harvest need to be within the 3am to 9pm time window, harvest hours do not appear to be much different between those used in 2003 and calculated optimal (Figure C1). However the differences in Figure C1 do lead to substantial increases in efficiencies as shown in Table C4.



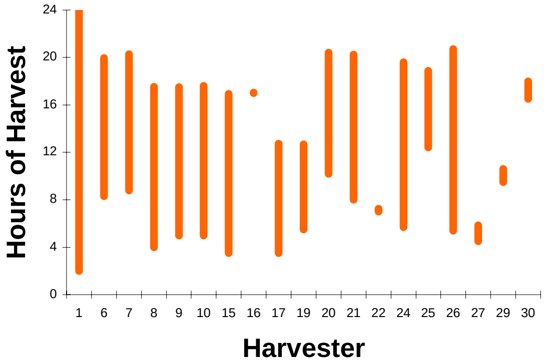


Figure C1. Scenario of 18 hour time window implemented in 2003 (left), and equivalent with optimised harvester start times (right)

Table C4. Impacts of optimising the start times of harvesters

Scenario	Loco shifts	Cut to Crush Delay (hrs)	Time spend waiting for bins (% of total harvest hours)	Bins
Existing groups and hours	13.9	8.5	7.5	1450
Existing groups and optimal hours	13.8	8.2	5.2	1441

The largest improvements were the waiting time for bins (Table C4). Going a step further, the start times of harvesters can be optimised on any set of objectives. This allows the sensitivity of transport impacts to be determined when trying to minimise either, locomotive shifts, bin fleet, waiting time for bins or cut-to-crush duration. These impacts are shown in Table C5.

Table C5. Sensitivity of optimising each transport objective individually.

	Loco shifts	Bins	Cut-to-crush delay (hrs)	Delays to Harvesters (%)
Weighted objective	14 (13.8)	1441	8.2	5.2
Minimise loco shifts	**14 (13.4)**	1335	8.2	10.2
Minimise bin usage	14 (13.7)	**1250**	8.2	10.6
Minimise cut to crush delay	14 (13.6)	1278	**7.2**	9.1
Minimise delays to harvesters	14 (13.9)	1395	8.7	**4.7**

The main message from Table C5 is that delays to harvesters (% of total harvest hours spent waiting for late bin deliveries) has the greatest fluctuation when changing the transport objective. Members of the Mourilyan steering group agreed that the table shows that the highest priority needs to be the minimising the waiting time for bins.

Extension of modelling to Sth Johnstone and Babinda

- In early 2004, the steering group decided to pursue regional wide scenarios (Mourilyan, Sth Johnstone and Babinda combined). The scenarios to be considered were:
- Supply chain impacts from reducing the number of sidings from 470 down to 300 and 250 respectively;
- Impacts of an extended time window of harvest for all 3 mills;
- Impacts on harvesting and transport from closing down Mourilyan mill.

The first two scenarios have been achieved prior to the Mourilyan case study ceased. The analysis required extension to the models to the Sth Johnstone and Babinda mills. In particular, the Transport Capacity Planning Model needed to be redeveloped to handle scenarios across multiple mills such as a) to c) above. Additional improvements to the Harvest Haul Model include a sub-routine that can automatically optimise the number of haul-outs required in each block and the number of haul-outs that a group should own. Also, average haul-out speed (from the paddock to the siding) is now automatically calculated as a function of haul distance.

The initial industry perception was that reducing the number of sidings would reduce transport costs (due to removing the high cost sidings) and would increase harvesting costs (due to increased haul out distances). When reducing the number of sidings, the Siding Location Optimisation model was used to select the 250 or 300 best sidings to keep. Considerable effort was placed into ensuring that the solution was sensible. That is, if certain farm paddocks were restricted to certain sidings due to creek crossings, this would be an additional constraint. Features of creek crossings, QR crossings and highway limitations were all accounted for. The solutions were validated (through a couple of iterations) by the industry representatives. The optimal location of 300 sidings is contained in Figure C2, in which the green lines represent the allocation of farm blocks to the individual sidings. This output was used as a basis to assess harvesting costs using the Harvest Haul Model and to produce siding rosters for the transport capacity planning model. Harvesting costs for the "number of siding" scenarios (Figure C3), which shows negligible impact (<1%) from reducing the number of sidings to 250, despite the >10% increase in average haul out distance (Figure C4). The number of sidings could not be reduced much below 250 due to limitation in accessibility to sidings for many farms.

Table C6 shows that reducing the number of sidings has a negligible impact on transport, in terms of locomotive shifts and bins. While this might be surprising, it is likely to be because many farm paddocks can only be hauled to sidings with high transport costs which ensures that these "high cost" sidings remain when reducing the sidings to 300 and 250. As a result of the "reduction of sidings" analysis, the industry representatives agreed that many of the 300 or 250 sidings would need to be upgraded to achieve and significant transport cost reductions.

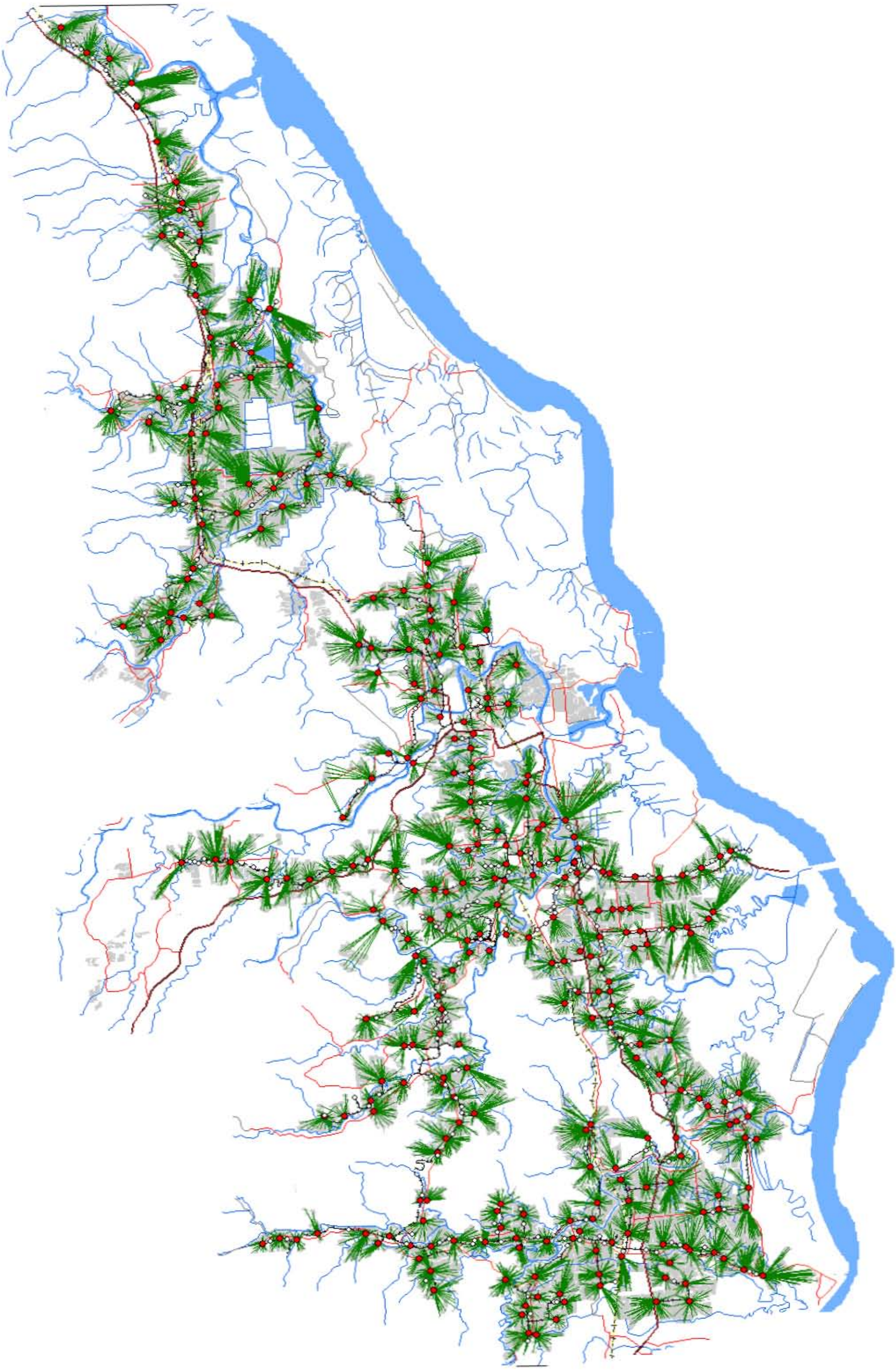


Figure C2. Optimal location of 300 sidings (red dots) and unselected sidings (yellow dots)

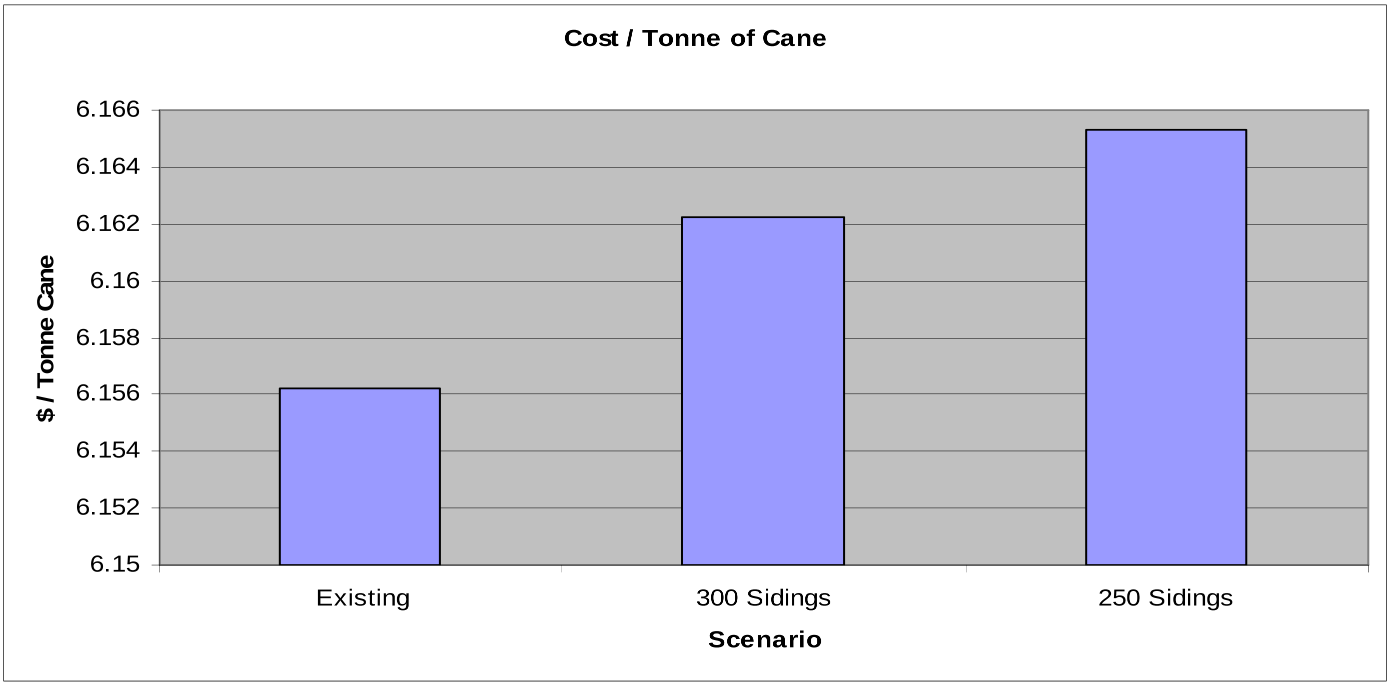


Figure C3. Costs of harvesting for the different number of sidings

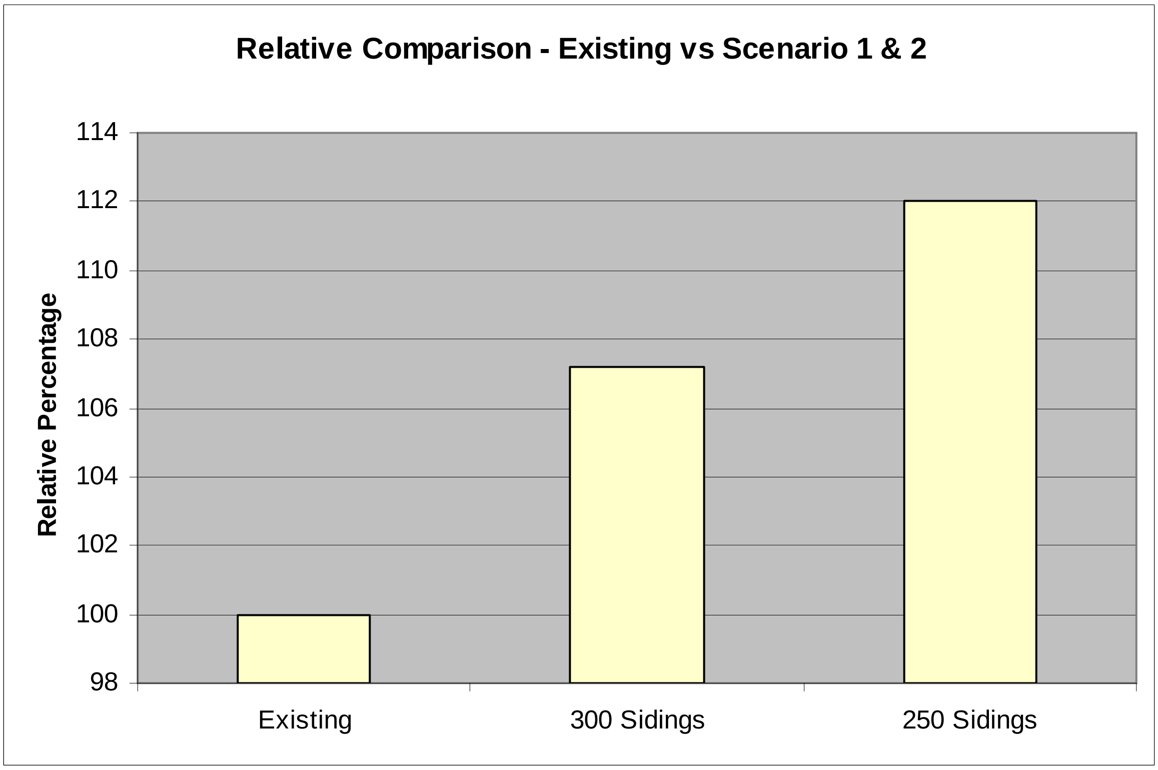


Figure C4. Increase in average haul out distance (versus existing) when reducing the number of sidings

Table C6. Transport impacts from reducing the number of sidings. Note, scenarios highlighted with a * are without a 50 bin delivery restriction to a siding

		Bins required		Locomotive shifts				
Mill	**Scenario**	**4t**	**6t**	**Morning**	**Afternoon**	**Night**	**Cut-to-crush (hrs)**	**Delays to harvesters (% of total crush)**
Babinda	**Base**	100	1087	5	6	4	11.4	8.8
	300 sidings	100	1086	5	5	4	11.3	8.6
	250 sidings	100	1087	5	5	4	11.3	8.7
	Base*	100	1087	4	6	4	12.2	14.3
	300 sidings*	100	1087	4	6	4	12.2	14.6
	250 sidings*	100	1087	4	6	4	12.0	13.6
Mourilyan	**Base**	886	477	6	6	3	8.2	1.4
	300 sidings	900	478	6	6	3	8.2	1.3
	250 sidings	873	478	6	6	3	8.2	1.2
	Base*	1020	479	5	5	3	9.1	3.1
	300 sidings*	1020	479	5	5	3	9.2	2.7
	250 sidings*	1016	479	5	5	3	9.3	3.2
Sth Jstone	**Base**	1500	0	9	8	5	9.0	12.5
	300 sidings	1500	0	9	8	5	9.0	12.7
	250 sidings	1500	0	9	8	5	8.9	12.7
	Base*	1500	0	8	9	5	9.1	14.9
	300 sidings*	1500	0	8	9	5	8.9	13.7
	250 sidings*	1500	0	8	9	5	8.8	14.0

The Transport Capacity Planning model was applied to assess the impacts of all three mills moving to an 18 hour or 24 hour harvesting time window (Scenario (b), above). Bundaberg Sugar transport officers applied two iterations of validation before the scenarios were regarded as reliable. The harvesting hours for "Existing", "18hr time window" and "24 hr time window" are contained in Figures C5, C6 and C7 respectively. The transport impacts are shown in Table C7. The main benefits to harvesting over a 24 hour time window is reduction in delays to harvesters and one less locomotive shift. The industry representatives regard extending the time window of harvesting for the remaining Bundaberg Sugar northern mills as one of the key options to be implemented as part of the regional plan for the Government assistance package.

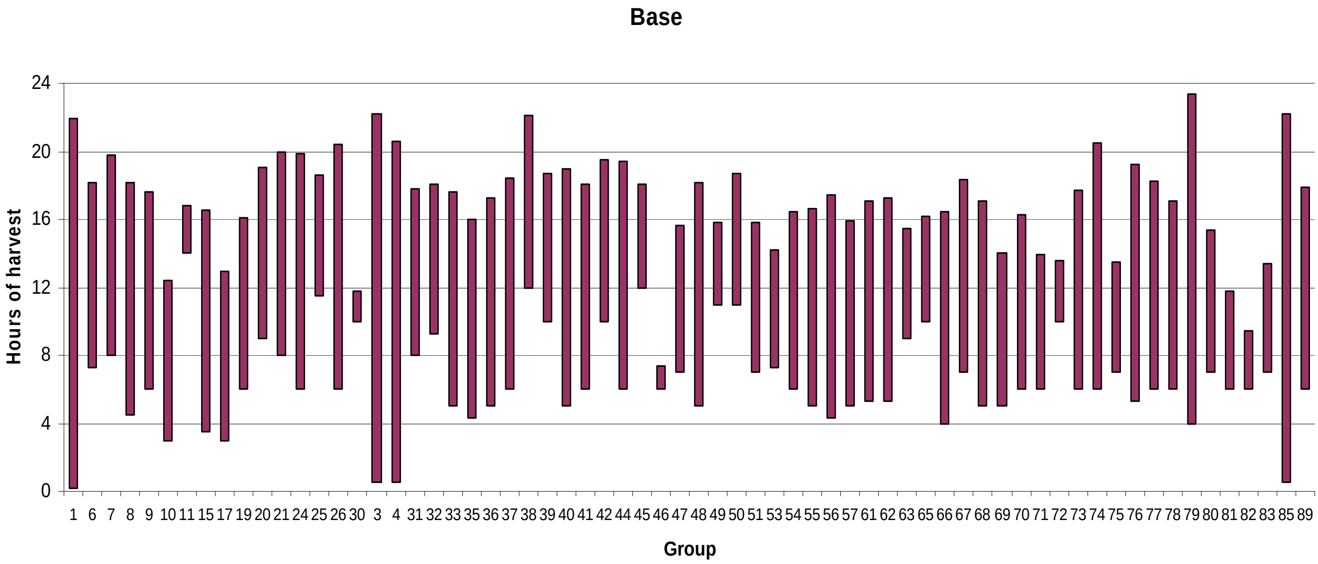


Figure C5. Hours of harvest for each of the groups in existing system, noting that the Mourilyan groups (groups 1 to 30) are already scheduled over an 18 hr time window.

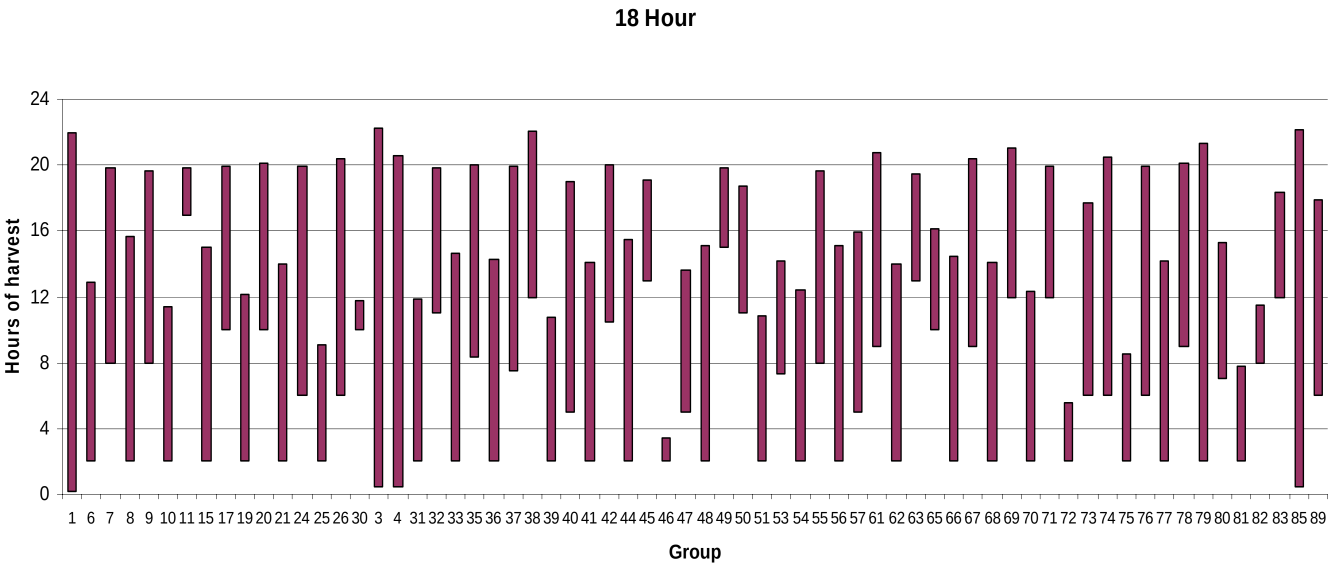


Figure C6. Harvesting groups scheduled over 18 hour time window, with the start times of Mourilyan groups rescheduled.

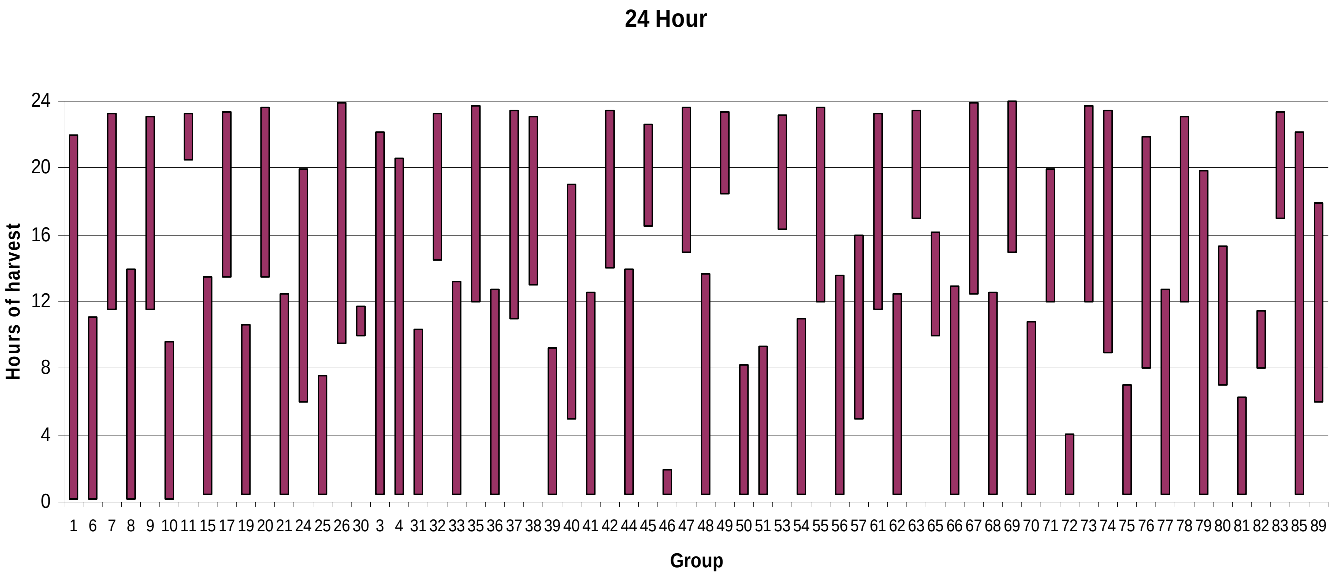


Figure C7. Harvesting groups scheduled over 24 hour time window.

Table C7. Impacts of increasing time window or harvest

		Bins Required		Locomotive shifts				
Mill	**Scenario**	**4t**	**6t**	**Morning**	**Afternoon**	**Night**	**Cut-to-crush (hrs)**	**Delays to harvesters (% of total crush)**
Babinda	**Base**	100	1087	5	6	4	11.4	8.8
	18 Hours	100	1087	6	5	2	10.9	3.3
	24 Hours	81	1086	6	4	3	9.0	0.6
Mourilyan	**Base**	886	477	6	6	3	8.2	1.4
	18 Hours	826	475	6	5	3	7.9	1.0
	24 Hours	751	479	5	5	4	6.4	1.0
Sth Jstone	**Base**	1500	0	9	8	5	9.0	12.5
	18 Hours	1492	0	9	8	4	8.2	1.2
	24 Hours	1498	0	7	8	6	7.3	1.0

Farm productivity comparisons

The purpose of research into the farm productivity comparisons is to identify specific factors to why some farms have significantly higher productivity than others. Rather than highlighting the well-known differences such as variety, soil type, and micro-climate, the aim is to identify factors (such as specific farm management, farm debt, business education levels in farming) that the industry could modify to increase productivity.

Spatial and intertemporal yield differences are well known in the industry, and results of the analysis of this issue in Mourilyan is reported here. A spatial visual comparison of a good and bad season in the late 1990s is shown in Figure C8.

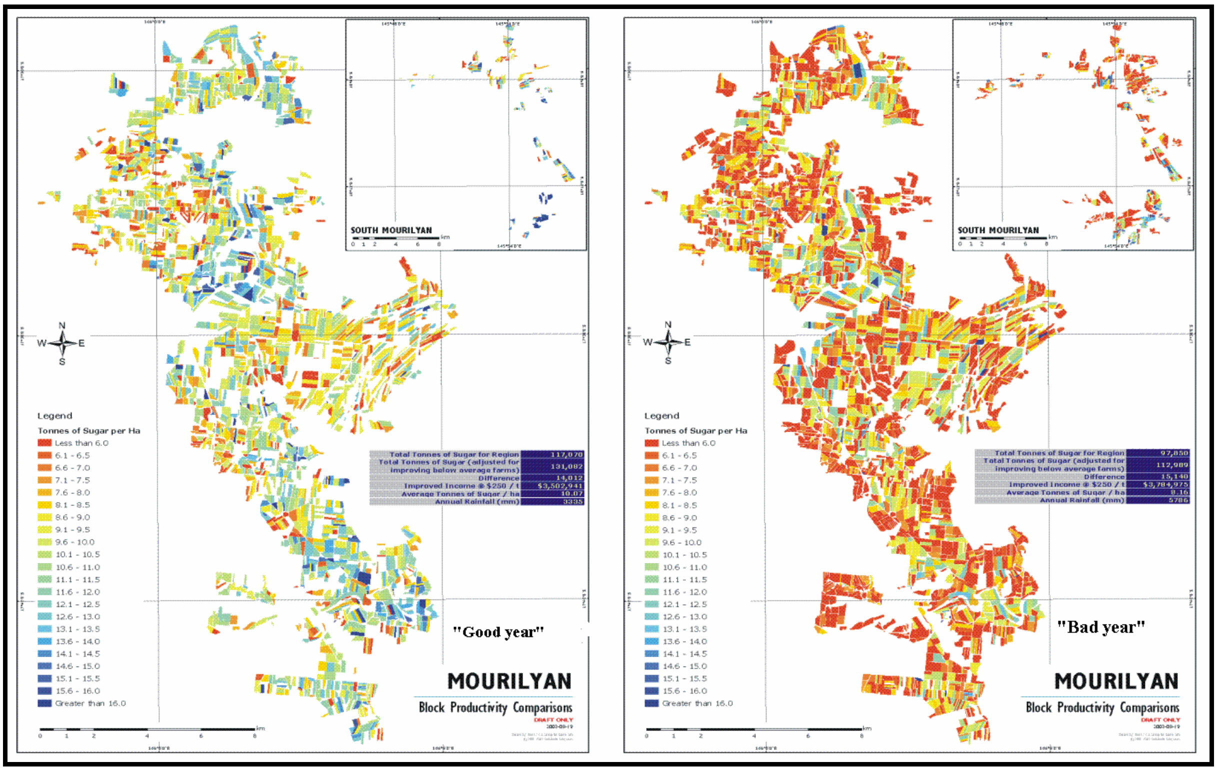


Figure C8. Intertemporal and spatial comparison of block yields in Mourilyan.

Although the two seasons were overall very different, there were high-yielding blocks in the bad season and low-yielding blocks in the good season. Some common pattern of the high and low-yielding blocks is observable between the two seasons. Nevertheless, there are striking differences in yield between neighbouring blocks throughout, implying differences in more than merely local climate or soils.

The impact of yield differentials on the regional industry is clearly large. If below-average yields in the above two seasons could have been brought up to the average yield, sugar production would have increased by 14 to 15%. Consequently, an additional $3.5m to $3.8m revenue would have flowed to regional stakeholders.

Further analysis probed the causes of the yield differences. A group of 19 farms was selected within a 2-km radius. The farms had more than 90% of their area under the same prevailing soil type. For this reason, and on account of their vicinity that all but eliminates microclimate effects, their natural resource endowment is very similar. Nevertheless, there are substantial differences between farms year-to-year and farm-to-farm in the same years. Figure C9 shows the yield span of the sample farms for five years.

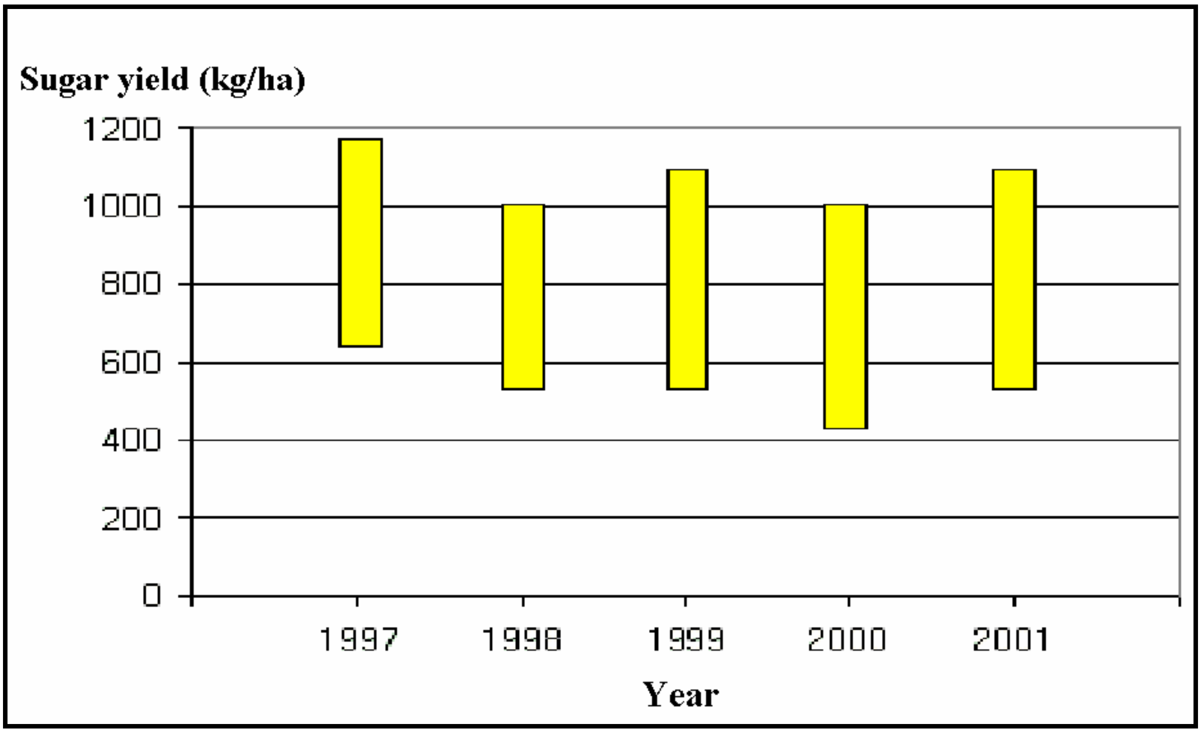


Figure C9. Yield span of 19 neighbouring farms in Mourilyan.

Although the time period included particularly good and bad seasons, year-to-year variation in sugar yield is much less than the difference in any given year between be highest and the lowest yield. Figure C10 indicates the relative position of the farms and their yield deviation from the sample average for five years. Even between neighbouring farms, a consistent difference in sugar yield is observable. The likely explanation for this yield difference is a substantial divergence in farmers' canegrowing practices or management. More research is needed to identify the components of canegrowing practice that lead to this difference, as well as the reasons behind the divergence in management. Plausible explanations for the latter would be (a) either lack of information about ways of more productive canegrowing, or (b) and conscious choice to run a low-input low-output enterprise (where inputs include both material inputs and farmer attention). It must also be kept in mind that profitability in canegrowing is not a direct function of yield: (a) increasing yield beyond a certain point is always unprofitable, and (b) maximum profit is not at maximum yield. Due to their substantial potential in raising incomes across the whole value chain, yield issues warrant further study: the identification of their causes must be followed by the identification of solutions to (a) remove grower disadvantage in resource endowment or information on best growing practice, and (b) to provide regional incentives to growers to increase cane yields.

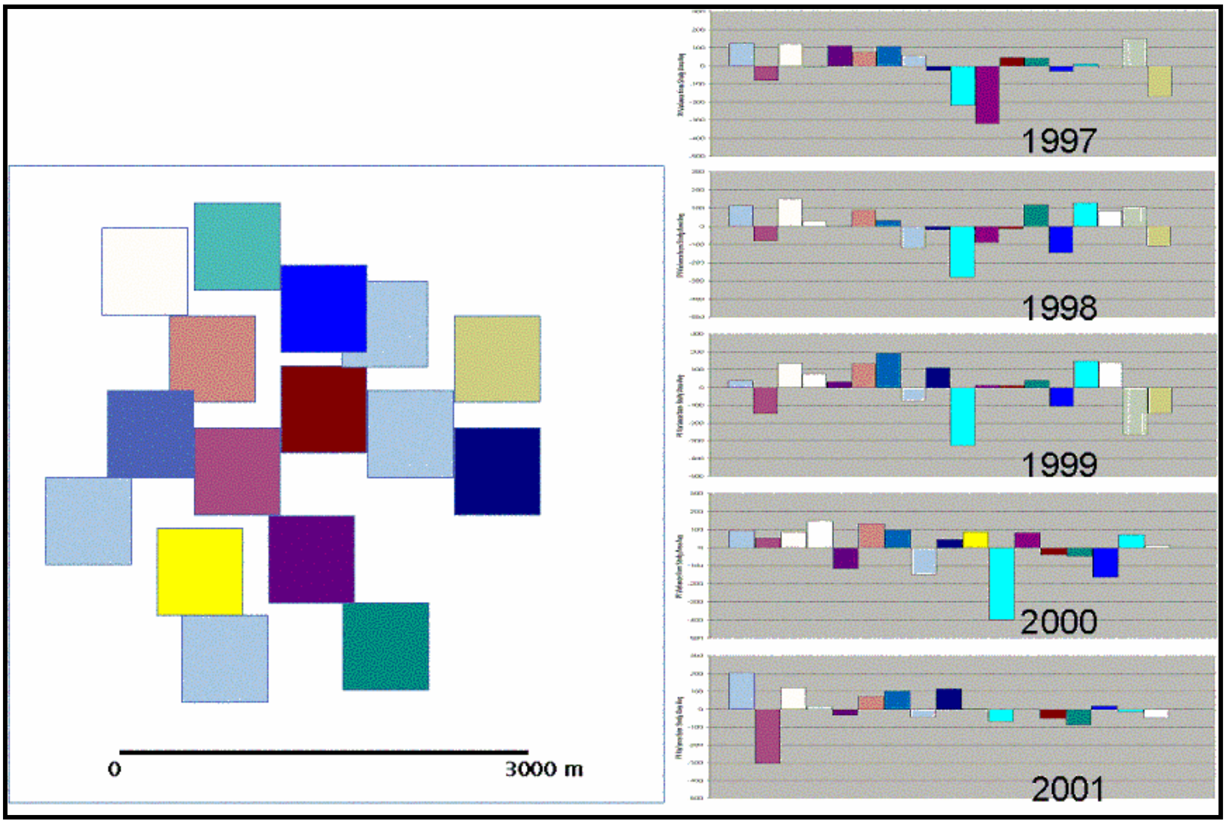


Figure C10. Spatial position and yearly sugar yield of a cluster of Mourilyan farms.

The initial assessment of neighbouring farms has been extended on the basis of statistical significance and empirical relevance. The four closest farms to each farm were assessed instead of the previous condition of a 2km distance between farm centroids. The new criterion for selecting farm pairs with substantially different sugar yield was greater than 2 tonnes of sugar yield per hectare difference for at least 3 out of 5 years. The location of the 32 farm pairs thus identified is shown in Figure C11, while Figure C12 indicates the yield difference and number of years in which yields were significantly different.

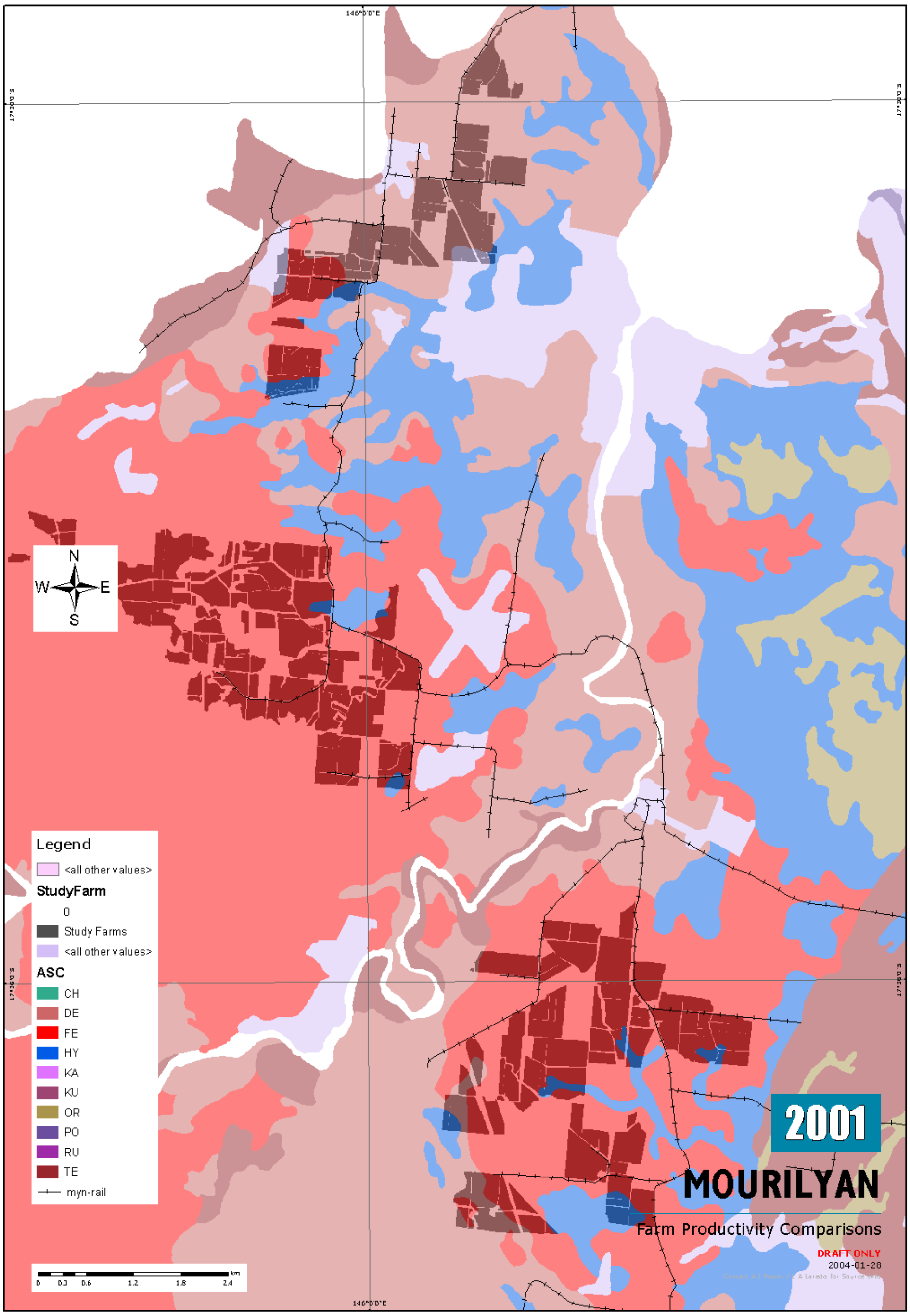


Figure C11. Location of farm pairs

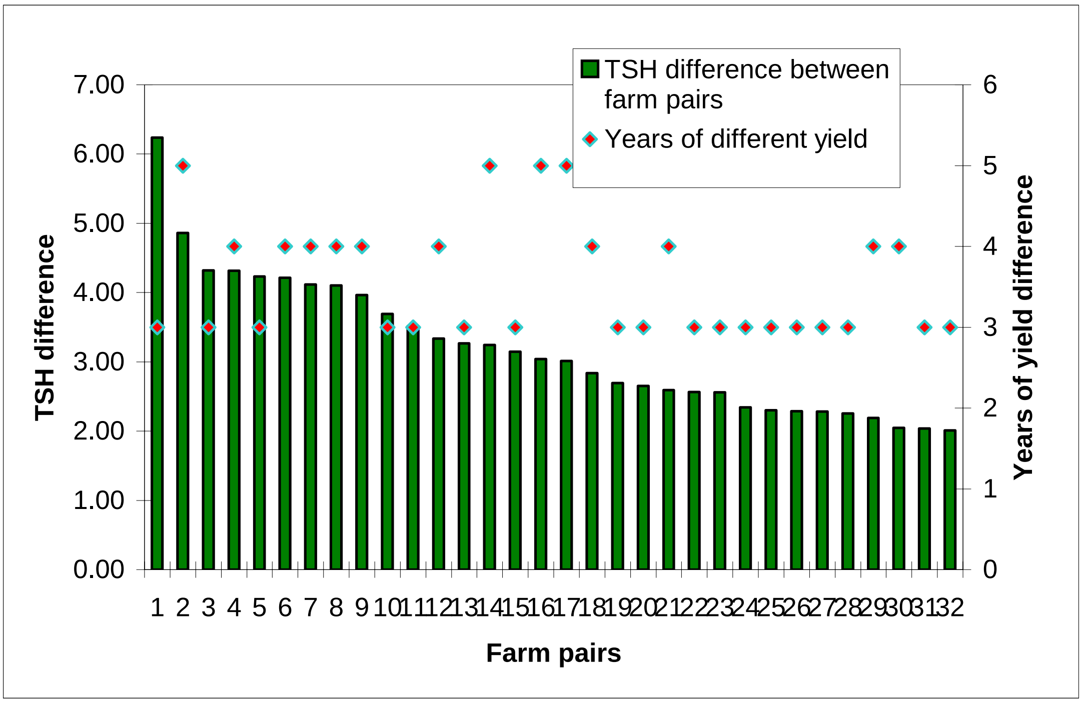
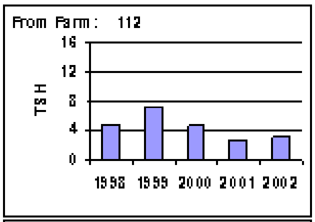


Figure C12. Sugar yield differences between the 32 pairs of farms selected for analysis

Extensive information has been assembled on the farm pairs to facilitate their consideration by stakeholders: a chart of sugar yields over the five-year period, area, cane tonnage and the distribution of cane varieties and crop classes (see Figure C13). This information has been provided to stakeholders to support the ongoing productivity initiative.

Mourilyan - Adjacent Farm Productivity Comparisons (1998 - 2002)

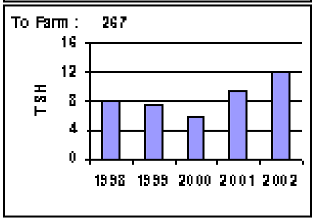
Farm Pair: 112-267 — 6.2 *TSH - Average difference (for more than 3 years out of the last 5 years)*



Season	*Area*	*Tonnes*
1998	8	357
1999	8	457
2000	8	271
2001	6	175
2002	6	105

Variety	*%*
Mixed	56%
Q158	25%
Q113	12%
Q138	5%
MXD	2%

Class	*%*
Plant	30%
3R+	21%
1R	17%
2R	10%
6R+	8%
Plant after Fallow	7%
4R	4%
5R	3%

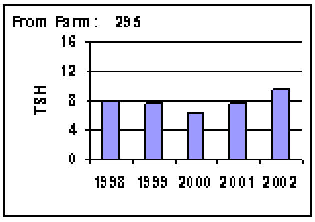


Season	*Area*	*Tonnes*
1998	29	2073
1999	28	1757
2000	24	1147
2001	27	1841
2002	25	2103

Variety	*%*
Mixed	27%
Q158	23%
Q166	13%
Q167	13%
MXD	7%
Q117	5%
Q152	4%
Q172	4%
Q174	2%
Q187	1%

Class	*%*
1R	28%
Plant	25%
2R	18%
3R+	16%
4R	12%
5R	1%

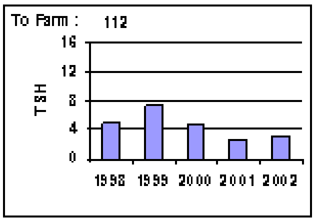
Farm Pair: 112-295 — 4.1 *TSH - Average difference (for more than 3 years out of the last 5 years)*



Season	*Area*	*Tonnes*
1998	32	2293
1999	32	2381
2000	27	1426
2001	27	1668
2002	30	2054

Variety	*%*
Q138	57%
Q158	30%
Q113	5%
Mixed	4%
MXD	2%
Q117	1%
Q166	0%
Q174	0%

Class	*%*
5R	17%
2R	13%
4R	12%
3R+	11%
Plant	11%
6R+	8%
1R	8%
Plant after Fallow	7%
Stand Over	5%
Fallow	3%



Season	*Area*	*Tonnes*
1998	8	357
1999	8	457
2000	8	271
2001	6	175
2002	6	105

Variety	*%*
Mixed	56%
Q158	25%
Q113	12%
Q138	5%
MXD	2%

Class	*%*
Plant	30%
3R+	21%
1R	17%
2R	10%
6R+	8%
Plant after Fallow	7%
4R	4%
5R	3%

Figure C13. Data on farm pairs

Appendix D Transport Scenarios for Mossman

A discussion paper
By
Andrew Higgins
CSIRO Sustainable Ecosystems and CRC Sugar

Background

In July 2002, the large 4-year project "Integrating and optimising farm-to-mill decisions for enhanced industry profitability" commenced and is jointly funded by SRDC, CRC Sugar, CSIRO and BSES. The project primarily focuses on improving efficiencies in the harvesting and transport system leading to reduced costs of production and increased profitability. Case studies are a key to the project and Mourilyan was the first case study when the project team joined their initiative in July 2002. Most of the modelling work at the early stages of the project were conducted through the Mourilyan case study. In August 2002, Mossman Agricultural Services presented the project team some preliminary regional plans for the 2003 harvest season, and asked the project team what they could contribute to aid the decision making for 2003. During September, 2002, the project team met with the Mossman industry at Mossman mill, and the main outcome was for the project team to explore scenarios to reduce transport costs, with particular emphasis on reducing loco shifts. Mossman officially became the second case study for the project and the project team worked closely with Mossman Agricultural Services to develop and adapt tools to the Mossman system.

As a result of the need to reduce transport costs during the 2003 harvest season, a Transport Capacity Planning Model was developed with considerable input and revisions from Mossman Agricultural Services to arrive at a model capable of producing scenarios for the Mossman region.

Scenarios

The following scenarios were tested:

1) Base scenario with harvest hours of 2002: Harvesting with 5 out of 7 days per week crush, and all harvesters cutting 5/7. Groups 238 and 254 are toll cane (removed) and the remaining groups cut the same harvest hours as in 2002. This scenario is the base case and all remaining scenarios are a variation from this. Hours of harvest illustrated in Figure D1 below.
2) No taxi service (i.e. double handling of bins) and double delivery: Harvesters will deliver to two adjacent sidings to prevent two trips from the loco. For example, if harvesting group 1 requires 60 bins but the siding only holds 30 bins, then the loco will drop the other 30 bins to a nearby siding and the harvester will deliver to this alternative siding (even if a longer haulout) once it has filled the first 30 bins. Also, a rake is not transported to the mill until there is enough room in the mill yard for the rake to fit.
3) Double delivery: Harvesters will deliver to two adjacent sidings to prevent two trips from the loco. That is, the scenario is the same as 3 except a rake is transported to the mill (or nearby storage) with the first available loco.
4) One siding per day: A harvester can only deliver to one siding per day, unless the two sidings are nearby one another.
5) Extended hours of harvesting 4am to 8pm - paired: See the Figure D2 below:
6) Harvesting across 24 hours: See Figure D3 below:

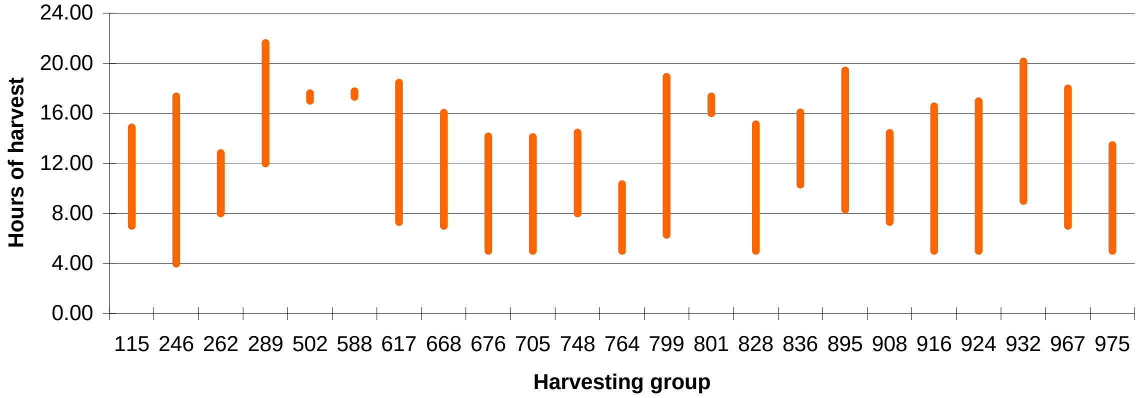


Figure D1. Hours of harvest in 2002 season

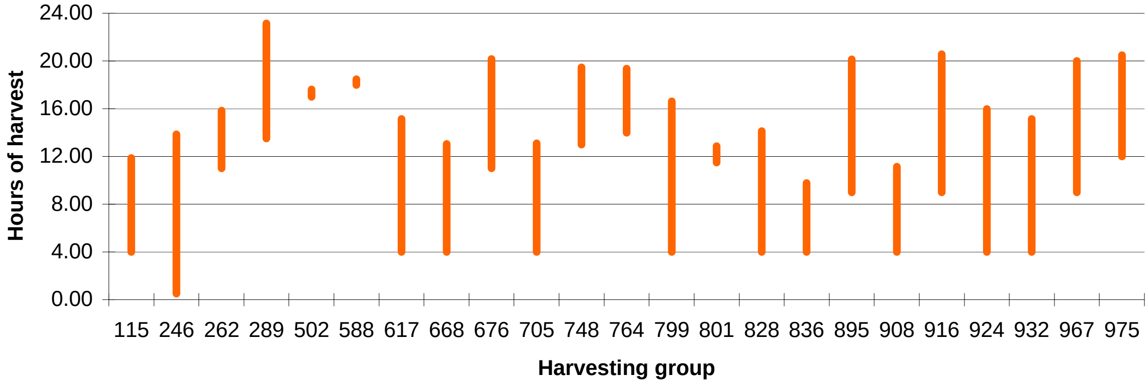


Figure D2. Proposed 4am to 8pm time window of harvest option

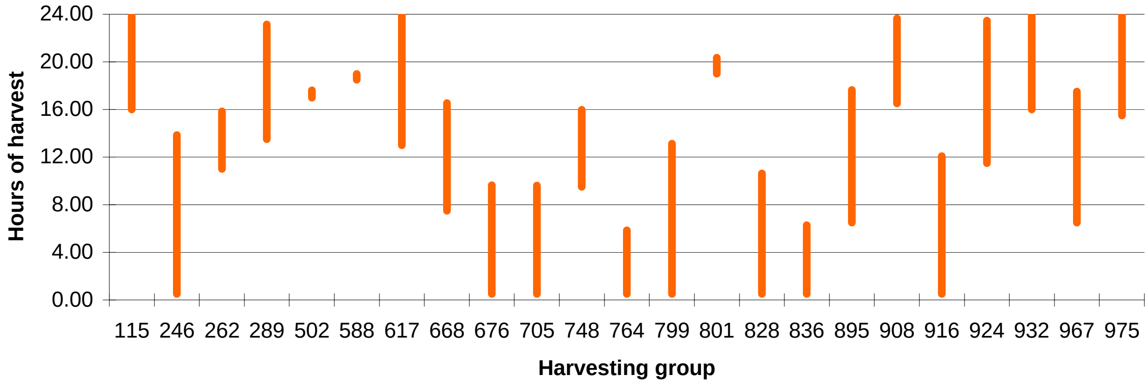


Figure D3. Harvesting across a 24 hour time window.

Combinations of the above scenarios are also made for example, extended hours of harvesting with no taxi service. The results for all of the scenarios are in the Table D1.

Table D1. Transport impacts from time window of harvest scenarios.

	Max bins required	Average number of shifts (8am - 4pm)	Average number of shifts (4pm - 12am)	Average number of shifts (12am - 8am)	Total shifts	Delays to harevsters waiting for bins (% of total harvest hours)	Average waiting time (hrs) for crushing
Base system with no changes from 2002	640	2.9	2.4	2.9	8.2	4.5	6.7
No taxi service and double delivery	640	2.4	2.3	2.0	6.8	10.6	6.5
Cut at one siding per day	640	2.8	2.2	2.8	7.9	5.6	6.3
Harvesting from 4am to 8pm	640	2.9	2.3	2.8	7.9	1.1	5.2
Harvesting from 4am to 8pm-Double delivery	640	2.7	2.2	2.6	7.5	6.1	5.6
Harvesting from 4am to 8pm-no taxi service and double delivery	640	2.7	2.1	1.8	6.5	5.3	5.6
Harvesting from 4am to 8pm-no taxi service, double delivery and max of 3 shifts	640	2.6	2.1	1.8	6.5	6.7	5.5
24 hour harvesting	482	2.4	2.2	2.2	6.8	0.0	2.4
24 hour harvesting - no taxi service and double delivery	619	2.2	2.0	2.2	6.4	0.0	2.8

All scenarios should be compared to the base system, which has the same harvest hours as in 2002. The number of loco shifts required accounts for meal breaks, servicing and crew changes. It does not account for idle time due to nothing to do. Therefore if the average number of shifts in Table D1 is 2.9, three shifts would be used. In the third scenario "Cut at one siding per day", the mill would put 3 shifts on at 8am to 4pm, 2 shifts for 4pm to 12 am and 3 shifts for 12am to 8am.

In Table D1, the average number of loco shifts is the average for that 8-hour period across all the days of the harvest season. For example in the base option the average number of loco shifts required from 8am to 4pm are 2.9, though some days will require more than 3 depending on the sidings where the harvesters are delivering to. In the third last option there is a restriction on the maximum number of shifts being 3 (the large loco and the 2 sets of tandems), which means that there are no more than three locos available at any one time. For all other options in Table D1, the locos available are the one large loco, 2 sets of tandems and the yard loco.

While a reasoning behind all of the above results are highlighted some below:

- While the basic gain from existing hours of harvest to "4am to 8pm" is not large (reduction of 0.3 of a loco shift per day and removal of delays to harvesters), there is a considerable gain if some of the existing inefficiencies are removed as well. For example, removing the taxi service as well will lead to the shift requirement per day being reduced from 8.2 (base) to 6.5. In this case, the mill could have three shifts from 8am to 4pm, and 2 shifts form 4pm to 12am and 2 shifts from 12am to 8am.
- The biggest gains are with 24 hour harvesting with no taxi service, which leads to reduction of almost two loco shifts per day (8.2 down to 6.4).
- While the number of bins required is only reduced for a couple of scenarios, the amount of times where 640 bins would be required is greatly reduced with the extended hours of harvest, as shown in Figure D4. This also dramatically reduces the delays due to bin shortages.

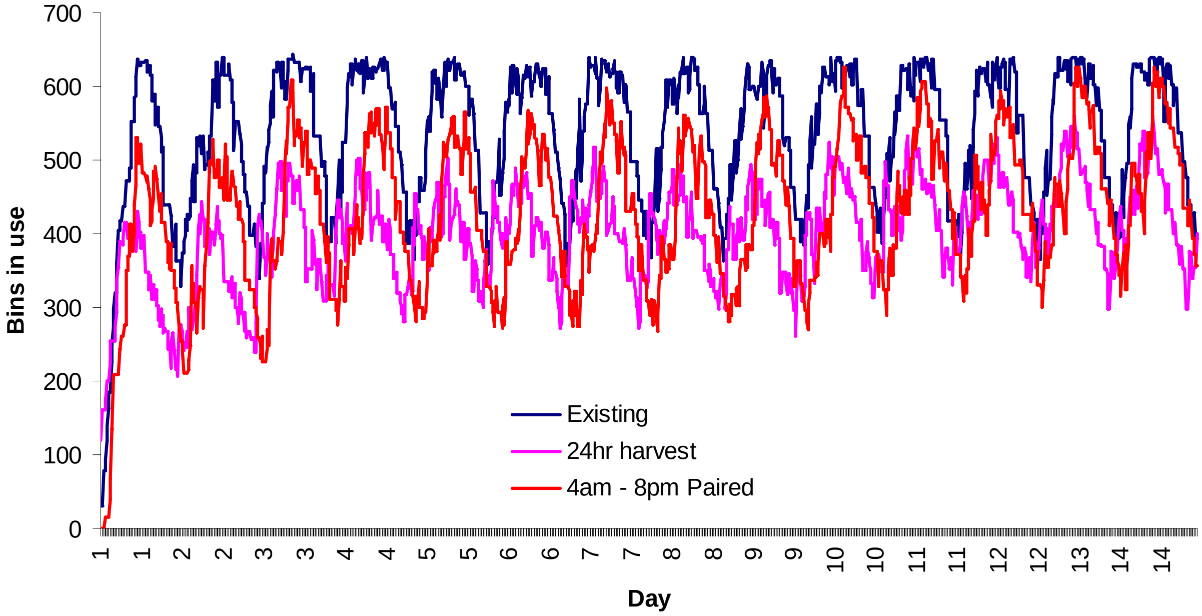


Figure D4. Number of bins in use throughout the day for each time window of harvest option

Appendix E Plane Creek Case Study

The Plane Creek RIB formulated bigger picture scenario for the region, which consists of 3 groups of 8 machines. The harvesting group scenario for the 3 by 8 machines (i.e. 24 machines in total) is shown in Figure E1. This figure doesn't highlight the boundaries of the three groups, but rather the boundaries of the 22 machines (assuming 2 spare machines) across the three groups within the Plane Creek region.

The Harvest Haul Model was applied to the Plane Creek entire region for the configuration of Figure E2 as well as to the existing harvesting groups. Savings in harvesting costs for the 3 by 8 machines scenario (versus existing harvesting groups) was $1.11/tc for a 900,000 tonne crop, $0.61/tc for a 1,350,000 tonne crop, and $0.45/tc for a 1,800,000 tonne crop.

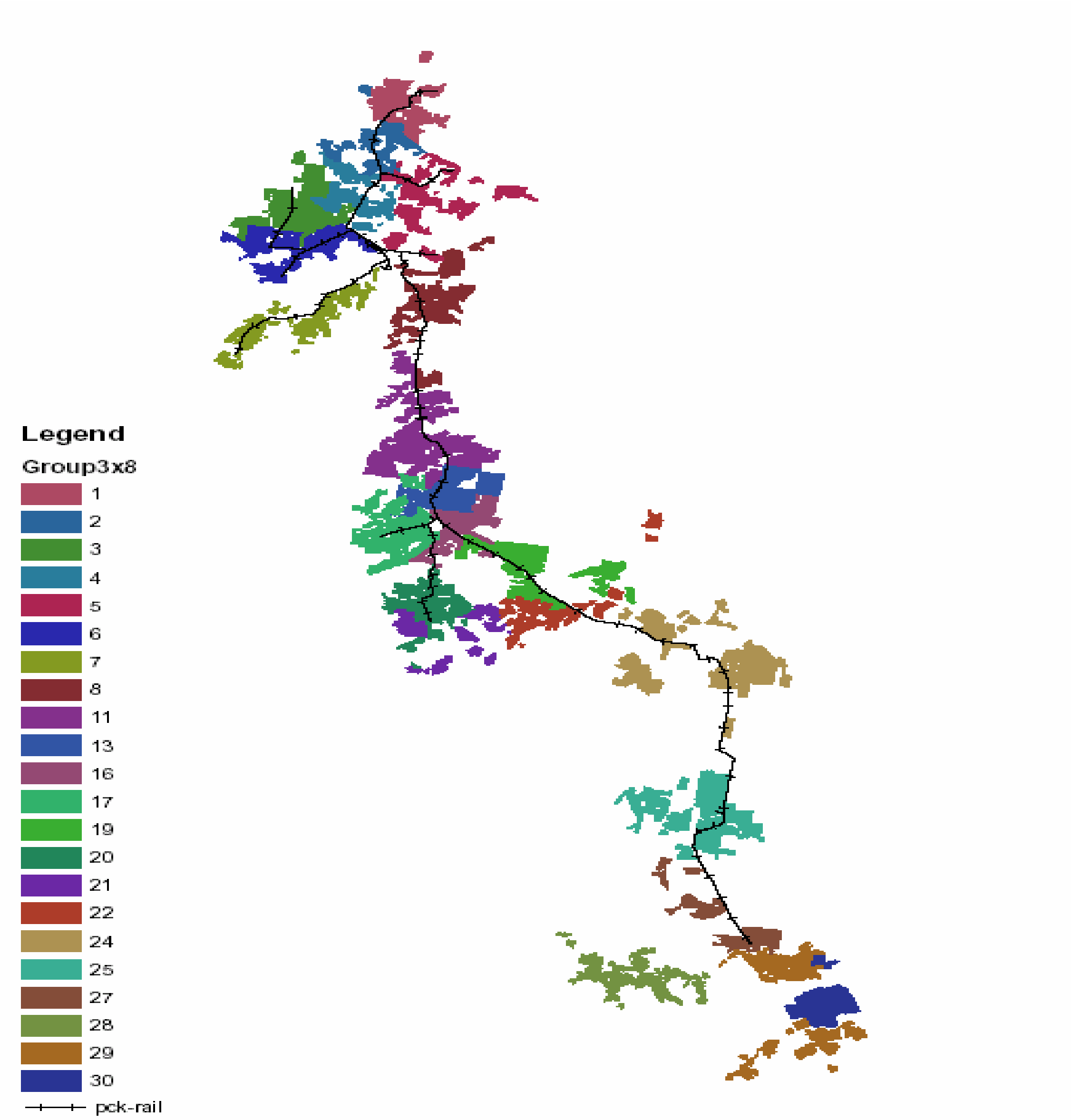


Figure E1. Cane land allocated to each of the 22 harvesters used in the 3 groups of 8 machines scenario of Plane Creek

To produce an operational plan from a transport perspective, a siding roster plan needed to be developed for the harvesting groups, which will show the harvester movements across sidings for the entire harvest season. The Transport Capacity Planning Model will then measure the transport requirements to service the harvesters. Three different harvest hour options were tested as shown in Figure E2. The transport impacts of the different options are contained in Table E1, which includes the extreme scenario of only 14 machines servicing the region. Table E1 shows major reductions in locomotive shifts, bin fleet and waiting time for bins for the 24 hour time window scenario versus the existing system. The Plane Creek RIB were looking for the option that minimises the harvesting and transport costs.

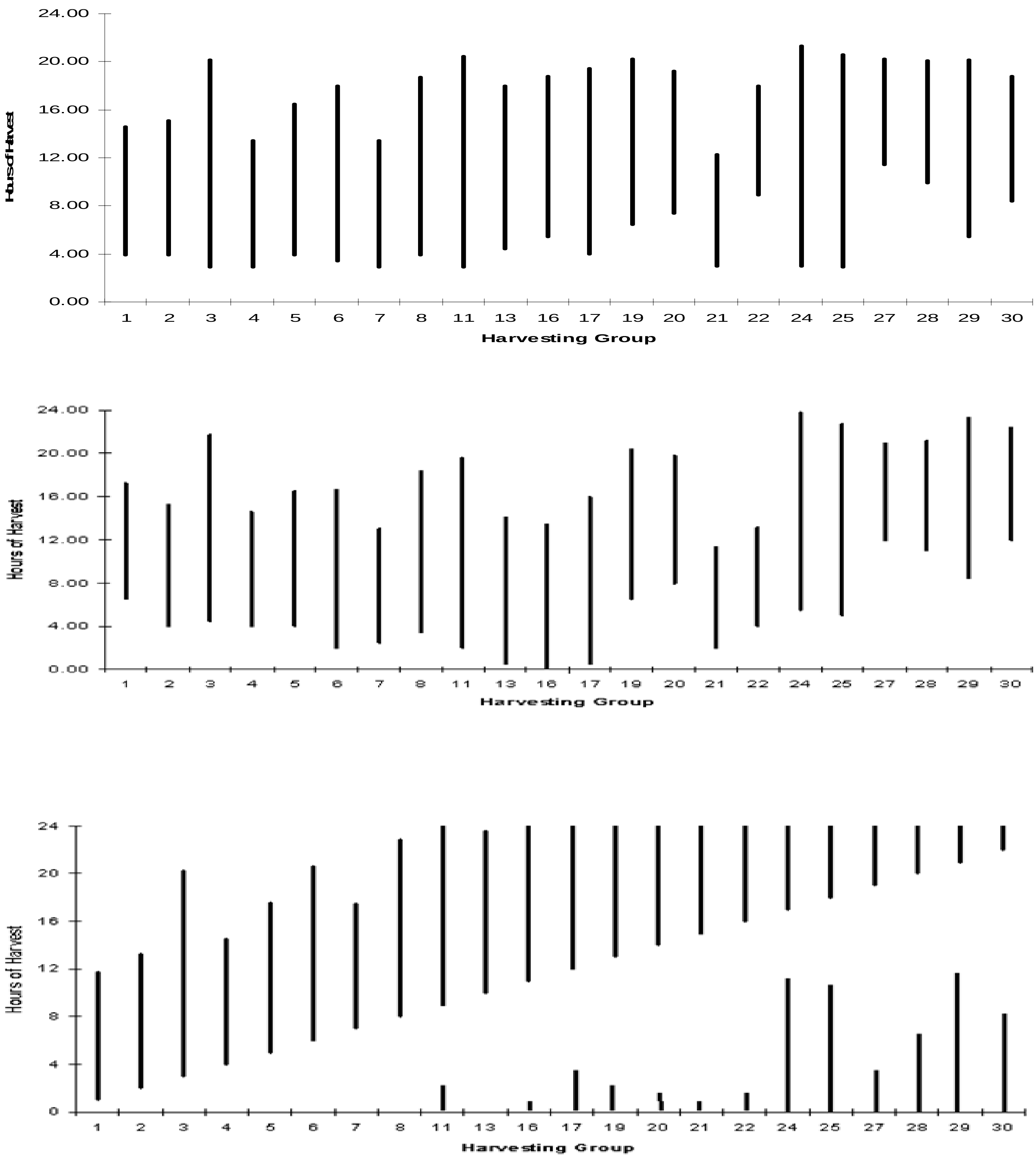


Figure E2. Harvest hour options for the Plane Creek three groups by 8 machines scenario, 18 hour window (top), 24 hour A (middle), 24 hour B (bottom)

Scenario	Bins Required	Loco demand (7am to 3pm)	Loco demand (3pm to 11pm)	Loco demand (11pm to 7am)	Cut-to-Crush delay (hrs)	% of total harvest spent waiting for bins
3x8-18 hours	2570	5	6	4	9	3.4
3x8-24 hours A	2375	5	5	5	8.5	1.7
3x8-24 hours B	1643	5	5	5	6.3	4.9
2x7-24 hours A	2445	5	5	5	8.5	7
2x7-24 hours B	1560	5	5	5	6.3	4.1
Existing	2600	7	5	4	9.8	19.8

Table E1. Transport impacts of different harvest time windows for the Plane Creek three group by 8 machine scenario

Climate constraints on season length

The Plane Creek RIB also considered the issue of season length and the positioning of the season within the year. Industry wisdom cautioned against extending the season into December due to the increasing risk of rain periods that can cause harvest stoppages or even the premature termination of the season and amounts of cane stood over. Research was carried out to quantify the extent of this risk and present it in a way accessible to stakeholders for the processes of the RIB.

Since there was a 92% correlation between recorded rainfall at Sarina Post Office and Plane Creek Mill, data from the Mill weather station only was used. Figure E3 shows the frequency of cumulative weekly rainfall for a number of threshold levels since 1889. Figure E4 shows the maximum, average and median of weekly rainfall between 1889-2002.

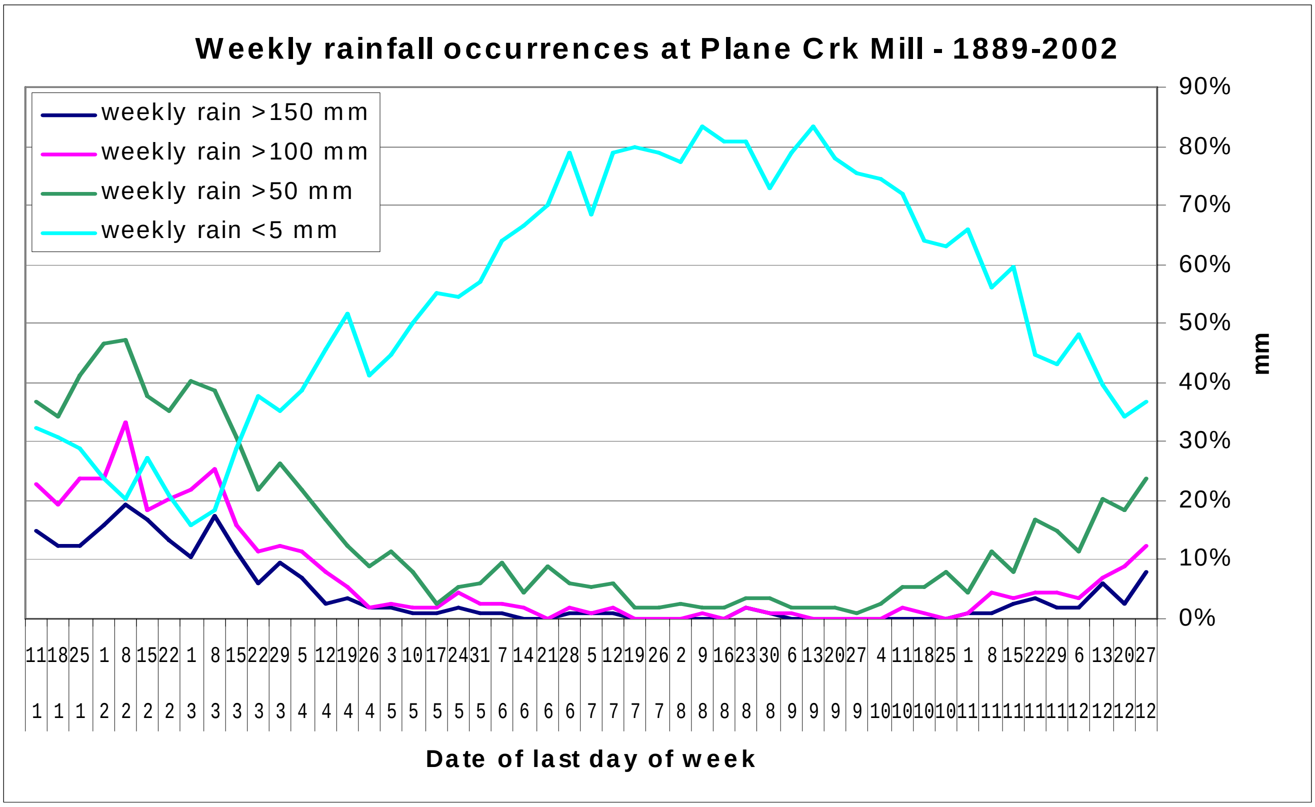


Figure E3. Frequency of weekly rainfall

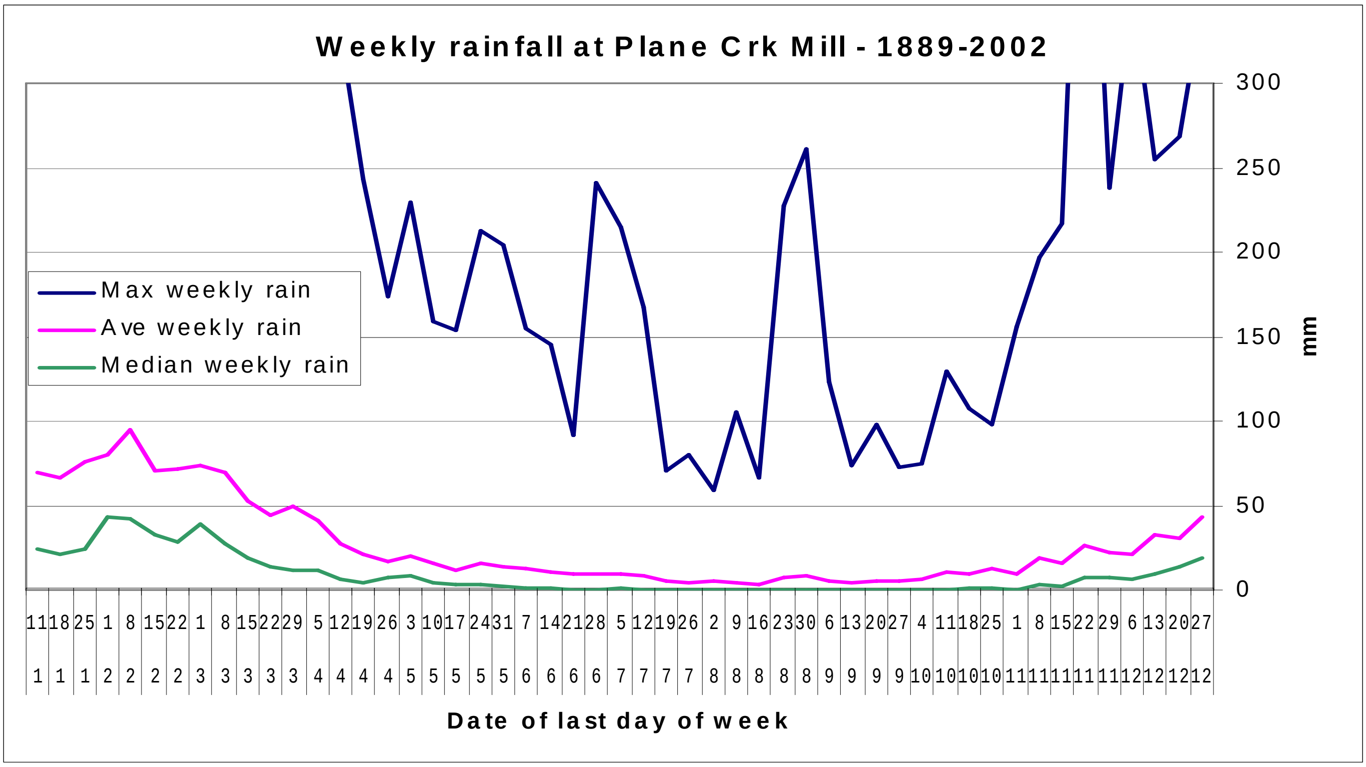


Figure E4. Maximum, average and median rainfall

Discussion with stakeholders concluded that while there is an increase in rainfall towards the end of December, this increase is small. What makes people apprehensive about extending the season is the potential of high rainfall, but the probability of this is still low in December.

At the stakeholders' request, an Excel program has been written to facilitate the querying of the data. For a chosen week and rainfall range, the program shows the frequency distribution of rainfall for the previous week over the last 113 years.

Appendix F Herbert Case Study

Number of sidings vs average haulout distance

A relationship is shown in Figure F1, which initially surprised many industry representatives who expected a more linear relationship. Some refinement is required so that priority sidings are kept when reducing the number of sidings, and that siding capacity and shunt time are also considered. In the unrestricted case, barriers such as creek crossings, farm boundaries, and highways are not considered. In the restricted case, these barriers are considered. The main impact of barriers is with a small number of sidings as it significantly restricts access between many paddocks and nearest sidings.

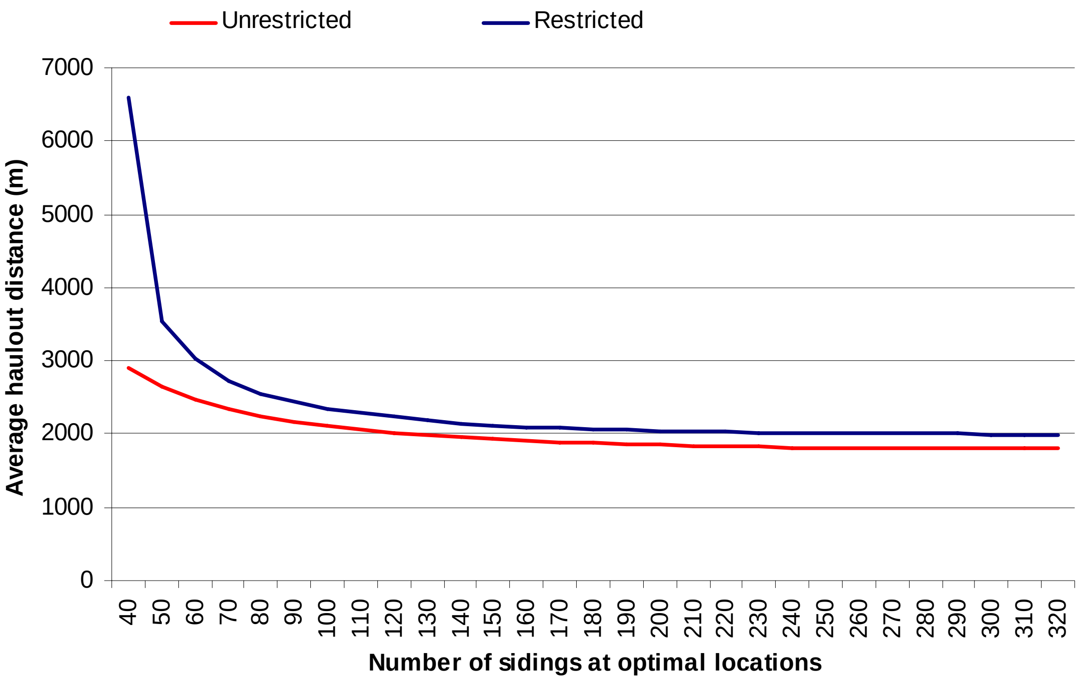


Figure F1. Relationship between number of sidings and average haul out distance.

Harvester rosters

Harvester rosters were produced for both the Victoria and Macknade mills and adopted during the 2005 harvest season, with Macknade's roster shown in Figure F2. These rosters demonstrated to the industry representatives significant transport advantages of having well balanced daily cane supplies as well as better management of congested branch lines. The harvester representative at the workshop agreed that a siding roster would encourage harvesters to better negotiate amongst themselves on the sidings they wish to use each day. The mill agreed this would also significantly reduce cane inspector time. Such rostering models will also be a key to implementing staggered start times of various harvesters and the Macknade mill, which an additional SRDC project (HGP007) was developed in 2005.

Group	Group number	Roster type	Tonnes est 2003	Daily bins	Roster section	1	2	3	4 (Day)	5	6	7	8	9 (Bins allotted each da)	10
BIASI Ray	101	8	52400	150	4	150	0	0	150	150	150	150	150	150	0
GILBERT	103	7	43500	133	6	133	133	133	0	0	133	133	133	133	133
BIASI John	104	7	46000	148	1	148	148	148	148	148	148	148	0	0	148
DAMETTO	106	7	46100	149	8	149	149	149	149	149	0	0	149	149	149
CANTAMESSA	108	6	31300	104	2	0	104	104	104	104	104	104	104	0	104
Q & R	109	7	55400	166	3	0	0	166	166	166	166	166	166	166	0
CONTARINO Joe	110	7	27800	88	7	88	88	88	88	0	0	88	88	88	88
CONTARINO Alf	111	6	5900	20	4	20	0	20	20	20	20	20	20	20	20
GIRGENTI Sam	112	8	40300	110	1	110	110	110	110	110	110	0	0	0	110
GARUTTI	113	6	13400	43	3	0	0	43	43	43	43	43	43	43	0
CARR BROS.	114	7	47200	156	7	156	156	156	156	0	0	156	156	156	156
AUDITORE	115	8	52500	160	6	160	160	0	0	0	160	160	160	160	160
SCHIFILITTI	116	7	34100	102	5	102	102	0	0	102	102	102	102	102	102
ADAMS	117	7	21500	81	1	81	81	81	81	81	81	81	0	0	81
TOIGO	118	6	14600	53	9	53	53	53	53	53	53	0	0	53	53
DIBELLA	119	6	24300	87	4	87	0	87	87	87	87	87	87	87	87
CHINOTTI	120	7	31500	109	3	0	0	109	109	109	109	109	109	109	0
LANCINI	121	7	36300	110	9	110	110	110	110	110	110	0	0	110	110
BLOOMFIELD	122	7	30200	88	7	88	88	88	88	0	0	88	88	88	88
MAHONY/MIZZI	123	6	19400	64	5	64	64	0	64	64	64	64	64	64	64
GIRGENTI Alf	124	7	33500	119	4	119	0	0	119	119	119	119	119	119	119
HILL	125	7	29000	93	9	93	93	93	93	93	93	0	0	93	93
CASTORINA	126	6	29200	123	9	123	123	123	123	123	123	0	0	123	123
SILVINI	127	7	30900	99	2	0	99	99	99	99	99	99	99	0	0
SORBELLO	128	7	36800	114	6	114	114	114	0	0	114	114	114	114	114
MORELLINI	129	6	26800	96	8	96	96	96	96	96	0	96	96	96	96
MILAN	130	7	51700	152	5	152	152	0	0	152	152	152	152	152	152
TABONE	131	8	53300	165	2	0	165	165	165	165	165	165	165	0	0
INUNCIAGA	132	7	34800	108	8	108	108	108	108	108	0	0	108	108	108
					Total	2504	2496	2443	2529	2451	2505	2444	2472	2483	2458

Figure F2. Harvester roster for Macknade showing a well balanced daily cane supply

Siding rationalisation benefits to harvesters in Herbert – 20 Priority upgrades

There was major development in the latter part of CSE005 in adapting the Harvest Haul Model to quantify the harvesting cost saving on a block-by-block and group-by group basis. Also, the Herbert region is initially focusing on 20 priority areas for immediately developing a large siding and removing existing sidings. These priority areas are shown in Figure F3.

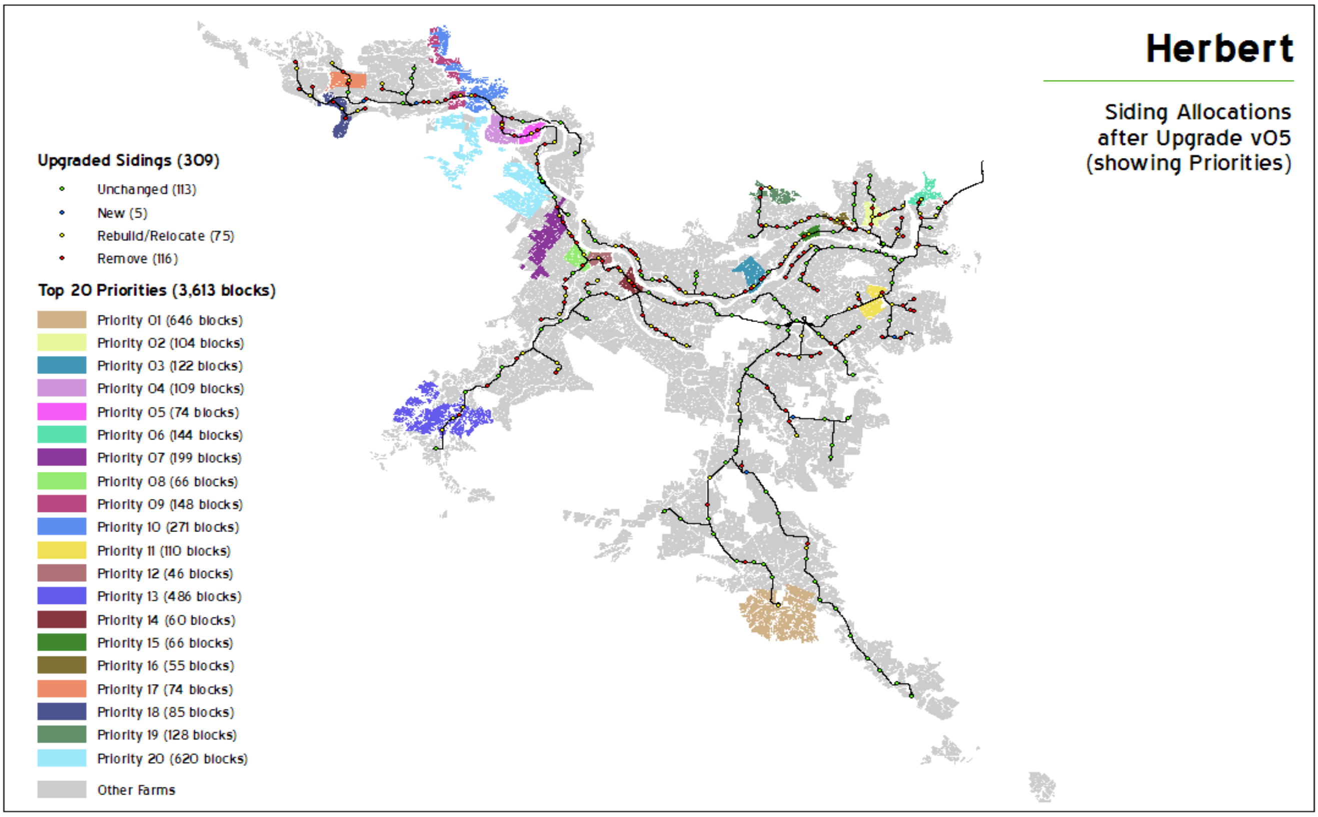


Figure F3. The 20 priority areas for upgrading sidings, where each colour represents blocks directly impacted by the 20 priority upgrades.

Both the Transport Capacity Planning and Harvest Haul models were used to conduct the analysis, with the results from the former model contained in Table F1. There are significant transport benefits in terms of locomotive savings from implementing the 20 priority siding areas. The benefits to harvesters (waiting time for bins) are increased when adding an extended time window of harvest. Table F2 shows a comparison of addressing the 20 priority areas versus the full siding upgrade/rationalisation (72 sidings) proposal.

Table F1. Impacts on transport from the 20 priority siding upgrades.

Scenario	20 Priority Siding Upgrade	Mill	Locomotive shifts: Morning	Locomotive shifts: Afternoon	Locomotive shifts: Night	Cut to crush (hrs)	Waiting time for bins (% of total harvest hours)
Base (Harvest hours of 2004)	No	Vic	14.5	8.4	7.7	9.2	33
		Mck	6.4	2.6	4.4	10	6
	Yes	Vic	13.9	7.9	7.6	9.3	30
		Mck	6.2	2.6	4.3	10.4	5
6pm finish	No	Vic	14.2	9.3	7.7	8.5	20
		Mck	6.4	3.6	3.6	9.3	4
	Yes	Vic	13.8	8.6	7.6	8.9	15
		Mck	6.1	3.6	3.6	9.9	3
8pm finish	No	Vic	13.9	9.7	7.7	7.8	17
		Mck	5.7	4.3	3.6	9	4
	Yes	Vic	13.4	9.4	7.3	8.3	12
		Mck	5.6	4.2	3.4	9.3	3

Table F2. Comparison of the 20 priority areas versus the full siding upgrade scenario (72 sidings)

Scenario	Mill	Locomotive shifts: Morning	Afternoon	Night	Cut to crush (hrs)	Waiting time for bins (% of total harvest hours)
Base	Vic	14.5	8.4	7.7	9.2	33
	Mck	6.4	2.6	4.4	10	6
20 Priority siding upgrades	Vic	13.9	7.9	7.6	9.3	30
	Mck	6.2	2.6	4.3	10.4	5
Full siding upgrade scenario	Vic	12.3	6.7	7.2	10.5	25
	Mck	5.7	2.3	4	10.8	5

Table F3 contains the average costs of harvesting (using Harvest Haul model) for each of the siding upgrade and time window of harvesting scenarios. The 20 priority siding scenario leads to a $0.03/tc reduction in harvesting costs as an average for the Herbert, which is not a large saving since most harvesting groups are unaffected. However, increasing the time window of harvest to an 8pm finish leads to an additional $0.24/tc as an average for the Herbert. These savings are a result from reduced shunt time, wait time for bins and fewer shunts. Savings are larger for Victoria mill than Macknade due to the greater reduction in bin wait time in Victoria.

Geographical details of the siding upgrades for each of the 20 priority areas are contained in Appendix I, which also shows the changes in allocation of blocks to sidings. The impacts at each of the 20 priority areas and each harvesting group impacted by the siding change are contained in Table F4.

Table F3. Average costs of harvesting for the siding upgrade and time of window scenarios

Mill	Sidings	Harvest Hrs	Avg. Haul Distance (km)	Avg. Haul Distance (km) - Wgt by Tonnes	Cost of Harvest $/t	Bin Wait Time (min/day)	Bin Wait Time (% of Harvest Hrs)
MKD	Existing	Existing Hrs	1.253	1.291	$6.62	16	5%
MKD	Existing	6pmFinish	1.253	1.291	$6.57	9	3%
MKD	Existing	8pmFinish	1.253	1.291	$6.58	10	3%
MKD	20 Priority	Existing Hrs	1.281	1.314	$6.63	15	5%
MKD	20 Priority	6pmFinish	1.281	1.314	$6.57	7	2%
MKD	20 Priority	8pmFinish	1.281	1.314	$6.58	9	3%
VRA	Existing	Existing Hrs	2.151	2.257	$6.66	89	20%
VRA	Existing	6pmFinish	2.151	2.257	$6.37	54	13%
VRA	Existing	8pmFinish	2.151	2.257	$6.31	46	12%
VRA	20 Priority	Existing Hrs	2.128	2.275	$6.60	81	19%
VRA	20 Priority	6pmFinish	2.128	2.275	$6.23	41	10%
VRA	20 Priority	8pmFinish	2.128	2.275	$6.17	34	9%
HBT	Existing	Existing Hrs	1.702	1.774	$6.64	52	13%
HBT	Existing	6pmFinish	1.702	1.774	$6.47	31	8%
HBT	Existing	8pmFinish	1.702	1.774	$6.45	28	7%
HBT	20 Priority	Existing Hrs	1.705	1.795	$6.61	48	12%
HBT	20 Priority	6pmFinish	1.705	1.795	$6.40	24	6%
HBT	20 Priority	8pmFinish	1.705	1.795	$6.37	21	6%

Table F4. Changes in harvesting costs, haul distance and bin wait times on a siding and group basis

Priority	Mill region	Harvesting group	Cost of Harvest $/t	Avg. Haul Distance (km)	Avg. Haul Distance (km) - Wgt by Tonnes	Group Bin Wait Time - % Harvest Hrs
Priority 01	VRA	22	-0.06	0.00	0.00	-0.02
Priority 01	VRA	23	-0.14	0.00	0.00	-0.04
Priority 01	VRA	25	-0.04	0.00	0.00	-0.01
Priority 01	VRA	28	-0.05	0.00	0.00	-0.01
Priority 01	VRA	31	-0.04	0.00	0.00	-0.02
Priority 01	VRA	32	-0.05	0.00	0.00	-0.01
Priority 01	VRA	33	-0.06	0.00	0.00	-0.02
Priority 01	VRA	35	-0.07	0.00	0.00	-0.01
Priority 01 Average			-0.06	0.00	0.00	-0.02
Priority 02	MKD	116	0.04	0.11	0.10	0.00
Priority 02	MKD	119	0.05	0.11	0.12	0.00
Priority 02 Average			0.05	0.11	0.11	0.00
Priority 03	VRA	41	-0.05	0.00	0.00	-0.01
Priority 03	MKD	41	0.11	0.21	0.25	-0.01
Priority 03	MKD	103	-0.01	-0.01	-0.01	0.00
Priority 03	MKD	108	0.05	0.10	0.14	0.00
Priority 03	MKD	110	-0.02	0.02	0.02	-0.02
Priority 03 Average			0.02	0.07	0.08	-0.01
Priority 04	VRA	73	0.00	0.12	0.14	0.00
Priority 04	VRA	81	-0.04	0.04	0.04	-0.01
Priority 04 Average			-0.02	0.08	0.09	-0.01
Priority 05	VRA	74	-0.09	0.04	0.05	-0.02
Priority 05	VRA	75	-0.04	0.06	0.07	-0.02
Priority 05 Average			-0.07	0.05	0.06	-0.02
Priority 06	MKD	114	0.03	0.07	0.07	0.00
Priority 06	MKD	121	0.03	0.05	0.04	0.00
Priority 06 Average			0.03	0.06	0.05	0.00
Priority 07	VRA	49	0.00	0.03	0.03	-0.01
Priority 07	VRA	66	-0.07	0.06	0.06	-0.02
Priority 07	VRA	69	-0.03	0.16	0.15	-0.03
Priority 07	VRA	70	0.00	0.09	0.07	-0.01
Priority 07	VRA	71	-0.12	0.06	0.05	-0.03
Priority 07	VRA	72	-0.12	0.02	0.04	-0.02
Priority 07 Average			-0.06	0.07	0.07	-0.02
Priority 08	VRA	69	-0.03	0.16	0.15	-0.03
Priority 08	VRA	70	0.00	0.09	0.07	-0.01
Priority 08 Average			-0.02	0.13	0.11	-0.02
Priority 09	VRA	75	-0.04	0.06	0.07	-0.02
Priority 09	VRA	80	-0.05	0.06	0.06	-0.01
Priority 09	VRA	84	-0.08	-0.02	-0.03	-0.02
Priority 09	VRA	87	-0.09	-0.01	0.00	-0.01
Priority 09	VRA	90	0.01	0.08	0.09	-0.01
Priority 09 Average			-0.05	0.03	0.04	-0.01
Priority 10	VRA	74	-0.09	0.04	0.05	-0.02
Priority 10	VRA	75	-0.04	0.06	0.07	-0.02
Priority 10	VRA	80	-0.05	0.06	0.06	-0.01
Priority 10	VRA	81	-0.04	0.04	0.04	-0.01
Priority 10	VRA	84	-0.08	-0.02	-0.03	-0.02
Priority 10	VRA	85	-0.11	0.01	0.00	-0.01
Priority 10	VRA	90	0.01	0.08	0.09	-0.01
Priority 10	VRA	93	0.00	0.03	0.03	0.00
Priority 10 Average			-0.05	0.04	0.04	-0.01
Priority 11	VRA	2	-0.24	-0.21	-0.20	-0.03
Priority 11	VRA	96	-0.12	-0.03	-0.04	-0.03
Priority 11 Average			-0.18	-0.12	-0.12	-0.03
Priority 12	VRA	45	-0.03	0.08	0.08	-0.01
Priority 12	VRA	66	-0.07	0.06	0.06	-0.02
Priority 12	VRA	69	-0.03	0.16	0.15	-0.03
Priority 12 Average			-0.04	0.10	0.09	-0.02
Priority 13	VRA	47	-0.11	0.03	0.01	-0.03
Priority 13	VRA	50	-0.04	-0.02	0.00	-0.01
Priority 13	VRA	51	-0.11	0.00	0.00	-0.02
Priority 13	VRA	53	-0.09	0.04	0.05	-0.02
Priority 13	VRA	54	-0.04	0.05	0.06	-0.02
Priority 13	VRA	66	-0.07	0.06	0.06	-0.02
Priority 13 Average			-0.08	0.03	0.03	-0.02
Priority 14	VRA	44	-0.09	0.00	0.00	-0.02
Priority 14	VRA	45	-0.03	0.08	0.08	-0.01
Priority 14	VRA	49	0.00	0.03	0.03	-0.01
Priority 14	VRA	66	-0.07	0.06	0.06	-0.02
Priority 14 Average			-0.05	0.04	0.04	-0.02
Priority 15	MKD	112	0.02	0.07	0.06	0.00
Priority 15	MKD	115	0.02	0.02	0.03	0.00
Priority 15 Average			0.02	0.05	0.04	0.00
Priority 16	MKD	113	0.00	0.07	0.05	-0.01
Priority 16	MKD	116	0.04	0.11	0.10	0.00
Priority 16	MKD	119	0.05	0.11	0.12	0.00
Priority 16 Average			0.03	0.10	0.09	0.00
Priority 17	VRA	87	-0.09	-0.01	0.00	-0.01
Priority 17	VRA	90	0.01	0.08	0.09	-0.01
Priority 17	VRA	91	0.10	0.15	0.19	-0.01
Priority 17	VRA	92	-0.01	0.04	0.08	0.00
Priority 17 Average			0.00	0.07	0.09	-0.01
Priority 18	VRA	88	0.19	0.34	0.41	0.00
Priority 18	VRA	90	0.01	0.08	0.09	-0.01
Priority 18	VRA	91	0.10	0.15	0.19	-0.01
Priority 18	VRA	92	-0.01	0.04	0.08	0.00
Priority 18 Average			0.07	0.15	0.19	-0.01
Priority 19	MKD	109	0.02	0.05	0.03	0.00
Priority 19	MKD	112	0.02	0.07	0.06	0.00
Priority 19	MKD	114	0.03	0.07	0.07	0.00
Priority 19 Average			0.02	0.06	0.05	0.00
Priority 20	VRA	45	-0.03	0.08	0.08	-0.01
Priority 20	VRA	54	-0.04	0.05	0.06	-0.02
Priority 20	VRA	55	-0.06	0.00	0.00	-0.01
Priority 20	VRA	69	-0.03	0.16	0.15	-0.03
Priority 20	VRA	70	0.00	0.09	0.07	-0.01
Priority 20	VRA	71	-0.12	0.06	0.05	-0.03
Priority 20	VRA	72	-0.12	0.02	0.04	-0.02
Priority 20	VRA	73	0.00	0.12	0.14	0.00
Priority 20	VRA	74	-0.09	0.04	0.05	-0.02
Priority 20	VRA	80	-0.05	0.06	0.06	-0.01
Priority 20	VRA	81	-0.04	0.04	0.04	-0.01
Priority 20	VRA	85	-0.11	0.01	0.00	-0.01
Priority 20 Average			-0.06	0.06	0.06	-0.02
Grand Average			-0.03	0.06	0.06	-0.01

Bin fleet optimisation in Herbert

Over the past 6 months, CSR Herbert requested a scenario analysis be performed to investigate opportunities to improve the utilisation of 10 tonne bins. The prior belief was that by improving the turn around rate of 10 tonne bins, there would be greater transport capacity for the region and fewer derailing of bins. Greater capacity is achieved since 10 tonne bins carry more cane per metre of track compared to 4 tonne bins, which means there is additional capacity at sidings and greater tonnage hauled by locomotives.

In order to investigate ways to improve utilisation of 10 tonne bins, several different scenarios were tested:

1) A base case with 10 tonne bins rakes used randomly
2) A base case with 10 tonne bins used only when needed
3) 10 tonne bins allocated to early start and late finish groups only, along with groups operating close to the mill
4) Priority crush of 10 tonne bins, where 10 tonne bin rakes are crushed ahead of 4 tonne bin rakes at the mill
5) Impact with 76 extra bins in the fleet
6) Impact with a further 304 extra big bins constructed from the 4 tonne bins
7) Impact with an extended time window of harvest with a 6pm finish, using start and finish times from previous analysis for the Herbert case study (see Milestone 5 and 6 reports for CSE005)
8) Impact with an extended time window of harvest with an 8pm finish

The scenarios were conducted using Victoria mill with 2005 harvest season data. The first 96 days of the harvest season were used to conduct the analysis, and the Transport Capacity Planning model was applied to generate the results. Table F5 contains a summary of statistics for the different scenarios. One point to note is that the results do not account for unforeseen delays, and do not account for rescheduling that the traffic office would do in the event of possible cane supply shortage. The results in Table F5 show that by allocating 10 tonne bins to early and late groups (and groups that operate close to the mill) did improve the turn around rate of the 10 tonne bins (Scenario 3 in Table F5). Increasing the number of 10 tonne bins in the fleet does not improve the turn around rate, since it created a queue of 10 tonne bins at the mill. However, it reduced the number of locomotive shifts required and waiting time for bins (Scenarios 5 and 6 of Table F5). Extending the time window of harvest substantially improved the turn around rate of bins and waiting time for bins. However, it increased mill stoppages, which was a surprise. This increased mill stoppages is due to a shorter queue of cane at the mill at any time of the day (i.e. closer to Just in Time) which made the mill more vulnerable to cane supply shortages. CSR Herbert plan to use these results to help form planning transport logistics during the 2006 harvest season, and to provide a cost/benefit analysis for constructing the big bins.

Table F5. Summary of results for 10 tonne bin analysis

Scenario	4t Bin turn around rate /day	10t Bin turn around rate /day	Locomotive shifts	Delays to harvesters (% of total harvest hours)	Mill stoppages (hrs)
1) Use 10t bins when needed	1.32	0.75	29.7	30.1	15.75
2) 10t bins allocated to any group	1.25	1.09	29.3	27.7	15.75
3) 10t bins allocted to early starters and near groups	1.2	1.32	29.4	27.5	15.5
4) Scenario 3 plus priority crush of 10t bins	1.19	1.43	29.6	25.5	15.25
5) Scenario 4 with 76 extra big bins	1.17	1.34	29	21.1	15.25
6) Scenario 5 with 304 big bins constructed from 4t bins	1.15	1.21	28.3	20	14.75
7) Scenario 4 with 6pm finish	1.18	1.6	29.3	10.3	21
8) Scenario 5 with 6pm finish	1.13	1.52	29	10	20
9) Scenario 6 with 6pm finish	1.16	1.18	28.4	8.7	20.25
10) Scenario 4 with 8pm finish	1.14	1.8	29.4	7	18.25
11) Scenario 5 with 8pm finish	1.09	1.68	29.2	6.9	21.75
12) Scenario 6 with 8pm finish	1.14	1.25	28.6	5.9	18.75
13) Scenario 3 with 8pm finish	1.13	1.52	29.6	11.1	19.5

Future Activities

The local region has been considering many longer term options, including:

- New layer of harvesting groups to form from participating existing groups linking by partnership across the region to respond to early start, wet weather and late season maturity opportunities.
- Initial response to be by co-ordinating direction of quotas. Movement of machinery possible.
- Jointly owned service company to run operations centre with accountability for harvesting and transport efficiency.
- Linked groups to share the cost of acquiring capacity with dual front (Corradini type) harvesters or similar.
- Infrastructure improvement to accommodate the potential movement of quotas and equipment to harvest on a front in different parts of the district to maximize throughput and sugar content.
- Linked harvesting groups to consider alternative business structures as a single unit group.

The above options are partly a result of outcomes from CSE005, which includes improved communication between growing, harvesting and milling sectors that developed during the life of CSE005. The above options were fully support by the leaders within the local industry, whom see a major role for the research team of CSE005. CSE005 officially finishes in June 2006, and the Herbert region agree the above options will require an R&D capacity beyond June 2006.

Appendix G Feedback on Questions at the Herbert industry workshop on 7th March 2005

Expectations of today's forum?

As growers – the quality of life in this new world with all external pressures.
Low expectations of any real chance of outcome due to past performance od these meetings.
Honesty and communication btw miller and grower – infrastructure developments and CSR long-term plan.
Better understanding of different sectors and things that we need to do to remain profitable.
Understanding of the cost sharing between sectors.
What we should adopt is one of cooperation and to have unity between sectors.
Open mind until we hear what everyone has to say.
Local area meeting to sort out the issues in those areas.
Reliability of mill transport system.
Harvesting hours between 4 am and 6 pm to be used up first before looking at the different options that are being presented
Increase efficiency of transport systems.
Penalties at both mill and harvester levels for non compliance ie: bin deliveries, bin weight etc.
Adherence of WHS.
All sectors are only as good or productive as the weakest link in the chain.
No cost transfer and to stay profitable and security across all sectors of the industry.
Researchers will talk away with them some of the local views.
Heading towards milling/harvesting/transport best practice.
Survey of farm accident if it were to happen in night hours.
No. of bins available for distribution and availability of loco power.
Hope for the industry.
Is decrease in infrastructure leading towards a plan of 24 hours harvesting.
Need CSR long-term views.
How are we going to keep labour force in this industry and identify the costs
Draw comparisons with other mill areas for bench marking.
Decrease number of siding – who will pay for the extra hauling costs.

Suggestions on how to make this workshop better?

Accurate milling and transport costs.
Cross section of the productivity areas
Get the point out of our heads to think along the lines of helping ourselves and not just CSR.
Agenda's with action outcomes.
Before next meeting send agenda out to inform.
Organisations QMCHA/canegrowers/CSR – leaders of these sectors to report back through these organisation – smaller group down the track.
Nominated people have a responsibility to talk at their grass root level.
CSR to convince the smaller group that they are serious for change.
General community to be involved later down the track Example: business people of the town.

General Notes taken at the Herbert industry workshop on 7th March 2005

Transport Capacity Planning Model

- Bin wait times not a great issue if they can work in daylight hours – will tolerate waits – why hasn't CSR invested in equipment
- Harvesters put a lot of money over the years to make a viable business – why hasn't CSR invested in equipment
- Low expectations of any changes due to past performance of meetings
- Want Honesty and communications – Infrastructure upgrades for CSR
- Want Unity with sectors – Unity between sectors
- Want an open mind to hear other solutions
- Each area is very different
- Harvesting has between 4am– 6pm to be looked at before looking at other options
- Increased efficiency of transport system
- Penalty for late bins or less full bins
- No cost transfers, stay profitable, security across all sectors
- Achieving Milling, Harvesting & transport best practice
- Work, Health and Safety issues for dark Harvesting
- Want to know the number of bins and locos available to harvesters
- What are CSR's long term views, less bins and maintenance
- How are they going to keep labour force in regions
- Comparisons to other mill areas for benchmark
- Decrease number of sidings in district – who pays for extra haulage costs?
- Account for cost to the Mill if breakdown occurs
- Aim for constant supply at Mill
- Milling performance has direct input on transport
- Mill processing effects back on transport and harvesting
- Improved Harvesting for best practice
- Waiting for bins – big issue. Want to be working instead of waiting for bins.
- Early morning starts effect CCS due to moisture
- Want Mill to run efficiently – CSR responsibility to put bins at siding
- SRDC, CSIRO, BSES (not a problem with harvesting)
- Issue is with the transport module – locos and bins and sidings -Effects harvesting – groups, times of harvesting
- Had continuous crushing previously
- Issue on changing hours of work with harvesting window change
- Want migrating groups
- Includes % of loco downtime in Transport model
- Test model if the Mill was efficient in emptying bins
- CSR changing locos wheel profile
- CSR Bin fleet (8900 4t bins) going into bigger bins with extra height
- CSR Sidings retraining – 3 year with Govt money otherwise 10 years
- To make groups bigger need to go to 2 shifts - would need a more reliable transport system and much less bin waiting
- If rationalisation of siding increases haul out costs – who pays for the cost of extra hauling out
- Possible Scenario – tipping cane into a pad at Mill (CCS + EM)?

Siding optimisation model

– some farmers are going to be effected

- Who will bare the cost of extra haulage
- Count number of blocks per distances ie. x 3tons / y .5km
- Wet weather impact on which sidings you can go to
- Hauls pre tonne per km – cost haul out
- in wet weather costs are increased (Risk of wet)
- Depend on Council roads – rego costs
- Need to run Float equipment (for movements) are costs involved

Siding roster model

–wet weather problems, machine breakdowns – can generate revised schedule

- Should depend on farmers decisions on which variety, or blocks they want to choose next ie. Will change which sidings needed to be used.

Harvest Haul Model – carry some costs forward to following year for some years

- 2 in one Harvesting – needs to be put in
- Reflects costs to contractor
- Wages should be increased from base to Professional wage
- Harvesters show figures – Mill should show figures
- HHModel – Coordinators – BSES – Canegrowers – HPPS
- Productivity Group – get a harvester from each region (report at region level)
- Harvester wants to give figures but what gains to him
- Compensation for joining groups

List of participants

Table 1	Josie Vecchio	
	Dorothy Hatfield	
	Margaret Shegog	
	Sue Castorina	
	Keith Castorina	
	Steven Castorina	
	Anthony Castorina	
Table 2	Dale Thomas	CSR
	Charles Girgenti	
	John Garutti	
	Gary Accornero	
	John Mammio	
	Merv Castles	
Table 3	John Dametto	
	Frank Succio	
	Darryl Morellini	
	Robert Aqualini	
	Pino Lenzo	
	Tony Crisafulli	
	Geoff Carr	
Table 4	Lenny Vecchio	
	Steven Sartor	
	Renzo Dibella	
	Alan Robino	
	Bruce Mahony	
Table 5	Brian Exelby	
	Joe Mizzi	
	Maurice Andrejic	
	Paul Steine	
	Tom Peatey	CSR
Table 6	Anthony Girgenti	
	Kevin Carey	
	Ricky Quabba	
	Paul Tabone	
	Liz Bosworth	
	Andrew Wood	CSR
Table 7	Alf LaRosa	
	Joe Girgenti (4-mile)	
	Joe Girgenti (Mungabulla)	
	Robert Lyon	
	Warren Russo	
	Robert Bonassi	
Table 8	Lucio Mastropollito	
	Lawrence Raiteri	
	Ron Kerkwyk	HCPSL
	Trevor Pallanza	
	David Chiesa	
	Michael Spina	
	Robert Silvini	
	Michael Sefton	HCPSL
Table 9	Terry Motti	
	Elio Castellani	
	Tony Lamari	
	Errol Cantamessa	
	Steven Grigolon	
	Tony Serra	
	Mario Porta	
Additions	Andrew Higgins	
	Di Prestwidge	
	Gary Sandell	
	Paul Giordani	
	Franco Zaini	
	Peter Allen	

Appendix H Review of Herbert Case Study

The review of CSE005 activities in the Herbert region were obtained through the use of focus groups. CSE005 participants from the growing, harvesting and milling sectors were a part of this process.

Maximising efficiencies and returns across industry sectors

When asked to explain what value chain research means to them, participants from the Herbert often referred to efforts to maximise efficiencies and returns across industry sectors. This was sometimes accompanied by the perception that industry sectors should be better off, or at least not worse off by changes in the value chain. Examples of value chain issues that were discussed included siding rationalisation, changes to the harvesting price system and the effect of farm layout on harvesting efficiency, many of which are being addressed in CSE005.

Understanding current systems and drivers

Participants identified improved understanding of the current system, the drivers of each sector and the interactions across sectors as a key feature and an important achievement of value chain research. A related theme here was the way in which value chain research should be used to understand how the costs and benefits of change should be shared across industry sectors. Another major theme was the way in which the value chain research of CSE005 allowed for the identification of weak links and blockages in the system.

Relationships and interaction across industry sectors

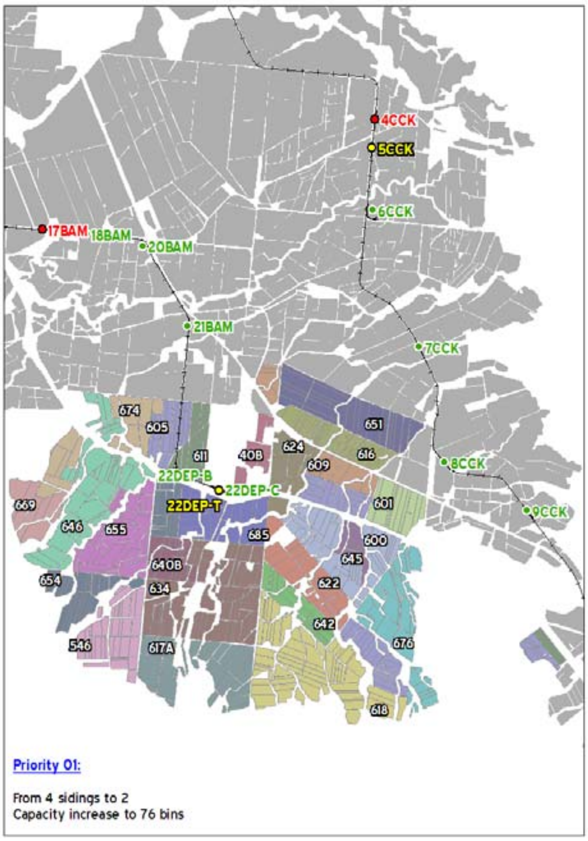
Discussions with the Herbert participants about value chain research centred on relationships and interactions across the industry sectors. Participants observed that value chain research involved complex negotiations between industry sectors. Some participants noted that the value chain research of CSE005 had achieved some improvements in communication and cooperation within and between industry sectors in the Herbert. The improvements in industry relationships also included increased recognition of industry problems and an increased willingness to work together to solve these problems. Many participants identified these improvements as key strengths of value chain research.

Improvements and opportunities for future value chain research

When asked to identify areas for improvement for future value chain research, participants in the Herbert again identified the need to improve relationships between industry sectors. For instance, members of the harvesting sector emphasised that the different industry sectors should see themselves as joint venture partners and recognise that they need each other. Most participants also reinforced the need to address the lack of trust between industry participants.

Participants in the Herbert identified a range of possible opportunities for future value chain research. For instance, a major theme that emerged from the focus group was the potential role for value chain models in scenario analysis, which would enable industry members to better understand how certain changes could affect the industry sectors. Participants emphasised that such models would need to be flexible, interactive and readily available. Participants also noted that such models would require input from across the value chain in order to ‘ground truth’ the models and ensure that people were confident with the reliability of the model results. This process has been a thrust of CSE005.

Appendix I Block to siding allocation impacts from each of the 20 priority upgrade areas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7CCK
8CCK
9CCK
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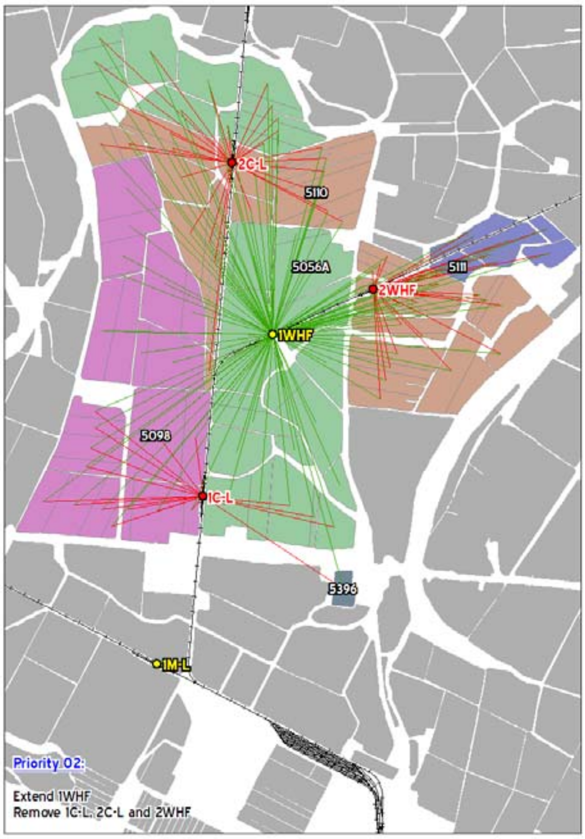
22DEP-C
22DEP-T
674
605
611
408
624
609
616
651
601
669
646
655
685
600
645
640B
634
654
622
642
676
546
617A
618
Priority 01:
From 4 sidings to 2
Capacity increase to 76 bins


2C-L
5110
5056A
5111
2WHF
1WHF
5098
1C-L
5396
1M-L
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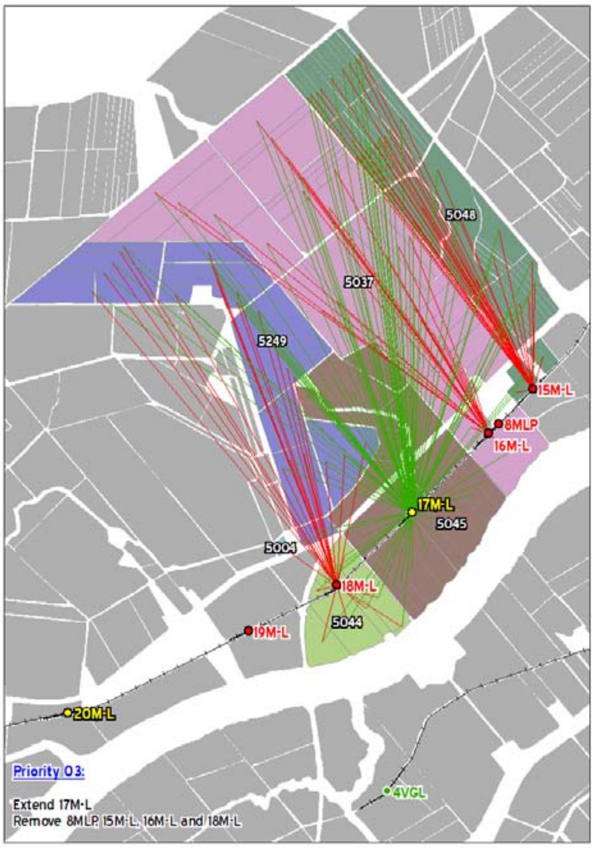
Extend 1WHF
Remove 1C-L, 2C-L and 2WHF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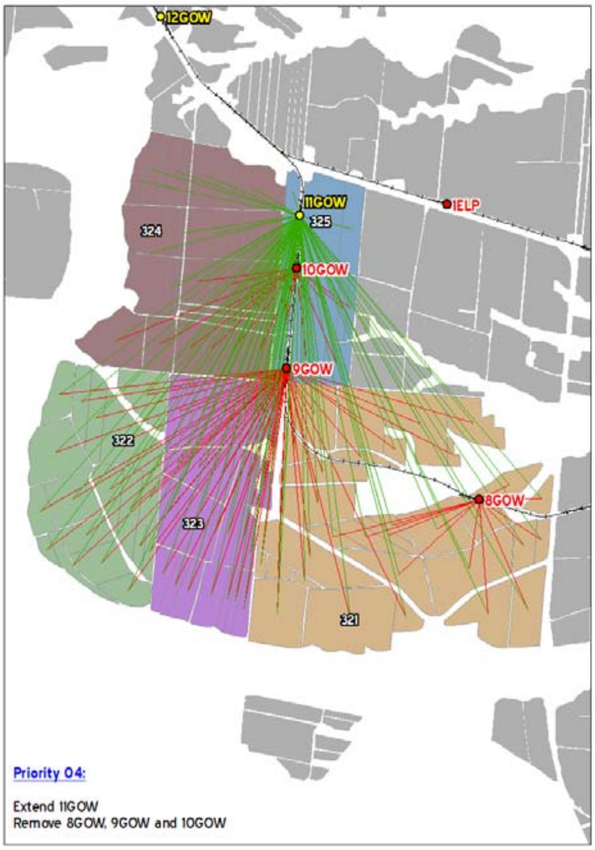
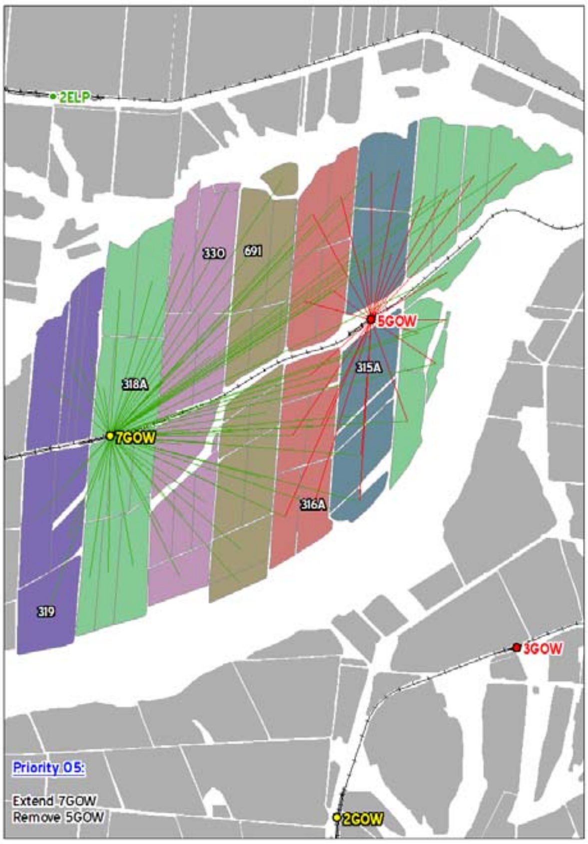
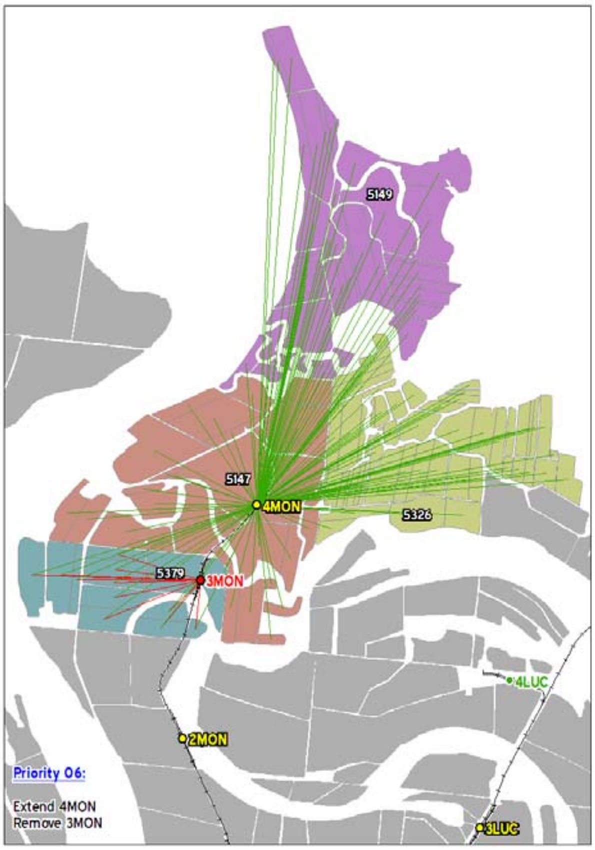
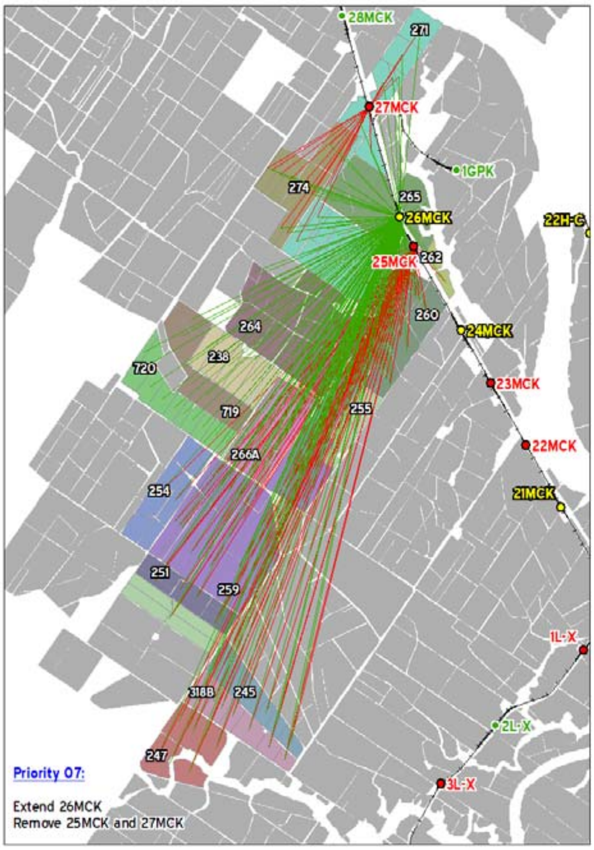
5037
5249
15M-L
8MLP
16M-L
17M-L
5045
5004
18M-L
5044
19M-L
20M-L
4VGL
Priority 03:
Extend 17M-L
Remove 8MLP, 15M-L, 16M-L and 18M-L


12GOW
11GOW
325
324
1ELP
10GOW
9GOW
322
8GOW
323
321
Priority 04:
Extend 11GOW
Remove 8GOW, 9GOW and 10GOW


2ELP
330
691
5GOW
318A
315A
7GOW
316A
319
3GOW
Priority 05:
Extend 7GOW
Remove 5GOW
2GOW


5149
5147
4MON
5326
5379
3MON
4LUC
2MON
Priority 06:
Extend 4MON
Remove 3MON
3LUC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27MCK
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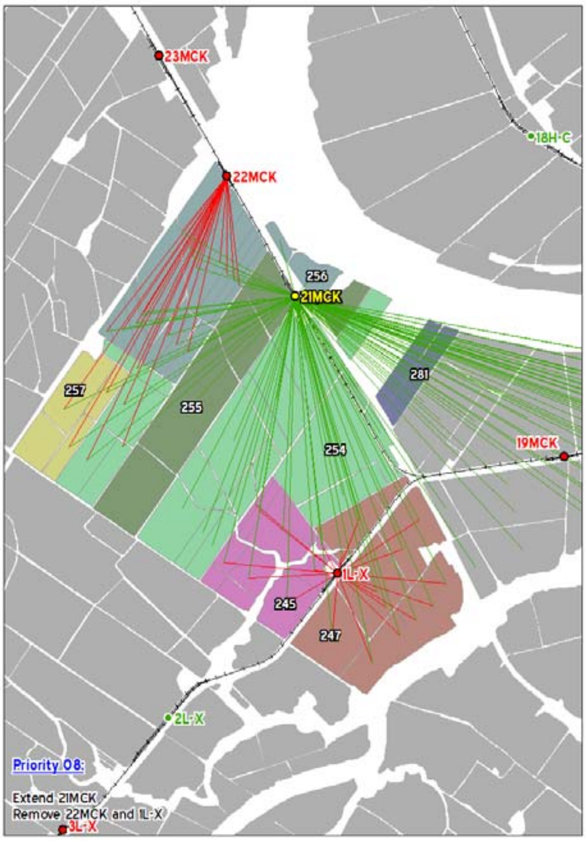
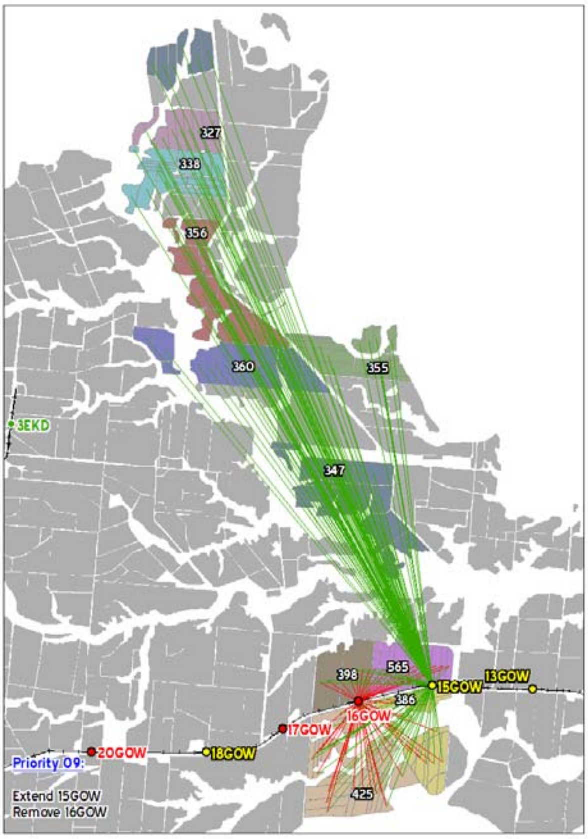
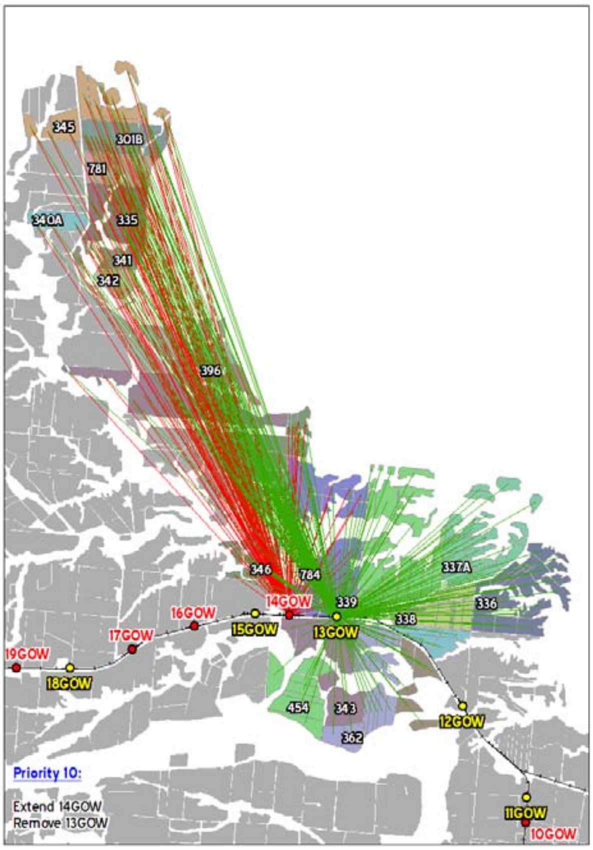
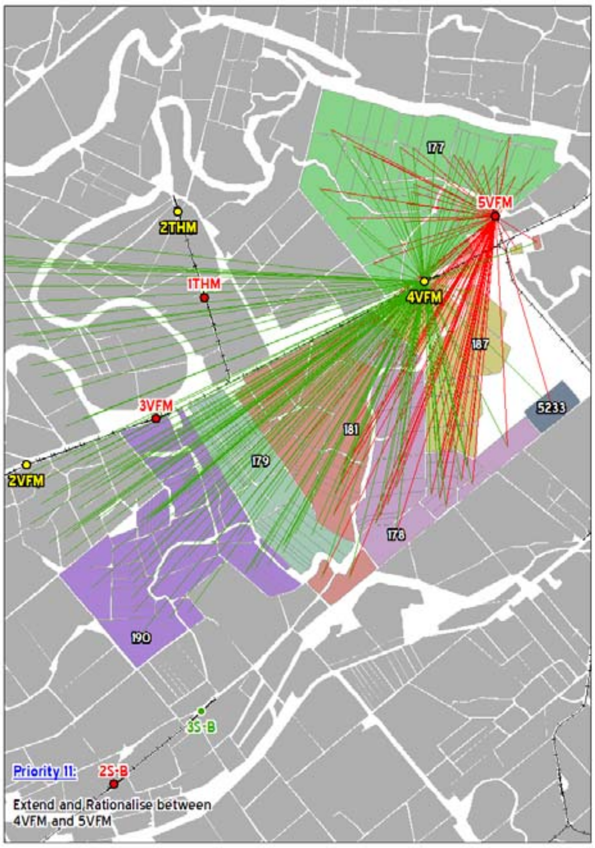
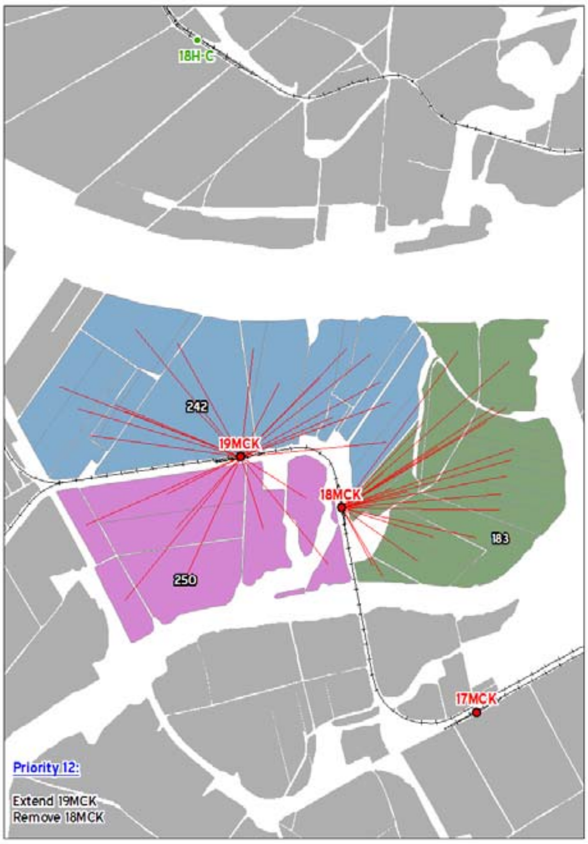
26MCK
22H-C
25MCK
262
260
24MCK
264
238
720
23MCK
719
255
22MCK
266A
254
21MCK
251
259
1L-X
318B
245
2L-X
247
3L-X
Priority 07:
Extend 26MCK
Remove 25MCK and 27MCK

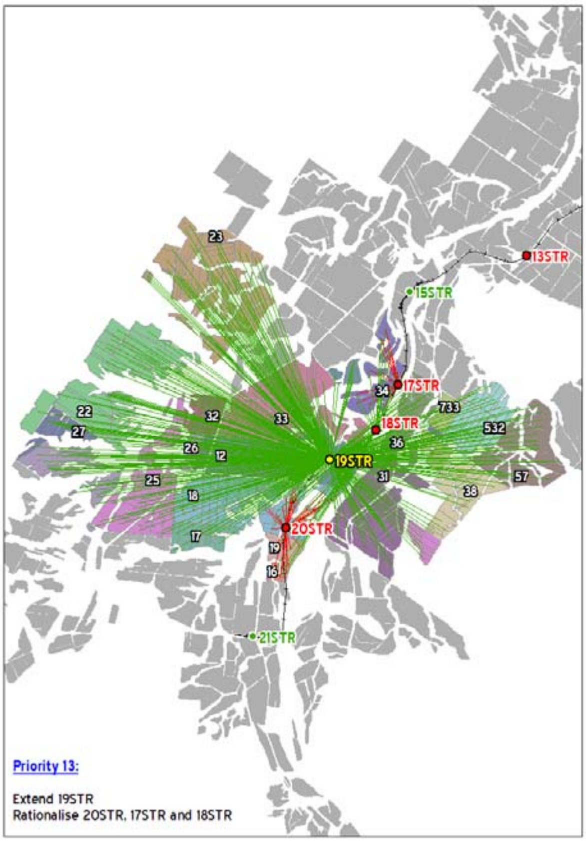

23MCK
18H-C
22MCK
256
21MCK
257
281
255
19MCK
254
1L-X
245
247
2L-X
Priority 08:
Extend 21MCK
Remove 22MCK and 1L-X
3L-X

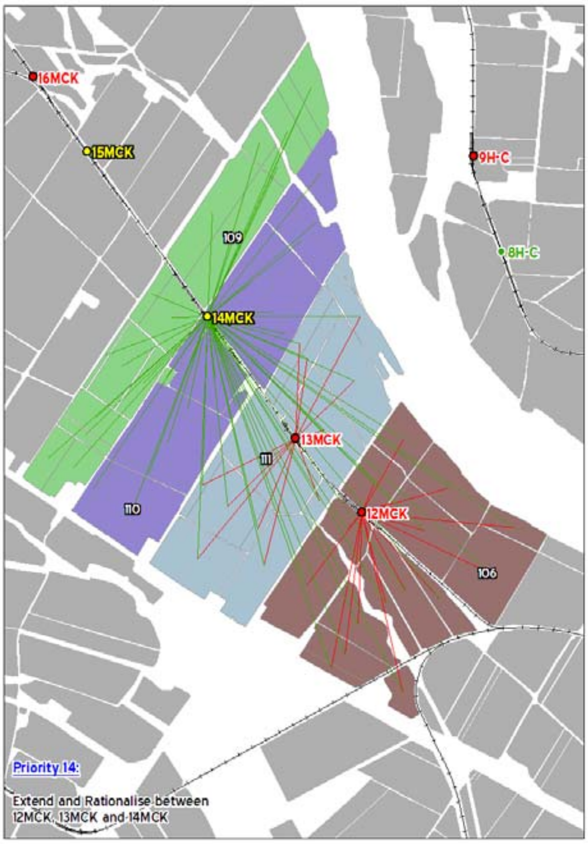

Priority 09:
Extend 15GOW
Remove 16GOW
3EKD
327
338
356
360
355
347
398
565
386
425
13GOW
15GOW
16GOW
17GOW
18GOW
20GOW

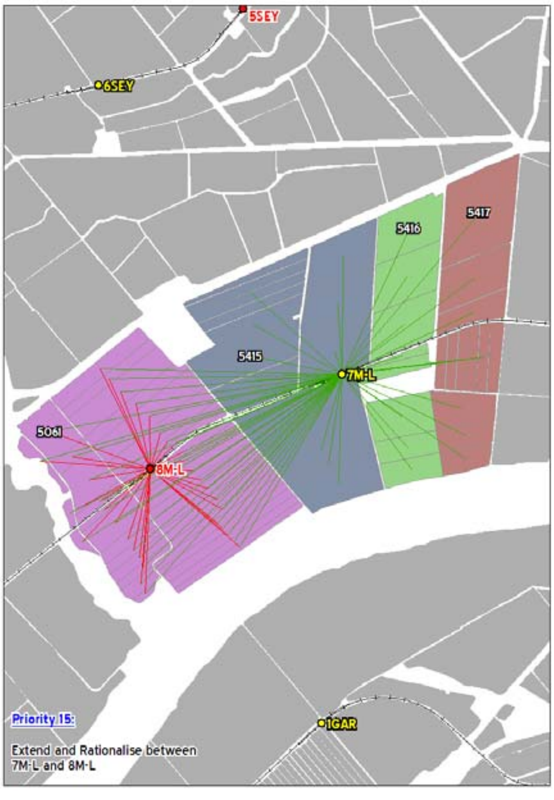

Priority 10:
Extend 14GOW
Remove 13GOW
345
301B
781
340A
335
341
342
396
346
784
337A
336
339
338
454
343
362
10GOW
11GOW
12GOW
13GOW
14GOW
15GOW
16GOW
17GOW
18GOW
19GOW

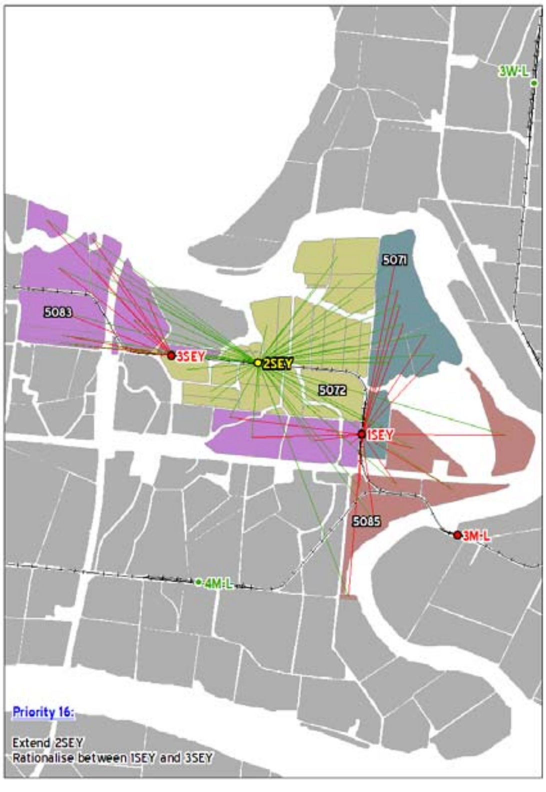

Priority 11:
Extend and Rationalise between
4VFM and 5VFM
177
187
181
179
178
190
5233
5VFM
4VFM
3VFM
2VFM
2THM
1THM
3S-B
2S-B

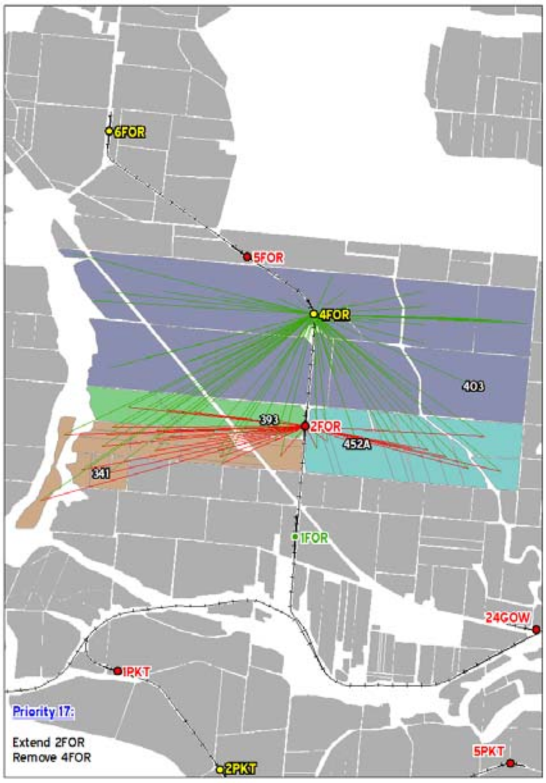

Priority 12:
Extend 19MCK
Remove 18MCK
18H-C
242
250
183
19MCK
18MCK
17MCK

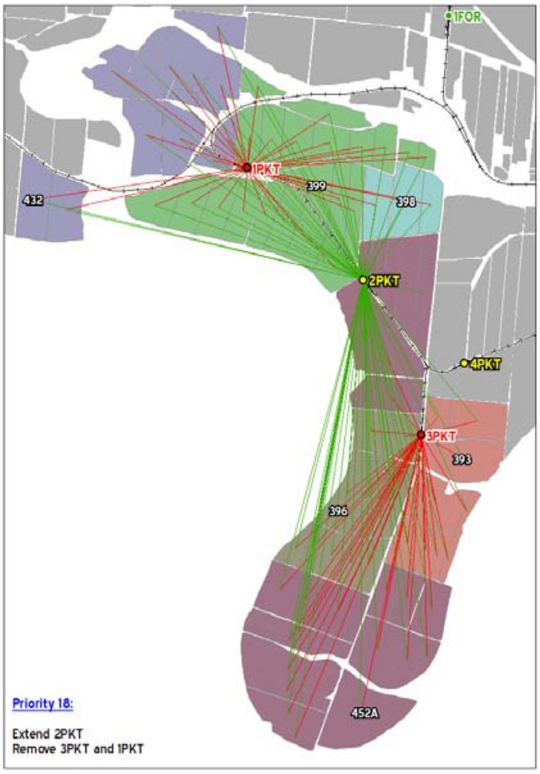

13STR
15STR
17STR
18STR
19STR
20STR
21STR
23
22
27
32
33
34
733
532
36
26
12
25
18
31
38
57
17
19
16
Priority 13:
Extend 19STR
Rationalise 20STR, 17STR and 18STR

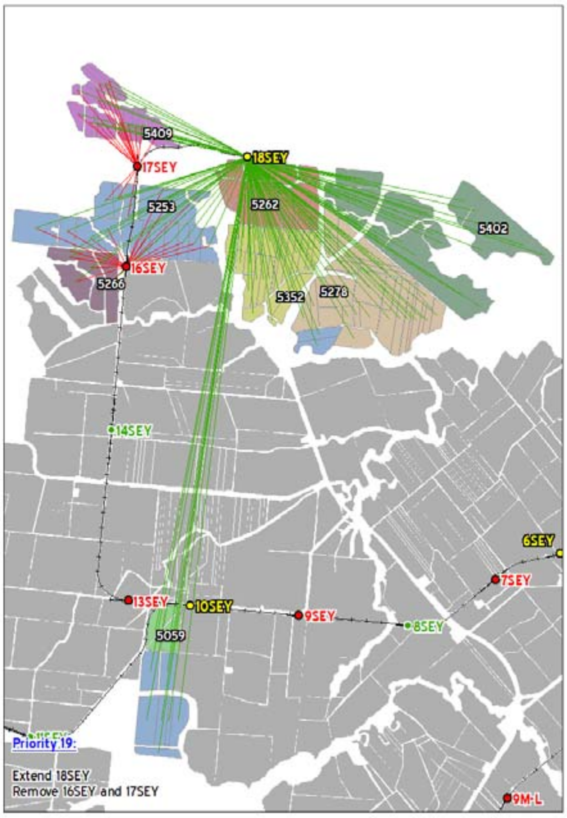

16MCK
15MCK
9H-C
8H-C
109
14MCK
13MCK
111
110
12MCK
106
Priority 14:
Extend and Rationalise between
12MCK, 13MCK and 14MCK

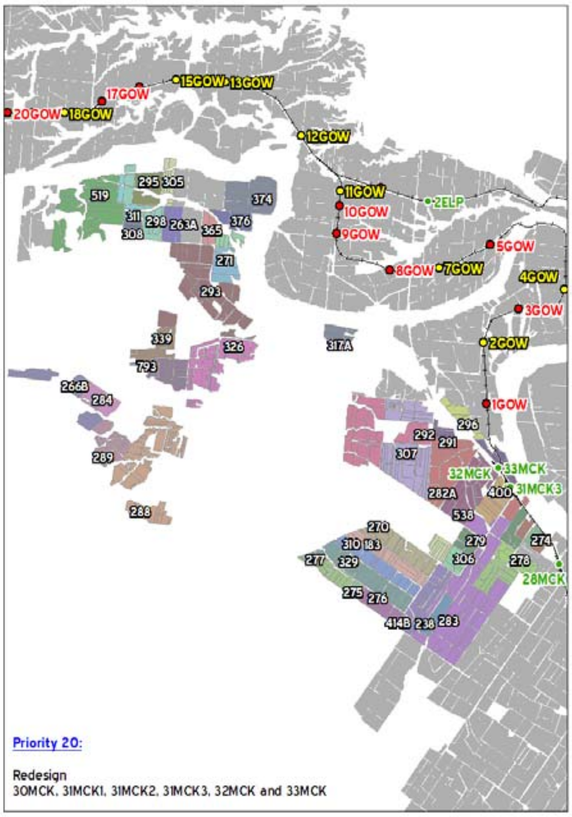

5SEY
6SEY
5416
5417
5415
7M-L
5061
8M-L
1GAR
Priority 15:
Extend and Rationalise between
7M-L and 8M-L


3W-L
5071
5083
3SEY
2SEY
5072
1SEY
5085
3M-L
4M-L
Priority 16:
Extend 2SEY
Rationalise between 1SEY and 3SEY


6FOR
5FOR
4FOR
403
393
2FOR
452A
341
1FOR
24GOW
1PKT
Priority 17:
Extend 2FOR
Remove 4FOR
2PKT
5PKT


1FOR
1PKT
399
398
432
2PKT
4PKT
3PKT
393
396
452A
Priority 18:
Extend 2PKT
Remove 3PKT and 1PKT


5409
18SEY
17SEY
5253
5262
5402
16SEY
5266
5352
5278
14SEY
6SEY
7SEY
13SEY
10SEY
9SEY
8SEY
5059
Priority 19:
Extend 18SEY
Remove 16SEY and 17SEY
9M-L


15GOW
13GOW
17GOW
20GOW
18GOW
12GOW
11GOW
10GOW
9GOW
2ELP
5GOW
8GOW
7GOW
4GOW
3GOW
2GOW
1GOW
Priority 20:
Redesign
30MCK, 31MCK1, 31MCK2, 31MCK3, 32MCK and 33MCK