final report

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Prepared by: Greenleaf Enterprises

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Meat and Livestock Australia Limited
Locked Bag 991
NORTH SYDNEY NSW 2059

Beef Loin Deboning Manual Saw Semi-Automation

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Contents

1 Executive Summary

There are significant yield and operator safety issues associated with current processing methods for deboning beef loins. The angle of cut is critical to achieving optimal yields. Whilst companies have experienced improved yields using trial make-shift saws they have involved operators working in close proximity to bandsaw blades. No commercial solution exists that removes direct interaction of operator with the saw while maintaining improved yields because the large variance in beef bone to meat ratio results in unacceptably large yield variations.

Scott Technologies in conjunction with JBS, MLA and AMPC have developed a prototype sensing saw (modified from existing equipment) that is intended to improve operator safety while maintaining improved yields. This semi-automatic system is currently in commercial trials. It requires the operator to place the meat primal into a cradle that guides the loin through a bandsaw using the best cut profile selected by the operator.

Scott Technology aimed to remove the operator away from a bandsaw by automating the sensing and 'driving' of the meat primal (the loin) through the bandsaw on a newly developed moving table.

This cost-benefit study reviewed the performance of the prototype Scott loin de-boning system, the in-house loin saw (Generic Loin Saw) and table boning against side chain boning which was used as the baseline for comparisons within this study.

Table 1: Comparative performance of three loin de-boning methods against a chain boning baseline

SUMMARY PERFORMANCE MEASURES*			
* Three methods compared back to Side Chain boning			
	Table Boning	Scott's Loin Saw	Generic Loin Saw
Capital cost	$0	$98,000	$58,000
Gross return Per head	$1.92	$4.05	$3.67
Total costs Per head	$0.00	$0.06	$0.13
Net Benefit Per head	$1.92	$3.99	$3.55
Net Benefit / cobotic unit	N/A	$1,422,686	$1,266,049
Annual Net Benefit for the plant	$687,201	$1,422,686	$1,266,049
Pay back (months)	0.00	0.83	0.55
NPV	$4,103,483	$8,476,843	$7,549,044

Trials conducted during the study demonstrated savings summarised in Figure 1. Removal of vertebra using either a generic or Scott saw delivered improvements in yield over both table boning and chain boning. Although the newly developed Scott's saw demonstrated improved yield over the generic saw the data collected was not considered significant due to differences in cattle types available for comparison between the two pieces of equipment. There was however a reduction in operational costs with the new saw due to reduced band saw blade costs. There was also a significant increase in operational safety by removing the operator's hands from the bandsaw cutting area but the actual dollar savings is minimal.

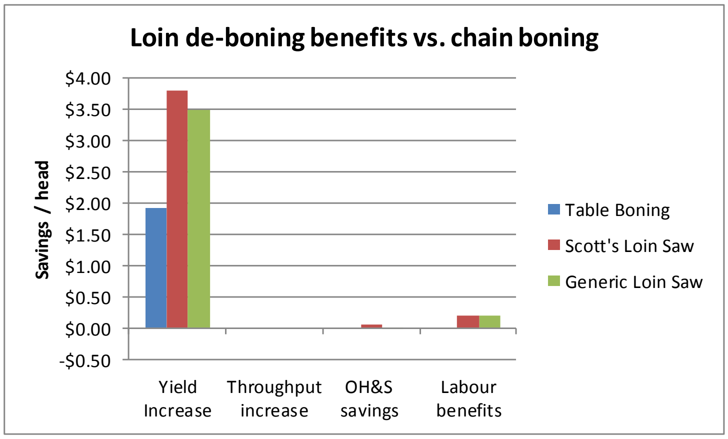

Figure 1: Breakdown of benefits between the de-boning methods

2 Background

There are significant yield and operator safety issues associated with current manual processing methods for deboning beef loins.

Previously JBS (formerly Swift) developed a beef loin saw by modifying an existing bandsaw, the in-house loin saw (Generic Loin Saw), with a triangular cutting path (using three wheels) rather than the typical oval cutting path (using two wheels). This configuration allows for the loin to be cut at the best angle for meat recovery.

Although this solution increased the yield obtained in the loin, it still results in some yield lost and requires the operator still place their fingers very close to the band saw. Consequently, no commercial equipment exists that uses this approach in a production environment..

The newly developed prototype system being reviewed in this cost benefit analysis removes the operator away from a bandsaw by automating the sensing and 'driving' of the meat primal (the loin) through the bandsaw on a newly developed moving table. The system is semi-automatic and requires the operator to place the meat primal into a cradle, activate 'two' clamps and then the system will determine the best cut profile and drive the loin through a bandsaw.

3 Project Objectives

The overarching objective of the developemnt project was for Scott technology to develop through a series of design interations and prototype tests a working prototype system that:

1. Improved on the existing yield benefits demonstrated by JBS's existing in-house saw solution; while
2. Eliminating the operational saftey risks of the current test system.

Greenleafs objectives as part of this operational review were to establish a base line manual perfomance and determine the degree to which the newly designed Scott's loin system achieved the following outcomes:

1. To improve accuracy of the chine bone removal and improve loin yield plus reduce wiz trim, hence increasing overall revenue and labour cost reduction.
2. Remove operator interaction with the saw blade, hence removing the risk of cuts, soft tissue and nerve damage, and ultimately the risk of amputation.
3. To measure the difference in yield between side chain boning of the loin against table boning and the two loin saw methods (including wiz meat residual) where side chain boning is used as the baseline on which to calculate benefit of the other methods.

The cost benefit assessment objectives were achieved.

4 Trial Methodology and Data Collection

This section provides an outline of the details of the research conducted in both Dinmore and Beef City boning room trials.

4.1 Data collection

Production sampling versus statistically robust yields

Most processing plants have internal reporting methods used to monitor primal cut yields as a percentage of carcase weight. This reconciliation of carcase weight into the boning room against weight of primals packed is an effective method when monitoring boning room yield over a day or a run of carcases. Assuming the loin saw delivers an improvement in yield over table or chain boning, you would expect the finished vacuum packed primals to be heavier than those processed using the lower yielding manual methods.

Given the variation in carcase weight, fat cover and carcase muscling, a very large number of carcase would need to be sampled to demonstrate this. Conducting comparative trials using left and right sides of the same carcase does minimise variation. However, a number of factors present variations in results that are greater than the variation in yield between table boning, chain boning and removal of the chine bone by Scott's saw. These sources of variation are summarised in Figure 2 and the methods used to run the trials and collect data are included in the methodology section below.

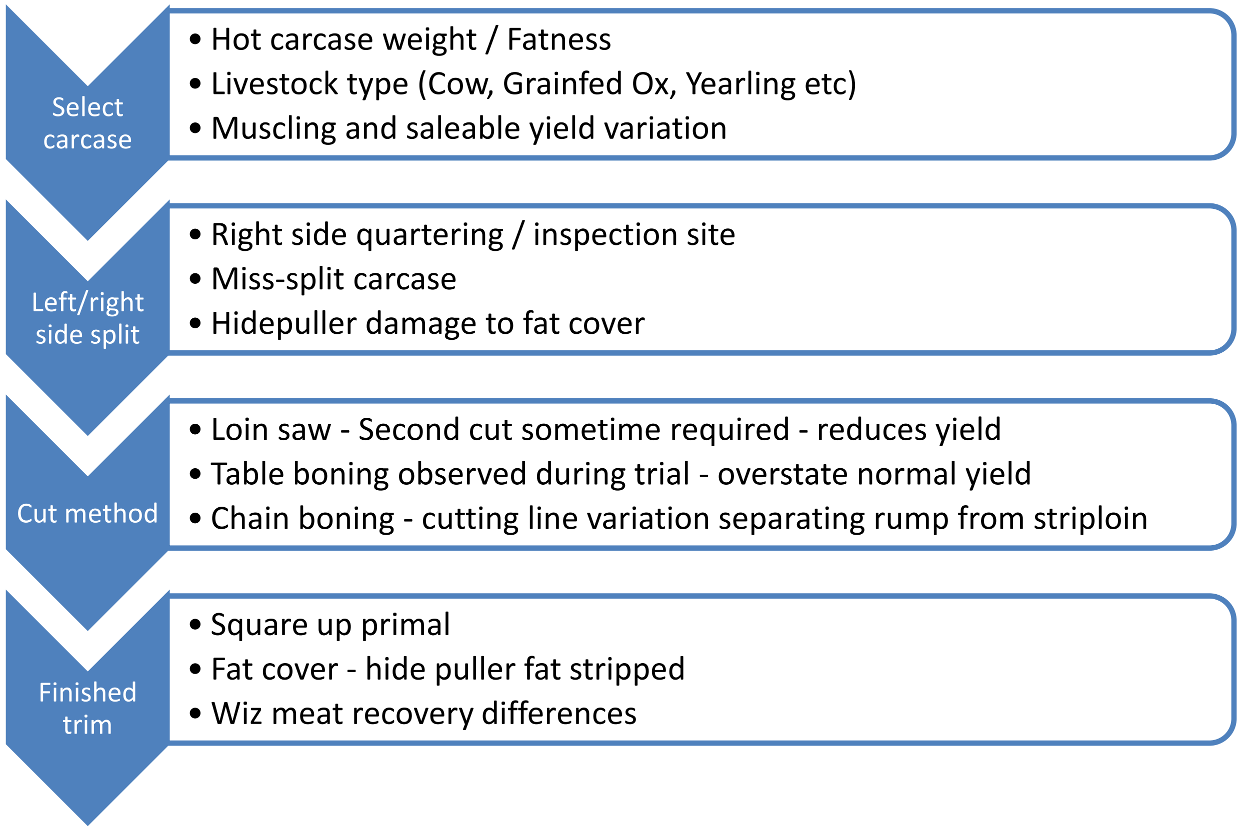

Figure 2: Sources of variation between samples requiring a different measurement methodology

4.2 Trial Methodology

1. Select carcase on chain
    a. Left and right side details recorded from carcase ticket
    b. Each side of the carcase followed through the boning process to the point of loin removal
    c. At the point of boning striploins the flank has been removed from the quartered side
2. Boning Striploin
    a. Side chain boned (One side of carcase)
        i. Rump separated from aitch bone, continuing down into striploin separation from the vertebrae leaving the rump attached to the striploin.
        ii. Continue to separate striploin from the vertebrae removing fully intact boneless rump and striploin from the carcase
        iii. Striploin separated from the rump with a knife cut on the boning table
        iv. Boned vertebrae removed from the carcase making a knife cut between the vertebrae
        v. Wiz knife removes remaining trim off vertebra and saved for weighing

b. Table boning (Manual)
    i. Bone in striploin removed by cutting through the vertebrae between the striploin and rump
    ii. Bone-in weight recorded
    iii. Bone-in striploin boned out on table off-line by the same boner and trimmed by same slicer
    iv. Wiz knife removes remaining trim off vertebra and saved for weighing
c. Saw de-boning (Generic loin saw and Scott loin saw)
    i. Bone in striploin removed by manual knife cut through the vertebrae between the striploin and rump
    ii. Bone-in weight recorded
    iii. Vertebra removed on loin saw (Generic and Scott loin saws) by the operator on duty that day
    iv. Both loin and vertebra saved for weighing
    v. Wiz knife removes remaining trim off vertebra and saved for weighing
d. Vertebra, rib, wiz trim, other bone, fat and finished striploin collected for further trimming and weighing

3. Weighing and recording results, start the process again

4.3 Table boning

Figure 3: Bone-in loin prior to table boning

Figure 4: Loin bone after table boning plus wiz trim

4.4 Loin saw boning

Figure 5: Bone-in loin after removing backbone with saw

Figure 6: button bones are removed from striploin with a wizard knife after saw cut

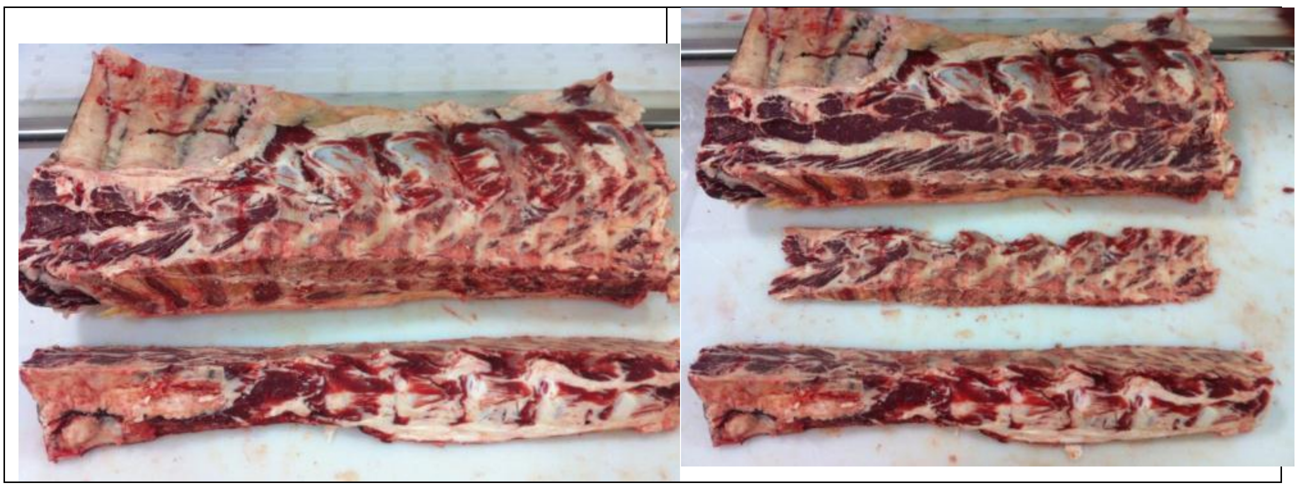

Figure 7: Ribs and vertebrae need to be separated for boning otherwise a second saw cut is required to enable boning

Figure 8: Measurement process to capture weight of bones relative to primal, wiz trim and fat weights

4.5 Side chain boning

Chain boning can be done by removing the bone from the hanging muscles as in Figure 9 and Figure 10. Alternatively the rump and striploin can be removed from the skeleton as done during the trials at JBS. In both options the separation of rump from striploin occurs after removing the muscles from the carcase. This cutting line between rump and striploin can be done in a slightly different place than removal of bone-in striploin for table boning or loin saw boning. This is an additional source of variation when comparing finished primal weights as a percentage of total carcase weight.

Figure 9: Chain boning removing the bone from the hanging muscle

Figure 10: Cutting line to separate rump and striploin after boning

Figure 11: Removal of bone-in striploin ready for table boning

Figure 12: Chain boned striploin and removal of vertebra from carcase for weighing post boning

4.6 Finished Specification

All primals were trimmed to packed specification. This included squaring up ends as required, measuring and cutting the same tail length for each primal and trimming fat cover back to correct depth.

Figure 13: Trimming boneless striploin primal to finished specification

4.7 Generic loin saw cutting line versus Scott's loin saw

Figure 14: Cut is very close to hands and requires cut to be curved following orange arrow on picture to remove vertebrae with highest yield

Figure 15:Steel mallet used to force the separation of ribs from vertebra where cut leaves ribs joined

Figure 16: Safety benefits of removing hands from cutting area

Figure 17: straight cutting line is easier for operator but could impact on yield slightly compared with generic saw although this was not evident in the data collected

Figure 18: Integration of system into processing line will be required so operator does not have to pivot 180 degrees

Figure 19: Adjustable table angle allows different settings for different runs of carcases.

5 Yield Difference

The key financial driver of profit for this loin de-boning system is the weight of striploin sold relative to the starting carcase weight. Weight of saleable striploin is directly impacted by the weight of wiz trim and bone removed from the striploin during the boning process. Comparative weight of these three products (finished striploin, wiz trim, and bone) are the factors used in the primary method for comparing yield between the different systems. A secondary method (comparing weight of finished striploin against hot carcase weight) was also used. Both methods demonstrated an improvement in yield using either loin saw over both table boning and side chain boning. However, the range of variables mentioned earlier in Figure 2 when using this second method create more variation in yield than that observed between the four boning methods measured during the trials. The time it takes to track carcases through the whole boning process and conduct full yields required for this analysis limits the sample size for each treatment which was the reason for using both calculation methods.

Table 3 and Table 2 summarise the yields results of all four boning methods using both yield calculations mentioned above. Weight is expressed as a combination of total carcase weights sampled during the trial. Note the "Loin Wgt" column and associated "Yield %" compares weight of finished loin back to hot carcase weight and demonstrate an improvement in yield of 0.13% of total carcase weight for JBS generic loin saw method as compared to side chain boning. There is also a reduction in wiz trim, expressed in the far right column as 3.4% of finished loin weight. This reduction in wiz trim represents an increase of the same percentage in finished striploin weight.

Table 2: Dinmore trials – Comparison of side chain versus JBS generic loin saw boning methods against carcase weight and loin weight

SUMMARY from "YIELD 16 8 12" Tab	*Side wgt*	*Loin wgt*	*Yield %*	*Wiz wgt*	*Yield %*	Wiz trim as % of Loin weight
Side Chain	2151	87	*4.05%*	4.9	*0.23%*	5.6%
Loin Saw	2188	92	*4.18%*	2.0	*0.09%*	2.2%

Wiz trim savings were observed in further trials as shown in Table 3 where table boning showed a reduction in wiz trim over chain boning of 2.2% of finished loin weight, loin saw showed an additional improvement of 1.5% over table boning and the Scott's loin saw showed a further reduction over the generic loin saw of 0.3% of total finished loin weight. Note the expression of loin yield as a percentage of total carcase weight followed similar trends but given the wide range of variables contained in this data is not considered a reliable and repeatable method for the limited size of the data set.

Table 3: Dinmore and Beef City trials 1 thru 4 comparing all four boning methods against carcase weight and loin weight

	Side wgt	*Loin wgt*	*Yield %*	*Wiz wgt*	*Yield %*	*Bone wgt*	*Yield %*	Wiz trim as % of Loin weight	Number of sides	Wiz Wgt/side
Side Chain	3088	118	*3.81%*	6.4	*0.21%*	47.5	*1.54%*	5.4%	20	0.32
Table Bone	3242	130	*4.02%*	4.2	*0.13%*	48.0	*1.48%*	3.2%	20	0.21
Generic Loin Saw	3363	133	*3.95%*	2.3	*0.07%*	48.3	*1.44%*	1.7%	20	0.11
Scott's Saw	2833	112	*3.96%*	1.6	*0.06%*	45.4	*1.60%*	1.4%	16	0.10

In summary, wizard trim very clearly shows the differences in the boning methods. Side boning produced in excess of 300grams of wizard trim while saw boning produced 100grams per side on average. This represents an increase of 200 gram saving in loin meat per side or 400grams per carcase.

These improvements in yield are summarised in the model in Table 4 which contribute to financial improvements discussed later in the report.

Table 4: Summary of yield improvements over side chain boning for three boning methods

	Table Boning	Scott's Loin Saw	Generic Loin Saw
Head / Hour	179	179	179
Head / Day	1,428	1,428	1,428
Head / Annual	357,000	357,000	357,000
Yield increase (% of HSCW)	0.08%	0.15%	0.14%
Yield increase (kg/head)	0.21	0.42	0.39

5.1 Other costs and benefits

5.1.1 OH&S Savings

Two main areas are identified where the saw will provide OH&S benefits. These are reduced sprain and strain injuries through eliminating the need for any operator interaction with a saw blade for the cutting of the vertebra. Data from the past 7 years of history was reviewed to calculate the costs of OH&S injuries as a result of bandsaws on the loin de-boning tasks.

Based on these assumptions the following frame work is presented to show OH&S Benefits (Table 5).

Table 5: OH&S Benefits of equipment

OH&S Benefits		Chain Boning	Table Boning	Scott's Loin Saw	Generic Loin Saw
Band Saw cutting					
Average cost of bandsaw accidents over 5 years	$120,000				
Risk of Limb Loss over 5 year period		0%	0%	0%	100%
Annual Cost		$0	$0	$0	$24,000
Annual Saving		**$0**	**$0**	**$0**	**-$24,000**
Annual Saving per head		**$0.00**	**$0.00**	**$0.00**	**-$0.07**
Sprain and Strain from lifting					
Cost of light duties claim, loss of operator	$5,000				
Number of occurrences per year		4	4	0	0
Annual Cost		$20,000	$20,000	$0	$0
Annual Saving		**$0**	**$0**	**$20,000**	**$20,000**
Annual Saving per head		**$0.00**	**$0.00**	**$0.06**	**$0.06**
TOTAL OH&S Benefit per annum		$0	$0	$20,000	-$4,000
TOTAL OH&S Benefit per head		$0.00	$0.00	$0.06	-$0.01

5.1.2 Labour Savings

The data displayed in Table 6 shows a saving of 1 labour unit for band saw operators. Across the boning chains at JBS, lines not using a generic saw are allowed to have one additional boner to remove the striploin on the chain. These savings are summarised in Table 6. Both the generic and Scott's loin saws were operated easily at chain speeds requiring three boners under manual loin de-boning conditions. Saw capacity would cope with chain speeds equivalent to four manual loin de-boners.

Table 6: Labour savings achieved with cutting equipment

Increased throughput through the room			Chain Boning	Table Boning	Scott's Loin Saw	Generic Loin Saw
Average daily hd			1428	1428	1428	1428
Average kg			280	280	280	280
Average Kg boned per day			399,840	399,840	399,840	399,840
Boning room cost / hour			$101	$101	$68	$68
Boning room cost / day			$811	$811	$541	$541
Labor cost \ per kg to bone			$0.00	$0.00	$0.00	$0.00
Labor cost \ per hd to bone			$0.57	$0.57	$0.38	$0.38
Labour productivity savings/ head			**$0.00**	**$0.00**	**$0.19**	**$0.19**
Task	**Rate / hour**	**WW Loading** 30.00%	**Number labor units**			
Band Saw operator	$26.00	$33.80	0	0	1	1
Boners	$26.00	$33.80	3	3	1	1
Knife hand	$23.00	$29.90				
Trimmers	$23.00	$29.90				
Total FTE's required			3.0	3.0	2.0	2.0
Staff training costs			0	0	1	1
Staff turnover rate		30%				
Number of staff being trained each year			0.00	0.00	0.30	0.30
Reduction in hrs required to train beginners			40	41	42	43
Hly training cost			$29.00	$30.00	$31.00	$32.00
Saving per trainee			$1,160	$1,230	$1,302	$1,376
Total Saving			$0.0	$0.0	$390.6	$412.8
Saving per hd			**$0.00**	**$0.00**	**$0.00**	**$0.00**

5.2 Equipment Costs

Table 7 shows the total cost of the equipment Including both capital and operational costs. Real costs will be site specific to every application. Some adjustment to boning configuration is required but installation costs for this equipment or not significant.

Table 7: Estimated capital, and operational costs of cutting equipment

Capital & Operational Costs			Chain Boning	Table Boning	Scott's Loin Saw	Generic Loin Saw
Capital purchase and installation						
Number of Units			0	0	1	1
Equipment purchase / Unit Cost			$ -	$ -	$ 88,000	$ 48,000
Total equipment capital			$ -	$ -	$ 88,000	$ 48,000
Installation					$ 10,000	$ 10,000
Other						
Total Cost			**$ -**	**$ -**	**$ 98,000**	**$ 58,000**
Annual Capital Cost			$ -	$ -	$ 12,250	$ 7,250
Annual Capital Cost per head			**$ -**	**$ -**	**$ 0.034**	**$ 0.020**
Maintenance Cost						
Hourly labour rate		$ 29.68				
Labour (Monthly hrs)			0.00	0.00	4.00	2.00
Annual labour			$ -	$ -	$ 1,425	$ 712
Materials						
Parts						
Total annual cost			$ -	$ -	$ 1,425	$ 712
Cost per head			**$ -**	**$ -**	**$ 0.004**	**$ 0.002**
Operational Cost						
Blades (Annual Cost)			$ -	$ -	$ 7,420	$ 37,100
	Blade unit cost		$ -	$ -	$ 29.68	$ 29.68
	Blades / day		0	0	1	5
Cleaning (Annual Cost)			$ -	$ -	$ 1,291	$ 775
Power						
Service Contract						
Ongoing Training						
Total annual cost			$ -	$ -	$ 8,711	$ 37,875
Cost per head			**$ -**	**$ -**	**$ 0.024**	**$ 0.106**

5.2.1 Capital costs

Equipment purchase price is based on prices supplied by the manufacturer.

5.2.2 Maintenance & Service Costs

Maintenance and Service costs are also supplied by the equipment manufacturer. Maintenance costs are additional running costs that the plants will incur with the installation of the equipment and include components such as parts and labour. A large difference in operating cost between the generic and new Scott's saw is the reduction in use of bandsaw blades with the new system. It is reported that blade replacement has reduced from 6 blades to 1 blade per day.

6 Cost Benefit Results

This section explains the summary results of the cost benefit analysis using the drivers shown in Table 8.

6.1 Drivers used in CBA analysis

The purpose of Table 8 is firstly to explain drivers that can be used to adjust the model parameters to best represent a given situation; secondly the numbers shown in this table represent the settings used for the analysis results shown under headings 6.2 and 6.3.

Table 8: Model Drivers and description (benefits compared to side chain boning)

PLANT SPECIFIC DRIVERS

Operational Assumptions		Sales Assumptions	
Discount rate	7%	Carcase Weight	280
Total hours operation/day	8	Value of Striploin	$14.00
Total days operation/year	250	Value of Wiz Trim	$5.00
Shifts per day	1	Value of Render	$0.05

	Table Boning	Scott's Loin Saw	Generic Loin Saw
Head / Hour	179	179	179
Head / Day	1,428	1,428	1,428
Head / Annual	357,000	357,000	357,000
Yield increase (% of HSCW)	0.08%	0.15%	0.14%
Yield increase (kg/head)	0.21	0.42	0.39
Machine Capacity (Head/hour)	0	200	200
Number of systems	0	1	1
Labour saving / shift	-1	0	0
Useful working life		8	8

6.2 Summary of Costs and Benefits

The combined results for the different benefits and costs associated with the performance of the Scott loin de-boning saw are shown in Table 9. Based on the drivers selected for the current analysis the gross benefit of the Scott loin saw is estimated at $4.05/hd, and a cost of $0.06/hd. This result shows an estimated average net benefit of $3.99 for every head processed through the equipment (including the cost of capital) as compared with chain boning. There is a $2.07/head net benefit over table boning based on the trial data sets and the pricing assumptions used in the model.

Table 9: Summary costs and benefits associated with each de-boning method compared with chain bone baseline

COST - BENEFIT ANALYSIS OF COBOTIC EQUIPMENT*						
* Three methods compared back to Side Chain boning						
	Table Boning		Scott's Loin Saw		Generic Loin Saw	
Benefit summary	$/hd	Total plant benefit	$/hd	Total plant benefit	$/hd	Total plant benefit
Yield Increase	$1.92	$687,201	$3.80	$1,357,472	$3.50	$1,248,286
Throughput increase	$0.00	$0	$0.00	$0	$0.00	$0
OH&S savings	$0.00	$0	$0.06	$20,000	-$0.01	-$4,000
Labour benefits	$0.00	$0	$0.19	$67,600	$0.19	$67,600
$ Benefit per head	**$1.92**	**$687,201**	**$4.05**	**$1,445,072**	**$3.67**	**$1,311,886**
Capital cost	$0.00	$0	$0.03	$12,250	$0.02	$7,250
Maintenance Cost	$0.00	$0	$0.00	$1,425	$0.00	$712
Operational Cost	$0.00	$0	$0.02	$8,711	$0.11	$37,875
Risk of mechanical failure	$0.00	$0	$0.00	$0	$0.00	$0
Risk of mechanical injury	$0.00	$0	$0.00	$0	$0.00	$0
Risk of product damage	$0.00	$0	$0.00	$0	$0.00	$0
Total cost per head	$0.00	$0	$0.06	$22,386	$0.13	$45,837
Total net $ benefit per head	$1.92	$687,201	$3.99	$1,422,686	$3.55	$1,266,049

Trials conducted during the study demonstrated savings summarised in Figure 1. Removal of vertebra using a saw delivered improvements in yield over table boning and side chain boning. Although the newly developed Scott's saw demonstrated improved yield over the generic saw the data collected was not considered significant due to differences in cattle types available for comparison between the two pieces of equipment. There was however a reduction in operational costs with the new saw due to reduced band saw blade costs. There was a significant increase in operational safety by removing the operator's hands from the bandsaw cutting area but the actual dollar savings is minimal.

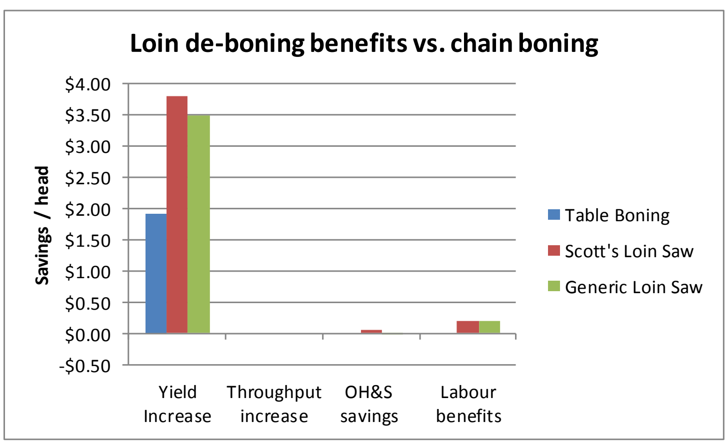

Figure 20: Breakdown of benefits between the de-boning methods versus side chain boning

6.3 Financial viability of equipment

Application of this equipment to any given plant will have something of a different impact, however based on the drivers show in Table 8 the following analysis provides a net annual return to the plant of approximately $1,400,000 including the cost of capital. Considering an initial total cost of investment of under $100,000, this delivers a payback period of around 1 month over side chain boning. Based on a 10 year life expectancy of the investment and discount rate of 7% (and all other factors being equal) the Net Present Value of investment is estimated at $8.4 million over side chain boning.

Table 10: Summary financial results comparing 3 de-boning methods against a chain boning baseline

SUMMARY PERFORMANCE MEASURES*			
* Three methods compared back to Side Chain boning			
	Table Boning	Scott's Loin Saw	Generic Loin Saw
Capital cost	$0	$98,000	$58,000
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7 List of Tables

8 List of Figures