Musculoskeletal Disorders in the New Zealand Sawmilling Industry – Prevalence, Risk factors and Intervention Strategies

A thesis in partial fulfillment of the requirements for the degree of Master of Ergonomics at Massey University

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ABSTRACT

Government injury data indicated that New Zealand's sawmilling industry had a high number of musculoskeletal disorder (MSD) claims of high cost. New Zealand's forestry and wood processing sector is also a growth industry, with 100 new mills likely to be developed by 2010. Required to address the high rate of MSDs is a systematic review of manual handling risk factors and the development of related intervention strategies.

Detailed information on the prevalence and nature of MSDs in NZ sawmilling was sought. Available Accident Compensation Corporation injury records provided limited detail on the work tasks causing MSDs in sawmill workers. An industry survey of reported accidents for a 12 month period (September 2000-August 2001) was completed to determine MSD prevalence, and to identify sawmilling operations with high manual handling risks. 56% of MSD reports were from millhands and tablehands, who complete the majority of timber handling tasks. Back injuries accounted for 37% of MSD reports, and upper extremity complaints a further 35%. Tasks creating the largest proportion of MSDs in sawmills were pulling, sorting and stacking of timber from green or dry tables/chains (conveyors moving freshly sawn or kiln-dried timber, from which boards are taken and stacked), filleting tasks (stacking timber with spacer sticks before drying), and grading/sorting on the green table/chain.

In case studies of two South Island sawmills, timber handling tasks at green and dry tables were investigated to determine manual handling risk factors. Karsh et al (2001) suggest that multiple intervention applications are the most successful in reducing MSDs. A range of assessment methods was therefore used to identify a range of manual handling risk factors and potential interventions. Assessments included worker interviews, archival data review, environmental assessment, lifting strength testing, force measurement, anthropometry, dimensional assessment, discomfort reporting, exertion scales, Rapid Entire Body Assessment, and application of a manual handling risk assessment.

The manual handling risks identified were related to a wide range of aspects of the task (frequency, workplace design), worker (experience, training), load (timber size, chain/table design), environment (temperature, lighting) and management (task rotations, maintenance schedules). The intervention strategies developed to reduce the manual handling risks included workspace geometry (such as the relationship of timber on the table to the packet, and packet spacing), workflow management (such as task rotations, and managing peaks and troughs in production), task technique training (such as board throwing methods, induction training, and the use of protective aprons), table design (such as height, type of

chain or conveyor), and glove design. Mill-specific recommendations based on these strategies were presented to the mills.

Further work is indicated to evaluate the effectiveness of recommended intervention strategies.

GLOSSARY

Green timber	Recently sawn or fresh lumber that has not yet been through any drying process.
Dry timber	Timber that has been dried, usually in a kiln but may be air-dried in the yard.
Long chain or long table	A straight conveyor system moving sawn timber from the mill. Boards are pulled from the conveyor and stacked into packets. Conveyors may be a link chain, plain steel belts, rollers, shaped nylon lugs or cleat design.
Round table	A large, rotating, circular platform onto which green sawn timber from the mill falls, and boards are pulled and stacked into packets.
Packet	A stack of timber of set dimension and board numbers that is strapped and/or wrapped in plastic. Each workplace has unique packet dimension requirements usually related to size for export containers and other transporting and storage issues.
Filleting or stripping	The stacking of packets of timber with small spacing sticks (called 'fillets' or 'strips') across the packet between each timber layer, to allow drying. Two or three layers of fillets/strips are also placed across all packets for stability in transportation.
Defilleting	The removal of fillets/strips from stacks of timber.
Sorting	Selecting same dimension and grade boards from the mixed boards and grades on the table/chain, and stacking into a packet.
Grading	Marking of boards on the table (usually with chalk) to denote their quality and thereby the packet to be stacked to. The timber grader has completed additional training for this revenue-related task. Automated grading (machine stress grading or MSG) may also occur.
Re-sawing	The return of once-sawn lumber to the mill for sawing to a smaller size.

REPORTS WRITTEN FROM THIS WORK
(Copies in Appendix 11)

1. Edwin, M., Tappin, D. & Bentley, T. 2002. *Musculoskeletal Disorders in the New Zealand Log Sawmilling Industry.* Proceedings of the 11th Conference of the New Zealand Ergonomics Society, 14 and 15 November 2002. Wellington. (pp 112-117)

2. Tappin, D., Edwin, M. & Moore, D. 2003. *Sawmill Accident Register Records – Main Findings of a Survey from 37 Mills.* COHFE Report, 4(5)

3. Tappin, D., Edwin, M. & Bentley, T. 2003. *Musculoskeletal Disorders in Sawmilling: ergonomics work systems assessments and suggested interventions.* COHFE Report, 4(6)

4. Tappin, D., Edwin, M., Bentley, T. & Ashby, L. 2004. *Addressing Musculoskeletal Disorders in the New Zealand Log Sawmilling Industry.* Contemporary Ergonomics. McCabe, P. (ed.). (pp 212-216)

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Thanks to the management and workers of the sawmills allowing these case studies. Their willingness to consider new ideas and their proactive approach to the prevention of musculoskeletal disorders within the industry must be applauded. It has aided in advancing the awareness of manual handling risk factors and interventions within the New Zealand sawmilling industry.

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Chapter 1 Introduction

1.1 Purpose

Government agency injury records indicated that the log sawmilling industry in New Zealand had a high number of musculoskeletal injury claims with associated high cost for compensation and rehabilitation (Laurs, 2000). In order to address this costly problem in a growth industry, practical intervention strategies to reduce musculoskeletal disorders (MSDs) are needed. The application of interventions to reduce the manual handling risk factors contributing to MSDs should lead to the reduction of MSDs within sawmilling. The assessment of intervention effectiveness is not however a component of this study.

This study had four aims:

1) To determine the prevalence and nature of MSDs within the NZ sawmilling industry.
2) Identification of the 'high risk' sawmilling task(s) associated with these MSDs.
3) The investigation of 'high risk' sawmilling task(s) to determine manual handling risk factors.
4) Development of a range of intervention strategies for the reduction of manual handling risk factors in sawmilling.

The study had two distinct phases. The first was the completion of a national accident register survey to address aims 1 and 2, and the second phase consisted of case study work with two sawmills to address aims 3 and 4.

1.2 Project Background

In early 2001, the Centre for Human Factors and Ergonomics (COHFE), operating as part of Forest Research, a Crown Research Institute, secured Public Good Science Funding (PGSF) for a project investigating MSDs in the wood processing industry.

Study objectives were:

- To determine the prevalence of musculoskeletal problems amongst wood processing workers.
- To identify high risk wood-processing tasks.
- To design and evaluate measures to prevent or alleviate musculoskeletal problems in this area.

The intended outcomes were:

- The reduction of risk factors for MSDs in the wood processing industry.
- Increased awareness of the operations and the contributory factors associated with the risk of MSDs.
- An improved understanding and potential adaptation of measures which reduce the risk of such injuries.

The original COHFE project objectives identified the 'wood processing industry' as the target. However initial investigation determined that 'log sawmilling' was the wood processing industry sector with the most musculoskeletal injury reports (Laurs, 2000). The COHFE project consequently focused only on the log sawmilling sector of the wood processing industry.

Stated COHFE project outcomes included 'the reduction of risk factors for musculoskeletal disorders', but for this study does not include those risk factors that might fall under the category of 'medical issues'. The study focused only on manual handling risk factors that may contribute to musculoskeletal disorders.

The Masters thesis component of this study did not differ from the COHFE project, but the original COHFE objectives and outcomes were re-interpreted as per the aims in 1.1.

1.3 Project Organisation

COHFE offered an 8-week service sub-contract, occurring between May 2001 and July 2002, for an ergonomist to assist with this project. COHFE volunteered support for this study to be used for the completion of a (100 point) Master of Ergonomics.

The Massey University supervisor for the sub-contracted ergonomist and master's student (Marion Edwin) was Professor Stephen Legg. David Tappin, as the primary ergonomist and project coordinator, was the master's student co-supervisor. Dr Tim Bentley, (whom at the outset of this project was in a management role with COHFE but is more recently employed at Massey University, Albany Campus) provided additional masters student co-supervision. Liz Ashby (ergonomist with COHFE) provided some project assistance.

M. Edwin and D. Tappin completed the majority of the work for this project. They worked together to complete the accident survey data gathering and analysis, and to develop assessment protocols for onsite assessment of manual handling risk factors. They then remained in liaison but separately completed the assessment and intervention development phases in 2 South Island (M. Edwin) and 2 North Island (D. Tappin) sawmill sites. Good communication was maintained for consistency and to enable formulation of a coherent national report.

This thesis covers the jointly completed data gathering and analysis (Chapter 3), but focuses on the methods (Chapter 4) and findings for assessments and interventions within the two South Island sawmills only (Chapters 5 and 6), presented as case studies. The discussion (Chapter 7) and conclusions (Chapter 8) sections summarise the joint findings. In practise, the relevant North Island findings were considered alongside the South Island findings in order to draw sound conclusions and develop recommendations appropriate to the research goals. The North Island findings are not specifically reported in this thesis. This study does not extend to the reassessment of manual handling risk factors following the application of recommended interventions.

Chapter 2 Literature Review

2.1 Forest Industry in New Zealand

New Zealand (NZ) supplies 1.1% of the total world forest products trade, and 8.8% of Asia Pacific's forest products trade – from only 0.05% of the world's forest resource. The NZ forest industry generated NZ$3650 million in export earnings in 2002 – behind only the dairy and meat industries. Of NZ's total area of 27 million hectares, forest covers 31% (24% natural forest and 7% plantation forest). In the year ended March 2002 over 20 million cubic metres of wood was harvested from NZ plantation forests – the bulk of this as logs for export, sawing or peeling, some pulp logs, and other round-wood as small logs and export chips (NZ Forest Industry Facts and Figures 2002/2003).

Whilst NZ's contribution to global wood production is relatively small, wood industry output is positioned to increase. At current new forest planting rates it is forecast that by 2010 NZ could harvest around 31 million cubic metres annually, representing a 68% increase from the 2001 harvest (retrieved from Ministry of Agriculture and Forestry [MAF] website, May 4, 2004. www.maf.govt.nz/forestry/publications/forestry-sector-issues/fsioverview.htm). This production increase will demand a corresponding increase in all forestry and wood processing industries, with MAF predicting that NZ$6.5 billion will need to be invested in wood processing before 2015. It is predicted that this growth will represent an increase in GDP from 4% in 1998 to 14% in 2025, with the total number of employees in wood-based industries doubling. To meet the increased production demands over the next 15 years, it is suggested that 100 medium-sized sawmills, 90 remanufacturing plants, and a mix of 20 panelboard and/or six pulp and paper plants will be required (retrieved from Forestry Insights website, May 4, 2004. www.insights.co.nz/products_processes_avo.asp).

Forest industry activities include forestry, logging, services to forestry, log sawmilling, wood chipping, timber re-sawing and dressing, pulp, paper and paperboard manufacture, plywood and veneer manufacturing, and fabricated wood manufacture. These industries employed 24,315 full time workers as at February 2001 (NZ Forest Industry Facts and Figures 2002/2003).

2.2 Accident Prevention and Occupational Health and Safety Agencies

NZ's Accident Compensation Corporation (ACC) is the government agency concerned with injury prevention, the provision of accident insurance, and injury compensation and rehabilitation services post injury. ACC collects injury statistics in order to target high injury sectors, both occupational and non-occupational. The Occupational Health and Safety Service (OSH) is the government agency promoting best practice in occupational safety and health in the workplace, particularly compliance with the Health and Safety in Employment (HSE) Act 2002. OSH's 2004-2009 Strategic Plan (2004) states the outcome 'enabled people taking active responsibility for achieving safe and healthy workplace environments'.

In NZ, ACC and OSH work together to target high injury sectors within industry, with common goals for injury reduction and health and safety promotion. Injury rates identified within the wood processing sector (including sawmilling) are therefore of concern to both groups.

2.3 New Zealand Wood Processing Injury Data

Review of ACC injury data (Laurs, 2000) for the four year period 1994/1995 to 1998/1999 revealed that in the wood processing industry, log sawmilling had the highest level of new claims, being 42% of all new claims (total for this period of at least 6500 new claims). In comparison, wooden structures sectors reported 15% of new claims, pulp, paper and paperboard 10%, wood product manufacturing (other) 9%, plywood and veneer 8% and timber re-saw and dressing 8% of new claims. Other areas reported lower levels of new claims.

Similar percentages were recorded for the cost of claims in these sectors (total of around $14 million over the five year period) with log sawmilling responsible for 39% of claims cost within the period surveyed.

Injury data from Laurs (2000) also reveals that soft tissue injuries (sprain, strain, internal organ) made up 51% of the new injuries, 14% laceration, puncture wound or sting, 10% deafness, and 7% gradual process in nature. A total of at least 17% of new claims were reported to be back injuries.

The same ACC data source indicates two primary causes of injury in wood processing. These are 'work property or characteristics' (more than one third of the reported injuries), 'lifting/carrying/strain' (around one sixth of the injuries), with 'other loss balance/personal control', and 'other or unclear cause' also frequently reported.

It was clear that in the NZ wood processing industry log sawmilling is the sector with the highest level of costly injury claims, many of these being back or other soft tissue strain/sprain or overuse injuries. What remains unknown are details of the work tasks and areas contributing to the high injury rates in sawmilling, details of injury type/body site, and information on the most effective and practical means of reducing injuries within log sawmilling.

2.4 International Injury Trends

A 1995 Washington State Department of Labor and Industries report (Stuart, Goggins and Zellers, 1995) investigated work related musculoskeletal disorder (MSD) risk factors due to the number and severity of injuries occurring in the wood processing industry. Review of workers compensation data (July 1 1990 – August 8 1995) for the three sawmills investigated in this study determined 'overexertion' (MSD) claims as accounting for between 27 and 35 percent of all claims. Overexertion claim costs were 36% - 180% higher than costs for 'non-exertion' claims.

In the sawmilling industry in Canada, in the five year period 1993 - 1997, the Workers Compensation Board of British Columbia (1999) reported 'overexertion' (MSD) claims as accounting for 27% of injury claims. The occupations listed as having the most overexertion claims were mill labourer (42%), labourer material handler (9%), sawyer (8%) and millwright (6%). Jones and Kumar (2004) state that the Workers Compensation Board of Alberta, for the sawmilling industry for the period 1997 – 2002, reported a total of 46.7% of accepted claims that were 'musculoskeletal' (MSD) in nature, and 45.5% of injuries that were to the upper extremity.

From France, a report on manual materials handling (pushing, pulling, lifting etc) and related occupational hazards (Heran-Le Roy et al, 1999) determined that the highest levels of intensive manual handling occurred in the manufacturing of wood, paper, and wood/paper products. 17.4% of subjects from these industries reported being exposed to manual handling activities for more than 20 hours per week. This study also highlighted the increased risks associated with simultaneous exposure of manual handling activities with other occupational hazards such as constrained posture and movement, vibration, thermal demands, shift work, constrained work pace, and psychosocial factors.

The wood and furniture industry in Sweden, Finland and Denmark is among the ten industries with a high incidence of musculoskeletal symptoms (Svane et al, 1989, as quoted in Christensen, Pedersen and Sjogaard, 1995). Despite efforts to identify other relevant literature from Scandinavian countries there was an apparent paucity, though language issues may have contributed to this.

Available international injury statistics for MSDs in sawmilling activities are however similar to those seen in the NZ sawmilling industry.

2.5 Musculoskeletal Disorders

'Musculoskeletal disorders' were defined for this project as *"a collective name for a range of conditions that affect muscles, tendons, bones and joints (including overuse syndromes and back injuries)"* (COHFE letter to sawmills, October 2001, Appendix 1).

This is consistent with ACC's currently accepted definition of occupational overuse syndrome: *'an umbrella term covering a range of disorders characterised by pain and/or other sensations in muscles, tendons, nerves, soft tissues and joints with clinical signs evident to a medical practitioner',* (1997, p 58). The NZ Acute Low Back Pain Guide (1999*),* further describes back injuries as *acute* - short term, less than three months, without leg symptoms or 'red flags'; or *serious* – persisting in nature, with 'red flags' such as "fractures of the spine, medical co-morbidity where a back problem makes a medical problem worse (e.g. osteoarthritis), intervertebral disc problems with serious complications or conditions that produce persistent severe pain that require a long time off work".

For the purposes of this study, MSDs are specifically:

- injuries/complaints that may be classified as occupational overuse (gradual process) in nature, such as carpal tunnel syndrome, epicondylitis, tendinitis, tenosynovitis, and the range of 'sprains and strains' that these disorders may be reported as, and
- acute and serious back injuries, and the range of 'sprains and strains' that these complaints may be reported as.

'Soft tissue injury' is a term used by ACC that includes some MSDs and other categories of injury. 'MSDs' does not include injuries such as crush, laceration, fracture, struck by, or struck against. However injuries of a sprain or strain nature that are received as a result of a slip, trip or fall are regarded as a MSD. Some literature refers to 'overexertion injuries' with causes including manual handling strain, repetition and static postures.

For the purposes of this study, 'overexertion injuries' will be considered MSDs.

2.6 Manual Handling and Risk Factors

Manual handling, as defined in the 'Code of Practice for Manual Handling' (OSH & ACC, 2001), is *"any activity requiring a person to lift, lower, push, pull, carry, throw, move, restrain, hold or otherwise handle any animate, or inanimate object".* Manual handling activities are the reported cause of many back injuries, strain and sprain injuries and other occupational overuse injuries that together form the larger injury grouping of 'musculoskeletal disorder' as defined previously. It is specifically noted that 'manual handling' refers not only to the obvious physical tasks of lifting, lowering, pushing, pulling, carrying etc, but also to static activities such as restraining, holding and manipulating objects.

Current literature explores a range of manual handling risk factors. Burdorf and van Riel (1996) discuss the impact of cumulative load, particularly frequency and duration of spinal loading in relation to back injury. The inherently variable nature of tasks, machinery, equipment and materials are said to have a 'profound effect' when measuring lumbar spine loading. Burdorf (1995, p. 3) indicates the unsuitability of 'a single measurement device' to determine 'all relevant dimensions of physical load on various body structures'. A range of measurement methods is suggested to 'capture the complex exposure with sufficient accuracy'.

Haslegrave and Corlett, in Wilson and Corlett (1995) discuss the different work types that may cause musculoskeletal disorders, these being repetitive or static work tasks or at the other extreme, work that requires exertion of high forces. They also suggest that different assessment types are necessary – biomechanical, muscle strength and posture criteria being more suited for heavy and infrequent tasks, psychophysical methods for moderate loads over moderate durations, and physiological methods for frequent lifting over long periods. These authors discuss a range of manual handling risk factors that should be investigated including environmental factors, psychosocial factors and factors related to the task itself including load, frequency, movement, posture and rest breaks.

Mital, Nicholson and Ayoub (1997) define a number of risk factors applicable when carrying out manual handling. The authors included these factors as they are 'widely accepted' (p 14) from 'various agencies' as needing to be 'controlled or modified in some systematic manner' to reduce injury risks. These risk factors are: physique, anthropometry, strength; physical fitness, spinal mobility; age and gender differences; psychophysical factors, motivation; training and selection; effects of static work; posture, handling techniques; loading characteristics; handles, coupling; repetitive handling; asymmetrical lifting, load asymmetry; confined environments/spatial restraints; safety aspects; protective equipment; handling in hot environment; task duration; work organisation.

In NZ, five categories of manual handling risk factors have been summarised in the Code of Practice for Manual Handling (OSH and ACC, 2001). These are; load, environment, people, task and management. These risk factors combine to increase the hazardous nature of manual handling tasks, and require controls to reduce manual handling risk.

Key aspects of the risk factors are:

Load Heavy objects require greater muscular effort to move/control, and the nature of the load (difficulty grasping/controlling) can further increase the risk. Loads that limit the view of the worker, are unstable, are animate and therefore unpredictable, or with sharp edges or of hazardous makeup (chemical or temperature) increase handling risks.

Environment Slippery flooring, small workspaces, steps or slopes, extremes of temperature or humidity, wind, wet conditions, dust or other pollution, noise, and poorly lit work areas increase the difficulty of manual handling tasks.

People Workers completing manual handling tasks also present a number of variables that may impact on the ease of task completion. Enough adequately trained workers to complete the task, and workers with the physical capacity to complete the work are necessary. Some workers may be disadvantaged by personal characteristics such as disability, body size, and fitness, or may have inadequate strength or range of movement to complete a task safely. Workers in isolation may be unable to complete tasks without assistance, and some tasks create significant fatigue that may reduce the worker's capacity. Workers who fail to take responsibility for health and safety initiatives within the workplace increase the manual handling risks they may expose themselves/others to.

Task Tasks that demand work with a large horizontal or vertical reach (particularly above shoulder and below mid-thigh); work that is repetitive; working consistently without breaks or in an awkward or constrained posture, present greater manual handling risks. Similarly work on unpredictable or rapid tasks, at a pace that the worker has no control over, from a seated, squatting, kneeling or crouching position, or in the presence of vibration are also increasingly hazardous. Manual handling activities that require poorly designed tools to be used, must be carried out as a team, and require equipment such as gloves may make the task more difficult. Mechanical aids must only be used with appropriate training in order to ensure that manual handling risks are not increased.

Management Organisational factors that impact on tasks include the scheduling of rest breaks, payment systems, shift work and job rotations, assignation of adequate employees for the job and proper equipment maintenance and provision. Good communication and organisation and a commitment to health and safety are relevant to the incidence of manual handling injuries.

Chapter 3 Sawmilling Accident Register Survey

3.1 Introduction

3.1.1 Aims and Objectives

The initial research aim was to determine the prevalence and nature of MSDs within the NZ sawmilling industry, followed by identification of the sawmilling operations associated with these MSDs. Once the task or tasks posing the greatest risks are known, contributory manual handling risk factors can be identified and intervention methods to reduce their effect can be developed. Thus the objectives of this phase of the research project are:

- To gather available accident/injury data regarding the NZ sawmilling industry.
- To analyse the data, and to determine the prevalence and nature of sawmilling industry MSDs.
- To gather data about sawmilling tasks and operations that are felt to be 'high risk' in terms of MSD causation.
- To analyse all accident/injury data and the findings about high risk tasks, to identify the task/s that have the highest risk.
- To make preliminary contacts with sawmilling personnel, and become familiar with industry tasks and roles for later stages of this research project.

3.1.2 Injury and Employment Data

Injury data for the NZ wood processing industry (see Section 2.3) revealed that the log sawmilling sector had a high frequency of new claims, largely back or upper extremity MSD injuries. These injuries are costly to the industry in terms of direct rehabilitation and compensation costs, and the indirect costs relating to lost productivity and decreased worker effectiveness.

Employment data for 2000 (NZ Forest Industry Facts and Figures 2002/2003) states that 'log sawmilling' employed 7080 (full time or equivalent) persons in 2000, and 'timber re-sawing and dressing' employed 1380. (2001 figures show an increase to 7420 persons employed in log sawmilling, but also noted was that a reclassification of some 'wood chipping' tasks as 'log sawmilling' mean that direct comparison cannot be made). Thus in 2000, log sawmilling employed 37.5% of the workforce in the wood processing sector, whilst accounting for 42% of new injury claims.

In summary, this analysis of employment figures verified that the largest group of employees experiencing the highest percentage of new injuries within the wood processing industry was in the log sawmilling sector.

3.1.3 Existing Data Limitations

ACC data listed the industry sector in which injuries occurred, but failed to identify specific tasks being undertaken at the time of injury, or additional injury details such as body part/s affected. In order to complete assessment and develop intervention proposals as per the overall research plan, it was necessary to determine task areas within log sawmilling with the greatest injury problems, and the specific nature of these problems.

3.2 Method

3.2.1 Accident Register Survey Development

A survey gathering company-held accident register information was deemed necessary. This would enable identification of the work tasks and areas within NZ sawmills with links to MSD injuries, and body areas affected by injury. It was acknowledged that different reporting systems were likely to be in use and that this would impact on the quality and consistency of information gathered. However as no other means of gathering current national data existed, this method was selected.

COHFE staff (trading as South Pacific Ergonomics Limited) had previous experience of completing a similar survey in another New Zealand industry. Survey methodology was therefore adapted from that previously used by COHFE staff. In addition to accident register data, feedback regarding sawmill personnel's impression of the tasks most likely to cause MSDs was sought, in the form of 'Best Guesses' data.

The three components of the Accident Register Survey were:
A cover letter (Appendix 1), explaining the context of the research; *Accident Register Records Survey* (Appendix 2), a table for recording injury date, department, job title, task, injury type, and body part affected, for (all) injuries that occurred between 1 September 2000 to 31 August 2001; *Best Guesses* (Appendix 2), a table for recording 'best guesses' for the 'top five' tasks most likely to cause MSDs in sawmills; detailing the department, job title, task and reasons why.

3.2.2 *Sawmill Identification*

A list of North and South Island mills producing more than 5,000m^3 of sawn timber per annum was obtained from MAF. Mills producing smaller quantities represented only a very small component of the sawmilling workforce and were therefore discounted.

Mills were grouped according to timber production. 'Small' mills produced between 5,000 and 9,999 m^3 (of sawn timber per annum), 'medium' mills produced between 10,000 and 19,999 m^3, and 'large' mills produced more than 20,000 m^3. A total 50 mills was listed: 10 small mills, representing 147 employees; 10 medium mills, representing 468 employees; and 30 large mills, representing 2304 employees. To these mills was added 7 larger mills known to the researchers (presumably not listed as they had not given MAF the approval to release data). Employee figures for these additional mills were not known. The number of employees reportedly employed by the 50 listed companies (total of 2919) represented 41 % of the sawmilling workforce. It was estimated that at least 50 % of the sawmilling workforce would be reached by inclusion of mills known to the researchers.

3.2.3 Survey

The 57 mill database was split into an approximate North Island/South Island division (though more mills are in the North Island due to the larger forestry industry). The researchers who lived closest to each mill then made personal telephone contact with appropriate mill personnel in early October 2001. A total of 53 mills were contacted. Some of the mills on the original list were no longer in operation. This initial telephone contact was followed up with the survey information being emailed, faxed or posted out to appropriate personnel – as ascertained during the telephone communication.

Personal telephone contact was made for a number of reasons. It enabled researchers to determine the most appropriate staff members and or management personnel to approach; it allowed gathering of accurate contact information – names, positions, telephone numbers, email addresses, postal addresses; it enabled researchers to explain the context of the research to ensure a high level of participant understanding and therefore an increased likelihood of survey response; it allowed gathering of production and employment information - annual sawn timber production, timber types milled, and number of employees; and enabled researchers to begin to develop rapport with key personnel within the industry with a view to future onsite research work.

Following telephone contact with 53 mills, a total of 50 agreed to participate in the accident register survey. Of these 50 mills, a total of 37 responded (74 % response rate). Many of the mills used electronic database systems and following removal of employee details, were able to provide electronic files for our use. This proved to be time efficient for mill personnel, and was an effective method for data gathering. A number of mills that failed to provide the data within the time frame were contacted again by telephone. This resulted in further data provision, and a total of 37 responses were received – a 74% response rate.

3.2.4 Sawmilling Job Definitions

Correct classification of job titles and task areas given in the accident register survey required clarification of industry job definitions. This became particularly salient when needing to determine whether kiln operators were to be considered as part of the 'sawmill' or not, and whether 'dry mill' activities were classified as 'sawmilling'. These work area definitions also reflect the data gathered by ACC, MAF and Statistics NZ.

Statistics NZ provided Australia and NZ Standard Industrial Classification (ANZSIC) data (Statistics NZ, 1993) for all relevant timber industry activity. The category of greatest relevance is that of 'Log Sawmilling', classification number C231100. Log sawmilling (C231100) is defined as follows:

"This sub-class consists of units mainly engaged in producing rough sawn timber, sleepers, palings, scantlings, etc, resawn timber from logs sawn at the same units. This sub-class also includes chemical preservation of rough timber of logs produced in the same unit.

Exclusions/References

Units mainly engaged in

a) hewing or rough shaping mine timbers, posts, railway sleepers, etc, or cutting firewood in forests are included in Sub-class A030200 Logging;

b) manufacturing softwood or hardwood woodchips are included in Sub-class C231200 Wood Chipping;

c) kiln drying or seasoning timber are included in Sub-class C231300 Timber Re-sawing and Dressing;

d) chemically preserving timber from purchased or transferred in as logs or sawn timber or in producing timber shingles are included in Sub-class C232900 Wood Product Manufacturing not elsewhere included; and

e) both cutting and retailing firewood are included in Sub-class G525900 Retailing not elsewhere included.

Primary Activities

- *Bark, ground, manufacturing*
- *Timber, re-sawn, manufacturing (from logs sawn at same unit)*
- *Shook manufacturing (for containers)*
- *Timber, rough sawn, manufacturing"*

The ANZSIC defines a closely related industry activity, Timber Resawing and Dressing (C231300) as below:

"This subclass consists of units mainly engaged in producing dressed timber such as floorboards, weatherboards or mouldings, re-sawn timber from timber already sawn at other units, or in kiln drying or seasoning timber.

Exclusions/References

Units mainly engaged in chemically preserving timber from purchased or transferred in logs or sawn timber are included in Sub-class C232900 Wood Product manufacturing not elsewhere included.

Primary Activities

- *Building timber, dressed, manufacturing*
- *Dressed timber, kiln dried or seasoned, manufacturing*
- *Dressed timber or mouldings manufacturing*

Statistics NZ have further advised that the term 'unit' is used flexibly, and can mean companies, societies, individuals, clients etc., but will often refer to an economic unit (personal communication, H. Webber, Statistics NZ, October 18, 2001). From this same source, 'scantlings' are 'timber beams of small cross section', and 'shooks' are 'a set of staves and headings for a cask (read container), ready to fit together'. However researcher contact with mill personnel and review of accident register data indicate that these terms are used inconsistently within the industry.

The following tasks are *not* classified as either log sawmilling or timber re-sawing and dressing under the ANZSIC system:

- Manufacture of wooden containers, pallets, packing cases, cork, wood bamboo or cane products, turned wood products, ornamental woodwork, wooden picture or mirror frames, parquet strips assembled into panels
- Chemically preserving timber from purchased or transferred in (from another unit) logs or sawn timber
- Manufacturing of particle boards, chip boards, other fabricated boards of wood, or laminations of timber and non-timber materials
- Manufacturing of wooden structural fittings, wooden components for prefabricated wooden buildings, wooden or wooden framed doors, roof trusses, wall frames, joinery or shop fronts
- Manufacturing of softwood and hardwood woodchips

For the purposes of this research the following tasks and work situations have been classified as 'sawmilling':

- Timber yard activities that both precede and immediately follow the logs being sawn
- Debarker operations
- Headrig operations
- Bandsaw, gangsaw, horizontal saw, cut-to-length tasks, breast bench, re-saw, and docking operations within green and dry mills
- Grading operations within both the green and dry mills
- Anti-sapstain processing as it occurs pre or post green table
- Saw doctor activities, and the activities of fitters and other maintenance personnel within the immediate sawmill environment
- Green table/chain (or round table) operations, and bin sorting activities
- Tasks that are essentially of the same nature as these 'green timber' activities but that are classified under dry mill or machine stress grading (MSG) or planer mill
- Timber that is re-sawn (broken down into smaller timber) within the same unit

- Filleting and timber seasoning tasks
- Other timber stacking and re-stacking tasks, but not including the activities of retail timber yards if these are detailed separately
- Kiln drying processes
- But not chemical treatments (pressure application) if these have not occurred within the 'same unit'. (Larger mills appear to separate out this work area, and therefore operate 'different units', such that we would not classify these tasks as 'sawmilling').

3.3 Results

3.3.1 Accident Register Survey Results

Data was analysed to determine the job/task of the injured worker at the time of the accident, whether the injury was classified as MSD in nature, and the body part injured. The job titles and definitions used were:

Grader - Primary task listed as or appeared to be grading, or determined to be so from job title or task information given.

Driver - Primary task listed as or appeared to be driving, or determined to be so from job title or task information given.

Maintenance - Primary task listed as or appeared to be maintenance, or determined to be so from job title or task information given.

Saw doctor - Primary task listed as or appeared to be saw doctor, or determined to be so from job title or task information given.

Sawyer - Primary task listed as or appeared to be sawyer, or if job title or task information given indicated primary task/s as any sort of saw operator. Including: gang saw, gang ripper, band saw, skill saw, slabbing, bench saw, breast bench, drop saw, chop saw, hobb saw, twin saw, headrig, horizontal saw, savage saw, snip saw, re-saw, docking, tailer out, infeed or outfeed.

Tablehand - Primary task listed as or appeared to be tablehand, or if job title or task information given indicated primary task/s as any sort of sorting table operator. Including: pulling and stacking timber from a green table, green chain, dry table, long table, round table, sorting table, sorting deck, or MSG operations.

Yardhand - Primary task listed as yardhand, or if job title or task information given indicated primary task/s as occurring in the yard. Including filleting, defilleting, some seasoning tasks, stacking, timber sorting, post peeling, and log grading tasks.

Millhand - Classified as 'millhand' if job title or task information given was unclear as to the primary role of the employee. Thus a 'catchall' category including: bin sorter operators, planer mill, strapping of packets, various timber sorting, lifting and handling activities when more clear classification of tasks/job title was not possible, tagging, debarker, kiln operations, filleting and defilleting if no indication of primarily done in the yard, chipper operations, quality control, and injuries that occurred when employees were walking or moving along walkways or otherwise unspecified work areas.

The total number of musculoskeletal injuries reported from the 37 mills that returned data for the twelve month period (1 September 2000 to 31 August 2001) was 505. Total injuries per the job title divisions are given in Table 3.1. The highest numbers of injuries were to those categorised as 'millhand' (30%), then to 'tablehand' (26%) and 'sawyer' (23%). The general 'millhand' category contains all injuries where the survey data provided gave limited or no information about the worker's job title, so injuries from this category could have fallen under any of the other job areas. These figures serve only as an indicator of high risk work areas, as the data provided by different sawmills varied in the reporting methods used, and the definition of work tasks and job areas used at each site.

Table 3.1 - Number and percentage of injuries reported per job title from 37 mills, for the 12 month period, 01.09.2000 – 31.08.2001

Job title	Number of injuries reported	Percentage of total injuries
Grader	15	3
Driver	13	3
Maintenance	35	7
Saw Doctor	16	3
Sawyer	115	23
Tablehand	131	26
Millhand	152	30
Yardhand	28	5
TOTAL	**505**	**100**

The definitions of injury types (non-MSD injuries such as lacerations and bruising were not recorded) and sites used were:
Neck and Head - MSDs affecting the neck (cervical vertebrae) and head region.

Back and Low Back - MSDs in the *low back* include injuries to the lumbar area, sacrum, coccyx and sacro-iliac region. MSDs in the *back* includes thoracic, 'mid-back' and 'upper back' injuries, and other undefined back/trunk injuries. Together these categories are generally referred to as *'back'* injuries.

Abdomen and Chest - Includes MSDs in the front of the chest and abdominal areas.

Shoulder - MSDs in the shoulder and shoulder girdle.

Arm - MSDs in the upper and lower arm including the elbow.

Wrist and hand - MSDs in the wrist joint and surrounding tissues, and in the hand including injuries to the palm, dorsum of the hand, fingers and thumbs.

Hip - MSDs in the hip joint and surrounding tissues.

Leg - MSDs in the upper leg or thigh area, the lower leg - shin or calf – area, the knee joint and surrounding tissues.

Ankle and Foot - MSDs in the ankle joint and surrounding tissues, and the dorsum of the foot, the sole of the foot and the toes.

Unknown - Injuries that are reported as musculoskeletal in nature but without listing the injured body area.

Dual Injuries - MSDs occurring in two body areas at the same time.

Injury data is given in Table 3.2 and Figure 3.1.

Back injuries accounted for 37% of injuries, including low back injuries at 10.3%. Incidence of wrist and hand injuries was 15.2%, arm injuries 10.3%, shoulder injuries 9.9%, leg injuries 8.5%, and neck and head injuries 6.5%. A small percentage of injuries were to the abdomen and chest, hip, and some were of unclear body area (totalling 3.2%). Adding together the results of shoulder, arm, and wrist/hand injuries, a total of 35.4% of injuries occur to the upper extremity, indicating a significant prevalence of MSDs of this body area.

Table 3.2. Injury data from Accident Register Survey

Body area affected	Number of Reported Injuries	Percentage	Specific Body Area Affected	Number of Reported Injuries	Percentage
Neck and head	33	6.5	Neck	26	5.1
			Head	7	1.4
Back and low back	187	37	Back	134	26.5
			Low back	53	10.3
Abdomen and chest	9	1.8	Abdomen	4	0.8
			Chest	5	1.0
Shoulder	50	9.9	Shoulder	50	9.9
Arm	52	10.3	Arm	36	7.1
			Elbow	16	3.2
Wrist and hand	77	15.2	Wrist	48	9.5
			Hand	29	5.7
Hip	4	0.8	Hip	4	0.8
Leg	43	8.5	Leg	10	2.0
			Knee	33	6.5
Ankle and foot	47	9.3	Ankle	41	8.1
			Foot	6	1.2
Unknown	3	0.6	Unknown	3	0.6
TOTAL	**505**	**99.9**		**505**	**99.7**

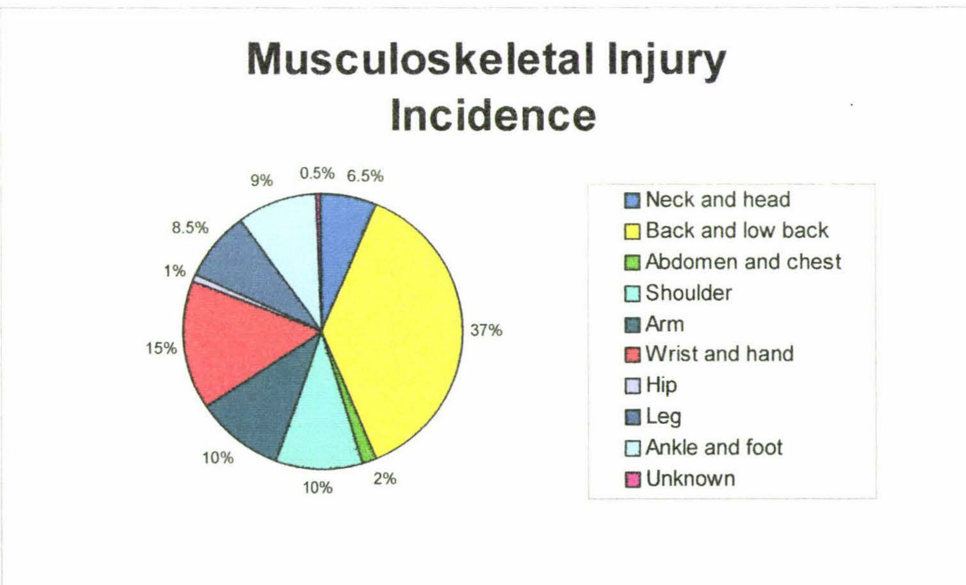

Figure 3.1. Musculoskeletal injury incidence from Accident Register Survey

3.3.2 *'Best Guesses' Results*

'Best Guesses' information was requested from industry personnel as part of the survey. Respondents were asked to give details of what they felt were 'the five tasks most likely to lead to MSDs at mills around the country'. This qualitative data component was requested to provide triangulatory supporting evidence for the results from the Accident Register Survey. The data (in full in Appendix 3) is summarised in Table 3.3.

Table 3.3. Data summary of sawmilling industry 'Best Guesses' for task areas most likely to lead to MSDs.

	Top Five Tasks (by total and weighted total)	Weighted total	Main comments by frequency
1	Pulling timber, packeting, sorting, stacking – greenchain, long table, drymill, MSG, round table	120	Twisting, turning, pulling. Heavy timber. Lifting. Repetitive. Poor technique
2	Stacking and filleting/defilleting timber - timber yard	44	Twisting. Lifting. Repetitive. Pushing/pulling.
3	Timber grading and sorting - greenchain	35	Repetitive wrist rotation turning boards. Heavy lifting.
4	Tailing out at breast bench, resaw, edger, other	34	Repetitive heavy lifting, turning, twisting, pulling timber
5	Changing/working with heavy/awkward saws or other equipment - saw doctors/fitters	28	Awkward heavy lifting, twisting, turning, reaching.

The reported area of MSD concern was recorded, and a weighted ranking system used (Appendix 3) to quantify the results. The weighting system totalled the number of times the described task rated '1' (most likely to cause MSD injury) and multiplied by 5, through to those rated as '5', multiplied by 1, and adding the ratings given for each task. The task area considered to be of greatest concern regarding MSDs is that to do with pulling and stacking timber from the green chain or table, or similar duties in the drymill. Filleting related tasks, timber grading and sorting activities, tailing out at saws, and maintenance tasks were also frequently identified as MSD problem areas.

3.4 Discussion

3.4.1 Survey Response

Survey responses from 74% of the mills contacted represented data from an estimated 38% of NZ sawmill workers. This was however only 37 mills out of approximately 330 in NZ (11%), with mills having varied production output and staffing numbers.

3.4.2 Task Definitions

'Sawmilling' tasks were specifically defined as including a range of timber yard activities that both precede and immediately follow the logs being sawn (see 3.2.4). This clarification was necessary as in practice the separation of tasks classified as 'log sawmilling', and 'timber re-sawing and dressing' in the ANZSIC coding is impractical. Small timber yards have the same workers completing all tasks, and it was difficult to determine what comprised activity within the 'same unit'. Within the industry there were divergent views on how tasks were classified with larger operations appearing to have clearer definitions, though these were not applied consistently across worksites. Functionally, many of the tasks from 'log sawmilling' and 'timber re-sawing and dressing' were very similar (for example green table and dry table), and thus for the purpose of this research project it was appropriate for the study to encompass both 'log sawmilling' and 'timber re-sawing and dressing' as per ANZSIC categories.

The need to clarify task definitions did not become clear until part way through the process of gathering survey data from industry. Thus data gathered for the accident register survey may not have included all relevant data from the 'timber re-sawing and dressing' task areas. However, as this survey was used to indicate highest priority for in-depth task analysis activities, and many duties had a high level of similarity with those in the 'log sawmilling' areas, it was hoped that the impact on study results and applicability were minimal.

3.4.3 Revised Injury and Employment Statistics

Clarification of the definition of 'sawmilling' as part of the data collection and review process determined that tasks within the ANZSIC categories for Log Sawmilling and Timber Re-sawing and Dressing could not easily be separated on the basis of function within many sawmills. This led to a definition of sawmilling that encompassed both ANZSIC categories, and need for review of the available statistics to incorporate this.

ACC data indicated that for new claims within the wood products sector from 1994/1995 to 1998/1999, Log Sawmilling and Timber Re-sawing and Dressing had 42% and 8% of new claims respectively, thus a total of 50% of new claims for this period (Laurs, 2000). It was reported that 'at least 6500 new claims' occurred during the four-year period reviewed, thus 3250 of these occurred within the 'sawmilling' industry.

Statistics NZ year 2000 data gave the total full-time equivalent persons engaged in Log Sawmilling as 7080, and in Timber Re-sawing and Dressing as 1380, thus a total of 8460 individuals were employed in the 'sawmilling' industry.

3.4.4 Injury and Job Data

A total of 505 MSD injuries were reported, with back injuries accounting for 37% and upper extremity injuries (arm, shoulder, hand) accounting for 35% of injuries. Millhands, tablehands and sawyers were the job categories with the highest number of MSD injuries (30%, 26% and 23% respectively), and these jobs required a large component of manual handling activity. However, given that the data provided by different mills was reported in varied formats/definitions of work tasks, these figures can only serve as an indicator for high risk work areas.

The qualitative 'best guesses' data highlighted concern by industry personnel for MSD injuries related to pulling and stacking green or dry timber from the chain/table, and filleting, grading, sorting, maintenance and tailing out activities.

3.4.5 Limitations

Survey limitations are discussed in Tappin, Edwin and Moore (2002) and Tappin et al (2004,) and include: only 11% of all NZ mills were represented; the selection method for mills may have skewed the data; data was reviewed for only a 12 month period; mills had varying levels of detail in the records and data aggregation may have lost some detail; the data provides incidence only, rather than frequency or severity rates; the nature and extent of biases is unknown for both accident register and best guesses data. It is also possible that variations in injury reporting systems may have resulted in the inclusion of non-work injuries with work injuries, and injuries that may have initially been recorded as work injuries could later have been discounted as such (as sometimes occurs when medical opinion is sought).

3.5 Conclusions

The Accident Register Survey allowed the gathering of available accident/injury data regarding the NZ sawmilling industry. Its analysis identified that millhands, tablehands and sawyers experienced the highest numbers of MSD injuries, with their primary work role being timber handling. That these timber handling activities are 'high risk' in terms of MSD causation was supported by reports from industry personnel; 'Best Guesses' reports identified that the range of manual handling tasks relating to pulling and stacking of timber from various tables or chains was of greatest MSD injury concern. The process of carrying out the Accident Register Survey allowed familiarisation with industry tasks and roles, and the development of contacts with key personnel from mills. The accident register survey process and findings are discussed in full in the COHFE report by Tappin, Edwin and Moore (2003).

It was therefore concluded that the primary focus for this study should be the manual handling tasks and risk factors occurring at the green or dry table/chain. Some awareness of other key injury areas such as filleting/defilleting and the work done by sawyers - particularly tailing out – should also be maintained, with a potential view to further studies.

These survey findings lead to the development of assessment methodologies to determine the manual handling risk factors at green and dry chains/tables.

Chapter 4 Assessment Methodology

4.1 Assessment Design

4.1.1 Assessment Aims

Sawmilling Accident Register Survey results showed manual handling at green and dry chains/tables posed the greatest MSD risk. As per the study aims, these sawmilling tasks required investigation to determine the manual handling risk factors, prior to the development of intervention strategies for the reduction of these manual handling risk factors. Literature identified manual handling risks as multi-factorial (OSH and ACC, 2001) and identified that multiple component interventions are most successful in controlling MSDs (Karsh, Moro and Smith, 2001). Task risk factor assessment therefore required a broad range of assessments.

Assessment methods must identify the contributory nature of:

- the load being handled
- the environment the work is being completed in
- the people carrying out the work
- the task itself
- and organisational, management and social aspects.

4.1.2 Mill Selection

Sawmills representative of NZ mill conditions were sought for validity of results, including assessment of a variety of green and dry table configurations. Workload balance for the ergonomists working on this project was required, as was geographic closeness - to keep travel costs and time within project constraints. Personal contact with key mill personnel through the Accident Register Survey had identified mills demonstrating a high level of motivation and commitment for such research work. Data on the types of green/dry chains operating at mills, and mill production outputs was determined from this initial contact. Selection criteria included the likelihood of the mill to put in place interventions identified, thus allowing future opportunity for re-assessment.

Accordingly, two North Island and two South Island mills were selected for assessment. The present study reports findings from assessments in two mills from the Canterbury/Westland region of the South Island. For reasons of confidentiality, mills were identified by number only. The operation studied at Mill 12 was a classic chain/long table handling green timber, and that studied at Mill 17 a dry table with a manual grading operation.

Telephone contact was made with key mill personnel, followed by written information about the assessment goals and process and the gaining of consent to work with the mill (Appendix 4).

4.1.3 Familiarisation with Sawmills

In October and November 2001 informal visits were made to two other local sawmills to increase this researcher's general knowledge and awareness of sawmill processes and functioning. This aided understanding of the data gathered in the Accident Register Survey, and allowed consideration of relevant assessment processes.

Figure 4.1 Conducting initial exploratory discussions (November 2001) with a worker at Mill 12

In November 2001 the researchers together made exploratory visits to the four selected mills (Figure 4.1). These visits gave both researchers an understanding of the similar but different processes occurring at each mill. Some selected data gathering at each site (archival data, video, photographic, dimensional analyses, production data, work scheduling) gave shape to the formal assessment tools later selected. This in turn allowed for productive discussion, as both researchers were familiar with the situation in each mill. Consequent to this, the selection of appropriate assessment methods and development of assessment protocols was possible.

4.1.4 Selection of Assessment Methods

From exploratory visits, the aspects of green/dry table tasks that were considered possibly relevant as manual handling risk factors and causative factors for MSDs were:

- Chain/table design, dimensions (task and load factors).
- Frequency of task performance (task and load factors).
- Speed of chain/table (task and load factors).
- Work methods and actions (task factors).
- Weight/size/shape/density of timber pulled (load factors).
- Rest breaks, task rotations and shifts (organisational factors).
- Pay and incentive systems (organisational factors).
- Workplace culture (organisational factors).
- Accident reporting systems and management methods (organisational factors).
- Maintenance (organisational factors).
- Production patterns and planning (organisational factors).
- Nutritional issues (people factors).
- Injury and discomfort history (people factors).
- Anthropometry of workforce, worker capacity (people factors).
- Training and skills of workers (people and organisational factors).
- Personal protective equipment (PPE) in use (organisational and task factors).
- Workplace temperature, lighting, general conditions (environmental factors).

In order to gather specific data on each of these areas, the following methods were selected:

- Semi-structured interviews – with team leaders, workers, leading hands, and other relevant management personnel.
- Archival data collection – production data, injury and sickness records, induction topics, health and safety education, work training, pay and incentive systems, maintenance records, and workplace culture.
- Onsite data collection and measurements – anthropometric data, Nordic Musculoskeletal Questionnaire (NMQ), lifting strength (dynamometer), chain speed, dimensional analyses, frequency of actions, video/photograph of tasks, forces required to move timber, number of workers, PPE used, perceived exertion, discomfort rating.

Specific assessment methods are detailed in Section 4.2. These assessment protocols were developed to enable both researchers to gather data in the same manner.

The schedule for two days of onsite assessment work was as Table 4.1. The break times varied slightly for each mill.

Table 4.1. Assessment schedule

	Day 1	Day 2
7.30 – 10.00 am	• Meeting with management/supervisors as required to discuss schedule/plans, formal consent to proceed • Brief group meeting with table workers to explain research process/consent issues • Interviews with individuals working on the table (consent forms signed, anthropometric data gathered, strength testing, other interview information). Approximately 15 minutes per worker	• Complete the effort (Borg RPE) and discomfort rating scales with workers as they work on the table. Alternating assessments every 10 minutes, through until morning tea
AM Tea		
10.15 – 12 noon	• Interviews continue • Set-up for force measure assessment (pulling timber from table), to be done when chain stopped	• Recording of video data for later movement analysis. To pre-select individuals for this video recording as per anthropometric stature data (one under 50^{th} %ile, one over 50^{th} %ile), and set up with individuals concerned/supervisor
Lunch (30 mins)	• Force measure assessment (while workers at lunch)	
12.30 – 3.00 pm	• Researcher lunch break • Completion of background data gathering (dimensional, table plans, PPE, timber statistics, roster details, environmental data, etc)	• Gather any additional data to complete manual handling assessment, and to complete other records • Actual trial of working on table
PM Tea		
3.15 – 4.30 pm	• Continue background data gathering • 5 minutes with table workers to educate regarding the assessments to be used in the morning (effort and discomfort rating scales)	• Effort and discomfort rating scales as per morning session
4.30 (finished)	• Complete force measure assessment while table stopped	

4.1.5 Company and Worker Consent

Before commencing onsite assessments, information sheets were provided and written consent (Appendix 4) was gained first from company management and then from each involved worker (via brief meetings). Management and all workers in this researcher's two selected mills consented to participate in the research. On initiating the worker interviews, (completed independently with each worker) consent was verified verbally, with further opportunity for discussion. This addressed the possible impact of peer pressure in the group meeting.

4.2 Assessment Protocols

4.2.1 Archival Data Collection

Data from existing company records was gathered. This included:

- Updated Accident Register data (in addition to that already held on file from the Accident Register Survey) and sickness records.
- Injury management system details.
- Injury management information given to workers.
- Hazard identification records.
- Health and safety system details.
- Worker training methods and system.
- Pay and incentive system details.
- Maintenance records and information on management of downtime or periods of decreased productivity.
- Notes about the culture of the organisation.

This information was critical to understanding the management, organisational and people factors that may be risk factors relevant to the incidence of MSDs.

4.2.2 Worker Semi-structured Interview

Individual interviews were completed with all available workers from the green/dry chain areas. A worksheet (Appendix 5) was used for guiding the interview and recording interview data. Data collected included personal details and job history (as per the UK Health and Safety Executive's modified NMQ [Wilson and Corlett, 1995]). Additional questions around the topics of nutrition, PPE, nature of work tasks, training, rest breaks, and possible job improvements allowed data gathering about factors of relevance to manual handling in this work area.

Anthropometric and strength (dynamometer) data was gathered as part of the interview. These methods are detailed in sections 4.2.3 and 4.2.4. For the interview, the worker was taken aside from the work area/co-workers for quietness, safety and privacy, but with the work area remaining within view to facilitate discussion and reference to the equipment and environment.

4.2.3 *Anthropometry*

Anthropometric data regarding the worker population is critical to optimal workplace design; e.g. if designing the escape hatch on a spaceship, knowledge of the shoulder and hip breadth of astronauts would be critical. In this sawmilling example knowledge of stature information including shoulder, elbow and knuckle heights was used to determine work surface heights, whilst shoulder breadth, span, and arm reach guided the determination of lateral workspace requirements. Hand measurements were deemed necessary as board grasp/coupling and glove fit issues were thought to be possible risk factors.

Data from workers was collected to determine whether existing NZ anthropometric data sources suitably represent this worker population.

Anthropometric height measurement data was taken with subjects standing with heels and back against a wall, and freestanding for other measurements. Retrospectively it was noted that this method did not follow the usual conventions for collection of height data, as subjects should be freestanding for all standing measurements (Pheasant, 1996). All subjects remained in work clothing, with normal work footwear on. Measurements were taken with a metal tape measure. Gender, age and handedness were known from interview data already collected, and ethnicity (European, Maori, Pacific Island) was per the researcher's judgement, at times verified by verbal enquiry. The following measurements were taken:

- Standing eye height
- Standing shoulder height
- Standing elbow height
- Standing hip height
- Standing knuckle height

- Span
- Bideltoid width
- Acromion grip length
- Hand length
- Hand breadth

Footwear height (at heel) was also measured and recorded. This was later subtracted from the height measurements for accurate measures.

4.2.4 *Lifting Strength*

The Jamar Back-Leg-Chest Dynamometer (PC 5039B/0039B) is designed to measure the isometric force in an upward direction that is produced by the back, leg, chest and shoulders. The dynamometer was used as per the manufacturer's instructions provided, for the selected arm and leg lift only. The arm and leg lift strength of the worker population can then be compared to the given normative population data for these lifts, and therefore an assessment of the relative strength of workers obtained.

The arm lift was selected as MSDs investigated in this industry frequently affect the upper limbs. The arm lift determined the relative upper extremity strength of these workers. The leg lift was selected as it is a relatively safe 'whole body' lift and the strength of major leg muscle groups, back and arms all come into play. This was relevant as the force exerted for a task is a significant factor in MSD causation 'in relation to the strength capacity of the muscles used' (Haslegrave and Corlett, in Wilson and Corlett, 1995, p.907). Thus an individual with good muscle strength uses less of the muscle capacity, and will not become as fatigued as quickly as someone with less strength. Fatigue is considered a forerunner for muscle discomfort and musculoskeletal disorders (ACC, 1997).

Following postal delivery of the dynamometer it was calibrated (calibration report in Appendix 5) and then handled with care between sites to maintain accuracy.

As per the instructions, workers were instructed that they could cease the lifting test at any point, and were not to apply more force than they felt would be safe for them. Workers stood with both feet on the base plate, straddling the dynamometer. For the arm lift the worker stood upright, with the elbows at right angles, and the bar grasped in a 'palms up' hold. The chain was adjusted for bar hold with the elbows flexed at ninety degrees. For the leg lift the workers stood with knees comfortably apart and the chain between their knees. The handle was at a height of 38 cm from the base plate, grasped with both hands. The ankles, knees and hips were partly flexed, but the spine remained in a neutral position.

Workers were instructed to hold the grip comfortably, to maintain concentration and to then exert a maximal vertical lift effort by pulling gradually upward. Three repetitions of each lift type were completed, with the maximum peak force applied being read by the researcher, recorded, and the pointer returned to zero. An average of the three measures was taken for each lift type.

4.2.5 Environmental Assessment

Environmental factors were reviewed for their impact on task performance. Data was obtained on illumination levels (lux) for various areas of the workplace. Note was made of the outside weather conditions and time of day these measures were taken, and shadow, glare or other relevant visual factors were observed. Noise was considered, and whilst noise level measures were not taken, recent noise assessment reports were requested and reviewed if available. Floor surface type and condition, general 'slipperiness', and housekeeping factors were observed and recorded, and thermal factors – heat, cold and wind - were observed and worker comments noted.

4.2.6 Personal Protective Equipment Review

Personal protective equipment (PPE) used by workers was observed, and information gathered on PPE issues at interview. PPE considered included gloves, hearing protection, footwear, protective headwear, overalls or general clothing, and other items such as leather aprons. Factors noted included type and size, availability and suitability, replacement policy, trials leading to selection and use of the item, modifications made to PPE items, and suggested changes.

4.2.7 Worker Schedules

Information was gathered on the typical rotation and roster system and number of workers. The formality of the roster/rotation system and the time the system had been in operation were determined. Actual job changeovers were observed, and the number of workers and task positions at each shift noted.

4.2.8 Timber Handled Statistics

Production data for timber handled via the green/dry table was gathered. The total quantity of timber pulled from the table and dimensions of this timber were noted for the weeks/months preceding the assessment, and for the days of the assessment. Records of chain/table downtime, or other reasons for high/low productivity were gathered if available, including maintenance records. The number of boards per stack/packet was determined for each board dimension. The number and position of stacks was noted, along with the timber sizes pulled onto the stack. The most frequently pulled timber dimensions were noted. The frequency of timber pulling (number of items) for each worker was then calculated.

4.2.9 Green/Dry Chain/Table Assessment

The type of chain/table system in use was detailed via plans, diagrams and photographs. Existing plans were collected if available and other sketches drawn and photographs taken to ensure adequate detail. Measurements of all relevant distances (table-pack, table edge to timber end), heights (table height, pack height), and general layout and design/size of the chain and table and related equipment (trolleys, fillet sticks, stack placement, other stacking devices and plant) were completed. Note was made of any planned alterations or upgrades to the work system.

Chain speed was measured (timed over 10 metres, calculated as m/s), and note made of the number of boards moved in relation to chain speed. Note was made of whether chain speed could be altered and by whom, and the range of speed alterations and speeds commonly used. The consequent impact on board numbers delivered was measured, and the perceived exertion of workers at varying chain speeds considered.

4.2.10 Force Measure

Quantification of the force required to begin to move a board from the table in a horizontal plane (board break-out force) was deemed necessary. Accurate measurement of this maximum peak force would allow comparison of table design features that may impact on force reduction for this component of the task. It was acknowledged that other factors are also critical for the task of pulling a board from the table. Different wood types (tree species), varying timber weight (green or dry timber), and varying timber roughness after cutting alter the friction between board and table. Another factor impacting on the biomechanical forces required for timber pulling are the gloves that must be worn for splinter protection and in some processes for protection from the anti-sapstain chemicals that are applied immediately following timber cutting. This force measure method was selected to gain a quantitative measure of the impact table/chain design has on the horizontal force required to remove timber from a green/dry table.

In order to carry out these force measures, an appropriate force-gauge needed to be selected, and a suitable means of attaching the measuring force-gauge to the table devised.

A belt that could be attached to the end of various sized boards was fabricated from industrial strength strapping, and a fastening system that could be effectively hand-tightened applied. A band of industrial strapping was attached to the belt, allowing connection of the measuring device to a point central to the front end of the board. Following initial testing the belt was found to require a rubber strip between the belt and the board to prevent slipping. It was then capable of holding a force application of 45kg.

A number of different devices were obtained from a local scales supplier, and a pilot test carried out onsite at one of the mills. Following this, the Bonso electronic scale No. 393-00, 50kg x 50gm was selected as most suitable. Selection was based on ease of use including grasp comfort and ability of the researcher to accurately read the result whilst carrying out the task. The Bonso scale provided a digital readout in 50gm increments that was easier to read than the dial readouts of other models. It had a 'tare' feature that allowed the scales to be 'zeroed' before each use, enhancing accuracy of measurement. The range at the pilot test was from 4kg for small dimension timber to 45kg for large dimension timber. The scales were calibrated at purchase, and were handled carefully to reduce the risk of altering the calibration. Figure 4.2 shows the Bonso scale in use for break-out force measurement.

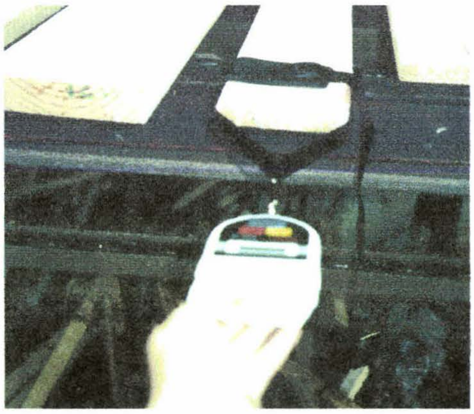

Figure 4.2. Force measure system in use.

The method used at each mill was to first determine the dimensions (cross sectional and length) of the most frequently produced lumber size (A), and the largest commonly produced lumber size (B). Eight pieces of lumber of each dimension were selected, and each board numbered for identification purposes (A1-A8, B1-B8).

Three different places on the chain/table were selected. Selection of the testing area reflected places where greater/lesser quantities of timber were pulled from, or where the chain/table appeared well or poorly maintained, dirty or clean. Both the condition and use of the chain (the moving component) and the condition and use of the table or bed (the stationery component) that the chain moves across were considered.

Whilst the chain was stationery (at lunchtime or end of work day) and at each selected area on the chain/table, the force required to pull each board from the table in a horizontal plane was measured and recorded three times at each placement. Total measures: 2 selected board dimensions with 8 boards of each, equals 16 boards. Each board measured in 3 different chain locations with 3 'pulls', equals 144 measures.

The specific method notes included:

- Ensure that pull-point straps located evenly on the sides of each board.
- Ensure that fingers did not impede the action of the scales.
- Move the scales away from the board until the 'slack' of the strapping and scale attachment hook is taken up, then zero (tare) the scales.
- Move slowly, steadily and smoothly (not accelerating or jerking) in a horizontal plane in a direction away from the chain/table until board movement begins. (Ensure safe footing and movement space).
- Record the highest force occurring as the board begins to move – this is the initial force used to overcome inertia.
- Record *three times for each board* the initial force required to commence board motion, thus the 'break-out' force required to remove the board from the chain.
- Move the board only 50-100 mm at each action, at each time commencing from the point at the table that the boards would usually begin to be pulled from.

4.2.11 *Rapid Entire Body Assessment*

Rapid Entire Body Assessment (REBA) (Hignett and McAtamney, 2002) is a postural analysis tool designed to be sensitive to a wide range of unpredictable postures. REBA incorporates trunk, neck and leg postures, upper arm, lower arm and wrist positioning (including the effect of gravity on arm positioning), dynamic and static postural loading factors and the human-load interface (coupling). REBA is reported by Hignett and McAtamney (2000) to have 'promising' initial reliability for inter-observer coding, with plans to undertake further reliability and validity testing (McAtamney, 2002). It was selected as an assessment method for this project as it reflects the wide range of causative factors for musculoskeletal disorders more effectively than other assessment methods reviewed (Rapid Upper Limb Assessment, Ovako Working Posture Analysis System, Portable Ergonomic Observation Method), whilst remaining a low technology method suitable for completion within industry settings.

REBA analyses of the actions used to move boards from table to stack was used to identify task completion methods and work height/placement issues of relevance to manual handling risk identification.

The most commonly produced lumber dimension (cross-section and length) was first determined. Most analyses were completed using common board sizes to reduce the number of time-consuming analyses required.

From the anthropometric data gathered from workers and using NZ Anthropometric Estimates (Slappendel and Wilson, 1992), one worker in the over-50th percentile stature range (standing eye height), and one worker in the under-50th percentile stature range (standing eye height) were selected. Other workers were selected for REBA analyses for specific reasons (such as experience versus inexperience, left or right handed) and tasks (such as large/small dimension boards), or work method (such as use of leather apron when pulling timber versus non-use of leather apron). For all workers selected for REBA analyses their stature, percentile ranking using NZ Anthropometric Estimates, handedness and experience was recorded.

The primary two workers selected were then videoed pulling/stacking a full pack of the most commonly pulled timber dimension. The date, time, individual's identity and pack details (timber dimensions) were recorded for each videoed task. Adequate footage of the following tasks was required:

- the first board stacked on the first layer of the pack
- boards that are mid-row, at a mid-fillet layer such as the third layer
- the first board of a layer applied immediately over a fillet
- boards from mid-row, on the top layer of the pack.

The video recording was later used to complete REBA analyses for each of the subjects. REBA scores were recorded for steps 1-3 below and step 4 if it occurred. The details for each subject were recorded on tables, with the actual layer number and board number noted for review purposes.

Step 1	Starting to pull board off chain (reach out to pull).
Step 2	Feeding board onto pack.
Step 3	Placing board on pack.
Step 4	(If observed) Replacing or 'jiggling' board into place.

4.2.12 BORG Rating of Perceived Exertion Scale

The Borg Rating of Perceived Exertion (RPE) scale measures the effort workers perceive they are exerting whilst working. The 15-point RPE scale (Borg, 1982) (Figure 4.3), has been found to have high correlation with heart rate (HR), e.g. a score of 6 correlates with HR of 60 per minute, and 15 with HR of 150 per minute. Thus a rating of perceived exertion using this scale gives an indication of HR relative to the task, if it is largely aerobic.

6	
7	**Very, very light**
8	
9	**Very light**
10	
11	**Fairly light**
12	
13	**Somewhat hard**
14	
15	**Hard**
16	
17	**Very hard**
18	
19	**Very, very hard**
20	

Figure 4.3. The 15-point Borg RPE Scale (Borg, 1982)

The Borg RPE was used to gather data on workers perception of exertion whilst pulling timber. The first 'work session' (worker most rested and fresh) and last 'work session' (worker most fatigued) of the day were determined. That is, the work period from the start of shift to the first morning break, and from the last break of the day through to finish of the shift.

A record sheet detailing session start time and times at 20 minute intervals throughout the shift was used. At the end of the shift the final rating was taken at either 25 minutes from the previous one, or 10 or 15 minutes from that previously recorded. That is, an interval of 30 or 35 minutes was unacceptable.

The available and consenting workers were educated on the use of the RPE scale. They were informed it was a measure of *how hard they feel they were working*, and was *to rate the effort they were using*. It was stated that comparing themselves to others, or reporting figures that made it seem as if they were requiring more or less effort than that experienced would distort the information gathered. That is, honesty in personal responses was requested, and they were reminded that the results were for use in research only (they would not be fed back to management to insist that they work harder/faster etc). Workers were familiarised with the numbers and meanings of the rating scale, and their need to give only a number to indicate perceived exertion.

Each worker was assigned an identifying number and their position/task on the chain noted. Just before each worker started work, RPE ratings were collected. This was continued every 20 minutes on the shift. The RPE scale was presented as a laminated A4 sheet for worker reference when reporting exertion levels. Guarding against workers comparing with each other was aided by the option of pointing to the rating number, though once they became more familiar with the system, workers generally elected to simply call out the number as they continued to work. Changes to production or chain stoppages were noted, as were worker position changes (moving to different stacks) at the table.

4.2.13 Discomfort Rating Scale

The determination of worker discomfort whilst pulling timber from the chain/table is relevant to a study investigating MSDs. Such psychophysical measures have been found to be appropriate in determining manual handling risks (Haslegrave and Corlett, in Wilson and Corlett, 1995). The ACC text 'Prevention of occupational overuse syndrome (OOS): A handbook for co-ordinators of workplace OOS prevention programmes' (1997), promotes the use of discomfort monitoring to aid in the early identification of potential problems in the workplace. A method used by Tappin (1989) was modified to reflect the 9 body parts previously defined in the Accident Register data analysis. These are neck and head, back and low back, abdomen and chest, shoulder, arm (upper and lower), wrist and hand, hip, leg (upper and lower), ankle and foot. Perceived comfort/discomfort was described on a five point rating scale: 1 – Very Comfortable, 2 – Comfortable, 3 – Acceptable, 4 – Uncomfortable, 5 – Very Uncomfortable, for each body part.

The first and last work sessions of the day were determined as per the Borg RPE protocol (Section 4.2.12). A record sheet detailing session start time and times 10 minutes after the start, and then at 20 minute intervals throughout the shift was used. The RPE and discomfort ratings were therefore taken alternately, with a rating being taken every 10 minutes.

As per the Borg, the available and consenting workers were educated in the use of the Discomfort Rating Scale prior to the start of the first shift. They were informed that it was a *measure of the perceived comfort of the named body areas*, using the body chart and the rating scale shown to them (Appendix 5). They were similarly instructed for honesty in reporting, and were familiarised with the numbers and meanings of the rating scale and their need to give only the body part and number to indicate their perceived discomfort. As per the Borg, workers were assigned an identifying number and their position/task on the chain noted. Discomfort ratings were then collected from all workers throughout the work sessions with their reference to the chart.

4.2.14 Nordic Musculoskeletal Questionnaire

The Nordic Musculoskeletal Questionnaire (NMQ) (Kuorinka et al, 1987) is a means of collecting information on the musculoskeletal problems of a workforce. Information is gathered on the worker's experience of aching, pain, discomfort or numbness in nine body areas (neck, shoulders, elbows, wrists/hands, upper back, lower back, hips/thighs/buttocks, knees, ankles/feet) within the previous 12 months. Further information on whether the discomfort was of recent occurrence (seven days previous), and whether it impacted on the individual's ability to carry out normal tasks over the previous 12 months is gained.

An abbreviated version of the modified NMQ (UK Health and Safety Executive, in Wilson and Corlett, 1995) and the accompanying Body Map were part of the worker interview (Appendix 5). The worker was shown the body map, and asked whether they had discomfort in any of the body areas. If yes, it was defined (left, right, or bilateral), and further questions asked about recency and impact on function. Responses were recorded.

4.2.15 Manual Handling Risk Score

The Manual Handling Hazard Control Record (ACC and OSH, 2001) (Appendix 5) assesses manual handling risk and identifies contributing risk factors so that suitable controls can be implemented. Sections 1-12 of this NZ assessment tool were used to give a rating of the manual handling risk associated with pulling timber from the green/dry table in each of the mills. Given the complexity of the task it was unclear as to how accurate the assessment tool would be, but it was selected as it would be understood locally.

Information required for this assessment included: task duration/cycle time; repetitions per shift; forces exerted per cycle; weights of items moved; environment, posture, workstation issues; and contributory factors. The sections identifying controls, action plan, monitoring and evaluation were not attempted, as these aspects are a component of the larger research project.

Chapter 5 Case Study – Mill 12

5.1 Introduction

Timber handling at green/dry tables was identified as the sawmilling task with highest MSD risk. Identification and measurement of specific manual handling risks will allow the development of interventions for risk reduction. Two mills in the South Island were selected for work system assessment. This and the following chapter outline the results, discuss the findings and present the recommendations for each mill. In the discussion sections the factors that arise in more than one area are cross-referenced. This cross-referencing demonstrates triangulation and strengthens the conclusions and recommendations made.

Mill 12 was in the Canterbury/Westland region of the South Island of NZ. The mill was categorised as a 'large' mill for our study purposes, producing around 30,000 m^3 of sawn lumber per annum, and employing around 100 persons. All timber processed was pinus radiata. Further detail about the mill and production data is withheld in the interests of privacy.

The work area investigated was a green (long) table. Timber handled was direct from the mill, in a range of timber dimensions and lengths. Lumber was removed from the green table into stacks (packs/packets) of same dimension boards, but without need for grading. The stacks were made onto trolleys that were manually shifted for the forklift to gain access. Packets were tallied and strapped before being moved to the yard via forklift.

Work tasks rotated through in this work area included: one person untangling timber so that it all lies flat on the table and is easy to pull for stacking; up to 8 persons pulling and stacking various dimensioned timber from the table; and up to 4 persons (working in pairs) completing the related filleting tasks for packets going into the kiln. Whilst the filleting work was acknowledged as being a part of the workload of staff, it was not specifically investigated in this study.

5.2 Assessment Results, Discussion and Conclusions

5.2.1 Archival Data

5.2.1.1 Results

Health and Safety Management System Staff were reportedly familiarised with the Health and Safety Statement of the mill on commencing employment. The statement explained that:

- It was an offence to endanger the safety and health of anyone on the job or to work in a way that may cause injury;
- That all workers were required to work in a safe way at all times;
- That workers were required to seek advice when any situation was dangerous or if they were uncertain about the safety of any machine or practice;
- Breaches of the Health and Safety in Employment Act or the health and safety rules may result in termination of employment.

Work Skills Record The work skills of each worker were recorded on a task sheet, signed by the worker and an employer representative. This outlined the machinery/plant that the worker is a) not to use, b) can use with supervision, c) is permitted and competent to use, and/or d) is able to train others in the use of. Verification of the effectiveness or actual use of this system did not occur.

Induction New workers reportedly spent approximately 30 minutes with the team leader, with this being 15 minutes discussion, and 15 minutes orientation to the mill area. A list of points for the supervisor to cover in this induction included: introduction to supervisor; job description; health and safety statement; task sheet; for workers working outdoors a review of the risks of sunburn and instruction regarding the location of sun-block/the importance of cover-up clothing; for forklift drivers, sighting of Occupational Safety and Health certificate and recording of its number on the Health and Safety Statement; issue of earmuffs if necessary; a check that steel capped boots were worn; evacuation procedure; hours of work, time sheet completion; location of toilets and tea rooms; explanation of 'no smoking' site rules; accident reporting procedures; explanation of procedure for ringing in sick; and explanation about leave applications.

Training The Leading Hand reported completing training with new workers in how to pull and stack timber, though there was no documented procedure. Verbal report of the Leading Hand's understanding of safe work methods included:

- Using the weight of the board to best advantage
- Waiting for the timber to come to you along the chain
- Allowing new workers to build fitness and skill
- Need to rotate workers from filleting (easier task, self-paced) to green chain (machine paced, physically demanding)
- Fitting workers into the team and awareness of their work preferences
- The need to be fair in allocation of work tasks
- The need to ensure that tasks were allocated depending on the capacity of the worker. Thus new workers are always rotated (alternate days) from filleting to chain, and usually start on lighter/smaller boards when pulling and stacking, building to heavier boards as their fitness and skill increased. Work pace is not expected to be rapid until some skills have developed. The Leading Hand indicated that he 'keeps an eye on' new workers to ensure that they are working with 'good' technique.

Pay System Workers on the green chain were paid the better of either a standard work rate or piece (contract) rate (i.e. a minimum wage guarantee) for work based on the performance of the team. The minimum wage rate was indicated to be $10 per hour, with contract rates of up to $15 per hour. Filleting and green chain outputs were considered together, with the piece rate based on the total volume of stacked (fillet and green chain) cubic metres of timber per week, for the team. This was a weekly pool, with workers that had been present all work days considered 'in the contract' for that week.

5.2.1.2 Discussion and Conclusions

Induction The induction given to new employees did not define a number of the hazards related to green chain work. This included:

- Manual handling factors - despite the known (verbalised) and significant risks when handling timber
- The statement regarding wearing of hearing protection does not reflect the noise management report of 2001/2002. It mentioned earmuffs only, and was not clear regarding the areas hearing protection was to be worn in or the level of protection required.

Failure to address these factors in the formal hazard documentation indicates that they may then be inadequately addressed at the workface. It is a requirement of the HSE Act that all hazards and controls are documented.

Training Whilst the Leading Hand gave a verbal report of the range of factors covered when he trained new staff members, these points were not formally documented. This Leading Hand was well educated in safe timber handling practices, demonstrated excellent work technique and had an apparent ability to effectively pass this on to others. However, it is likely that future Leading Hands without the same background would not train others as effectively, placing workers at risk.

Based on interview findings, observation, postural analysis, and researcher expertise, key work methods and issues to be covered in training are:

- Wait for the timber to come to you on the chain.
- Walk in close to the timber to grasp it from the table, avoid bending forward and over-reaching with stationary feet (see REBA Findings in 5.2.11.2).
- Move your feet in the direction the timber is to move in, walk with it.
- Keep a wide base of support (feet apart) for stability.
- Use knee and hip action to reduce bending and twisting with the back.
- Develop left and right handed work methods to share the workload and reduce overuse problems.
- Work with wrists as straight as possible (avoiding extremes of flexion/extension, or radial/ulnar deviation).
- Use gravity to best advantage, push the timber down and allow the timber to slide onto the stack.
- Use a 'throw' (as if passing a rugby ball) to provide the impetus for timber movement.
- Once the timber is moving, guide it into place on the stack.
- Use a leather apron and guide the timber onto the stack with the hip/thigh to share the workload with the upper extremities (see Worker Semi-structured Interviews in 5.2.2.2, PPE in 5.2.6.2 and REBA Findings in 5.2.11.2).
- Use the apron's protection to allow the thigh to act as an additional leverage point for handling timber that has fallen off the side of the stack.
- Place the first board of the layer on one side of the stack and then slide other boards with greater ease/speed alongside this guide board. (If working two to a stack the guide board is usually placed centrally).

- Learn to 'throw' and 'bounce' boards into place over bearers and fillet sticks, but also use the 'guide board' principle if possible.
- An alternative to throwing the first board over fillet sticks is putting the first board of the post-fillet layer on top of the pre-fillet layer, then having a team member lift the end of this board up so that fillet sticks can then be placed under. This gives a short work break, a stretch, a reason for some teamwork, and avoids the awkward first board post-fillet throw.
- Avoid lifting and placing of boards, rather they should be slid/supported on the table or stack, via 'throw' and 'guide' actions.
- Regularly rotate between heavy or intense stacking tasks and lighter or slower tasks.
- Allow new/inexperienced workers to gradually develop the strength and technique required for heavy/larger timber handling, and the speed/coordination required for more frequent handling of smaller timber dimensions.
- Develop a smooth and relaxed work rhythm.
- Work within your capacity (do not become too fatigued, or lift more than you can comfortably manage).
- Stretch before and during work, start day slowly.
- Report discomfort early and ensure that action is taken (self, management, team) to accommodate this.
- Eat/drink according to the nature of the job. It is very physical work, and to perform well and avoid injury it is suggested that all workers eat healthily including breakfast, adequate snacks and lunch, and drink plenty of water during work. (See Borg RPE Scale in 5.2.12.2).

Pay system The team contract system appeared to be motivating for workers without being a major focus. The team basis appeared to encourage a healthy level of teamwork, though there is also a possibility that stronger team members could pressure others to work at a level that exceeds their comfortable work capacity.

5.2.2 *Worker Semi-structured Interviews*

5.2.2.1 Results

The data gained from worker interviews is summarised below (see Appendix 6 for full results).

Nutrition 50% of workers often had no food, just coffee, before commencing work, and had varying (small) quantities of fluid intake during the day.

PPE (also from observation) 42% of workers used one or two wrist braces, believing that these assisted their comfort and protected them from injury. One worker used a leather apron for clothing and body protection whilst handling timber. All workers used the gloves as provided and they were generally reported to provide adequate protection, with one comment that they would be better with a strap across the back of the hand to improve the fit. Fit of gloves was observed to be poor, with workers experiencing gloves coming off as they were working, and frequently needing to pull gloves back on to their hands. Hearing protection was worn consistently only at the 'pusher' position at the front of the line, but not by others. Steel capped boots were worn as standard.

Hardest/easiest work tasks Timber pulling was reportedly more difficult with: large board sizes; mill going very quickly; fewer skilled workers available; inadequate space between stacks; stacking irregular sized timber; and handling re-sawn timber. It was said to be easiest when: able to work in a good rhythm (no stop/start); adequate number/skilled workers on chain; and with a trustworthy team of workers. The most difficult task was reportedly pushing full (and requiring repair) trolleys from the table.

Training Key factors as reported for ease in timber handling and learning the necessary work skills were: using the weight of the board - push it down so it slides off the table; wait for the timber to come to you on the chain; use your whole body, not just your arms; throwing the boards 'like a rugby ball', don't 'flick' with your wrists, work within your capacity, rotate work positions, don't lift or carry boards unnecessarily, slide them; throw the timber and then guide it into place; use a leather apron so hip/thigh can assist with guiding/lifting boards, and to keep the boards close to the body.

Rest Breaks 33% of workers reported some difficulty gaining adequate rest and hydration/nutrition within the 15 minute breaks.

Improvements Maintenance of the chain and repair of existing trolleys was a key need identified by many workers. Other suggestions included provision of a drinking water supply nearby, a means of controlling chain speed, regular rest breaks, alternative means of storing fillet sticks, preventing re-sawn timber from causing snare-ups, provision of additional trolleys and increased task rotations.

5.2.2.2 Discussion and Conclusions

Nutrition Half of the workers had an insubstantial breakfast (often no food, just coffee) before commencing work, and many workers had little fluid intake during the day. Given the consistent physical nature of their work, it was likely that their nutrition was less than adequate for their work requirements (see Training in 5.2.1.2 and Borg RPE Scale in 5.2.12.2).

PPE Wearing of PPE was consistent for gloves and steel-capped boots, but inconsistent and likely inadequate regarding hearing protection (see Environmental in 5.2.5.2). Wearing of leather protective aprons appeared to be poorly understood and therefore was inconsistent and perhaps inadequate, given the apparently safer work method occurring with apron use (see Training in 5.2.1.2 and PPE in 5.2.6.2). Glove requirements could be further researched due to apparent poor fit (see PPE in 5.2.6.2). The benefit of wrist brace wear was perhaps questionable for this work task and could be researched further.

Hardest Tasks The most difficult tasks were reportedly pushing out full (damaged) trolleys, working with large boards, and when working very quickly (if limited staff, or to clear a backlog).

Training Workers recognised some key factors in their training for timber handling that made it easier/safer to complete the work tasks (see Training in 5.2.1.2, PPE above, REBA Findings in 5.2.11.2 and Borg RPE Scale in 5.2.12.2). The use of leather aprons was however poorly understood and not part of the work culture at this workplace despite the apparent benefit of using these.

Rest Breaks Morning/afternoon tea break length (15 minutes) appeared inadequate for workers to access their break area, to use the toilet, and gain adequate rest and nutrition, given the physical nature of their work. Despite two thirds of workers not reporting that this is a problem, observation of distances to travel between work and break areas, and nutrition information, indicates that this is a potential area of concern.

Improvements Workers identified the primary area for improvement as chain and trolley maintenance.

5.2.3 *Anthropometric Data*

5.2.3.1 Results

Data collected from these workers (Table 5.1) paralleled that for the New Zealand population as given in NZ Anthropometric Estimates (Slappendel and Wilson, 1992). Mill 12 worker measurements were taken with normal work clothing on, and 5mm error allowance. Footwear heel height was measured then subtracted to gain comparative height data.

Table 5.1. Anthropometric data from Mill 12 workers

Gender	Ethnicity	Hand	Age	Eye	Shld	Elb	Hip	Knuck	Span	Bidelt. Width	Acrom Grip L	Hand Lgth.	Hand Brdth.
M	EUROPEAN	R	22	1710	1430	1110	900	740	1900	500	650	180	95
M	MAORI	R	18	1735	1515	1155	965	775	1860	470	700	200	90
M	EUROPEAN	R	26	1690	1460	1150	890	760	1800	450	650	190	90
M	EUROPEAN	R	21	1695	1475	1155	895	785	1780	460	660	190	100
M	EUROPEAN	R	20	1660	1430	1100	875	760	1850	470	630	190	90
M	EUROPEAN	R	28	1570	1360	1010	820	710	1720	500	630	180	95
M	EUROPEAN	R	19	1580	1390	1050	790	720	1840	500	730	200	95
M	EUROPEAN	R	36	1690	1490	1140	830	780	1840	500	690	195	100
M	EUROPEAN	R	29	1765	1535	1155	915	825	1860	490	650	190	95
M	EUROPEAN	R	24	1620	1420	1060	850	700	1940	460	690	200	90
M	EUROPEAN	R	31	1595	1375	1055	845	715	1840	460	650	185	80
M	MAORI	R	32	1640	1440	1090	860	760	1840	510	610	185	90
			1st %ile	**1517**	**1317**	**986**	**759**	**667**	**1709**	**432**	**582**	**174**	**80**
			2.5th %ile	**1540**	**1337**	**1004**	**777**	**680**	**1730**	**440**	**594**	**176**	**82**
			5th %ile	**1560**	**1354**	**1020**	**792**	**692**	**1748**	**446**	**605**	**179**	**84**
			50th %ile	**1663**	**1443**	**1103**	**870**	**753**	**1839**	**481**	**662**	**190**	**93**
			95th %ile	**1765**	**1532**	**1185**	**947**	**813**	**1930**	**515**	**718**	**202**	**101**
			97.5th %ile	**1785**	**1550**	**1201**	**962**	**825**	**1948**	**522**	**729**	**205**	**103**
			99th %ile	**1808**	**1570**	**1219**	**980**	**838**	**1969**	**530**	**742**	**207**	**105**
			Std devtn	62	54	50	47	37	56	21	34	7	5
			Count	12	12	12	12	12	12	12	12	12	12

5.2.3.2 Discussion and Conclusions

NZ Anthropometric Estimates (Slappendel and Wilson, 1992) can be used for relevant design considerations.

5.2.4 *Lifting Strength*

5.2.4.1 Results

A comparison of the data gathered from lifting strength testing with 12 green table workers (Table 5.2) with that reported by Keyserling, Herrin and Chaffin (1978), (as cited in the Jamar Back-Leg-Chest Dynamometer instruction booklet, Therapeutic Equipment Corporation, New Jersey. [undated]), determined that for the *leg lift* all workers had 50th percentile or above strength, with 75% of workers of 90th percentile or above; and for the *arm lift* 66% of workers had 50th percentile or above arm lift strength, with 25% of these with 75th percentile strength.

Table 5.2. Dynamometer data from Mill 12 workers

Subject number	Arm Strength (kg)				Leg Strength (kg)			
	Lift 1	Lift 2	Lift 3	Mean	Lift 1	Lift 2	Lift 3	Mean
1	45	45	45	45.0	129	125	137	130.3
2	30	24	27	27.0	145	140	160	148.3
3	42	40	42	41.3	155	130	145	143.3
4	44	50	46	37.8	163	164	175	167.3
5	37	29	28	31.3	90	84	98	90.7
6	47	45	45	45.7	158	156	155	156.3
7	46	46	46	46.0	162	153	165	160.0
8	41	42	38	40.3	149	145	152	148.7
9	49	50	50	49.7	119	138	141	132.7
10	32	30	35	32.3	89	113	108	103.3
11	27	29	32	29.3	101	87	97	95.0
12	50	52	52	51.3	150	147	151	149.3

5.2.4.2 Discussion and Conclusions

The workers employed at this mill are relatively strong for the leg and arm lifts tested. This does not indicate a sound basis for attributing musculoskeletal discomfort and work difficulties to 'poor strength', but suggests that manual handling risk factors lie in other domains.

5.2.5 Environmental

5.2.5.1 Results

Lighting levels The building housing the work area had a south-facing open wall running alongside the green table, and an open east wall at the far end of the green table. The northern wall was solid concrete, and on the west the green table area joined with the mill. Overhead skylights and the light entering from the open sections of the building were the predominant light sources. Only one overhead light at the mill end of the chain existed. Of note was that work shifts were reportedly daytime only with no very early or late shifts, and no grading or other visually demanding tasks occurred. Illuminance (lux) was measured around the green table work area. It was noted that on commencing work at sunrise (7.00 am) the work area was subjectively 'dark'. Findings are given in Table 5.3 below.

Table 5.3. Illuminance at Mill 12 green chain

Time and conditions	Place	Lux
Late summer, 4.10 pm, bright day with some overhead cloud	Back wall, behind chain	780 lux (west/mill end of chain) to 2,000 lux (east/far end of chain)
	Main work/front side of chain	1,500 lux (mill end) to 3,300 lux (far end of chain)
	Ends of stacks nearest the south/open side of the building	3,800 (mill end) to 8,300 lux (far end of chain)
	Outdoors (in sun)	42,000 lux
Late summer, 8.05 am, cloudy day	Back wall, behind chain	45 lux (mill end) to 82 lux (far end of chain)
	Ends of stacks nearest the south/open side of the building	350 (mill end) to 415 lux (far end of chain)

Noise A recent noise assessment noted that radio speakers were the greatest source of noise in this workplace. A copy of this assessment (June 1991) was provided, with the summarised recommendations being:

- Grade 2 hearing protection required (mandatory) for those working an 8 hour shift in the first position on the green chain and further down the chain, whether or not the mill or radio are on (ear plugs or ear muffs)
- Grade 3 hearing protection (earmuffs) is required during 8 hour shifts at the top of the green chain
- Earmuffs and ear plugs should be checked regularly – earmuffs should have adequate clamp force and cushion condition, and permanent earplugs should be washed (preferably daily), and disposable plugs replaced regularly. Main relevant findings are dB(A) measurements (Leq.8hrs) of 96.2 at the top of the green chain (pusher position), 90.1 at the first green chain station, and 89.3 in the middle of the chain opposite the radio.

Floor Surface The concrete floor was smooth and even except where narrow trolley wheels had damaged the surface. Steel bolts protruded from the floor behind the table (left in place following plant relocation) and were a tripping hazard. Grit and sawdust were built up under the table, and fillet sticks for stacks were stored under the edge of the table, spilling out onto the walkway and collecting sawdust and grit.

Thermal Issues Workers reported that southerly conditions (generally cold air flows) were uncomfortable as the wind/rain blows in. The common wind direction over summer months was from the north-west, so workers were generally protected from this. Dust and grit may however blow up in windy conditions and become a visual health hazard.

5.2.5.2 Discussion and Conclusions

Lighting Given the suggested lighting level of 200-250 lux for packing/despatch tasks (Kroemer and Grandjean, 1997), and early morning starts on the chain, the low lighting at the mill end of the chain in the early morning is potentially inadequate for the work tasks (45–350 lux). On dawn (7 a.m.) this area appeared subjectively 'very dim' in comparison, and it can only be assumed that in winter it would be darker and more difficult to work in.

Noise The June 1991 noise report appeared to have been interpreted incorrectly. That is, whilst the message about earmuffs (Grade 3 protection) being necessary at the top of the chain (for the 'pusher') was largely being followed, the message about all other green chain workers needing to wear either ear plugs or ear muffs (Grade 2 protection) was not. (See Hearing Protection in 5.2.6.2).

Floor surface Trolley wheel damage to concrete (from narrow rimmed wheels without rubber rims, and wheels with broken bearings) made it more difficult to push trolleys (see Trolley Design in 5.2.9.2). Trip hazards existed in the form of steel bolts protruding from the floor behind the table and fillet sticks spilling out from under the table. In windy conditions sawdust and grit on the floor may become airborne (as the building is exposed on two sides) with risk of eye injury. Closer attention to general housekeeping (sweeping and tidying) and to fillet stick storage methods (see Fillet Stick Pick-up in 5.2.11.2) would reduce slipping and tripping hazards.

5.2.6 PPE

5.2.6.1 Results

Gloves Workers used a glove with a leather reinforced palm and knuckle bar, leather thumb/fingers and cotton back and cuff. Staff reported that several glove types from one supplier were trialed, resulting in selection of the style with slowest wear and best protection. Gloves were reportedly $3.15 per pair, and lasted an average of 3-5 work days. This varied depending on tasks completed. Gloves lasted longer for those doing less timber pulling/stacking, such as the forklift driver, the supervisor or the 'pusher'. Workers did not report problems with sweating or heat build-up, and felt that the gloves had good flexibility and adequate protection.

Cheaper ($1.60) but similar gloves (fabric back of fingers for 3^{rd}-5^{th} digits, leather knuckle bar and leather thumb/front) lasted only 1-2 days when used for pulling timber. Gloves with a double leather palm, forefinger and thumb and cotton elsewhere were also trialed, but though more expensive ($4.50) this style was not selected as the gloves were found to be less effective.

Gloves are provided and available for replacement when needed. They are 'one-size fits all'. This researcher noted that for her hand (185mm length and 85mm breadth) these gloves did not fit well, being loose, catching at times on timber and coming off. Anthropometric data indicated hand length for workers of 180 - 200mm, and hand breadth of 80 - 100mm. No workers reported glove fit problems.

Hearing Protection All workers are reportedly issued with and have earplugs, however no workers were observed to be wearing these at any time. A solid headband style earplug was observed stored on the side of a forklift but not worn, reportedly as they were uncomfortable. Workers were disbelieving that noise was a health issue in this environment, and also stated it was too hot to wear earmuffs, and that earmuffs were uncomfortable. One worker consistently wore earmuffs in the front section of the chain and other workers did this often, but others entering the area for short times or working immediately adjacent to this area did not wear hearing protection.

Footwear Steel capped boots are a requirement for work in this area, and were observed to be worn consistently by all workers.

Hard Hats Hard hats were not compulsory in this area. One worker did however feel that the 'pusher' would be well placed to wear a hard hat due to occasional snare-ups with timber sometimes becoming airborne.

Overalls Overalls were available, but workers were observed to wear and stated a preference for wearing 'old clothes' instead. Heat management over summer months was an issue raised by some workers, with shorts and singlets felt to be preferable to other clothing. Workers were often observed to wear no clothing on their upper body and only shorts on their lower body whilst working. Singlets or old t-shirts that were loose at the front of their trunk were often worn, resulting in workers taking care to keep timber away from their body.

Leather Aprons Leather aprons are available to be worn for timber pulling and stacking, however only one worker was observed to use an apron. Some workers reported that they are too stiff to wear comfortably. The only worker wearing an apron was an experienced green chain worker, stating that he had learned (at a different mill) how to work using the apron. The worker reported that apron use was encouraged in an educational paper he had completed on sawmill/chain work (via an industry training body).

The method and benefits of apron use was discussed with this worker. Right handed people should wear the apron on the left side, and vice versa. The apron should be used most when working on the lower half of the stack - timber should slide along the upper leg/thigh on the apron to reduce the need to bend. Correct apron use encourages work from a squat rather than a position of lumbar curvature. This allows the legs to assist with positioning of the timber rather than just using the arms, spreading the physical load and decreasing the effort required by the arms. Using the leg area (protected by the apron) as a lever allows boards to be lifted with greater ease if they should fall from the side of the stack.

5.2.6.2 Discussion and Conclusions

Gloves Whilst workers were happy with glove fit and function, they were observed to be have poor fit and adjustment, catching and coming off at times whilst working (see Worker Semi-structured Interviews in 4.2.2.2). They were however found to be cost effective, and to offer adequate splinter protection and thermal comfort. An alternative glove style may have better fit and function and last for longer before requiring replacement. Gloves used at the green chain should meet the following specifications (D. Tappin, personal communication):

- Timber splinter protection.
- Sufficient 'feel' and 'tactile feedback' for the task(s).
- Unrestricted hand postures and movements required for tasks.
- No significant increase in the muscle effort/grip force (through glove inflexibility) required to achieve these hand postures and movements.
- No contribution to the occurrence of localised physical discomfort through direct pressure, movement over skin or irritation.
- Must allow workers to stay within existing cycle time and acceptable quality parameters on a sustainable (absence of physical discomfort) basis.
- Sizes of gloves must enable 95 percent (2.5th - 97.5th percentile ranges) of both existing and potential user populations to achieve a

comfortable, snug fit when undertaking the tasks for which they are intended.

- Should be of a construction that permits local modification of the glove when users need it (i.e. when the functional dimensions of their hand(s) are outside the percentile range stated above, or between glove sizes, or finger amputations exist).
- Should not get uncomfortably hot (or cold) when being worn for these tasks.
- Should not cause the wearer's hand(s) to sweat excessively where this could require increased muscle effort to overcome.
- Should be sufficient to withstand normal operating conditions (e.g. donning/doffing) throughout the design life of the glove system without affecting other aspects of performance.
- Should be accepted by those working in the industry as a suitable alternative to other gloves and/or bare hands.
- All sizes and configurations must be available without significant delay.
- Should be considered affordable by sawmill operators.

Hearing Protection Earplugs were not observed being worn at any time, and earmuffs were inconsistently worn at the position where it was a requirement. Comfort was reportedly a factor in hearing protection wear, as was appreciating the need for hearing conservation and having the wear of plugs/muffs enforced. (See Environmental in 5.2.5.2).

Leather Aprons Leather apron wear does appear to have considerable advantage to the timber handler, but workers require training for correct use (see Archival Data in 5.2.1.2 and REBA Findings in 5.2.11.2). Use of the leather apron allows safe handling of timber close to the body (therefore with reduced force on the back and arms), and 'load sharing' between the upper extremity and hips/thighs. A skilled worker wearing a leather apron uses leg and hip flexion to guide board placement rather than arm control and back flexion, particularly on the lower stack positions. The leather apron protects the workers clothing from sap/resin build up and from catching on rough timber, and protects the soft tissues of the body from splinters or bruising from the boards. In this workplace it was not current 'culture' to use an apron whilst working, and its successful introduction would require a systematic approach.

5.2.7 Worker Scheduling

5.2.7.1 Results

Information was gathered primarily from discussions with the team leader and leading hand, from staff interviews and from observation.

Task rotations - Workers usually rotated between task areas on a half daily basis. Decisions about staff placement were made by the team leader and leading hand based on the skills of the worker, work pace required due to mill pace, strength required due to size of timber, the previous work rotation of each worker, and complaints of discomfort/fatigue. Each staff member generally does filleting work on alternate days from pulling and stacking timber. A local physiotherapist had recently recommended that rotations between greenchain and filleting should occur on a half daily basis. This was based on the physiotherapist's assessment of the causes of wrist pain being experienced by workers. However, despite this recommendation, rotations continue to be a largely once daily event.

Task rotation changeovers were consistently observed to occur daily, with some additional half daily (or more) changeovers noted. Additional task rotation was noted when timber was coming from the mill very quickly. At these times additional staff were moved from filleting to the greenchain to decrease workloads and clear timber backlog.

Worker numbers and positions –13 work positions existed in this green table area, including the related filleting task that table workers rotate to. These were:

- *'pusher'* - the first work position at the front of the greenchain (Figure 5.1). This worker wore earmuffs and often a hard-hat. Role is to straighten and untangle timber that has fallen haphazardly from the conveyor overhead, so that as it moves down the chain it is easy to pull. Boards were positioned with a small overhang from the table edge and free from overlap with other boards. Re-sawn timber created a problem as it dropped onto the timber direct from the mill, frequently creating a tangle. Some snare-ups were observed with a risk of boards breaking and becoming airborne, as had reportedly occurred in the recent past. The chain was intermittently stopped to allow a backlog to be cleared. When the mill was running smoothly and re-saw was not operating the relative effort for the 'pusher' appeared low.
- 1^{st} position on chain – pulling and stacking timber to go back through re-saw or from re-saw, or general pulling and stacking.

Figure 5.1. 'Pusher' at left, and two workers handling re-sawn timber

- 2^{nd} to 8^{th} positions on chain – pulling and stacking all board sizes (Figures 5.2, 5.3 and 5.4). Some stacks had 2 people stacking, depending on the quantity of timber of that dimension coming off the chain. Space appeared cramped when two workers were working to one stack.

Figure 5.2. Workers on the green chain

Figure 5.3. Stackers working together on one packet. (Note lack of protective clothing on worker on the left, and loose clothing of the worker on the right).

Figure 5.4. Stackers working together to insert fillet sticks

- 9^{th} to 13^{th} positions were filleting – either indoors or outdoors. Filleting was completed at this mill with two people working together lifting the boards from the un-filleted stack into the filleting cradle. (Figures 5.5 and 5.6) Fillet sticks were placed at fixed intervals between each layer of boards for kiln drying. These workers were intermittently asked to return to the chain to clear a backlog, or to do tasks such as returning missed timber to the correct stack from the end of the chain.

Figure 5.5. Filleting workstation. Cradle with almost completed stack for kiln drying, and un-filleted stack (high base) that boards were taken from

Figure 5.6. Filleters working together

5.2.7.2 Discussion and Conclusions

Rotations The system used for rotations in this mill was informal. Decisions were not recorded, were unplanned, were made on the basis of memory and on-the-spot discussion with team members, and relied on the judgment of the leading hand and/or supervisor. There was a potential for strain to be placed on individual workers via poor decision-making or even deliberate over-work of an individual, with some indication that this had occurred. The rotation period was half day or whole day, with a tendency for whole day rotations. This exposed workers carrying out the heaviest work tasks to considerable risk, which could be reduced via more frequent/shorter task rotations.

Regular rotation of workers through tasks that use different muscles and actions and at a different level of physical intensity reduces the risk of musculoskeletal injury. (See BORG RPE Scale in 5.2.12.2). Regular and shorter rotations allow new workers to more easily adjust to task requirements. Given that some workers reported limited ability to gain rest, see to personal needs, and gain adequate nutrition within the two 15 minute breaks (see Worker Semi-structured Interviews in 5.2.2.2), there may be some value in considering using two longer work breaks of 30 minutes, instead of one 30 minute and two 15 minute breaks. This would require further investigation, and is a work pattern that would lend itself to 6 rotation periods per day. A benefit is that workers that have perhaps missed a substantial breakfast have the opportunity to eat at an earlier time during the day, enhancing their resulting physical performance. Others will choose to eat two smaller 'lunches', but all will have the opportunity for a longer physical rest from the work being performed. For the work schedule in use at the time of the assessment, rotations could be:

7.30 – 8.45	1.15 hrs
8.45 – 10.00	1.15 hrs

tea break	
10.15 – 12.00	1.45 hrs
lunch	
12.30 – 1.45	1.15 hrs
1.45 – 3.00	1.15 hrs
tea break	
3.15 – 4.30	1.15 hrs
Total	*8.00 hrs*

Rotations should alternate between heavy or intense to light or slow work tasks. It is suggested that a whiteboard or other visible schedule system be used (and/or paper recording so previous days schedules can be tracked), and should be controlled by the team leader or leading hand. It is suggested that regular swapping between filleting and stacking occur. Rotations will depend on worker skill levels; e.g. new and inexperienced workers may not cope well with more than one rotation on a heavy timber stacking task before needing to be rotated into a light task area, though a more experienced worker could manage a heavy task, followed by a medium-heavy task.

5.2.8 Timber Handled Statistics

5.2.8.1 Results

For the week of 25 Feb-1 March 2002, 45,257 boards were handled, and the two weeks prior to this saw 40,770 and 39,460 boards pulled and stacked (see Appendix 6). Thus 9051, 8154 and 7892 boards per day, or 1293, 1165 and 1127 boards per worker, with an average of 7 workers pulling and stacking each day.

Taking these figures, Table 5.4 (over) showing estimated outputs (boards pulled and stacked) per worker was developed. It is based on the recorded amount of timber pulled on the two days of the assessment, and the figures from two weeks prior. Whilst a separate record was kept of mill cutting/operating times (usually 6-8 hours per day) no other formal record was made of green table downtime or other production stoppages/reasons.

Table 5.4. Estimate of boards handled per worker at Mill 12

Boards per day	**Boards per hour**	**Seconds per board**	**Boards per minute**
1000	125	28.8	2.3
1100	137.5	26.2	2.3
1200	150	24	2.5
1300	162.5	22.2	2.7
1400	175	20.6	2.9
1500	187.5	19.2	3.1
1600	200	18	3.3

Video analyses allowed some data to be gathered on actual work pace. Thus the work pace of one board in 9.3, 11.5, and 7.6 seconds was observed during a reasonably slow work period, and one board in 7.0, 9.6, and 10.4 seconds during a faster and steadier period when some additional workers were on the chain. Periods of downtime were observed when no boards were stacked for some time, trolleys were moved, and mill hold-ups waited for. Depending on the pace and/or dimensions of timber coming from the mill some workers had more than others to stack. Down time (when the mill was not operating) at times impacted on green table work pace; e.g. should the mill operate for 6 hours (rather than 8 hours) on a day when 1165 boards are pulled per worker, the work pace for stacking would increase from *146 boards per hour* (over 8 hours - 2.4 boards per minute, 25 seconds per board) to *194 boards per hour* (over 6 hours - 3.2 boards per minute, 18.7 seconds per board).

Informal reporting indicated that an average of 60 - 75 packets were pulled per day. 60 packets per day was felt to be a 'quiet' day, 75 packets per day a 'big' day, and more than 75 packets per day a 'really big' day. Timber sizes produced were variable, and this impacted on the number of timber pieces pulled. Large timber is harder and slower to pull and stack, with less produced by the mill.

Timber was cut according to orders received and dependent on the nature of each log (each cut being made to optimise yield). Mill pace also depended on the nature/size of logs and the mechanical efficiency of the mill itself. If the mill was 'running well' few stoppages occurred.

Green table workers handled re-sawn timber twice. It was pulled and stacked into packets before going back into the mill to be sawn to half the thickness, and then pulled and stacked again.

5.2.8.2 Discussion and Conclusions

Green table stoppages and production output Records of mill cutting/operating times were kept, but record was not made of green table operating times and downtime and the reasons for the downtime. Thus the impact of green table down time (including at times a backlog of timber resulting in mill stoppages) was poorly understood despite its likely impact on production efficiency. (See Green Table in 5.2.9.2). The effect of this downtime on the amount of timber handled and frequency/handling rate was also unknown, but could usefully be considered in terms of work pace for green table workers.

Re-saw Timber for re-saw required stacking when it first came from the mill, and was then sent back through re-saw. The re-sawn timber then fell onto the timber coming from the main mill and created frequent 'snarl ups' before being re-stacked. The 'snarl-ups' were time-consuming and somewhat dangerous for workers to sort out, and created green table stoppages. The additional handling of re-sawn timber increased the amount of timber that was pulled each day without an overall production increase. The trolley required for the 'back to re-saw' stack took additional space in the tight work area.

Alternative means of redirecting timber through the re-saw operation would reduce the amount of stacking required. Pulling/dropping timber off onto a conveyor going back to re-saw may be feasible.

5.2.9 Green Chain/Table Assessment

5.2.9.1 Results

No site or table construction plans were available. Data reviewed was therefore limited to photographs and dimensional information gathered at site visits.

Table/Chain design When first viewed in November 2001 the timber stacking area was serviced by one 39.5 m chain table. Prior to the February 2002 onsite visit an additional faster moving 16.5 m chain table was placed ahead of the older chain table. Thus a total table length of 56 m, with the shorter front section moving more quickly than the longer rear section. The older/slower table section visible in Figure 5.7 below, was 3050 mm wide and 905 mm high (to the top of the chains), and the new and faster section was 3680 mm wide and 920 mm high.

Figure 5.7. Older section of table in foreground

The chains of both sections were a link-chain design (Figure 5.8 below), with each link being a total of 70mm in length and 40mm in width, made of 10mm (circular) steel. Four of these chains ran in gutters along the length of each table. The chains ran around a drive shaft that operated for the new section from the front end of the table and in the old section from the far end of the table. The area where the drive shafts and chains came into contact was unguarded. The returning chain ran in a gutter under the upper transporting section of the chain. The lumber sat across the top of the chains and was thus transported along the table.

Figure 5.8. Link-chain table.

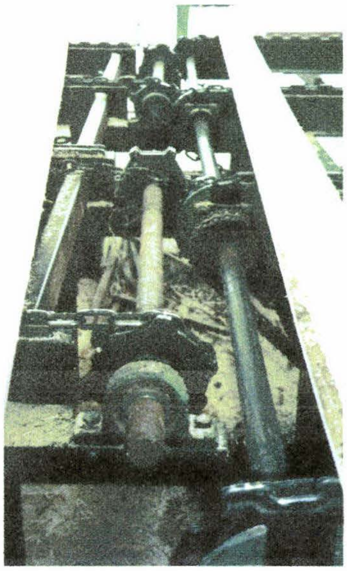

Figure 5.9. Meeting point of the faster (right) and slower (left) tables

During the 2 days of onsite assessment, the longer/slower end section of the table's 3rd chain was not functioning (visible in Figure 5.9). The table was thus operating with only 3 chains. This table was also observed to have a number of breakdowns (at least 4 during the 2 days onsite) that occurred when a chain slipped off the crank, due to chain looseness. The chain was however reportedly not loose enough for 2 links to be removed to re-tighten the chain. On two consecutive occasions this breakdown caused the entire mill to shut down due to the backlog of timber. On one of these occasions the chain motor blew a quantity of smoke, though appeared to keep running effectively once the chain was replaced on the crank.

Figure 5.10. Stacking operations. (Note the use of the fillet stick to stop the chain operating whilst a backlog of boards is cleared).

The chains/tables can be stopped by pulling on a line running along the front edge of the table. One of the lines required a single pull to stop it and to start it, and the other a double pull for stop and start. One of the lines did not run the full length of the table. There was no safety lock-out system to prevent someone from re-starting the chain. The chain once jammed in such a manner that it appeared that it may snap, with a risk of flinging back. The Leading Hand that replaced the chain later voiced fear of being injured by being struck with the chain, as well as concern that he may get his fingers caught in the chain. It was noted that workers at times used a fillet stick (arrowed in Figure 5.10) to hold the stop line tight, apparently in order to hold the table 'stopped', or at least to act as a visible cue that the table was being held 'stopped'.

Chain Maintenance The green chain had a largely informal maintenance system, with repairs and work being carried out on request in addition to a standard weekly check. Workers indicated dissatisfaction with the standard of maintenance on the chain and table, and were fearful of injury when it broke down (such as being struck by chain fling-back or catching body parts when replacing the chain on the crank). They voiced concern that no method had yet been found to address the issue of the chain becoming gradually looser, so that it slipped off the crank with increasing frequency. The maintenance person indicated that he was working on modifications to address this problem.

It was noted that the mill maintenance system was more formal, with only the maintenance person and one other qualified worker able to make machine repairs/adjustments following mill stoppage. This differs from the informal handling of green chain repairs.

Chain Speed The first section of the table ran 8.3 m/s, and the second at 15.9 m/s. Thus the first chain ran at almost twice the speed of the second chain. This acted to clear the timber quickly from the beginning of the chain, reportedly preventing timber backlog when the mill was running efficiently. However a backlog was observed at the point that the faster table met the slower table, despite some timber already being removed from the table onto the first stacks. The chain speed was reportedly unalterable.

Packet/trolley Position The trolleys and the timber packets on the trolleys were placed at varying distances from the table edge. The distance from the table edge to the flat end of the boards in the packet was between 1400mm and 1800mm. Some shorter workers commented that some of the trolleys/packets were too far away. Figure 5.10 shows varied packet-table distance.

Re-sawn timber was pulled/stacked first from the table. Then large timber (250mm widths) was pulled/stacked, to make it easier to pull smaller sizes. Other sizes were then pulled, and the last 3 packs (representing the additional length on the chain) were repetitions of the first 3 pack sizes (allowing missed timber to be pulled, and workload sharing). The most common 'small' timber size produced was 150 x 25mm, and most common 'large' timber size produced was 200 x 40mm.

Packet Sizes/Heights Each completed packet was approximately 2.5m^3 of sawn timber. The packet height was dictated by container size and transport needs. Two rows of fillet sticks (inserted across the packet for stability in transportation) increased the packet height by 50mm.

A chart indicated the number of boards to be stacked in each packet for each dimension of board (Appendix 6). Packet height was calculated from this. Actual packet dimensions were also recorded at onsite visits. Total packet height varied between 505mm and 1050mm, with the most commonly pulled timber (150 x 25mm) at 725mm total height.

Fillet Stick Size The fillet sticks used for filleting/stripping were 36mm wide, 19mm high and 1240mm long when at full length. Only broken fillet sticks were used for the packets being stacked from the table, for economic reasons. Good fillet sticks were reserved for use in kiln drying.

Two sets of fillets were used for each packet stacked from the table, with placement at any level providing they were evenly spaced.

Trolley Design A total of 12 trolleys of various design were observed in use. Trolleys ranged in height from 357mm to 560mm from the ground to the top of the bearers (Figures 5.11 and 5.12). Timber from the table surface, moved with gravity down onto a low trolley, was reportedly easier (preferred) than moving boards onto the top of a tall stack.

Some finished packet heights on the trolleys (from the floor) were measured at 1205mm, 1245mm, (from two of the tallest trolleys) and 1090mm (from a shorter trolley).

Figure 5.11. Tall trolley

Figure 5.12. Short trolley

Trolleys were approximately 3650mm long and 1370mm wide. The trolleys that were easiest to move had wide (50mm) wheels with a rubber rim. These rolled easily and did not damage the concrete surface. Some trolleys with narrow (25mm) wheels without a rubber rim had significant bearing damage. The wheels did not run smoothly on the axle and were crooked and buckled (Figure 5.13). Some trolleys had bent axles. Some damage was reportedly a result of the forklift knocking into the sides of the trolleys when picking up the packets.

The narrow wheels without a rubber rim had caused damage to the concrete surface (Figure 5.14), contributing to difficulty moving the trolleys. On several occasions 3 people were required to push a damaged and fully laden trolley to the position required for the forklift to remove the timber. Workers were observed to brace with one or both of their feet against the table to move the trolley. The forklift was sometimes used to take some packet weight so that the trolley could be moved.

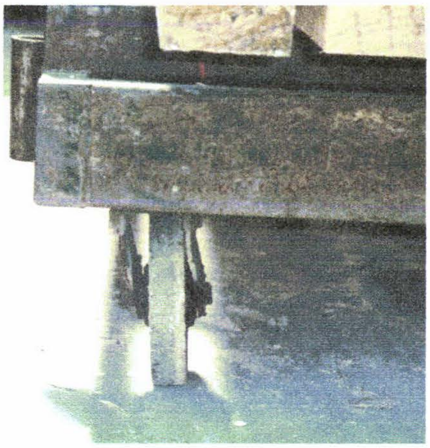

Figure 5.13. Crooked and poorly functioning trolley wheel.

Figure 5.14. Damaged concrete floor.

5.2.9.2 Discussion and Conclusions

Guarding and Safety Stop The unguarded drive shafts that moved the chains were a hazard. Workers had frequent need to replace loose chains onto the drive shafts whilst they were still moving so easy access was considered necessary, though the dangers were appreciated by those doing this task. Of concern also was the apparent potential risk for the chain to jam, break and perhaps fling back. The lack of an emergency stop line running the full length of one of the tables was a concern. A worker may have to move several metres from their station to reach the line to stop the chain.

Also of concern was that the safety stop systems for the two tables had differing control functions. One required a single pull to start and stop, the other a double pull. It was therefore possible that a worker needing to stop the table could make the error of pulling the line twice for a stop, but be on the section of table where this would at first pull, stop, and then on second pull, restart, the table. Lack of a formal safety lock-out system for the tables places workers at risk, with any worker along the length of the table potentially able to restart the chain at any time, despite work that may be being carried out. These risks are greater in an environment that is noisy and where verbal communication is at times limited, and where there are multiple workers - as at this green table.

Table Height Table height is critical for the task of pulling and stacking timber. An ideal table height would cater to both 97.5th percentile males and 2.5th percentile females and take into account footwear height and 200mm of elbow clearance (to allow comfortable timber handling). Using NZ anthropometric data (Slappendel and Wilson, 1992), the range for optimal table height (if adjustable for each worker) is therefore between 785mm and 1045mm, or for a fixed height table, 920mm. (See REBA Findings in 5.2.11.2).

These calculations are based on the following assumptions:

- People choose to grip boards somewhere between elbow and knuckle height, to avoid too much elbow flexion and shoulder elevation, or forward bending.
- The heavy nature of the task means that an appropriate work surface height is 200mm below standing elbow height (static anthropometric data). The lower work surface is related to the dynamic nature of the task - workers often stand with their legs apart so that they can move easily and apply forces effectively, consequently lowering their elbow height.

- NZ Anthropometric Estimates (Slappendel and Wilson, 1992) data is representative of the user population.
- Data from 45-60 year old females was not included as none were present in the worker populations sampled.
- 2.5th percentile female (19-45 year olds) knuckle and elbow heights plus footwear = 705 to 985 mm, which a table height of 920 mm would accommodate.
- 97.5th percentile male (19-45 year olds) knuckle and elbow heights plus footwear = 875 to 1245 mm, which a table height of 920 mm would accommodate.

Table 5.5. Key Anthropometric Data for Table Height Calculations (all mills)

All measurements in mm, 35 mm footwear allowance, rounded down to nearest 5 mm	**Elbow height plus footwear allowance minus 200 mm working clearance below elbow**			**Knuckle and elbow heights plus footwear allowance**	
	5th percentile	**50th percentile**	**95th percentile**	**Knuckle height - elbow height range (5th and 95th percentiles)**	**Mid-distance knuckle-elbow (easy reach)**
19-45 year old males	870	950	1025	805 - 1150	980
45-60 year old males	860	930	1000	795 - 1130	960
19-45 year old females	800	870	940	775 - 1070	920

Data from all mills/populations (both of the North and South Island mills) was used for these calculations to strengthen the findings. Table heights at the mills surveyed were: Mill 43 (dry table), 850 mm; Mill 30 (green/round table), 600-850mm; Mill 17 (dry table), 970mm to top of rail, 890mm to chain surface; Mill 12 (green table), 905mm old section, 920mm new section.

Chain Maintenance The informal maintenance system without any documentation did not allow for review of reasons for downtime or tracking of breakdowns (see Timber Handled Statistics, in 5.2.8.2), created confusion about what was requested and when, and could cause workers to make the assumption that requests were noted when they may not have been. Workers assumed that 'management didn't care' when problems took some time to be rectified, so timely feedback to work teams was indicated. Informal maintenance systems allow the potential for safety issues to be overlooked, as critical 'keep the mill operating' issues may take precedence. From a musculoskeletal injury perspective, poor equipment maintenance can create the need for extra force to move/adjust poorly maintained equipment, high stress as workers must frequently conduct running repairs on faulty equipment, and feelings of frustration and fear that at times dangerous maintenance problems must be constantly faced.

Chain Speed The two separate chain systems moving at differing but unalterable paces (fast for the first section and slower for the end section) created some backlog problems at the junction of the two tables. This was however reportedly a more effective system for timber clearing than operating off a single slower paced chain, as previously.

Packet/Trolley Position from the Table Preferred packet position from the table (distance from the timber end as it rests on the table to the packet end) appeared to be a function of anthropometry (those with smaller stature preferring the stack closer) and timber size/weight (smaller/lighter timber being easier to throw across a larger distance, and heavier/larger timber being easier to stack when it is close).

Data from both the North and South Island mills was considered to strengthen the findings. Timber end on table, to packet end distances were: Mill 43, 1100 – 1400mm; Mill 30, 1600 – 3300mm; Mill 17, 900 – 1250mm; Mill 12, 1400 – 1800mm.

Male and female arm span data was selected as the basis for calculating an optimum distance between the timber on the table and the packet end. The distance should enable the transfer to occur without excessive lateral spinal movement or twisting, stepping, or hitting the timber end or packet. The optimal distance between the timber end on the table and the packet is suggested to be between 1100mm and 1400mm. This distance will be affected (both positively and negatively with regard to manual handling risks) by:

- How far the timber must be transferred up or down the table to the appropriate packet.
- Length of the timber (longer lengths may need more room to gather sufficient momentum, shorter lengths may need less room so that the timber is not totally supported by the worker).
- Speed of the table (less space between the table and packet reduces task cycle time).
- Amount of traffic in the transfer area (extra space required for tasks other than timber pulling).
- Height of the packet(s) in relation to the table (may need more space if the transfer is onto a packet higher than the table)
- How many packets there are.

Packet Spacing Adequate workspace should be provided at each packet for timber to be safely and easily handled, without workers feeling cramped or restricted in timber handling methods. For packets where two workers consistently work together, the lateral spacing should be increased. Packet width plus 1020mm (elbow span for 95^{th} percentile NZ male) is considered the minimum for packet/trolley spacing. Therefore a packet with a width of 1200mm would require an overall lateral workspace requirement of 2220mm for each single worker workstation, and 3240mm for a dual worker workstation. The overall chain length should therefore allow this spacing for each trolley.

Board Overhang The distance by which boards overhung the table edge also impacted on manual handling technique (see REBA Findings in 5.2.11.2). Having more timber over the table edge should allow:

- Workers to position themselves closer to the load, with feet further under the board and less bending.
- Workers to position themselves for less spinal rotation by starting behind or in front of the board rather than beside the board
- Reduction of inertia and the overall board weight to be pulled, as a greater amount of the timber's weight is already past the fulcrum on which it is balanced (i.e. the table edge), creating better board control and decreased effort.
- Reduction of the force required to tip the board downwards (where this is done to gather board speed quickly as it is transferred).

Data from all mills was used to strengthen the findings. Timber overhang at the mills surveyed was: Mill 43, 760mm; Mill 30, 100mm back from table edge to 300mm over table edge; Mill 17, 35mm; Mill 12, 200-400mm. The optimum amount of overhang will vary with table design, other functions (docking, grading etc) occurring at the table and where timber is being transferred too. It is suggested that timber should overhang the table edge by 750mm to 1000mm.

Packet Size/Height Finished packet heights (from the floor) on varying height trolleys were measured at between 1245mm and 1090mm. The transfer of common and large dimension timber (from the table to the packet) should not require timber to be moved to a height significantly greater than that of the table (table heights 905mm and 920mm). Transfer of timber up onto the packet requires work against gravity and requires greater effort and a greater risk of injury as a result. (See REBA Findings in 5.2.11.2).

The packet height is a function of the trolley height, the total packet height (including fillet sticks), and the floor height of the trolley area. Achieving the same height as the table may require modification to any or all of these elements. The largest proportion of timber handling should occur between elbow and knuckle heights. Additional force to lift the timber against gravity should be avoided.

Trolley Design It was noted that it might be possible to reduce the height of some of the tallest trolleys by modifying the wheel mounting. This would make the total packet height lower and therefore be easier for timber transfer. (See REBA Findings in 5.2.11.2).

The weight of a packet of green timber was reported as between 2.5 and 2.8 tonnes. Therefore the trolley should be built to carry this weight with ease. The wheels should have enough tolerance of lateral forces so if a forklift did make contact, that wheel/bearing damage would not occur. Wheels with a firm rubber (or similar) rim would reduce the wear and tear on the concrete, keeping the physical task of moving the trolleys in and out as easy as possible for the future (see Floor Surface in 5.2.5.2). It is noted that a lower trolley would also be likely to reduce the risk of damage from lateral forces, as the effect of the weight of timber would be smaller. Trolleys should be well maintained to ensure they remain functional and safe to use.

To reduce the difficulty getting the first pieces of timber in place on the trolley bearers, an angled 'landing pad' built into the trolley to bounce timber along may assist. This would be a plate of 300-400mm length and of bearer width, placed immediately in front of the bearer, inclined upwards to finish flush with the bearer. This would make throwing the first boards in the stack easier by allowing less accuracy - the thrown board can bounce and slide, or be pushed up onto the bearer even if it lands short of it (see 'REBA' in 5.2.11.2).

Fillet Stick Storage Fillet sticks were stored under the front edge of the table and were obtained by bending and reaching under the chain. Whilst broken sticks were used for filleting, the collection of sticks under the table was haphazard and spread some distance including out into the walkway, and included small/unusable fillet sticks, other garbage and sawdust build-up. (See Floor Surface in 5.2.5.2).

Fillet stick storage within easier reach of workers was indicated. A shelf or rack under the table may be suitable. This would: reduce the time taken for obtaining fillets; make it physically safer and easier to reach them; make it easier to clean under the chain area; and keep the walkway clear of obstruction. Fillet sticks that are too small or damaged to use should be disposed of.

5.2.10 Force Measure

5.2.10.1 Results

The most frequently handled board size was 150 x 25 x 4000mm, and the most handled large board was 200 x 40 x 4000mm. 8 boards of each size were selected from timber on the table, and the force required to initiate the movement of each board in a horizontal direction from the chain was measured, as per the protocol outlined in Section 4.2.10.

The sites selected for measuring the timber to be pulled off were:

Position 1 Near the start of the first section (fastest chain), at a point where the bulk of the timber was pulled from the table.

Position 2 Near the end of this first and fastest section of chain, where a large proportion of timber is removed from the table.

Position 3 At the midpoint of the second and slowest chain, where a relatively small amount of timber is pulled from the table.

The force required to initiate horizontal movement from the chain of the most commonly pulled timber size (150 x 25 x 4000mm) averaged 7.4kg. The force required to initiate horizontal movement of the most commonly pulled larger timber dimension (200 x 40 x 4000mm) averaged 14.6kg (Appendix 6). These figures represent the horizontal 'break-out' force (initial force) for timber from a stationery chain or table only and additional forces pertaining to lifting and carrying, timber direction and control, and actions to keep timber moving also occurred.

Data from both South Island and North Island mills was considered together (Table 5.10) to understand the impact of different chain types.

Table 5.6. Force Measure Comparison All Mills

Mill Number	Timber Dimensions	Table Type	Green/Dry	Mean Break-out Force (Kilograms)
Mill 43	90 x 45mm x 4.8m	Roller chain	Dry	1.00
	240 x 45mm x 6.0m	Roller chain	Dry	3.44
Mill 17	125 x 40mm x 3.6	Flat chain with cleats	Dry	4.88
	300 x 50mm x 3.0 - 3.6m	Flat chain with cleats	Dry	11.60
Mill 30	150 x 50mm x 3.8 - 6.0m	Round table with timber base	Wet (anti-sapstain)	17.62
	100 x 75mm x 5.4 - 5.8m	Round table with timber base	Wet (anti-sapstain)	24.27
	200 x 25mm x 4.8m	Round table with timber base	Wet (anti-sapstain)	20.63
	Various other dimensions	Round table with timber base	Wet (anti-sapstain)	10.92 - 27.88
Mill 12	150 x 25mm x 4.0m	Chain link	Wet	7.38
	300 x 50mm x 3.0 - 3.6m	Chain link	Wet	14.61

5.2.10.2 Discussion and Conclusions

The mean break out forces for all chains measured was lowest with a roller chain. Whilst timber dimensions/lengths and green/dry nature must also be taken into account, the solid timber round table required the greatest forces, and other flat chain or chain link tables required more force than the roller chain, but less than the wooden round table. The use of a (well-maintained) roller chain system for timber stacking will therefore offer the least resistance and hence a lower manual handling risk.

Further to use of a roller chain, inclining the table bed (angling it slightly downwards towards the workers) will reduce the amount of inertia to be overcome before the timber begins to move. This reduction in the energy necessary to gain momentum with each board will further reduce manual handling risks. There will be an ideal angle (range) where the inertia is substantially reduced, but boards remain stationary until the pulling force is applied. Ascertaining the degree of incline/tilt will require trial.

5.2.11 REBA

5.2.11.1 Results

An experienced male worker, above 50th percentile for height measures (per NZ Anthropometric Estimates 1992, Slappendel and Wilson) and an inexperienced below 50th percentile male worker were selected for the assessment. Unless otherwise stated, the lumber being handled for all REBA analyses was the most commonly pulled dimension, 25 x 150 x 4000mm (Appendix 6).

Notes regarding scoring:

- Load/force score was rated as 0 if no weight was lifted/carried at that point of movement. For tasks suspected to be low force (pulling from chain etc) a 1 was given, but the same task for larger boards or for boards being moved with some additional lifting, was scored 2.
- A coupling score of 1, 'Fair' was given for all holding tasks as gloves reduce grasp strength and the boards do not have a fixed handle or easily grasped shape.

- It was difficult to accurately assess hand/wrist position in some instances from video, due to gloves obscuring the hand and poor video definition/position.
- Activity scores of 1 were usually given to denote the frequency of the action, though in some instances to denote the rapid posture change or unstable base.
- REBA scoring is as per the table below.

REBA Score	Risk Level	Action Level
1	Negligible	None necessary
2-3	Low	May be necessary
4-7	Medium	Necessary
8-10	High	Necessary soon
11-15	Very High	Necessary NOW

Table 5.7. REBA scoring system.

The *very high* scores were for tasks including:

- Pushing a full trolley out
- Throwing a board out onto the first layer of a packet

The *high* scores were for tasks including:

- Pulling a board from the table when positioned too far away, as in Figure 5.15 (not using feet to move closer)
- Picking up fillet sticks from under chain
- Pulling and lifting boards onto tops of packets
- Placing/aligning boards on first/lower layers of packets

Figure 5.15. Pulling a board from too far away. (Note flexed and laterally rotated spine, and degree of right shoulder flexion)

5.2.11.2 Discussion and Conclusions

The forces involved with timber stacking are complex. They include friction from the table/chain surface, friction from the varied board surfaces (rough/smooth etc), and varying timber weights and timber dimensions. Boards must be propelled off the moving table, and placed accurately in a stack. Force is required at times to lift/carry the board into position, and at other times to direct the board (lateral force). Force is also required to slow the movement of the timber. Overall timber weight is not the only factor as boards are usually slid off the table and/or along the timber already on the packet.

A range of training and design factors are indicated from consideration of REBA data. They include the following (some information from D. Tappin, personal communication):

- Ensure that workers stay close to the timber being pulled, avoid trunk bend and arm reach to the boards (mid-range movements are strongest). (See Training in 5.2.1.2 and 5.2.2.2).
- Use weight of board to assist the movement of the board down onto the packet. (See Training in 5.2.1.2 and 5.2.2.2).

- Use leather aprons for effective handling of timber onto lower packet layers particularly. (See Training in 5.2.1.2 and 5.2.2.2, and Leather Aprons in 5.2.6.2).
- Design trolleys so that timber is always lower than the top of the table height (see Table Height, Packet Size/Height and Trolley Design in 5.2.9.2).
- Design trolleys so that a solid 'landing pad' allows the first board layers to be bounced out to the correct position on the trolley, rather than needing to be thrown out the full distance over the last bearer. (See Trolley Design in 5.2.9.2).
- Ensure trolleys are repaired for ease in moving them. (See Trolley Design in 5.2.9.2).
- Have boards protrude further from the table edge to allow greater ease in getting alongside them and therefore handling ease and a range of movement options. (See Board Overhang in 5.2.9.2).
- Have fillet sticks in an easily reached position.

5.2.12 Borg Rating of Perceived Exertion Scale

5.2.12.1 Results

The Borg RPE Scale was completed (as per the protocol in 4.2.12.), with results as Tables 5.8 and 5.9 over.

Table 5.8. Borg RPE Record first session of day, 28.02.02

Notes regarding activity				Chain started 10 minutes late, 7.40	Chain stopped, stripping for 10-15 minutes	Back from stripping for 5 minutes	Steady work	Chain stopped again	Glut of timber	Steady work	
Worker Number	**Experienced/ Inexperienced**	**Worker Position**	**Timber size handled**	**7.50 am**	**8.10 am**	**8.30 am**	**8.50 am**	**9.10 am**	**9.30 am**	**9.50 am**	**Mean**
1	Exp.	P2	150x25	11	7	absent	absent	absent	absent	11	9.67
2	Inexp.	P1	150x25	14	7	11	11	6	11	(P4) 12	10.29
6	Inexp.	P5	varied	11	7	11	12	13	210x20 15	14	11.86
7	Inexp.	Pusher	all	11	7	11	11	11	210x20 13	11	10.71
13	Not known	P4	250x40	11	13	11	11	11	11	11	11.29
14	Not known	P3	210x40	11	stripping 11	13	13	absent	250x40 15	helper present 13	12.67
15	Not known	P6	250x40	11	17	12	no boards, stopped	11	13	13	12.83

Table 5.9. Borg RPE Record last session of day, 28.02.02

Notes regarding activity				Steady work	Steady work	Steady work	Steady work	Steady work	
Worker Number	**Experienced/ Inexperienced**	**Worker Position**	**Timber size handled**	**3.15 pm**	**3.35 pm**	**3.55 pm**	**4.15 pm**	**4.30 pm**	**Mean**
1	Exp.	P3	varied	12	10	9	9	9	9.80
2	Inexp.	P4	varied	11	10	12	10	stopped	10.75
4	Inexp.	P1	varied	9	14	12	12	12	11.80
6	Inexp.	P6	varied	13	11	13	13	15	13.00
7	Inexp.	Pusher	all	11	11	11	13	13	11.80
13	Not known	P5	varied	11	15	13	13	13	13.00
14	Not known	P2	varied	13	13	13	13	13	13.00
15	Not known	P7	varied	stopped	13	17	16	13	11.80

5.2.12.2 Discussion and Conclusions

The experienced worker (more than 5 years in this type of work) appeared to perceive slightly lower levels of exertion than those workers known to be less experienced (less than 1 year in this type of work). Workers reported a mean greater perceived exertion (13.56, 'somewhat hard') at the end of the day than at the beginning (11.33, 'fairly light'). These findings reinforce the conclusions already made about training needs (see Training in 5.2.1.2 and 5.2.2.2), work rotations (see Rotations in 5.2.7.2), and nutrition (see Nutrition in 5.2.2.2), and reinforce all endeavours to reduce the manual handling risk factors such that the work tasks are as sustainable as possible for all workers.

5.2.13 Discomfort Rating Scale

5.2.13.1 Results

The Discomfort Rating Scale was completed (as per the protocol given in 4.2.13), with results as in Tables 5.10 and 5.11.

Table 5.10. Discomfort Rating Scale Record first session of day, 28.02.02

Notes regarding activity			Chain started 10 minutes late, 7.40	**Steady work**	**Chain stopped, stripping for 10-15 minutes**	**Steady work**	**Chain stopped 9.10-9.20**	**Steady work**	**Glut of timber coming through 9 people on chain**	**Glut continues**	
Worker Number	**Worker Position**	**Timber size handled**	**7.40 am**	**8.00 am**	**8.20 am**	**8.40 am**	**9.00 am**	**9.20 am**	**9.40 am**	**10.00 am**	**Mean**
1	P2	150x25	3 all body	2 all body	Stripping	absent	absent	absent	1 all body	1 all body	2 all body
2	P1	150x25	2 all body	2 all body	Stripping	2 all body	2 all body	2 all body	2 all body	4 hand (fingers jammed), 2 other body	4 hand, 2 other body
6	P5	varied	4 neck, 2 other body	4 neck, 2 other body	Stripping	4 neck, 3 other body	4 neck, 3 hands, 2 other body	3 all body	3 all body	4 neck, 3 other body	4 neck, 3 hands, 2.57 body,
7	Pusher	all	2 all body	2 all body	Stripping	2 all body	2 all body	2 all body	3 all body	2 all body	2.14 all body
13	P4	250x40	2 all body	2 all body	Stripping	1 all body	1 all body	2 all body	2 all body	2 all body	1.71 all body
14	P3	210x40	2 all body	3 back, 2 other body	Stripping	3 back, 2 other body	3 all body	3 all body	3 all body	3 all body	3 back, 2.57 all body
15	P6	250x40	5 left arm, 1 other body	5 left arm, 1 other body	Stripping	5 left arm, 1 other body	5 left arm, 1 other body	4 left arm, 1 other body	4 left arm, 1 other body	4 left arm, 1 other body	4.57 left arm, 1other body

Key: 'all body' refers to all 9 body areas, and 'other body' refers to all the body areas not already described for that time period.

Table 5.11. Discomfort Rating Scale Record last session of day, 28.02.02

Notes regarding activity			Steady work	Steady work	Steady work	Steady work	
Worker Number	**Worker Position**	**Timber size handled**	**3.25 pm**	**3.45 pm**	**4.05 pm**	**4.25 pm**	**Mean**
1	P3	varied	2 all body	2 all body	3 knee, 1 other body	1 all body	3 knee, 1.5 other body
2	P4	varied	3 left shoulder, 2 other body	2 all body	2 all body	2 all body	3 left shoulder, 2 other body
4	P1	varied	4 wrists, 2 other body	4 wrists, 2 other body	4 wrists, 2 other body	4 wrists, 2 other body	4 wrists, 2 other body
6	P6	varied	4 neck, 3 other body	4 neck, 3 other body	5 neck, 3 other body	5 neck, 3 other body	4.5 neck, 3 other body
7	Pusher	varied	3 all body	3 all body	3 all body	3 all body	3 all body
13	P5	varied	2 all body	2 all body	2 all body	2 all body	2 all body
14	P2	varied	3 all body	3 all body	3 all body	4 back, 3 other body	4 back, 3 other body
15	P7	varied	4 left arm, 3 other body	4 left arm, 3 other body	4 left arm, 3 other body	4 left arm, 3 other body	4 left arm, 3 other body

Key: 'all body' refers to all 9 body areas, and 'other body' refers to all the body areas not already described for that time period.

5.2.13.2 Discussion and Conclusions

Two of seven workers (29%) reported feeling uncomfortable/very uncomfortable (scores of 4 and 5) in the first work period of the day, and four of eight workers (50%) reported feeling uncomfortable/very uncomfortable in the last work period. Thus discomfort levels increased during the work day, suggesting that the work tasks were physically demanding. That two workers commenced the work day feeling uncomfortable was also of concern. Current NZ injury management literature on the subject of occupational overuse syndrome prevention (ACC 1997) suggests that the experience of discomfort early in the work shift and persisting after the end of the shift may be an indicator of increasingly severe and chronic musculoskeletal problems. Muscle fatigue that does not recover overnight is classified as having gone beyond the 'early warning' phase and can develop into a MSD.

The Discomfort Rating Scale findings, though from a small sample group, reinforce the need to investigate manual handling risk factor reduction.

5.2.14 NMQ

5.2.14.1 Results

Results of the abbreviated Nordic Musculoskeletal Questionnaire are shown in Figure 5.16. Table 5.12 (over) shows the data aggregated per body part and the number of reports of discomfort in the last 12 months given as a percentage.

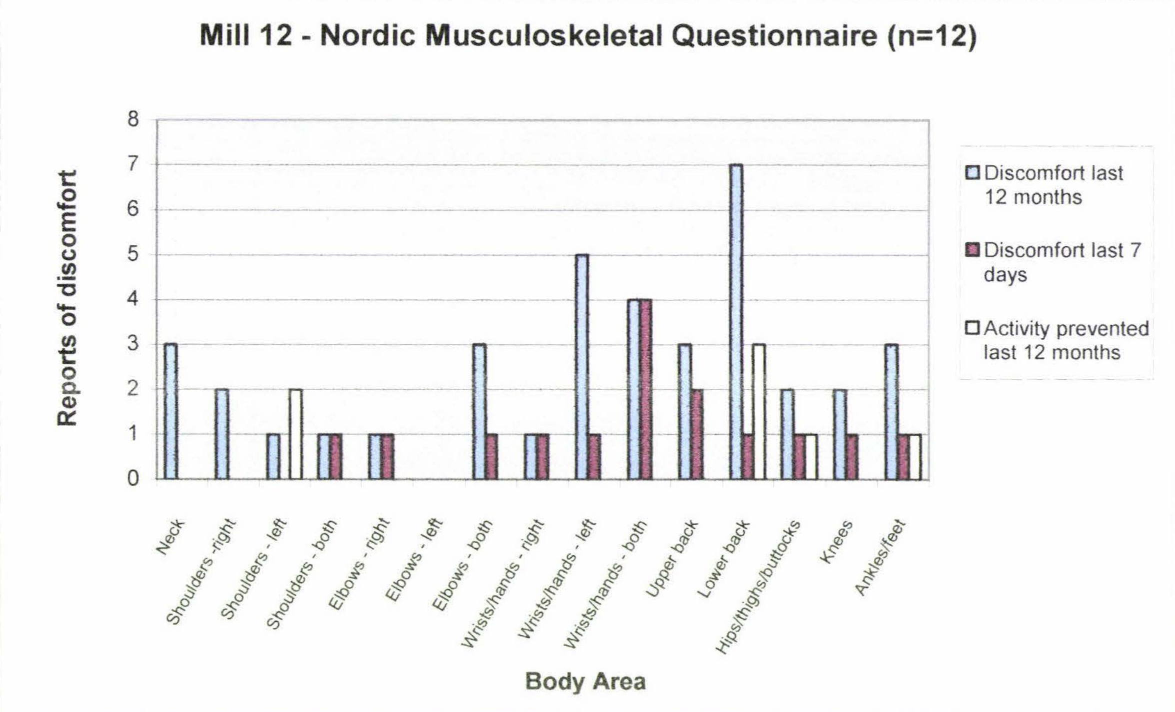

Figure 5.16. NMQ Results Mill 12

In the 12 months prior to assessment, one/both wrist discomfort was reported by 83% of green chain workers and lower back discomfort by 58%. In the 7 days prior to assessment, one/both wrist discomfort was reported by half of green chain workers. In the 12 months prior to assessment, one quarter of workers reported lower back discomfort that prevented participation in normal activities.

Table 5.12 NMQ discomfort reports last 12 months - results as a total and percentage for each body area

Body Area	Total for body area	Discomfort last 12 months
Neck	25%	25%
Shoulders -right Shoulders - left Shoulders - both	 33%	17% 8% 8%
Elbows - right Elbows - left Elbows - both	 33%	8% 25%
Wrists/hands - right Wrists/hands - left Wrists/hands - both	 83%	8% 42% 33%
Upper back	25%	25%
Lower back	58%	58%
Hips/thighs/buttocks	17%	17%
Knees	17%	17%
Ankles/feet	25%	25%

5.2.14.2 Discussion and Conclusions

Musculoskeletal discomfort (particularly wrist and lower back) with some resultant limitation of capacity to complete normal daily activities was common among this group of green chain workers. This finding reinforced the need to investigate manual handling risk factor reduction.

5.2.15 Manual Handling Risk Score

5.2.15.1 Results

The Manual Handling Risk Score (ACC/OSH 2001) was completed for the timber pulling/stacking task (Appendix 6). Load Scores of 2, 4 and 10 were estimated for a range of timber sizes. When these Load Scores were combined with Posture, Work Conditions and Environment, and Time Scores they resulted in total Manual Handling Risk Scores of 56, 72 and 120 for the pulling/stacking task. All these scores are in the *'50+'* category, with score grading as *'injuries are likely regardless of the strength and fitness of employees. Elimination of the task or workplace redesign is a priority'.*

5.2.15.2 Discussion and Conclusions

Manual Handling Risk Scores indicated that pulling timber at this mill was a task in which *'injuries are likely regardless of the strength and fitness of employees'*, and further verified the need to consider MSD risk factors and manual handling risk factor reduction.

5.3 Intervention Recommendations

A list of intervention recommendations for Mill 12 was developed based on the assessment findings and with consideration of other findings from all mills in the study (two North island and two South Island). The recommendations were prioritised according to their perceived impact on reducing the incidence and severity of musculoskeletal disorders for timber handling at this green table. The intervention recommendations were provided in a package of information to the mill. The three documents provided were:

- Summary of Assessment Findings (Appendix 7)
- Recommendations for Reduction of Manual Handling Risks (Appendix 7)
- Prioritised Recommendations (summary)

A number of recommendations relating to the configuration of the timber transfer workspace (table, trolleys, packet placement, fillet stick storage etc) were developed to address the various means of reducing the forces involved when handling and transferring timber. The recommendations were suggested starting points for further refinement through trials, and required operational verification before the actual heights and ranges could be determined as suitable. Following this were recommendations for addressing redundant timber handling, gloves, task rotations, training, maintenance issues, workplace cleanliness, lighting and noise.

The recommendations were intended to provide a basis for further discussion, trials and decision-making relevant to the mill, with researcher assistance as required. It was hoped that the mill would then adopt and complete a number of the suggested actions, such that the effectiveness of the interventions in reducing musculoskeletal risk factors could later be evaluated. This ongoing work with the mill, including specific re-assessment was outside of the scope of this Master's thesis project. (Brief notes on intervention application and other outcomes from the larger COHFE project are provided in Appendix 10).

Recommendation 1 Table height to top of chains/rollers should be 920mm, if a fixed height table. A table adjustable in height for each worker would however be ideal. The range could be between 785 and 1045mm (based on 2.5th percentile female and 97.5th percentile male elbow heights (plus footwear allowance and minus 200mm elbow clearance).

Recommendation 2 Incline the table bed. (The degree of tilt would require trial).

Recommendation 3 Timber should overhang the table edge by 750 - 1000mm.

Recommendation 4 That tables are designed to minimise the horizontal pull force to move timber from table to packet. This appears to be reduced most significantly by the use of a roller chain system.

Recommendation 5 The distance between the end of the timber as it rests on the table to the end of the packet should be 1100 - 1400mm.

Recommendation 6 The overall height of the second to last layer of timber in the packet (therefore the height to which the last layer is lifted to) should be 920mm – the same as the recommended table height.

Recommendation 7 Lower the trolley height to allow the total packet height (to top of second to last layer) to be equal to or less than the table height.

Recommendation 8 Decrease the overall height of the timber packets (make them wider and shorter), to decrease the height stacked too.

Recommendation 9 Use a 'landing pad' on the trolleys/bearers to bounce the timber along to reduce the effort required for positioning the first layer of timber.

Recommendation 10 That the packet width plus 1020mm (elbow span for 95th percentile male) is considered the minimum for packet/trolley spacing. For a packet width of 1200mm, the overall lateral workspace requirement would therefore be 2220mm for each single-worker workstation.

Recommendation 11 That for packets where two workers consistently work together, that the overall lateral workspace requirement is packet width plus 2 x 1020 (elbow span for 95th percentile male). Thus for a packet of 1200mm, the overall lateral workspace requirement will be 3240mm, for a dual worker workstation. The overall chain length should therefore allow this spacing for each trolley.

Recommendation 12 That trolleys are built with structural stability and strength adequate for their purpose.

Recommendation 13 That fillet sticks are stored within easy reach, and in such a way that it is easy to clean around them.

Recommendation 14 Alter the system for handling re-sawn timber.

Recommendation 15 That gloves are provided that have good fit and protection suitable for all workers.

Recommendation 16 That the rotational system is formalised and consistently adhered to, with at least 4 rotations through varied work tasks per day.

Recommendation 17 That key safe work methods for pulling and stacking timber are covered at induction followed by buddy training with an experienced operator. The key work method/training points should be added to and altered following trial.

Recommendation 18 The maintenance system should allow all necessary repairs to be identified, communicated and tracked, so that all repairs and maintenance requests are systematically and effectively dealt with. Specifically, repairs to the chains should occur so that they are all functioning effectively and the tensioning issues are addressed.

Recommendation 19 Remove the bolts protruding from the floor at the rear of the chain.

Recommendation 20 Review chain stoppage/lockout systems and communication issues.

Recommendation 21 That the work area at the chain is swept and tidied regularly.

Recommendation 22 That the results of the June 1991 noise assessment are accurately followed.

Recommendation 23 That lighting levels at the greenchain are increased.

Chapter 6 Case Study – Mill 17

6.1 Introduction

Mill 17 was in the Canterbury/Westland region of the South Island of NZ. The mill was categorised as 'large', producing around 26,000m^3 of sawn lumber per annum and employing around 90 persons. The mill produced largely pinus radiata lumber, with a small percentage of native lumber (of note as native timbers are generally heavier, posing additional manual handling risk). Further detail about the mill and production data is withheld in the interests of privacy.

The work area investigated for this study was the dry table where sorting, grading and stacking of recently kiln-dried timber occurred. Timber arrived at the dry table in filleted stacks (filleting allows the kiln drying process to occur effectively), via gantry crane/automated rollers and was unloaded via automated plant onto the table. A total of 9 workers in the immediate vicinity of the dry table then processed the timber. Rotated tasks included placing timber onto the moving table from the unloader, grading and docking, tallying, stacking, wrapping and strapping of packets, managing fillet sticks and coordinating with the crane operator and dispatch/other staff.

Mill personnel had voiced strong commitment to safe work practices in initial contact with the researchers. Management and workers were enthusiastic for involvement in a study with immediate relevance to their own work functioning and a contribution to industry practices.

6.2 Assessment Results, Discussion and Conclusions

6.2.1 Archival Data

6.2.1.1 Results

Health and Safety Management System New employees were taken through a sheet of identified hazards in the work area. This included:

- Dry store (crane, walking between packs, tripping on in/out-feed rollers, hard hat wear).
- Tally box (stairs).
- Pit (out-feed rollers, stacker controls).
- Trolley stackers/table workers (walking in front of trolleys, pushing trolleys out, clearing rails/floor, bar on side of table, on/off switches).
- Grader (docking, skill saw use, on/off switches, roller use).
- Unloader (walking behind, sticks flying, fingers jamming in rollers, unloader controls, steps nearby).
- Sticks area (belts, operations of controls).
- And procedures relating to cutout switches, hold cards, and job standards.

The health and safety manual listed additional hazards and safety issues including strapping, muster areas, first aid, fire extinguishers, knife use, steel capped boots and the smoking policy.

An accident/incident report form was used detailing injury type/property damage, description of incident, potential for injury/damage, and means of controlling the problem.

Accident Register Review Accident register records showed injuries related to uneven flooring (trolley rails), with a recent severe injury. At the unloader, fillet sticks became airborne causing injury, and the unloader rollers move boards towards the operator, causing finger-jamming injuries. Also reported was one incidence of overuse-type strain to the hand (grader) from constantly turning boards over, and back problems from twisting/bending over to pick up fillets and other actions.

Training There was no formalised work method training for timber handling. Training was within the team via the team leader or second in charge, and experienced workers assisting new workers. It was noted that training in manual handling (lifting only) had been provided with many workers able to quote the advice given.

Pay System A system of four or five pay steps existed, with progression based on performance and enthusiasm etc. Additional task roles such as quality or health and safety representative were recognised.

Workplace culture A strong focus on health and safety and good housekeeping was evident. Procedures were in place to monitor performance and outputs, and documentation was reviewed to develop best practices, enhance outputs, and reduce injury risks, with these functions occurring within organised work teams.

6.2.1.2 Discussion and Conclusions

Health and Safety Management System Little mention of manual handling risks was made in the hazard identification for the dry chain area. This addition would however strengthen the usefulness of the hazard identification process and identify a wider range of controls. (See 'Workplace Culture' below, 'Training' in 6.2.2.2 and 'Table Speed' in 6.2.9.2). Resources such as the ACC Worksmart Back Plan and related documents including the Manual Handling Hazard Control Record may assist with this process.

Accident Register Review Accident register records showed problems related to uneven flooring from trolley rails (see 'Floor Surface' in 6.2.5.2). Contradictory information was given to employees as it was suggested that to avoid getting hit by timber the walkway by the table should be avoided. However the alternative walkway at the rear of the trolleys is uneven and difficult to walk over due to the trolley rails. The trolley rail problem was highlighted by a recent severe injury occurring in the area.

Records showed that fillet sticks becoming airborne at the unloader caused injury (see 'Unloader Design' in 6.2.9.2) but it appeared that little was done to effectively address this problem. The grill that had been in place overhead to stop flying sticks had recently been removed without further evidence of action to address the issue.

Records also showed that finger-jamming injuries were common at the unloader (see 'Unloader Design' in 6.2.9.2), as the rollers moved boards rapidly towards the operator. Operators carried out fast and forceful actions at this workstation (see 'REBA' in 6.2.11.2) and benefit (especially when becoming fatigued) from the stability offered by supporting themselves on the edge of the work surface. Records showed some MSD injuries including overuse strains to the hand, and back problems.

Training No standardised training programme covering key safe work methods for new employees was in place. 'Experienced' workers trained new employees, but without prior identification of the safest timber handling techniques and with the risk that bad timber handling habits were passed on. Given the number of aging workers with old injuries in this work team (see 'NMQ' in 6.2.14.2), some unusual work styles and movement methods were observed that might cause new workers to develop non-optimal techniques. Some interest was shown in the development and use of a video for training purposes. Key work methods (such as those identified in 5.2.1.2) should be determined. If a video was developed, task techniques shown should include varied timber handling: for different timber sizes; to suit different builds; to rest muscle groups; using leather aprons (see 'Aprons' in 6.2.6.2), and to carry out specific actions such as bouncing boards over fillets and replacing boards that fall off the packet. Incorrect techniques could be highlighted with an explanation as to why they are undesirable. Emphasis should be placed on the fact that the timber transfer task is sustainable with good technique, comfortable work pace (see 'Table Speed' in 6.2.9.2), regular rotations and good workspace layout. However, occasional events such as boards falling off, dragging boards back, sustained rapid work pace etc, can be hazardous and may be overlooked. A video should recognise individual differences in acceptable work technique, and this should be included in the training. This could include: applying high force at the start and then guiding the board only, getting the board going and then applying force as they guide it, getting the board going and tipping it to get momentum, or using backhand techniques to reduce MSD risk exposure. Training in key methods should be covered at induction and followed by ongoing 'buddy training' at the workface with an experienced and skilful operator.

Workplace culture Whilst this workplace had a strong focus on health and safety, some lack of analysis of injury causative factors, especially the overlooking of manual handling risk factors (see 'Health and Safety Management System' above) was in evidence. Formal documentation of manual handling risk factors and the identification of appropriate controls would aid in their prevention and management, and meet the requirements of the HSE Act.

6.2.2 *Worker Semi-structured Interviews*

6.2.2.1 Results

The data gained from worker interviews is summarised below (see Appendix 8 for full results).

Nutrition Most workers reported having a substantial breakfast, balanced meals during the work day and evening, and additional fluid intake during the day to counter the fluid loss related to the physical workload.

PPE (also see 6.2.6) Some workers used a light weight plastic apron for clothing protection whilst handling timber. Workers used one of the knit fabric glove types available, with selection based on fit, comfort and protection. Hearing protection was worn by some workers to protect reduced hearing, or for general auditory comfort. One worker found all earmuffs to be uncomfortable so he limited earmuff wear time. Hard hats and safety glasses were worn by all workers at the workstations where this was a requirement. Steel capped boots were worn as standard.

Hardest/easiest work tasks The hardest work was reported to be unloading as this worker handled all timber. The task was particularly hard when handling large timber sizes and/or the table speed was fast. Other 'hard' tasks were: the grading task with high cognitive demand - particularly when the table was going fast; when all workers when pressured for output and speed of work; and stackers when having to move timber up/down length of table.

The easiest work was reported to be when work was constant (no stop/start); working on pit stacker and working in the fillet sticks area.

Training Key factors for ease in timber handling and learning the necessary work skills were reportedly:

- Get the timber onto the bar and use bar as a fulcrum.
- Slide the timber on the rail/stack, don't lift/carry.
- Get a 'guide board' in place on the side of the stack, then slide other boards alongside.
- Keep stack close to table.
- Use the weight of the board - push it down so it slides off by itself.
- Learn to manage the 'bounce' of the timber to control it.
- Develop your own pattern and rhythm, and left/right/both sides work preferences.
- Walk behind the timber.
- 'Throw' the boards onto the stack.
- Use your whole body, not just your arms/back.

Rest Breaks Most workers found that the two 30 minute breaks were adequate. These reportedly allowed good rest and adequate time to eat food, but were not so long that it was difficult to 'get started' again. Rotations of 1.5 hours were reported as suitable, particularly when allocated a physically or mentally demanding job.

Improvements Worker suggested improvements were:

- An extra step all the way along the walkway near trolleys to make it easier to step on and off the platform.
- Reduce the height of the rails over the floor, consider walkway across.
- Trolley wheels with easy-push design.
- Consider scissor hoists on trolleys.
- Have an automated unloader system or modify the unloader so that fillet sticks do not catch and timber handling is unnecessary.
- Place rollers on rail edge.

- Have a mechanical block on the pit-stacker to move the front edge of the narrower export packs closer to the table end.
- Move tally board further away so have more trolley space for stacking .
- Maintenance of squeaky chain.
- Keep chain speed steady and 'reasonable'.
- Modify cleats so boards don't catch when taking them off chain.

6.2.2.2 Discussion and Conclusions

PPE Wearing of PPE was consistent for gloves (see 'Gloves' in 6.2.6.2), steel-capped boots, hard hats (where required) and safety glasses (where required). Some workers wore light-weight plastic aprons (see 'Aprons' in 6.2.6.2) for clothing protection, and some workers wore hearing protection (see 'Hearing Protection' in 6.2.6.2) though this was not a requirement.

Hardest/Easiest Work Tasks Workers felt the unloading task was the hardest physical task (see 'REBA' in 6.2.11.2, 'Worker Scheduling' in 6.2.7.2, and 'Timber Handled Frequency' in 6.2.8.2) and the grading task a difficult combination of high cognitive demand and fast pace. Stacking was difficult with fast table speed (see 'Table Speed' in 6.2.9.2) and when manually moving timber the length of table. Constant work pace, steady work at the pit-stacker and fillet sticks were felt to be easiest.

Training Workers recognised some key training factors for timber handling that made it safer and easier to complete the work tasks (see 'Training' in 6.2.1.2, 'REBA' in 6.2.11.2, and Borg RPE in 6.2.12.2) The use of leather aprons (see 'Aprons' in 6.2.6.2) was not a part of the work culture but could be considered as another means of reducing the manual handling risks workers are exposed to (see 'Health and Safety Management System' in 6.2.1.2). Training factors should be addressed following table design factors, as the existing position of the rail and high cleat height on the chains creates awkward actions that are not necessary (see 'Rail Position' and 'Cleat Design' in 6.2.9.2).

Improvements Primary areas for improvement were felt by workers to be the design of the unloader (see 'Unloader Design' in 6.2.9.2), trolley rails/flooring (see 'Floor Surface' in 6.2.5.2) and trolley pushing (see 'Trolley Design' in 6.2.9.2).

6.2.3 *Anthropometric Data*

6.2.3.1 Results

Data collected from these workers (Table 6.1) paralleled that for the New Zealand population as given in NZ Anthropometric Estimates (Slappendel and Wilson, 1992).

Table 6.1. Anthropometric data from Mill 17 workers

Gender	Ethnicity	Hand	Age	Eye	Shld	Elb	Hip	Knuck	Span	Bidelt. Width	Acrom Grip L	Hand Lgth.	Hand Brdth.
M	EUROPEAN	R	35	1640	1430	1060	830	710	1840	520	650	185	85
F	EUROPEAN	L	21	1515	1355	1005	795	715	1580	460	580	175	75
F	EUROPEAN	R	36	1460	1270	1070	760	700	1640	480	580	180	80
M	EUROPEAN	R	51	1685	1475	1115	915	775	1940	480	670	195	100
M	EUROPEAN	R	49	1575	1555	1055	865	725	1760	450	590	175	90
M	EUROPEAN	R	56	1495	1335	1005	805	675	1740	450	600	190	100
M	EUROPEAN	A	54	1645	1465	1125	885	775	1740	480	650	195	95
			1st %ile	**1373**	**1185**	**952**	**709**	**638**	**1470**	**417**	**528**	**165**	**67**
			2.5th %ile	**1405**	**1221**	**970**	**729**	**651**	**1515**	**426**	**542**	**168**	**70**
			5th %ile	**1432**	**1252**	**985**	**747**	**663**	**1553**	**434**	**555**	**171**	**73**
			50th %ile	**1574**	**1412**	**1062**	**836**	**725**	**1749**	**474**	**617**	**185**	**89**
			95th %ile	**1715**	**1572**	**1140**	**926**	**787**	**1944**	**514**	**680**	**199**	**105**
			97.5th %ile	**1742**	**1603**	**1155**	**944**	**799**	**1983**	**522**	**692**	**202**	**108**
			99th %ile	**1774**	**1639**	**1172**	**964**	**812**	**2027**	**531**	**706**	**205**	**112**
			Std devtn	86	97	47	55	38	119	24	38	9	10
			Count	7	7	7	7	7	7	7	7	7	7

6.2.3.2 *Discussion and Conclusions*

NZ Anthropometric Estimates (Slappendel and Wilson, 1992) can be used for relevant design considerations.

6.2.4 *Lifting Strength*

6.2.4.1 *Results*

A comparison of the data gathered from lifting strength testing with 5 dry table workers (Table 6.2) with that reported by Keyserling, Herrin and Chaffin (1978), (as cited in the Jamar Back-Leg-Chest Dynamometer instruction booklet, Therapeutic Equipment Corporation, New Jersey. [undated]), determined that for the *leg lift* 80% of workers had 75th percentile or above strength and 20% had 25th percentile strength; and for the *arm lift* 80% of workers had less than 50th percentile arm lift strength and 20% had less than 25th percentile strength. Two workers did not attempt the test due to current/old injuries).

Table 6.2. Dynamometer data from Mill 17 workers

Subject Number	Arm Strength kg				Leg Strength kg			
	Lift 1	Lift 2	Lift 3	Mean	Lift 1	Lift 2	Lift 3	Mean
2	24	24	23	23.7	63	55	50	56.0
3	15	15	20	16.7	60	*	*	60.0
4	40	45	47	44.0	115	115	115	115.0
5	25	29	28	27.3	70	74	78	74.0
7	37	35	34	35.3	108	120	112	113.3

(* Worker did not continue as this test made lower back uncomfortable)

6.2.4.2 *Discussion and Conclusions*

The workforce population employed at this mill is relatively strong for the leg lift, but relatively weak for the arm lift. As these work tasks demand arm and shoulder function of a constant and forceful nature, this result could suggest that the work tasks are relatively well designed - as the workers were managing them despite apparently limited strength in muscle groups required for the arm lift. (See 'NMQ' in 6.2.14.2).

6.2.5 Environmental

6.2.5.1 Results

Lighting levels The work area was inside a building with skylights on the southern wall and overhead lighting. Measurements were taken at 11.45 am on a cloudy/rainy day in mid February. Work occurred at night and day. Illuminance (lux) was measured as per Table 6.3.

Table 6.3. Illuminance at Mill 17 dry table

Time and conditions	Place	Lux Level
11.45 am, cloudy/rainy day in February	On table directly in front of unloader	520 lux
	On table directly in front of grader	650 lux
	Between 3rd and 4th chain sections in front of grader	900 lux
	Between 5th and 6th chain sections in front of grader	800 lux
	At front of table, 7 metres from table end,	630 lux
	At front of table, 3 metres from table end	550 lux
	Directly in front of pit stacker	700 lux
4 pm on cloudy/rainy day in February	On table directly in front of grader	720 lux

The grader required lighting levels that were adequate for visual inspection tasks. This was a critical role that had a significant impact on profit, with few grading errors tolerated. Depending on chain speed, the grader may have only two seconds to make the grading decision and dock the board.

Noise Verbal reports were that noise testing had been completed for the area, and that mandatory hearing protection was not required. High impact/loud noise occurred when layers of timber fell from the unloader onto the table; squeaky chain noise was constant; a radio was usually on and intermittently interrupted by the speaker communication system used by the tally person. Other noise occurred intermittently, but was apparently below the level requiring continuous hearing protection. Some workers did prefer to wear hearing protection (in one case to protect already partly damaged hearing from deterioration), and muffs and plugs were available.

Floor Surface The 485mm high wooden platform alongside the table was the most commonly used flooring area. This surface was not slippery, and being wooden had some inherent cushioning. There were steps up to the platform at several points between the trolleys, and at either end. The junction of this flooring and the side of the table did not include a toe-space, and workers were thus prevented from gaining an optimal standing position. This was further evidenced by the number/amount of boot markings on the lower 150mm of the table side, where workers had kicked the edging as they worked. The position of the step at the left of the pit stacker acted to prevent an easy reach to the end of the chain to grasp boards with the left hand. This appeared to impact particularly on shorter workers.

The remainder of the work area was on concrete flooring. The trolley railings (right angle steel) were fixed to the concrete creating an uneven flooring surface that must be crossed to access the trolleys and other work areas. One worker was recently off work with a significant injury from tripping on the railings, and another worker reported a recent ankle strain from a similar incident. The uneven floor surface was therefore a hazard.

The tally box was a small glass-fronted office area positioned above the end of the table, accessed by a steep stairway with hand railings either side. The tally person sat in the tally-box, recording on computer the timber lengths/sizes stacked.

Thermal Issues The outside door by the tally box stairs was usually left open to allow some air-flow, though no comment was made specifically about thermal comfort/discomfort in the larger work area. It was noted that it sometimes 'got hot' due to the kilns positioned nearby, though this was not of concern to any worker.

6.2.5.2 Discussion and Conclusions

Lighting The recommended lighting level for timber inspection tasks was given as 750 lux (CIBS Code for Interior Lighting, 1984), but for the grader was measured at between 650 (directly in front of grader) and 900 lux (mid-table). Thus the lighting directly in front of the grader could be improved for this timber inspection task (see 'Grader Workstation Design' in 6.2.9.2). This might be achieved by altering the position of an overhead mirror (used by tally person) that was blocking some light, or the addition of another light source.

Noise Whilst hearing protection was reportedly unnecessary at the dry table work area (per testing), workers complained that the constant squeaking of the chains on the table was irritating. (See 'Maintenance' in 6.2.9.2).

Floor surface The junction of the dry table flooring platform and the side of the dry table did not include a toe-space, and workers were thus prevented from gaining an optimal standing position. This was addressed to a degree by the presence of the rail where the stackers worked, as the rail forced them to stand away from the side of the table, thus creating a toe space. The grader and unloader (see 'Unloader Design' and "Grader Workstation Design' in 6.2.9.2) were however forced to use additional stooping or reaching to timber on the table due to the lack of toe space at their workstations.

The floor surface where trolley rails are was hazardous but frequently navigated by workers in this area. (See 'Accident Register Review' in 6.2.1.2 and 'Improvements' in 6.2.2.2). Provision of a safer and easier to navigate walkway area would reduce injury risks.

6.2.6 PPE

6.2.6.1 Results

Gloves Several glove types were available and used according to personal preference and glove fit. The two females preferred the ' Showa' cotton knit glove with rubberised fingers/palm/thumb as these offered good protection and comfort, and were a good fit for their smaller hands. Gloves were replaced when the worker felt it necessary. Some preferred a 'woolly' glove with a rubber mesh overlay, and others a cotton model similar to the Showa with a rubberised surface over the palm and a less protective coating over the remainder of the glove. A worker with an index finger amputation noted that it was safest to cut the finger off the glove to prevent it catching as she worked. All workers had hand length of between 175 and 195 mm, and hand breadth of between 75 and 100 mm.

Hearing Protection (See 6.2.2). Annual hearing tests were completed for all workers.

Footwear (See 6.2.2).

Hard Hats Hard hats were not a requirement for wear at the dry table. However when moving through/entering the adjacent work area where the crane operated, hard hats were to be worn. Therefore all dry table operators had hard hats issued to them and these were worn on a daily basis when moving to and from their work area. A hat rack was available that allowed hats to be stored to facilitate this safety requirement.

Overalls/Aprons No workers were observed to wear overalls. In this dry chain area, light plastic aprons were worn by some workers for clothing protection. Leather aprons were not used, reportedly as timber was not resinous/sticky, and as dry timber was lighter and therefore easier to move without thigh/hip action and the apron's protection.

6.2.6.2 Discussion and Conclusions

Gloves One worker with a finger amputation cut off the matching finger on the glove to prevent it's catching, with some consequent loss of protection. Whilst workers appeared satisfied with the gloves available, further research into glove types most suited to dry timber handling could benefit. (See 'PPE' in 6.2.2.2). This should include gloves to fit both men and women, and means of effectively coping with digit amputations. Gloves should meet the specifications as outlined in 5.2.6.2.

Hearing Protection Some workers chose to wear hearing protection to protect already slightly impaired hearing. Given this concern and complaints about chain noise (see 'Noise' in 6.2.5.2) regular review of the noise levels may be indicated as plant changes may impact on the noise levels recorded. Ensuring measurement of the high impact noise occurring when layers of timber slide off at the unloader is important.

Aprons Light-weight aprons were used at this worksite for clothing protection only. Thick leather apron use protects clothing and allows the soft tissues of the body to be protected from splinters or bruising from the boards. Used effectively, leather aprons appear to allow the timber to be kept closer to the body in handling (slid across or against the leather aprons), thus reducing the forces acting on the back and arms. (See 'Training' in 5.2.1.2). Apron use (in other mills) was observed to allow skilled workers to use leg and hip flexion rather than back flexion when stacking into the lowest stack positions.

6.2.7 Worker Scheduling

6.2.7.1 Results

This information was gathered from interviews with individual team members, from displayed boards and schedules, and from observation whilst onsite.

Task Rotations	Worker rotations were on a fixed schedule as below:	
1st rotation	6.30 am – 8.00 am	(1.5 hours)
2nd rotation	8.00 am – 9.30 am	(1.5 hours)
First break 30 minutes		
3rd rotation	10.00 am – 11.30 am	(1.5 hours)
4th rotation	11.30 am – 1.00 pm	(1.5 hours)
Second break 30 minutes		
5th rotation	1.30 pm – 2.30 pm	(1.0 hour)
6th rotation	2.30 pm – 4.00 pm	(1.5 hours)
Third break 15 minutes (optional if late shift)		
7th rotation (optional)	4.15 pm – 6.00 pm	

Thus a total of 8.5 hours per day, with 7.5 hours on Fridays as finish time was at 3 pm. This equates to 44 paid work hours per week, given a half hour of paid work breaks per day. If overtime was being worked, an extra fifteen minute break was taken at 4.00 pm. Rotations were therefore of 1 or 1½ hours in duration, or if overtime was being worked, a 1¾ hour duration. Intermittently a second shift might be called in, and this was worked from 4.00 pm to 1.30 am, with rotations of the same length and pattern. Workers from this workplace reportedly self-determined that it was preferable to have two longer work breaks during the day, rather than one longer and two shorter breaks. Workers generally indicated that this allowed them to have a better break and more food/drink than was possible in a standard 10-15 minute tea break.

Rosters were managed by the team leader to ensure that all workers were fairly rotated through each position, that work was within individual capabilities, and that discomfort issues were accommodated. Some limitations to the combination of worker placements existed because of worker skill limitations, physical capacity limitations, and to some degree worker preference.

Key roles were those of grader and tally-box operator, as they required cognitive skills, attention, and rapid work speed, gained only through experience and specific knowledge. The unloader's role was key in that it was physically demanding and set the pace for the entire operation. At times the team informally made alterations to the rostered positions, to accommodate brief periods when workers had to complete other activities. This required teamwork, trust and respect of each other's skills, and was managed reasonably effectively within this team. The team leader determined the rotation schedule each morning, requiring some knowledge of the timber production schedule.

Worker numbers and positions A total of 9 workers were in the immediate dry table area in the following roles:

- Sticks Sorting, collecting and stacking fillet sticks as they came out of the unloader. Very light task, self-paced, unskilled, and away from the main work area.
- Unloader Physically demanding role. When the unloader machinery allowed the layers of timber to fall from the pack, the fillet sticks fell through and the timber moved onto the start of the table. The unloader took each board, untangled it, and pulled it into a position close to the working edge of the table. They moved it over a ledge between the edge of the unloader table and the start of the main table (Figure 6.1) with the goal that each set of cleats was filled. The unloader therefore handled each piece of timber that moved down the table.

Figure 6.1. Unloading task. (Unloader is person on the left, grader is on the right)

- Grader The grading role was a key task (Figures 6.2 and 6.3). The grader had considerable knowledge of export/domestic grading levels, and knew of grade requirements per pack and other quality aspects. The grader had only several seconds to make a judgment about grade quality. They looked for timber splits, knots, resin pockets, and other types of damage. This required turning the board over with one hand, inspecting it visually along all sides, and making a judgment. The board was marked with chalk to designate the grade and therefore the packet that it would be stacked onto further down the table. The grading role required considerable training and understanding of the timber industry and production goals. The grader might also use the suspended skill saw to dock damaged ends off timber or cut extra-long lengths to appropriate size.

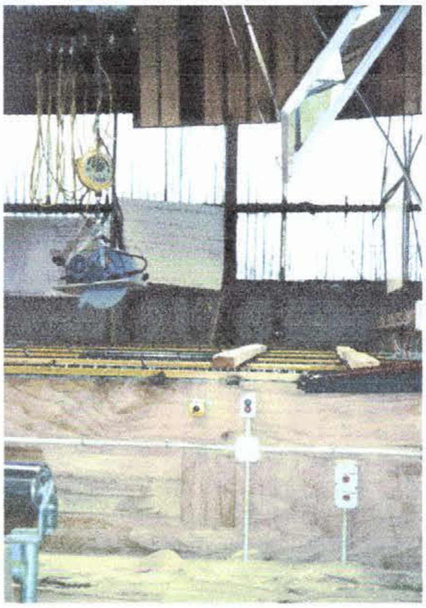

Figure 6.2. Grading workstation viewed front on

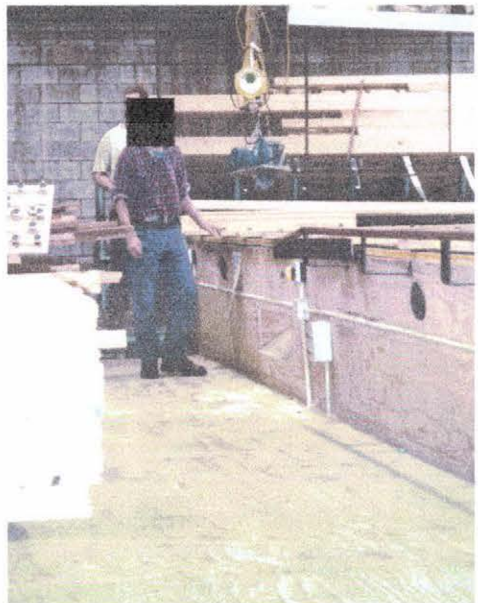

Figure 6.3. Grading workstation viewed from side

- Table stacker (2 positions) Workers took the graded timber and stacked it into packets on the trolleys (Figures 6.4, 6.5 and 6.6). Care was taken to pack per the standards. This included no 'shorts' or double-ups on the sides of packets, no greater than 'x' length etc. The requirements varied depending on the customer and transportation requirements. Care was also taken to insert fillet sticks to ensure packet stability.

Figure 6.4. Two workers stacking onto same packet. (At rear, pit stacker at front)

Figure 6.5. Worker positioning timber on packet

Figure 6.6. Worker pulling timber from table

- Pit Stacker The worker at the pit-stacker (Figures 6.7 and 6.8) was in a key role. The pit-stacker took the bulk of the timber (most common dimension and grade) from each of the unloaded packets. The pit stacker machinery was height adjustable, and provided for rapid stacking of boards. Skill was required to meet the requirements for packets with no 'shorts' or double-ups on the outer edges, and to meet timber length requirements etc.

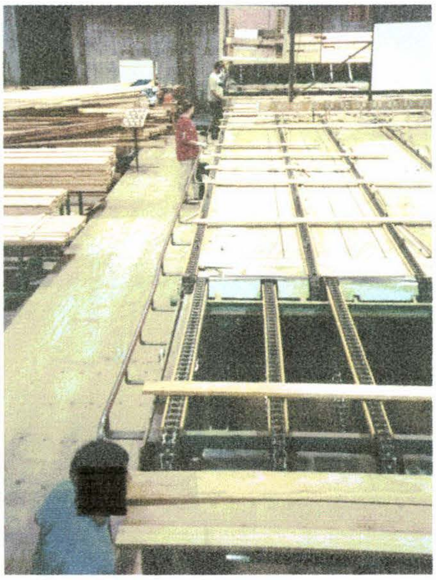

Figure 6.7. Dry table. Pit stacker at front, table stacker central, grader at rear

Figure 6.8. Pit stacker workstation showing height adjustable packet holder positioned at the end of the dry chain

This position required a fast work pace, though this could be relieved by a table-stacker also filling a packet of the same timber dimension/grade. As per Figures 6.9 and 6.10, the pit-stacker could work with either a one or two handed board-handling technique.

Figure 6.9. Pit-stacker using one-handed technique

Figure 6.10. Pit-stacker using using two-handed technique

- Tally-box This role was key in the dry table operation. The tally-box operator sat at a computer in a small room above the dry table that allowed a view down the length of the table. The tallying task required considerable concentration, knowledge of the computer system, grading and ordering systems and other processes. Thus the tally-box operator was necessarily experienced in the industry. The tally-box operator used radio communication to maintain contact with dry table workers, and could stop the dry table if necessary. The tally-box operator recorded timber grades and lengths, and so tracked timber output for the operation.

- Floater/strapper This job consisted of lighter and more varied work tasks. The floater moved into the warehouse and storage areas, and liaised with wrapping personnel (to ensure that adequate trolleys were available for timber coming off the table) and crane operators.

Figure 6.11. Packet preparation by the wrapper.

- Wrapper Similar to the floater/strapper role, this was a light work task with movement in and out of the warehouse and storage areas and liaison with the crane operator. The wrapper strapped and wrapped packets of timber as in Figure 6.11, and worked with the floater/strapper to ensure that adequate trolleys were available for timber coming off the table. The wrapper was aware of crane operations in order to support the dispatcher's role.

- Crane Operator The crane operator controlled the overhead crane system to move packets of timber around the warehouse area as linked with dispatching and table operations. The crane operator was in radio contact with associated personnel.

- Dispatch Dispatching of product was completed in an adjacent work area. Completed packets of timber were sent to meet order requirements.

Teamwork at the dry table was important. Communication occurred between the tally-box operator and the grader (via radio) and other team members for planning what to do with each timber dimension, to manage the changeover of timber sizes and part-packs, to meet order requirements, and to meet the various grading requirements for different markets. The tally-box operator made sure that correct labels were printed and attached to packets, and that the correct packet grading and packing instructions were followed (different Australian/US and various customer requirements).

6.2.7.2 Discussion and Conclusions

The roles of the unloader and grader were reportedly the hardest on the dry table team; the unloader as work was physically demanding, and the grader as work was mentally and physically demanding. These work positions may benefit from being somewhat shorter in duration than other task rotations. Other means of addressing the demands on the unloader and grader should also be considered. (See 'Improvements' and 'Hardest/Easiest Work Tasks' in 6.3.2, 'Floor Surface' and 'Lighting' in 6.3.5, 'Timber Handled Frequency' in 6.3.8, and 'Table Speed' in 6.3.9).

6.2.8 Timber Handled Statistics

6.2.8.1 Results

A review of figures from end October 2001 to end February 2002 (Appendix 8) (and taking into account the time when the table was not operating), allowed mean and range board handling figures to be determined for workers stacking timber (Table 6.4). This work team kept track of any downtime on the dry table for the purpose of enhancing productivity. A total of 7 workers operated at the table, with both the unloader and the grader handling each board and three others stacking timber from the table (therefore handling all boards between them).

Table 6.4. Mean and range for boards handled at Mill 17

	Total boards handled per hour	**Boards handled per hour, each stacker**	**Boards handled per minute, grader and unloader**	**Boards handled per minute, each stacker**	**Seconds per board, grader and unloader**	**Seconds per board, each stacker**
High	2294	764.67	38.23	12.74	1.57	4.7
Mean	1156	385.33	19.27	6.42	3.11	9.3
Low	739	246.33	12.32	4.11	4.87	14.6

The grader and unloader worked at a pace of between 739 and 2294 boards per hour - or 1.57 seconds per board at fastest, with a mean of 3.11 seconds per board, and 4.87 seconds per board at slowest. The pit stacker handled much of the timber from the table, and the other two workers at stacking positions handled smaller amounts of timber at a slower pace. The average work pace of the pit-stacker and other stackers was averaged at between 4.7 and 14.6 seconds per board. The rotation system ensured that workers did not consistently remain at grading, unloading or pit stacking positions where timber handling frequency was highest.

6.2.8.2 *Discussion and Conclusions*

The unloader and grader handled up to 2300 boards per hour. Table speed (see 'Hardest/Easiest Work Tasks' in 6.2.2.2 and 'Table Speed' in 6.2.9.2) should therefore accommodate a comfortable and safe work pace for both of these workers. The workloads of the pit stacker and other table stackers should be balanced, as the pit-stacker usually handled more timber than the other workers (see 'Pit Stacker Workstation Design' in 6.2.9.2).

6.2.9 *Dry Chain/Table Assessment*

6.2.9.1 *Results*

No site or table construction plans were available for review. Data reviewed was therefore limited to photographs and dimensional information gathered at site visits.

Table/Chain Design The total table length from where the unloader placed the timber onto the cleats through to where the pit stacker took it off the chain for stacking was a little over 17m. The first 5m were taken up by the packet-unloading and table-loading task, and grader operations. Timber was pulled from the table over the last 12m, with the pit-stacker being at the end of the table. The total table width is 6m, with 7 individual chains. The height to the top of the chain was 890mm. The chain had cleats that separated the timber at approximately 400mm intervals. These intervals allowed the tally person to record the length of each board from the tally-box above. As in Figure 6.12, the chain moved in a nylon gutter (for reduced friction), with the edges of the gutter and the upper surface of the metal chain being contacted by the boards.

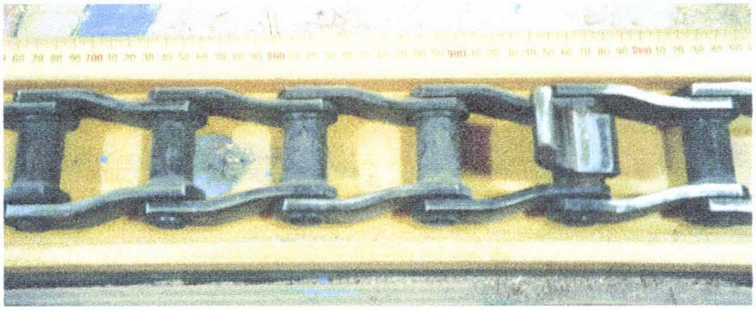

Figure 6.12. Chain in the nylon gutter

There were two styles of cleat - a 'triangular' type that was commercially available and a customised 'curved' model as in Figures 6.13 and 6.14. It was reported that the curved cleat was put in place in order to use an automated timber-turner, but this was found to be unsatisfactory. Cleats were between 95mm and 115mm in height from the table surface.

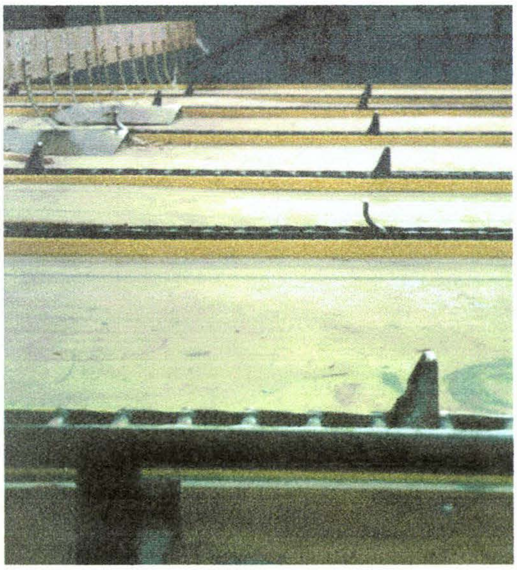

Figure 6.13. Two cleat types

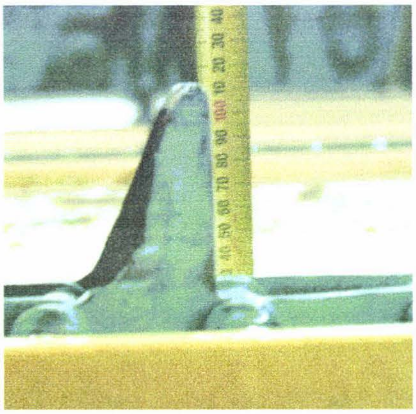

Figure 6.14. Triangular cleat (112 mm height)

Board position (overhang) at the table edge was constant at 30mm due to a guide bar just beyond the grader. A rail (Figure 6.15) ran along the front edge of most of the table from around the same point. The rail was 80mm above the table/chain height, and a total of 970mm to the upper surface.

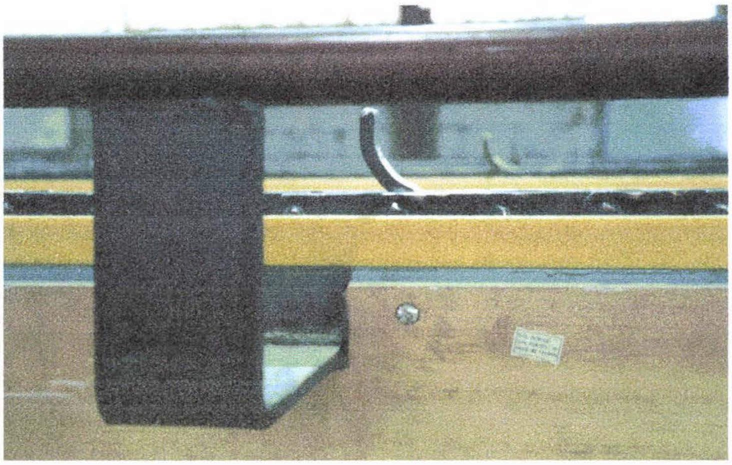

Figure 6.15. Rail at side of table with curved cleat visible under

The rail's purpose was reportedly to allow easier timber handling. It was said to enable the rapid elevation of a board from the table surface, freeing it from the cleats that would drag it along the table before it could be pulled off. Some workers commented that the rail was useful to slide timber along the table length, therefore reducing the amount of lifting. The rail demanded that stackers completed the following actions:

1 Reach over rail and grasp board (usually with one hand)
2 Lift and pull board up onto the rail
3 Grasp board with two hands and pull it out from the table whilst pushing down on the board end. This freed the far end of the timber from the cleats by using the rail as a fulcrum, and prevented the board being dragged along the table (which made it difficult to slide off into a packet).
4 Direct the board onto the correct pack by sliding it on the rail and allowing gravity to assist its movement down onto the packet, taking board weight only as needed.
5 Direct/handle the board into the correct position in the packet.

Unloading Workstation The unloader was reportedly modified from its original geometry, causing more fillet stick jamming as a consequence.

Timber was automatically tipped from the stacks, falling onto the platform in front of the unloader (Figure 6.16). Fillet sticks fell through onto a conveyor that took them out to be sorted/restacked in an area at the rear of the main work area. Fillet sticks did however catch and jam the timber intermittently, usually being cleared by the unloader hitting them with a length of timber (additional physical demand and stress). It was noted that an overhead grill was in place at the first onsite visit that had been removed by the time of the second visit. The grill was hung at a point that was to have reduced the possible danger from flying fillet sticks, but was reportedly ineffective.

Figure 6.16. Unloader with grill visible (upper left). Height differential between the unloading platform and the rest of the table is visible.

The unloader took each piece of timber from the platform area and untangled it from the pile up. They then pulled it back over the edge of the table and levered it (pushed down on it once an adequate lever arm had been pulled over the table edge), then threw the timber over the ledge between the unloading platform and the lower moving section of the dry-chain. The unloader endeavoured to fill each set of cleats with timber, in order to keep the chain moving efficiently. This task was reportedly the most physically demanding and tiring. The platform that the timber fell onto in front of the unloader had additional rollers (Figure 6.17) to move the timber toward the unloader. A knee/thigh-operated button at the front

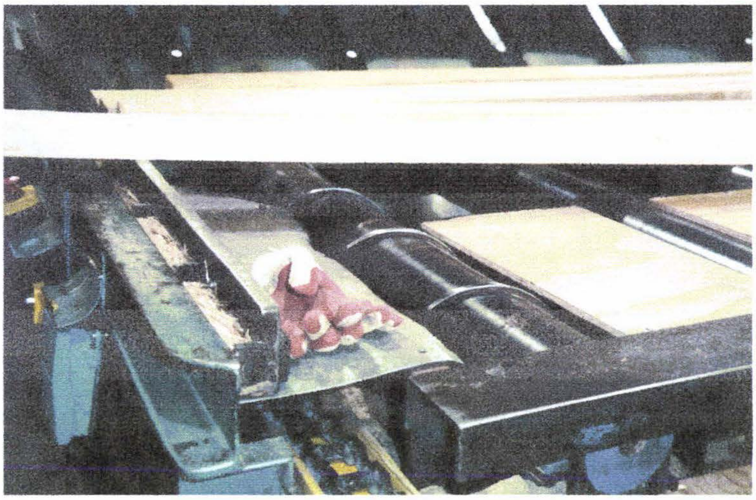

Figure 6.17. Unloader's workstation (during a break) showing controls and rollers that move the boards towards the operator.

edge of the table controlled this roller. Workers observed unloading demonstrated spinal rotation movements with high forces, with most workers developing a largely right-handed work method (Figure 6.17) and a steady work rhythm.

Figure 6.18. Unloader in action, with spinal twisting.

Grading Workstation The grader visually inspected each board and at times docked boards with a suspended skill-saw. They turned boards with their non-dominant hand, inspected the board along all sides, and chalk-marked the grade on the board with their dominant hand. If docking was necessary (to remove split sections, resin pockets or other sections of poor quality that impacted on board grade/value) this was done rapidly to avoid slowing the flow of boards along the table. A roller could be raised from the table bed to move the boards closer to the table edge. This was operated by controls at the front edge of the table (Figures 6.2 and 6.3).

Chain Controls Near the grader were controls to stop/start the chain, and the control to speed/slow the chain. Other stop/start controls were at the pit stacker and in the tally-box station.

Chain Maintenance The maintenance person working on the kilns was responsible for the dry-chain area. Maintenance was not regular (as maintenance in the kilns area was very busy/timetabled), but if there was a table breakdown attention was reportedly immediate. An issue that had been unsuccessfully addressed was the constant chain squeaking. This was reportedly unable to be rectified as to lubricate further risked oil getting onto the timber.

Chain Speed The chain speed was controlled by the fast/slow buttons that could be altered by any of the work team. It was usually made faster when there was pressure to get product ready for transport. The unloader's and grader's capacity limited the pace that the table and team could work at. The unloader for the physical limitations of moving the timber, and the grader for the mental and physical demands required of grading/docking. Two skilled workers graded their perception of chain speed, and this was used to give the speeds as below:

Moderately fast	0.444m/s (for 75x50 boards). Cleats/time was measured at 2.0secs/cleat (board), counted for 1 minute
Moderate	0.429m/s (for 100x50 boards).

	At another time 0.439m/s was determined a 'medium' speed
Moderately slow	0.370m/s (for 200x50 boards, slowed down as unloader unable to move the bigger boards as fast). At this point cleats/time was measured at 2.5secs/cleat, counted for 38 seconds. At another time, 50x50 rimu was being stacked, and this was measured at 2.6secs/cleat (over 1 minute). This was determined to be quite slow for this small board size, and was consequently sped up by one of the workers to the moderately fast pace above.

Packet/Trolley Position Trolley placement options were limited by the design of the work area, as they could not be moved closer than the edge of the flooring platform. Trolleys were moved on rails up to the platform edge, and the packet stacked onto the trolleys. The distance of the packet end from the table varied (Figure 6.19) depending on the amount of board overhang on the trolley, determined by the stacker. Some packet ends were measured at only 900mm from the table edge, others 1250mm from the table edge (with most at around 1200mm). However as the rail protruded 200mm from the table edge, the actual table/packet end distance could be considered as between 700 and 1050mm, with most at around 1000mm.

Each filleted packet that came to the dry-chain from the kilns had timber of the same cross-sectional dimension, so timber stacked from the dry-chain was placed into different packets according to length and grade only. A total of 8 trolley positions were possible at the dry-chain, with the 5 central positions most commonly used. The most common timber size/grade was stacked directly onto the pit-stacker at the end of the table, so reducing the timber handling onto trolleys.

Figure 6.19. Varied packet distance from table

Trolley Design The new (preferred) trolleys (Figure 6.20) were at 860mm from the floor, whereas the older wooden ones (Figure 6.21) were 960mm, and a prototype new trolley (that was determined to be too high for comfortable use) was 1030mm. The 860mm trolley therefore represented a consensus about what was suitable and workable for all team members.

Figure 6.20. New trolleys, shortest (at front) preferred

Figure 6.21. Old wooden trolley

The trolley wheels tended to jam against the side of the rails (Figure 6.22). At times this meant that the trolleys were at risk of tipping over, given their relative height and heavy load on top. There was some discussion regarding different wheel design and slightly lower steel rails to reduce the friction from the rail edge against the side of the wheel. Wheels on the new trolleys were 150mm diameter, nylon. Wheels on the old trolleys were 305mm diameter, steel.

Figure 6.22. Nylon trolley wheels with tendency to wedge on railings

The new trolleys ran on right-angled steel affixed to the concrete floor by one side (55mm protrusion from the floor base), 800mm apart. The older trolleys ran on the same right angled steel, but with the right angled steel turned over forming an upturned 'v' that the wheels ran along, approximately 900/950mm apart. The older styled trolleys appeared to run more smoothly despite their large size and heavy structure. New trolleys could be moved between rails depending on where they were required, and therefore allowed greater flexibility.

Packet Sizes/Heights A chart indicating the number of boards to be stacked in each packet (depending on timber dimension) was available (Appendix 8). Packets were at set sizes according to board dimension, with overall packet size related to shipping, transportation limits and customer demand. Differing pack specifications existed for domestic and export sales. Pack specification data was displayed near the dry-chain on a board, and in greater detail in a manual. Workers became familiar with pack specifications over time such that they no longer referred to the charts. Examples of pack size were:

- Boards of 25mm thickness and 50mm width were stacked 25 high and 19 wide per packet. Therefore 475 boards per pack, with fillet sticks after the 9^{th} and 17^{th} layers.
- Boards of 50mm thickness and 300 mm width were stacked 12 high and 3 wide (so 36 boards per packet), with fillet sticks after the 5^{th} and 9^{th} layers.

Some packets may contain more boards as short boards might be doubled up (end to end) inside the packet. Packets also had a maximum board length that was allowable. This packet specification and board number data was used in conjunction with productivity statistics to calculate frequency of timber pulling, and total items stacked per day.

Packet heights were calculated from the packet specification chart (timber depth x number of rows plus 20mm, the depth of two fillet sticks). Packet sizes were between 530mm and 660mm total height for domestic packs, and between 660mm and 770mm for export packs. Packet height (specifically to the top of the second to last row of timber) was critical in determining optimal work height.

Fillet Sticks Fillet sticks were stored on the floor by the table edge, and to the right of the pit stacker in a bin under the stairs. Fillet stick holders were positioned on the front of the table (Figure 6.23) but were not observed in use. This appeared to be as one holder had supports 1100mm wide, and fillet stick length is approximately 700mm (by approximately 40 x 10mm) so the holder was simply unable to be used as it was designed. The other holder was 640mm wide so theoretically of a suitable size for holding fillet sticks, but was perhaps further away than is comfortable for use or was simply not used as the other holder did not work, a consistency issue. Fillet sticks were instead stored in piles on the floor, along the table edge.

Figure 6.23. Fillet stick holders (metal hooks) along the table, and fillet sticks placed on the floor.

6.2.9.2 Discussion and Conclusions

Table Height Table height is a critical factor in the task of pulling and stacking (and grading) timber. (See 'Table Height', in 5.2.9.2). Whilst the height to the top of this chain was 890 mm, the effective table height was 970 mm because of the rail height (see 'Rail Height' and 'Trolley Design' below). Using the workings given in 5.2.9.2, a fixed height table should be at 920mm.

Chain Maintenance The consistent squeak of chains (see 'Noise' in 6.2.5.2) was reportedly irritating to workers, and maintenance review to address this was indicated.

Table Speed Fast table speed was identified as one of the hardest work tasks (see 'Hardest/Easiest Tasks' in 6.2.2.2 and 'Timber Handled Frequency' in 6.2.8.2), particularly for the grader and unloader, and at times the stackers. The maximum table speed selected should be sustainable and not injurious (see 'Training' in 6.2.2.2 and 'Timber Handled Frequency' in 6.2.8.2). Trials with table speed measurement versus error rate/comfort levels/stress levels of the grader may result in a quantifiable (via a 'speed indicator') team-determined work pace (or range of work paces) that can be set more accurately than the simple but un-measurable 'faster/slower' control that existed. This may include ideal safe table speed for various timber dimensions. Table speed should be included in manual handling hazard identification (see 'Health and Safety Management System' in 6.2.1.2) for the work area.

Rail Position The rail eased difficulty caused by the cleats, but consequently created additional physical actions (see 'REBA' in 6.2.11.2). Rail position also impacted to limit board overhang, causing the actions to remove the board to be more complex and forceful (see 'Force Measure' in 6.2.10.2, 'Board Overhang' below, and 'Training' in 6.2.2.2). There may be benefit in lowering the rail and considering use of rollers to reduce the friction when pulling boards from the table. The rail may be able to be completely removed once cleat changes are made. Workers will require specific training (see 'Training' in 6.2.2.2) to optimise the benefits from changes made to the rail.

Cleat Design As the cleats moved timber down the table while it was being taken from the table and stacked, there may be benefit in lowering the cleats and removing some of them entirely - from perhaps the 4th, 6th and 7th chains from the front edge of the table (see 'REBA' in 6.2.11.2). Workers will require specific training (see 'Training' in 6.2.2.2) to optimise the benefits of changes made to cleats.

Board Overhang For timber stackers, the rail at the table edge limited the amount of board overhang (inside the rail), with a metal guide in place to make board overhang a consistent 35mm. This impacted on manual handling technique (see 'Rail Position' above and 'REBA' in 6.2.11.2) with workers using increased spinal flexion and greater spinal rotation to move boards. For the unloader, lack of board overhang required the worker to reach over the table edge to pick up all boards, often whilst supporting/stabilising themselves on the table edge as they pulled back and levered each board over onto the chains. This created considerable spinal rotation forces and was a high risk manual handling activity. Supporting the body with one hand on the table edge also increased the risk of finger injuries (see 'Unloader Design' below).

Having significantly more timber (750 – 1000mm) over the table edge has a number of biomechanical advantages (as discussed in 'Board Overhang' in 5.2.9.2). More board overhang will also allow packet placement closer to the board ends, as is preferred by some workers (see 'Packet/Trolley Position From the Table' below).

Packet/Trolley Position From the Table Packet position in relation to the table varied between 900 –1250mm, (or 700 – 1050mm if the rail was considered as the table edge) largely able to be accommodated by trolley placement. Details are discussed in 'Packet/Trolley Position From the Table' in 5.2.9.2, recommending that the distance between board end and packet distance is 1100 – 1400mm. The preferred distance may be less when shorter timber lengths are stacked from the table.

Packet Spacing Adequate workspace should be provided at each packet for timber to be safely and easily handled, without workers feeling cramped or restricted in timber handling methods. The 'Packet Spacing' discussion in 5.2.9.2 shows workings, and the overall table length should allow this spacing. It is not recommended that workers cross into each other's work space to stack, due to the risk of being hit by timber as it is pulled from the table. It is important that adequate space exists between stacks for the necessary movement between, but that stacks are not spaced so far apart that additional travel up and down the table occurs. As this mill used tall trolleys, between-packet clearance was calculated thus:

- For total trolley plus packet height of 980mm or less (5^{th} percentile female elbow height plus footwear allowance and minus 20 mm clearance) the between packet clearance should be 550mm (95^{th} percentile female hip breadth plus clothing/movement clearance allowance).
- For total trolley plus packet height of more than 980 mm, the between packet clearance should be 620mm (95^{th} percentile male bideltoid breadth plus clothing/movement clearance allowance).

Packet Size/Height From the platform that they stood on, workers effectively stacked boards at between 380mm (height of new trolley bearers above their platform, see 'Trolley Design' below) and 910 - 1150mm depending on the timber dimension and therefore packet size. Other taller trolleys may increase total packet height to 1250mm.

Transfer of common/large dimension timber (from the table to the packet) should not require timber to be moved to a height significantly greater than that of the table. Transferring timber up into a packet requires greater effort and creates a higher injury risk. The largest proportion of timber handling should occur between elbow and knuckle heights. Therefore the height of the second to last row of boards (the height that the last row is stacked to) should be no higher than the table (or perhaps the rail, see 'Rail Position' above). Thus the height of the second to last row of timber would ideally be 920mm (see 'Table Height' discussion above) or 970mm if no adjustments were made to the rail position (see 'Rail Position' above) or 890mm if the rail were removed/lowered to match table height.

Altering the overall packet height (by making the packets wider and shorter) may make the overall height stacked to more suitable.

Trolley Design The new trolleys were problematic in terms of wheels jamming on the rails, and a tendency to tip (in the direction of movement) when being moved with a full load. The extreme height of the trolleys was necessary to counter the 485mm work platform that workers operated from beside the table. Trolleys should be built to withstand the range of forces they are subjected to. Particularly they should have suitable wheels and bearings, and the wheels should move smoothly with minimal force even when fully loaded. They should not tip or be otherwise unstable, and should be maintained to ensure they remain functional and safe to use. Modification of rail/wheel configuration and trolley design to reduce the risk of packet tipping and the forces required for trolley movement was therefore indicated.

Trolley design impacted on the overall packet height (see 'Packet Size/Height above). Overall packet height could be addressed by combining the use of height adjusting scissor lifts in the trolley.

To reduce the difficulty getting the first pieces of timber in place on the trolleys/bearers (see 'REBA' in 6.2.11.2), a 'landing pad' to bounce timber along may assist (see 5.2.9.2 Trolley design). This trolley modification would reduce the force necessary for placement of the first row of timber.

Unloader Design The unloader workstation was problematic in terms of:

- Fillet sticks jammed or became airborne (see 'Accident Register Review' in 6.2.1.2).
- Need for the unloader to reach onto the table to grasp boards (see 'Board Overhang' above and 'REBA' in 6.2.11.2) with a lack of toe-space (see 'Floor Surface' in 6.2.5.2).
- The unloader's need to handle every board at variable work speeds (see 'Timber Handled Frequency' in 6.2.8.2, 'Table Speed' above and 'Hardest/Easiest Work Tasks' in 6.2.2.2).

- The unloader worked with repeated spinal flexion and rotation movements with heavy loads (see 'REBA' in 6.2.11.2).
- The unloader risked finger-jamming when stabilising themselves on the front edge of the table (see 'Board Overhang' above).
- Table design such that a ledge and height differential existed between the unloader platform and the rest of the table, and required all timber to be moved over it. This may instead be achieved with altered roller functions.

A review of the automated unloader's design and operation was indicated to address all these issues.

Grading Workstation Design The grading workstation was problematic in terms of:

- Need for the grader to handle all boards (see 'Timber Handled Frequency' in 6.2.8.2).
- Grader completed a demanding combination of rapid and repeated physical work (including skill saw use) and cognitive effort (see 'Timber Handled Frequency' and 'Hardest/Easiest Work Tasks' in 6.2.2.2).
- Table speed variable and impacted on grader work speed (see 'Table Speed' above).
- Need for the grader to reach onto the table to grasp boards (see 'Board Overhang' above) with a lack of toe-space that created additional need for forward reach (see 'Floor Surface' in 6.2.5.2).
- Lighting level varied and lower than recommended in places (see 'Lighting' in 6.2.5.2).

Some change to the grading workstation design and table speed was indicated to address these issues.

Pit Stacker Workstation Design The step placed close on the left of the pit stackers primary work area blocked this worker from moving comfortably with their feet when taking boards from the end of the table. This particularly impacted on shorter workers, causing an increased risk of shoulder and back strain (see 'REBA' in 6.2.11.2). Modification of the step position was indicated.

The pit stacker machinery was designed so that even narrow timber packets had to be stacked against the supports in the same position as was necessary for wide timber packets. Modification of the pit stacker machinery to allow the supports to adjust forward would reduce the distance timber must be moved to, and would reduce both the manual handling risks and time taken to perform the task. This is relevant as the pit stacker handles the bulk of the timber from the table (see 'Timber Handled Frequency' in 6.2.8.2).

Fillet Stick Holder Design The fillet stick holders at the table edge were unsuitable and therefore unused. Fillet sticks were instead stored on the floor alongside the table and workers bent to pick them up. This posed both a tripping and a manual handling hazard. Bulk fillet sticks were stored near the pit-stacker and table hands walked along to pick them up. This slowed the work pace and increased the risk of injury from walking around other timber handlers.

Fillet stick storage at a suitable height and within easier reach of stackers was indicated. This would reduce the time taken for obtaining fillets, make it physically safer and easier to reach them and be easier to clean around. Care should be taken with the design to ensure that an obstruction to worker movement is not created.

6.2.10 Force Measure

6.2.10.1 Results

The most frequently pulled timber was (dry) pinus radiata 125 x 40 x 3600mm. In the 'large timber' category, the commonly pulled timber size was 300 x 50 x 3000 – 3600mm. Eight pieces of timber of each of these sizes was selected from the timber available. The force required to initiate the movement of each piece of timber in a horizontal direction from the chain was measured per the protocol in 4.2.10.

The sites selected for measuring the timber to be pulled off were:

- Position 1 Grader workstation at start of table. Four boards in one cleat position, and four boards in a second cleat position.
- Position 2 Opposite trolley number 5, where only the smallest timber could be pulled off under the rail. A large proportion of the timber removed from the table is removed from this area.

A third position was unable to be selected as the position of the rail at the table edge prevented the timber being pulled off in a horizontal plane. This reduced the amount of data gathered, but was unavoidable within the industrial setting.

The break-out force required to initiate horizontal movement from the chain of the most commonly pulled timber size (125 x 40 x 3600mm) averaged 4.88kg. The break-out force required to initiate horizontal movement of the most commonly pulled larger timber dimension (300 x 50 x 3000 – 3600mm) averaged 11.6kg. (See Appendix 8 for all data). These figures represent the horizontal 'break-out' or initial force for timber from a stationery chain or table only, and additional forces pertaining to lifting and carrying, timber direction and control, and additional actions to keep timber moving also occur.

6.2.10.2 *Discussion and Conclusions*

As per the 'Force Measure' discussion in 5.2.10.2, the mean break out force for all chains measured was lowest with a roller chain. Chain maintenance is key to low forces for timber removal from the table, and placing the table on a slight incline would also reduce forces for timber removal. At this mill the horizontal pull was not the only action required to move timber from the table as the presence of the rail above the table edge (see 'Rail Position' in 6.2.9.2 and 'REBA' in 6.2.11.2) required boards to also be lifted over and onto the rail.

6.2.11 *REBA*

6.2.11.1 *Results*

Diversion from the protocol (4.2.11) was necessary for this assessment, as the timber size could not be selected per worker. Thus whilst the most commonly produced lumber size was reportedly 125 x 40 mm x 3.6m, varying lumber sizes were observed and assessed for the REBA analyses (Appendix 8), as below. Whilst an above 50th percentile male and below 50th percentile female (NZ Anthropometric Estimates 1992, Slappendel and Wilson) were selected for assessment, the wide range of varying tasks/rostered persons for each task meant that the selection protocol was also not followed specifically.

Notes regarding scoring:

- Load/force score rated as 0 if no actual weight being lifted/carried at that point of movement. For tasks suspected to be low force (pulling from chain etc) a 1 is given, but the same task for larger boards or with boards also being moved with some additional lifting of the board, a 2 is scored.
- A coupling score of 1, 'Fair' was given for all holding tasks as the gloves reduced the grasp, and the boards, whilst generally able to be grasped, do not have a fixed handle or grip.

- It was difficult to accurately assess hand/wrist position in some instances from video, given glove wear and video definition/position.
- Activity scores of 1 were usually given to denote the frequency of the action, though in some instances to denote rapid posture change or unstable base.
- REBA scoring is as per Table 5.7.

The *very high* scores (indicating that action is necessary *now*) were for:

- Pushing a full trolley out.
- Pulling a board from the table from too far away (feet and body not close to the load).
- Reaching forwards for boards at the unloader*.
- Pulling boards back for leverage, at the unloader*.
- Applying force downwards and lifting board end over, at the unloader*.
- Throwing a board out onto stack*.
- Aligning boards at bottom of stack*.

(*for a female with less than 50th percentile, per NZ data, elbow height)

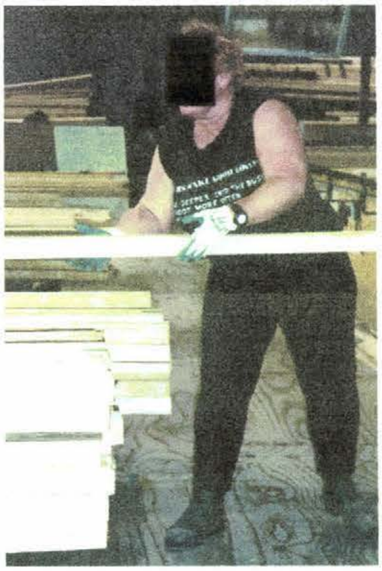

Figure 6.24. Below 50th percentile elbow height female throwing timber onto packet. (Note that though this packet is only half-filled, shoulder elevation is occurring).

The *high* scores (indicating that action is necessary *soon*) were for:

- Pulling back and levering boards at the unloader and pit stacker.
- Reaching for boards at the pit stacker.
- Lifting and pulling boards from the table.
- Pulling and lifting boards onto stacks, especially high stacks.
- The unloader lifting front of board and throwing it onto the chain.
- Placing first layer of boards onto stack.

6.2.11.2 Discussion and Conclusions

As discussed in 5.2.11.2, the forces involved with timber stacking are complex. A range of training and design factors are indicated from consideration of REBA data. They include the following (some information from D. Tappin, personal communication)

- Design trolleys so that they are easy to push out; including rails, wheels, bearer height etc (see 'Trolley Design' in 6.2.9.2).
- Design trolleys so that a solid 'landing pad' allows the first board layers to be bounced into the correct position on the trolley (see 'Trolley Design' in 6.2.9.2).
- Ensure that workers use optimal technique and appropriate PPE at all times when handling timber (see 'Training' in 6.2.1.2 and 'PPE' in 6.2.6.2).
- Design unloader machinery and workstation to reduce/make redundant the timber handling required – both in terms of the forward reach required to pick up boards, and the need to pull boards back and push down on them to lever them over onto the table (see 'Unloader Design' in 6.2.9.2).
- Ensure that boards have greater overhang at the table edge to reduce the reach onto the table (then up onto the rail) for boards (see' Rail Position' and 'Board Overhang' in 6.2.9.2).
- Ensure that workers stay close to the timber being pulled, avoiding trunk bend and arm reach to the boards (see 'Training' in 6.2.1.2)

- Design the pit stacker workstation for ease of movement when pulling back and levering boards (see 'Pit Stacker Workstation Design' in 6.2.9.2).
- Alter the rail position along the table edge to reduce the movements required to remove boards from the table (see 'Rail Position' in 6.2.9.2 and 'Force Measure 'in 6.2.10.2).
- Reduce pack height and/or trolley height and/or use scissor lifts in conjunction with trolleys to reduce height boards stacked to (see 'Packet Size/Height' and 'Trolley Design' in 6.2.9.2).

6.2.12 Borg RPE Scale

6.2.12.1 Results

The Borg RPE Scale was completed (as per the protocol in 4.2.12) with results as Tables 6.5 and 6.6.

Table 6.5. Borg RPE Record first session of day, 14.03.02

Notes regarding activity			**75x50 radiata clears**	**Table stopped briefly**	**Stopped for timber size change-over**	**Changed to 100x50 radiata clears, working consiste ntly now**	**Steady work**	
Worker Number	**Experienced/ Inexperienced**	**Worker Position**	**6.30am**	**6.50 am**	**7.10 am**	**7.30 am**	**7.50 am**	**Mean**
4	Exp.	Grader	6	6	8	12	10	8.4
7	Exp.	Pit stacker	11	9	7	7	7	8.2
8	Inexp.	Table 2	6	11	10	13	13	10.6
9	Inexp.	Table 1	9	9	9	9	9	9.0
10	Inexp.	Unloader	7	7	7	10	11	8.4

Table 6.6. Borg RPE Record last session of day, 14.03.02

Notes regarding activity			Fairly fast, 50x50 (small) rimu	Line stopped then started again for 75x50 rimu	Line moving at 30 boards/min	Steady work	Steady work	
Worker Number	**Experienced/ Inexperienced**	**Worker Position**	**2.40 pm**	**3.00 pm**	**3.20 pm**	**3.40 pm**	**4.00 pm**	**Mean**
4	Exp.	Grader	9	12	12	(Floating then back) 12	(Now grading) 12	11.4
6	Exp.	Table 1	13	15	15	(Now pit) 16	16	15.0
7	Exp.	Table 2	11	9	9	(Now grading) 10	(Now Table 1) 10	9.8
9	Inexp.	Unloader	11	11	10	10	10	10.4
10	Inexp.	Pit stacker	15	13	13	(Now table 2) 12	13	13.2

Workers reported a mean greater perceived exertion at the end of the day (11.96, fairly light) than at the beginning (8.92, very light).

6.2.12.2 Discussion and Conclusions

Workers felt they were working with somewhat greater exertion at the end of the work day, though this was still categorised as light work. This finding still adds a little weight to conclusions already made about training needs, such as learning energy efficient work methods, (see 'Training' in 6.2.1.2) various equipment and workstation design factors (see 6.2.9.2), timber handling frequency (see 6.2.8.2) and work rotation planning (see 6.2.7.2). Further data gathering would likely result in more clearly determined trends, and is indicated to strengthen the validity of possible interpretations.

6.2.13 *Discomfort Rating Scale*

6.2.13.1 *Results*

The Discomfort Rating Scale was completed (as per the protocol in 4.2.13), with results as Tables 6.7 and 6.8.

Table 6.7. Discomfort Rating Scale first session of day, 14.03.02

Notes regarding activity			**75x50 radiata clears**	**Steady work**	**Changed to 100x50 radiata clears**	**Steady work**	**Steady work**	
Worker Number	**Experienced/ Inexperienced**	**Worker Position**	**6.40 am**	**7.00 am**	**7.20 am**	**7.40 am**	**8.00 am**	**Mean**
4	Exp.	Grader	L knee 4, other body 2	L knee 4, other body 2	L knee 4, other body 2	L knee 4, other body 2	L knee 4, other body 2	4 L knee, 2 other body
7	Exp.	Pit stacker	1 all body	1 all body	1 all body	1 all body	1 all body	1 all body
8	Inexp.	Table 2	2 all body	2 all body	3 all body	3 all body	3 all body	2.6 all body
9	Inexp.	Table 1	2 all body	2 all body	2 all body	2 all body	3 all body	2.2 all body
10	Inexp.	Unloader	Low back 4 other body 2	Low back 4 other body 2	Low back 4 other body 2	Low back 4 other body 2	Low back 3 other body 2	3.8 low back, 2 other body

Table 6.8. Discomfort Rating Scale last session of day, 14.03.02

Notes re action at that time			**Steady work**	**75 x 50 Rimu**	**Steady work**	**Steady work**	**Steady work**	
Worker Number	**Experienced/ Inexperienced**	**Worker Position**	**2.30 pm**	**2.50 pm**	**3.10 pm**	**3.30 pm**	**3.50 pm**	**Mean**
4		Grader	4 feet and knees, 3 other body	5 head, 4 feet and knees, 3 other body	5 head, 4 feet and knees, 3 other body	absent	4 feet, knees, hips, 3 other body	4 head, feet, knees; 3.25 hips; 3 other body
6		Table 1	3 right shoulder and arm, 2 other body	3 right shoulder and arm, 2 other body	(now in pit) 3 right shoulder and arm, 2 other body	3 right shoulder and arm, 2 other body	4 right shoulder and arm, 2 other body	3.2 R shldr; 3.2 R arm; 2 other body
7		Table 2	2 all body	(now in pit) 2 all body	(now grading) 2 all body	2 all body	2 all body	2 all body
9		Unloader	3 all body	3 all body	3 all body	3 all body	3 all body	3 all body
10		Pit stacker	4 lower back, 3 other body	(now table 2) 4 lower back, 3 other body	4 lower back, 3 other body	4 right wrist and lower back, 3 other body	4 right wrist and lower back, 3 other body	4 low back; 3.4 R wrist; 3 other body

Two of five workers (40%) reported feeling uncomfortable (scores of 4) in one body area in the first work session of the day, and three of five workers (60%) reported feeling uncomfortable in the last work session, but from pre-existing injuries rather than task-related discomfort. One worker noted that wearing a back belt makes him perspire, but he prefers this to getting cold if he takes it off. He also experiences discomfort behind the ears with both earmuffs and glasses on. Apart from these known specific injury sites most workers felt comfortable or acceptable whilst working during both the first and last work periods. One worker developed right wrist discomfort whilst pit-stacking during the last work period of the day.

6.2.13.2 Discussion and Conclusions

Some workers reported discomfort whilst working from pre-existing injuries or conditions and one worker reported new task-related discomfort at the end of the work day. Though from a small sample (both sample size and the number of work sessions investigated), these findings support the suggested need to reduce manual handling risk factors to make work tasks more sustainable and manageable for 'less resilient' workers (see 'NMQ' in 6.2.14.2) as well as those commencing work without discomfort.

6.2.14 NMQ

6.2.14.1 Results

Results of the abbreviated Nordic Musculoskeletal Questionnaire are shown in Figure 6.25. Table 6.9 (over) shows the data aggregated per body part and the number of reports of discomfort in the last 12 months given as a percentage. In the 12 months prior to assessment, 72% of dry table workers reported discomfort in one/both wrists, and 57% one/both shoulders, lower back, and hips/thighs/buttocks.

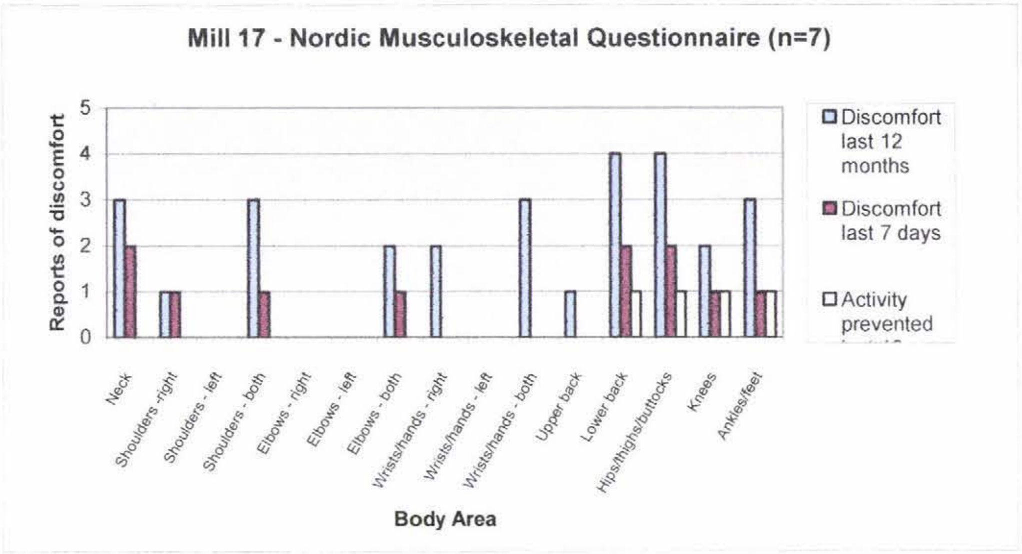

Figure 6.25. NMQ Results Mill 17

This group consisted of 4 males between the ages of 49 and 56 years, one mid-30's male, and two females (mid 30's and early 20's). The somewhat older participants reported a number of injuries that were pre-existing and not necessarily task-related (arthritis, old injury pain etc). Only one worker did not have an old or recent significant injury causing discomfort.

Table 6.9 NMQ discomfort reports last 12 months - results as a total and percentage for each body area

Body Area	Total for body area	Discomfort last 12 months
Neck	43%	43%
Shoulders -right		14%
Shoulders - left	57%	
Shoulders - both		43%
Elbows - right		
Elbows - left	29%	
Elbows - both		29%
Wrists/hands - right		29%
Wrists/hands - left	72%	
Wrists/hands - both		43%
Upper back	14%	14%
Lower back	57%	57%
Hips/thighs/buttocks	57%	57%
Knees	29%	29%
Ankles/feet	43%	43%

6.2.14.2 Discussion and Conclusions

Musculoskeletal discomfort (of varying causation) was common among this group of dry table workers. The finding that only one worker did not have an old or recent significant injury reinforces efforts to reduce manual handling risk factors so that 'less resilient' workers can sustain employment. Conversely, this work system could interpreted to be satisfactory, as these 'less resilient' workers have sustained work task performance (see 'Training' in 6.2.1.2 and 'Lifting Strength' in 6.2.4.2).

6.2.15 Manual Handling Risk Score

6.2.15.1 Results

The Manual Handling Risk Score (ACC/OSH 2001) was completed for the timber pulling/stacking task (Appendix 8). Load Scores of 1 (men) and 2 (women) were estimated for shorter/smaller board sizes, and for larger/longer board sizes 4 (men) and 10 (women) were estimated. When these Load Scores were combined with Posture, Work Conditions and Environment, and Time Scores they resulted in total Manual Handling Risk Scores of 48, 56, 72 and 120 for the pulling/stacking task. All these scores are in the *'50+'* category, suggesting that *'injuries are likely regardless of the strength and fitness of employees. Elimination of the task or workplace redesign is a priority'.*

6.2.15.2 Discussion and Conclusions

Manual Handling Risk Scores indicated that pulling timber at this dry table was a task in which *'injuries are likely regardless of the strength and fitness of the employees'*. This result further verified the need to consider all manual handling risk factors and determine risk reduction strategies.

6.3 Intervention Recommendations

A list of intervention recommendations for Mill 17 was developed based on the assessment findings and with consideration of other findings from all mills in the study (two North Island and two South Island). The recommendations were prioritised according to their perceived impact on reducing the incidence and severity of musculoskeletal disorders for timber handling at this dry table. The intervention recommendations were provided in a package of information to the mill. The three documents provided in the package were:

- Summary of Assessment Findings (Appendix 9)
- Recommendations for Reduction of Manual Handling Risks (Appendix 9)

- Prioritised Recommendations (summary)

A number of recommendations relating to the configuration of the timber transfer workspace (table, trolleys, packet placement, fillet stick storage etc) were developed to address the various means of reducing the forces involved when handling and transferring timber. The recommendations are suggested starting points for further refinement through trials, and require operational verification before the actual heights and ranges can be determined as suitable. Recommendations are also made for addressing various workstation design factors, work speed, manual handling hazard identification, gloves, training, maintenance issues, flooring and lighting.

The recommendations were intended to provide a basis for further discussion, trials and decision-making relevant to each area, with researcher assistance as required. It was hoped that the mill would then adopt and complete a number of the suggested actions, such that the effectiveness of the interventions in reducing musculoskeletal risk factors could later be evaluated. This ongoing work with the mill, including specific re-assessment, was however outside of the scope of this Master's thesis project. Brief notes on intervention application and other outcomes from the larger COHFE project are provided in Appendix 10.

Recommendation 1 Table height to top of chains/rollers should be 920 mm if a fixed height table. An adjustable table height would however be ideal. The range could be between 785 and 1045 mm (based on 2.5th percentile female and 97.5th percentile male elbow heights (plus footwear allowance and minus 200 mm elbow clearance).

Recommendation 2 Removal of cleats from the first, fourth, sixth and seventh chains.

Recommendation 3 Remaining cleats to be reduced in height to 20 – 30mm.

Recommendation 4 Reduction of rail height. Ideally this will be to the same height as the top of the table/chain, but this will be dependent on cleat adjustments made.

Recommendation 5 Incline the table bed. (The degree of tilt would require trial).

Recommendation 6 Timber should overhang the table edge by 750 - 1000mm.

Recommendation 7 Review the overall functions and operations at the unloader. This may include different configurations of rollers/roller speeds to move timber forward and then onto the chain.

Recommendation 8 That tables be designed to minimise the horizontal pull force to move timber from table to packet. This appears to be reduced most significantly by the use of a roller chain system.

Recommendation 9 The distance between the timber end as it rests on the table to the end of the packet should be 1100-1400 mm.

Recommendation 10 The overall height of the second to last layer of timber in the packet (therefore the height to which the last layer is lifted to) should be 920mm – the same as the recommended table height.

Recommendation 11 Consider lowering the trolley height or using height adjustable scissor lifts to allow the total packet height (to top of second to last layer) to be equal to or less than the table height.

Recommendation 12 Decrease the overall height of the timber packets (make them wider and shorter), to decrease the height stacked too.

Recommendation 13 Use a 'landing pad' on the trolleys/bearers to bounce the timber along to reduce the effort required for positioning the first layer of timber.

Recommendation 14 That packet width plus 1020mm (elbow span for 95^{th} percentile male) is considered the minimum for packet/trolley spacing.

Recommendation 15 That for packets where two workers consistently work together, that the overall lateral workspace requirement is packet width plus 2 x 1020mm (elbow span for 95^{th} percentile male).

Recommendation 16 That for situations where one worker stacks timber onto two or more adjacent packets, that the overall lateral workspace requirements should include a minimum of 610mm clearance each side of the outside packets (so 1020mm space to the next packet as both workers must have clearance). For between packet spacing, if the total packet height on the trolley is less than 980mm the between packet clearance should be 550mm. For between packet spacing where the total packet height on the trolley is above 980mm, the between packet clearance should be 620mm.

Recommendation 17 That the position of the step at the pit-stacker is modified to allow the pit-stacker operator to get closer to the timber that is coming off the chain and therefore to avoid over-stretching.

Recommendation 18 That the pit stacker machinery be modified to allow narrower timber packets to be stacked closer to the table end, thus reducing the transfer distance.

Recommendation 19 That trolleys be modified to reduce the risk of tipping when being pushed out with a full packet. This will require lengthways stabilisation.

Recommendation 20 That trolleys be modified to provide a 'landing pad' to reduce the distance and leverage forces required for throwing/placing the first row of timber. This may need to drop away to allow the crane to pick up the packet.

Recommendation 21 Determine the table speed that is appropriate for key tasks (various timber types/dimensions) and develop a method of controlling this via a 'speed indicator' control. Consciously consider work pace/table speed as a factor in manual handling risk management.

Recommendation 22 Determine the maximum sustainable and effective work pace for the timber grader, as this is most likely to limit the overall table speed.

Recommendation 23 That fillet stick holders are modified so that fillet sticks are stored within easy reach.

Recommendation 24 That gloves are provided that have good fit and protection suitable for all workers.

Recommendation 25 That key safe work methods for pulling and stacking timber are covered at induction followed by buddy training with an experienced and skilful operator. Consider use of a training video highlighting key work methods and techniques.

Recommendation 26 That manual handling risk factors are clearly identified in the health and safety manual and task description documents pertaining to this work area. Use of the ACC WorkSmart Back Plan and related documents including the manual Handling Hazard Control Record may assist with this process.

Recommendation 27 That an even flooring surface across the trolley railings be installed.

Recommendation 28 That lighting levels are increased to 750 lux for the area immediately in front of the grader. This may be achieved by altering the position of the mirror used for tally purposes or the addition of another light source.

Recommendation 29 That the issue of airborne fillet sticks/parts of fillet sticks at the unloader is reviewed and appropriate actions taken.

Chapter 7 Discussion

7.1 Accident Register Survey

An industry survey of accident register data identified several timber handling tasks within sawmilling with a high incidence of MSD injuries. This corresponded with results from the 'Best Guesses' section of the industry survey that asked mill personnel which areas they believed were most likely to cause MSD injuries. Tasks highlighted from both aspects of the survey were the pulling and stacking of timber from the green or dry chains or tables, filleting related tasks, and various timber grading and sorting activities (Tappin, Edwin and Moore, 2002).

The work systems of the green or dry table of two South Island sawmills were assessed to identify the manual handling risk factors. Results from each mill have been discussed in detail in Chapters 5 and 6. The analyses lead to the development of mill specific recommendations to address a range of manual handling risk factors for timber handling. Consideration of the results of each mill together allows the following discussion.

7.2 Development of Recommendations - Layout

Details of the findings that were synthesised in the development of the mill-specific recommendations have been given previously in the 'Discussion and Conclusions' sections of Chapters 5 and 6. This atypical reporting style has been used in an effort to reduce the confusing and tedious repetition of each of the 15 methods for each case study mill, which would be expected in conventional research report formats. Thus this chapter contains summary and discussion of the *categories of recommendations* that were specified for each case study mill. This provides order to, and simplifies the multiplicity of information presented in the case studies. General 'discussions' topics follow these sections.

7.3 Identified Risk Factors

The groups of identified timber handling risk factors are discussed by Edwin et al (2002) and Tappin et al (2003), and include: workspace geometry changes, workflow management, task technique training, table design, glove design and other factors. The recommendations made for each mill (a total of 29 for Mill 17, and 23 for Mill 12) are discussed under these general categories.

Mills were encouraged to put in place interventions across a range of the areas for optimal outcomes, as suggested by Karsh et al (2001), whom indicate that the most successful means of reducing manual handling injuries is via the application of multiple factor interventions.

7.3.1 Workspace Geometry Changes

The height, size, spacing, and relationship of equipment/plant to the worker are key factors in the making manual timber handling tasks physically easy. The goal is to work using low force, mid-range movements and comfortable actions in an environment that suit all users.

- It was recommended that the height to the top of the chains or rollers be 920 mm, to cater to elbow height (minus 200 mm elbow clearance, plus footwear allowance) for the 2.5^{th} percentile female to the 97.5^{th} percentile male. Whilst adjustable table heights for each worker (between 785 and 1045 mm) would be ideal, this appeared largely impractical. This chain/table height also applies to any rails or rollers that are used for the reduction of friction when sliding the timber from the table onto the packet.
- Timber should overhang the table edge by 750-1000 mm, to enable the worker to grasp it from a variety of positions and close to the body with ease. This overhang also places the centre of gravity of the board nearer the table edge, so that less effort is required to slide the board (going with gravity) onto the packet.

- The distance from the end of the timber as it rests on the table, to the packet end should be between 1100 and 1400 mm. Thus not so small that movement is cramped and awkward, but not so large that additional 'carrying' of the board is required between table and stack.
- The height of the second to last layer of boards in the packet that timber is stacked onto should not be higher than the table/chain surface (recommended as 920 mm). Thus boards should never be moved up from the table against gravity. This requires packet dimension, trolley height and table height to be taken into account.
- Packet spacing should allow each worker to move comfortably without risk of bumping into other workers/boards, and without having to move further than is essential between packets if stacking to more than one packet.
    - For one worker per stack, packet spacing should be packet width plus 1020 mm (elbow span for 95th percentile male) as a minimum.
    - For two workers per stack, packet spacing should be packet width plus 2 x 1020 mm, thus 3240 mm.
    - For situations where a worker stacks to more than one packet, the packets should have between-packet space based on 95th percentile female hip breadth plus clothing allowance – thus 550 mm, and with elbow space allowed outside this (610 mm either side) to prevent collision with other workers/boards. If the packet height on the trolley is however greater than 980 mm (5th percentile female elbow height plus footwear allowance and minus 20 mm clearance) between-packet space should be 620 mm (95th percentile male bi-deltoid breadth plus clothing/movement allowance).
- Items such as fillet sticks should be stored within easy reach, and in such a way that the action of picking them up and restocking the

supply is not hazardous or time-consuming, and that they are easy to clean around.

- Trolleys (or other items used to stack the packets onto) should be of a height that allows the second to last layer of timber to be less than the height of the table/chain.
- Trolley design with a 'landing surface' to ease the throwing out of the first boards onto the stack should be considered, or other means of easing this first difficult throw.
- Trolleys should be maintained for ease of movement (good wheels).
- The floor surface should be clean and free of steps, other height differentials, and items that may trip the worker or reduce the effective floor space or cause them to reach further to grasp and stack timber.

7.3.2 Workflow Management

The system of rotation between the work stations should be organised so that all workers are clear about expectations. Staff skills must be taken into account when planning rotations. Efforts should be made to reduce peaks and troughs in timber flow.

- Heavy work (large timber dimensions) should be alternated with light work (small timber dimensions).
- Fast work should be alternated with slow work.
- Work tasks should be alternated for variety in physical actions.
- And mental/physical tasks should be alternated for workload balance.
- Rotation requirements should be formalised and included in induction programs so that all workers understand the reasons for rotating regularly.

7.3.3 Task Technique Training

Many factors contributing to good timber handling methods are not intuitive or 'common sense'. Safe and effective timber handling therefore requires specific training and education to ensure that workers are capable of performing work in the safest manner, know how to use the tools and devices that may assist, and do not develop bad work habits. This should include:

- The use of leather aprons to share the load of the arms with the lower limbs (allowing the board to slide on the apron across the upper thigh/hip, and using the thigh as a lever when handling boards).
- The use of leather aprons to protect body parts and clothing from injury/damage.
- Keeping the board as close as possible to the body.
- Working with wrists in neutral, and other joints in strong mid-range positions.
- Various methods of standing, grasping and moving the timber ('back-hand', 'fore-hand' etc), with attention to moving the legs rather than twisting/bending, smooth and rhythmic actions, and paced, steady work.
- Good induction training including buddy training with a skilled worker.
- There is also potential for industry initiatives with training videos/packages covering these points.

7.3.4 Table Design

The design of the table should be such that boards can be grasped easily and pulled from the table with minimal effort (reduced break-out force). This includes:

- Timber overhang from the table and table height as discussed above.

- The design of the chain that moves the timber along – particularly the friction inherent in the surface contacting the timber. The 'break-out' (initial) force required to move a board from the table was significantly lower with roller chains.
- If the chain has cleats that hold the timber as it is moved along the table, they should not have the effect of dragging the timber along the table as it is being pulled off. This is a function of cleat height and position on the chains, chain speed, trolley and packet height, packet distance from the table, and chain design for ease of pulling off. If the worker is able to pull the board quickly from the table, and the board can be tilted, freeing the far end from the cleats and to slide down onto the packet, cleats are not a problem.
- Table design with an inclined bed.
- Other low friction table edges/surfaces.
- Good table and chain maintenance is key to minimising the forces required for timber transfer from the chain to packets. Maintenance needs should be identified and communicated quickly, with action as soon as possible.

7.3.5 Glove Design.

Gloves should be of good fit for all hand sizes, of an appropriate design for the work task, and replacements should be readily available. Design should include appropriate reinforcing at key wear points for adequate splinter protection, whilst retaining adequate flexibility and grasp feedback.

7.3.6 Other Factors

Environmental factors include lighting adequate for the task (especially if timber grading is completed manually) and an environment where noise is managed effectively with appropriate PPE. The hazard identification system should include all relevant manual handling factors, and key safety factors for the area addressed.

7.4 Comparison with Other Research

It is standard convention to review research findings in light of other like research. However as literature review did not identify other field research investigating manual handling risk factors in sawmilling, this topic is essentially void.

Comparison can only be attempted between the findings of the accident register survey component of this study, earlier injury reporting from NZ, and injury reporting from the sawmilling sector in Canada.

NZ sawmill accident register records for a 12 month period accounted for a total of 505 MSD reports. Of these, the majority (56%) occurred to those in jobs classified as 'millhands' or 'tablehands'. Low back injuries accounted for 37% of the MSD reports, and injuries to the upper extremity accounted for 35.4%. Two Canadian sources (Workers Compensation Board of British Columbia, 1999, and Jones and Kumar, 2004) reported (for differing 5 year periods) 27% and 46.7% respectively, of sawmilling claims as overexertion or MSD claims. In British Columbia, 51% of sawmilling industry overexertion claims were to 'mill labourers' or 'labourer material handlers', thus apparently carrying out similar manual handling duties to NZ 'millhands' and 'tablehands'. Jones and Kumar (2004) (Alberta) reported that 45.5% of all sawmilling industry injuries were to the upper extremity, and 27.9% were bodily reaction/exertion in nature.

However whilst these sources all point generally to labouring or timber handling workers in sawmills, and overexertion or MSD complaints, and back and upper extremity complaints, no information is similar enough for direct comparison and it does not give further direction to this research project. It can only be hoped that future research will come available that allows some understanding of the NZ sawmilling industry issue within the context of international trends and findings. The vital role of the timber industry in countries such as Finland would indicate that comparative work could eventuate.

7.5 Limitations

The accident register survey had some limitations (Tappin et al, 2003). Data was only gathered from 11% of NZ mills, and this represented an estimated 38% of NZ sawmill workers. Data was collected for a period of only 12 months, and the method of sawmill selection may have created unknown bias in results. There were some difficulties consistently determining job classification and task definitions, and there were varied levels of detail in the records. Aggregation of the data resulted in some loss of detail. Data gathered does not provide frequency or severity rates, only incidences. The varied recording systems used may also have included non-work injuries with work injuries, or captured injuries that may have initially been recorded as work injuries, but on medical investigation had a change of status.

In carrying out the assessments, the impact of the researcher's presence may have altered the observed behaviours and activities. The small number of mills worked with is also a limitation of this study, in combination with a short period of assessment (only two days at each mill), and limited numbers of participants at each mill site. It was difficult to complete between mill comparisons given the small sample of mills worked with.

The significant limitations forced by the carrying out of research work within the context of a busy industrial environment must also be acknowledged. These 'action research' methods (personal communication, D. Tappin, 21 April 2004) demand a flexibility of approach and pragmatic methodologies that may sit uncomfortably in the 'scientific' category. Methods must be able to be modified to fit around unplanned events such as machinery breakdown; the researcher approach must be tactful in order to not upset key personnel whom still have a job to do; as many individuals as possible must be engaged in order to maximise the value from such participative approaches; highly efficient use of time is required – such as completing dimensional analyses whilst workers are taking a tea break; all whilst endeavouring to maintain optimally rigorous scientific method, and frequently whilst working alone. Such demanding research environments have the potential to create many inherent flaws in the quality of data gathered, but despite this the integration and aggregation of such findings allows progression toward research goals. The quality of this research project may have been aided by acknowledging such issues at the outset.

Further to these limitations of such 'action research', is the disadvantage forced by uncertain actioning of the recommendations by the mill. Thus testing of the suitability of recommended actions may never occur, so valuable feedback about the suitability of the original research methods may be entirely lost.

7.6 Future Work

Further work is indicated in determining the benefit of one timber handling work method over another, including the use of leather aprons and wrist braces, and timber throwing techniques. Of benefit also will be further work to refine the design of gloves to suit both green and dry timber handling tasks.

It is hoped that the mills involved will proceed with developing action plans around the recommendations made, such that the formalised repetition of some or all of these assessments at the mills will determine the effectiveness of the interventions in decreasing MSD risk and consequent injury (longitudinal study). Future review of injury records post intervention should be included.

Additional and similar studies in the areas of timber filleting (or stripping), and the work of sawyers and those 'tailing out' is also indicated.

Chapter 8 Conclusion

Sawmilling often requires workers to carry out manual handling of sawn timber, with consequent risk of MSD. The area with highest MSD injury incidence was timber handling from green and dry tables/chains, with reported upper extremity and back injuries occurring in equal numbers.

In the two mills studied, a battery of assessments to investigate the task, the workers, the load, the environment and management were carried out, and a range of manual handling risk factors identified. These included workspace geometry issues (such as the relationship of timber on the table to the packet, and packet spacing), workflow management (such as task rotations, and managing peaks and troughs in production) task technique training (such as throwing methods, induction training, and the use of leather aprons), table design (such as height, style of chain, and the nature of the chain/table surfaces), and glove design.

Identification of these risk factors lead to the development of intervention strategies for risk reduction. Recommended intervention strategies included height and design of the chain or table, packet spacing and distances between tables and packets, timber placement on the table, recommended work rotation practices and suggested timber handling methods, and were detailed specifically for each mill. The benefit of actioning multiple interventions (as suggested in a literature review by Karsh et al [2001]) for the reduction of MSDs was highlighted.

This study has met the aims as outlined in 1.1:

1) *Prevalence and nature of MSDs* An industry survey of accident register data identified and categorised MSD incidence in sawmilling.

2) *High risk tasks* The sawmilling tasks associated with MSDs. were identified, and sawmilling personnel detailed the tasks they believed featured in MSD causation.

3) *Manual handling risk factors* The task of timber handling at green/dry tables was consequently selected for detailed analysis. Work system assessments to measure and understand the range of manual handling risk factors (load, environment, people, task, management) resulted in the identification and quantification of multiple risk factors.

4) *Intervention strategies* Consideration of the risk factors allowed the development of intervention strategies to reduce MSD risks, formulated as recommendations to each of the mills in the study. Recommendations addressing the groups of risk factors were presented to each mill.

The opportunity for considerable future work exists. Longitudinal study with the same mills would allow reassessment to determine whether interventions were successful in achieving MSD reduction. More specific study could occur with specific timber handling methods and in other associated timber handling work areas.

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Appendices

Appendix 1

- COHFE letter to sawmills October 2001

COHFE
Centre for Human Factors and Ergonomics

8 October 2001

Dear

As I outlined to you in our recent telephone conversation, COHFE are carrying out PGSF funded research within the sawmill sector of the wood processing industry which aims to identify musculoskeletal disorder (MSD) risk areas, and then to design and evaluate methods for reducing the level of risk and subsequent injuries. Musculoskeletal disorders is a collective name for a range of conditions that affect muscles, tendons, bones and joints (including overuse syndromes and back injuries).

The first step in this process is to determine which tasks within the industry are being most problematic, by asking for Accident Register records for the last twelve months from a sample of approximately 55 sawmills around the country. We will then be going into selected plants to assess the commonly reported tasks, from which interventions will be developed that aim to reduce the risk of musculoskeletal disorders occurring.

The first accompanying sheet is for recording accident register reports for your sawmill. If it is easier to send us photocopies of your actual register entries (with the names of individuals removed or made illegible) then please feel free to do so. The second sheet asks for your best guesses of tasks in sawmilling most likely to lead to musculoskeletal disorders. So as not to make the task too onerous, we have asked for minimal detail, but please feel free to add as much information as you can. You are welcome to email, fax or post your responses to us, and please call us if there is anything you are not sure about.

All information received will of course be treated as confidential. The identity of individual sawmills will be known only to the researchers. By way of feedback, we will of course be happy to provide a summary of the overall 'league table' of tasks and injuries on request.

So that we can use the information you provide to us, we would very much appreciate that you return the completed forms by Wednesday 17th October 2001 to:

David Tappin (david.tappin@cohfe.co.nz) or
PO Box 300 540, Albany, Auckland or
Fax: 09 415 9028.

Thank you for participating in this project.

Yours sincerely,

David Tappin COHFE Ergonomist
Marion Edwin Ergonomist contracted to COHFE

AUCKLAND Building 69, Enterprise Centre, Massey University Campus. P.O. Box 300-540, Albany, Auckland. Telephone 09 415 9850 Facsimile: 09 415 9028
ROTORUA Forest Research Campus, Sala Street, Private Bag 3020, Rotorua. Telephone: 0800 737 327 Facsimile: 07 343 5528 www.cohfe.co.nz

Appendix 2

- Accident Register Records survey form
- 'Best Guesses' survey form

COHFE
Centre for Human Factors and Ergonomics

Musculoskeletal Disorders in Sawmills: Accident Register Records Survey

Please go through the Accident Register(s) at your sawmill and record the following details for each report entry for the 12 month period: **1 September 2000 to 31 August 2001**. All information will be treated as confidential. Only the researchers will know which records come from which sawmill. Thanks for your help.

Department	Job Title	Task (that the employee was doing)	Injury Type (tick one) Strain/sprain, MSD injuries	Cuts	Other (describe)	Body Part Affected	Date (of injury report)
Long table	e.g. Operator	pulling green wood off table	3			Right shoulder	2/11/00
Timber yard	Eg. Yard hand	strapping pallets		3		Palm of right hand	20/3/01
Sawshop	Eg. Saw doctor	saw maintenance			Scratch	Right eye	6/7/01

Photocopy more of these sheets as needed.

If you have any questions about how to fill in the form, or what we will do with the information once we get it, please contact David Tappin on: 09 415 9850 or Marion Edwin on: 03 312 7175. We would very much appreciate that you return the completed forms by Wednesday 17th October 2001 to: David Tappin david.tappin@cohfe.co.nz , or PO Box 300 540, Albany, Auckland, or Fax 09 415 9028

COHFE
Centre for Human Factors and Ergonomics

Musculoskeletal Disorders in Sawmills: Best Guesses

The idea of this form is to give people in the industry a chance to say where they think the problems lie nationwide.

From your own experience in the sawmilling industry, what would you consider to be the 5 tasks most likely to lead to musculoskeletal disorders at mills around the country? Also, what is it about each task that you feel makes it high risk?

Put the one you think most likely at the top (No. 1).

	Department	Job Title	Task	Why?
1				
2				
3				
4				
5				

Thanks for your help.

If you have any questions about how to fill in the form, or what we will do with the information once we get it, please contact: David Tappin on: 09 415 9850, or Marion Edwin on: 03 312 7175.

We would very much appreciate that you return the completed forms by Wednesday 17th October 2001 to:

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Appendix 3

- 'Best Guesses' full results
- 'Best Guesses' rating summary

Top Five 'Best Guesses' for cause of MSD in Sawmilling							
Task Description	**Mill No.**	**Rating 1**	**Rating 2**	**Rating 3**	**Rating 4**	**Rating 5**	**Reason**
Pulling timber/packeting/sorting/stacking - greenchain/long table/drymill/MSG/round table							
	12		1				Back sprains, wrong technique
	24	1					Repetitive use of upper body, Twisting of trunk and lower body
	25		1				Shoulder, back strain, exertion pulling timber if using poor techniques
	43	1					
	19	1					Timber heavy, have to move at speed. Twisting, turning pulling involved.
	37	1					Green timber heavy and high lifting
	37		1				Dry chain with repetitive turning motion
	13			1			Pulling, twisting
	23			1			Removing timber from round table, weight of timber and bending - back
	12	1					Wrist sprains, wrong technique
	29			1			Can be a problem if wrong techniques used
	45					1	Repetitive action with up to moderately heavy boards
	32	1					Traditionally classed as very heavy work. Some lumber, particularly big section wood, is very heavy
	34	1					Lifting, timber handling
	9		1				Movement of heavy timbers
	40	1					Lifting, twisting, pulling (green)
	40		1				Lifting,twisting, pulling (dry)
	4	1					Repetitive heavy lifting/turning/twisting
	33		1				Pulling, bending, twisting, lifting
	8	1					A variety of heights, weights and positions (of timber) bin sorter being installed Feb 2002
	3	1					Repeated heavy lifting
	45			1			Lug loader operator, pulling green timber to the zero line - pulling heavy boards while over-reaching
	10	1					Poor fitness, technique, body shape
	17	1					Heavy timber and twisting involved
	11	1					Heavy lifting, turning timber on a repetitive basis
	41b	1					heavy timber, job can't be mechanised
	22	1					heavy work
	17			1			Drychain lifting and twisting - back injuries
Timber grading and sorting - greenchain							
	32		1				Constant turning of the wrist as the boards are turned over
	23		1				Turning boards - wrist
	31		1				
	42		1				Constant turning and stacking of large/heavy boards
	4					1	Turning over timber, repetitive heavy lifting, turning, twisting
	36	1					Repetitive strain from turning boards
	40				1		Bending, lifting and pulling
	33				1		Repetitive turning of timber
	11					1	Heavy lifting, turning and twisting of timber on repetitive basis
	41b		1				heavy timber, speed of belt, grading, moving and stacking
	43		1				Grading and turning of timber
Stacker Operator - mechanical stackers							
	35		1				Rushing if understaffed, inexperienced
Timber grading and sorting - gang ripper table							
	35	1					Incorrect work method, training and experience
Stacking and filleting/defilleting timber - timber yard							
	43			1			
	31			1			
	29	1					Filleting heavy green timber with reaching, bending, twisting, levering of timber on repetitive basis all day
	24		1				Repetitive bending pulling and lifting
	33	1					Bending, twisting, lifting, pushing
	3		1				Repeated heavy lifting - resorting into stacks
	3			1			Repeated heavy lifting - stacking down timber
	7	1					Bending and twisting body a lot when restacking packs
	7			1			Twisting of body and pushing heavy trollies when sorting timber
	17		1				lifting and twisting
	16	1					Lifting and twisting
Cutting timber - sawmills							
	30		1				General heavy lifting, happens frequently
	16		1				Constant lifting of heavy timber
Horizontal vertical saw/resaw operations							
	8		1				Turning large, heavy flitches (hands free systme being installed)
	35					1	Walkways, steps split - many work levels
	17				1		feeding into resaw, lifting and twisting and heavy
	41b			1			feeding timber, large timber, feed in not automated
	11				1		Heavy lifting, turning and twisting of timber on repetitive basis
Strapping packs							
	17					1	bending twisting and repetitive

Docking saw operation/chopline - cutting timber to length and stacking							
	13				1		Working in stooped position
	9	1					Repetitive work
	2		1				Constant heavy lifting
	33			1			Bending stacking blocks
	35			1			OOS wrist, twisting/turning wrist
Headrig operators - realigning logs on log deck							
	49		1				Use of extended steel lever to realign logs with risk of back injury
Picking up and stacking shook - reman, tablehand							
	45		1				Repetitive task
	25	1					Repetitive grasping, bending, reaching etc, mostly wrist hand
Tailing out at breast bench/resaw/edger/other							
	23					1	Returning flitches to benchman - heavy task
	13	1					Pulling bending and twisting
	29		1				Stacking multiple pieces of green timber, reaching out to stack at height while handling more than one piece at a time
	4		1				Repetitive heavy lifting, turning, twisting, pulling timber at breast bench
	4				1		Repetitive heavy lifting, turning, twisting, pulling timber at resaw
	40			1			Feeding lumber into edger, heavy lifting a nd pulling
	2				1		Constant heavy lifting
	45	1					Green, heavy timber, often need to grab/move timber when over-reaching (3-way sorting of timber coming out of gang-edger)
	11		1				Heavy lifting, pulling, turning and twisting of timber on repetitive basis
	10		1				Poor fitness, technique, body shape
Benching/slabbing tasks at breast benches							
	13		1				Pulling bending and twisting
	23				1		Benchman grade sawing tasks with heavy flitches handled
	34		1				Lifting timber onto saw bench and conveying back and forth
	4			1			Repetitive heavy lifting, turning, twisting
	2				1		Constant heavy lifting
	7				1		Twisting of arms and wrists when feeding timber through saw
	11			1			Heavy lifting, turning and twisting of timber on repetititve basis
	19		1				Heavy timber - twisting, turning, pulling
Dressing timber/planers							
	45				1		Throwing timber off stacker infeed deck - twisting motion with moderately heavy boards
	3				1		Repeated heavy lifting
Gang ripper cutter, infeed/grading							
	42			1			Grading with constant turning of boards
	42	1					Infeed with constant turning/carrying/lifting action
Freeing jammed timber							
	42				1		Tugging, pulling etc
	8			1			Drop sorter operator freeing up jams, confined space (new mill with new system)
	30	1					Body strain, action happens frequently
General timber handling/yard work							
	36		1				Bending and lifting is not something that people do well' - tablehands, edger operators, graders
	29				1		Requires concentration, care and good technique
	2	1					Stacking timber, constant heavy lifting
	33					1	Repetitive bending, lifting, twisting, pushing and turning of timber
	41b					1	general machine operation and belt functions causes several 'nip' points
	9			1			Sprains and cuts due to inattention
Changing/working with heavy /awkward saws or other equipment - saw doctors/fitters							
	23	1					Continuous wrist action when hammering saws to tension
	49	1					Headrig, twin table, resaw operators lifting blades to change them, with risk of back injury and cuts
	32				1		Some aspects of this job require some awkward lifting and twisting/turning
	42					1	Handling awkward/heavy saws (headrig) in/out of awkward position
	36			1			Changing saws - awkward reaching positions
	36					1	Heavy awkward machinery, cause back problems when lifting and twisting for breakdown maintenance
	7		1				Heavy lifting and moving of machinery for repairs
	41b				1		Moving Equipment
	31	1					
Cabs							
	43				1		

Forklift/loader/Bell d[illegible]ng - timber yard							
	35				1		Uneven surfaces, incorrect method of getting on/off/seating
	40					1	Loading/unloading logs, sitting for long periods, bumping
	32			1			Strains due to sitting for long periods and bouncing around on the seat. With a sealed yard our problems are less than at some sites
Debarking	13					1	Shovelling/scraping away bark
Cleaning tasks	32					1	Working in confined spaces. Often stooped over or kneeling involves some awkward lifting
Walking - all of site	36				1		Most mills are built on multi-levels with lots of stairs, also lots of broken boards, fillets that people trip over - trips and falls during normal tasks
	25			1			Lots of sprained ankles, unevens surface etc
Notes: MSD's greatly reduced by 2 hrly rotations (35)							

Top Five 'Best Guesses' for cause of MSD in Sawmilling									
Task Description	**Rating 1**	**Rating 2**	**Rating 3**	**Rating 4**	**Rating 5**	**Total**	**Weighted Total**	**Comments Summary**	**No.**
Multiplier for weighting system	5	4	3	2	1				
Pulling timber/packeting/sorting/stacking - greenchain/long	16	6	5		1	28	120		
								Exertion required	3
								Wrong technique	5
								Repetitive	6
								Twisting, turning, pulling	12
								Timber heavy	12
								Paced work	1
								Lifting	7
								Bending	2
								Varying heights, weights, timber positions	1
								Poor fitness	1
								body shape	1
								Over-reaching	1
greenchain	1	6		2	2	11	35		
								repetitive wrist rotation turning boards	8
								stacking large/heavy boards	2
								heavy lifting	3
								turning,twisting	2
								bending	1
								pulling	1
Stacker Operator - mechanical		1				1	4	Rushing if understaffed, inexperienced	1
Timber grading and sorting - gang ripper table	1					1	5	Incorrect work method, training and experience	1
Stacking and filleting/defilleting timber - timber yard	4	3	4			11	44	heavy timber	1
								reaching	1
								bending	3
								twisting	6
								levering	1
								repetitive	2
								pulling	1
								lifting	5
								pushing	2
Cutting timber - sawmills		2				2	8	lifting heavy timber	2
Horizontal vertical saw/resaw		1	1	2	1	5	12	turning large heavy flitches	2
								multilevel work areas	1
								lifting & twisting	2
								feeding resaw	1
Strapping packs					1	1	1	bending twisting and repetitive	1
Docking saw operation/chopline - cutting timber to length and stacking	1	1	2	1		5	17	Working in stooped position	1
								Repetitive work	1
								Constant heavy lifting	1
								Bending stacking blocks	1
								OOS wrist, twisting/turning wrist	1
Headrig operators - realigning logs on log deck		1				1	4	Use of extended steel lever to realign logs with risk of back injury	1
Picking up and stacking shook - reman. tablehand	1	1				2	9	repetitive grasping, reaching, bending	2

Tailing out at breast bench/resaw/edger/other	2	4	1	2	1	10	34	Returning flitches to benchman	1
								Pulling bending and twisting	1
								Stacking green timber, reaching out to stack at height while handling more than one piece at a time	1
								Repetitive heavy lifting, turning, twisting, pulling timber at breast bench	1
								Repetitive heavy lifting, turning, twisting, pulling timber at resaw	1
								Feeding lumber into edger, heavy lifting a nd pulling	1
								Constant heavy lifting	1
								Green, heavy timber, often need to grab/move timber when over-reaching (3-way sorting of timber coming out of gang-edger)	1
								Heavy lifting, pulling, turning and twisting of timber on repetitive basis	1
								Poor fitness, technique, body shape	1
Benching/slabbing tasks at breast benches		3	2	3		8	24	Pulling bending and twisting	1
								Benchman grade sawing tasks with heavy flitches handled	1
								Lifting timber onto saw bench and conveying back and forth	1
								Repetitive heavy lifting, turning, twisting	4
Dressing timber/planers				2		2	4	Throwing timber off stacker infeed deck - twisting motion with moderately heavy boards	
								Repeated heavy lifting	
Gang ripper cutter, infeed/grading	1		1			2	8	Grading with constant turning of boards	2
Freeing jammed timber	1		1	1		3	10	Tugging, pulling etc	
								Drop sorter operator freeing up jams, confined space (new mill with new system)	
								Body strain, action happens frequently	
General timber handling/yard work	1	1	1	1	2	6	16	Bending and lifting is not something that people do well' - tablehands, edger operators, graders	
								Requires concentration, care and good technique	
								Stacking timber, constant heavy lifting	
								Repetitive bending, lifting, twisting, pushing and turning of timber	
								general machine operation and belt functions causes several 'nip' points	
								Sprains and cuts due to inattention	
Changing/working with heavy /awkward saws or other equipment - saw doctors/fitters	3	1	1	2	2	9	28	Continuous wrist action when hammering saws to tension	
								Headrig, twin table, resaw operators lifting blades to change them, with risk of back injury and cuts	
								Some aspects of this job require some awkward lifting and twisting/turning	
								Handling awkward/heavy saws (headrig) in/out of awkward position	
								Changing saws - awkward reaching positions	
								Heavy awkward machinery, cause back problems when lifting and twisting for breakdown maintenance	
								Heavy lifting and moving of machinery for repairs	
								Moving Equipment	
Cabs				1		1	2		
Forklift/loader/Bell driving - timber yard			1	1	1	3	6	Uneven surfaces, incorrect method of getting on/off/seating	
								Loading/unloading logs, sitting for long periods, bumping	
								Strains due to sitting for long periods and bouncing around on the seat. With a sealed yard our problems are less than at some sites	
Debarking					1	1	1	Shovelling/scraping away bark	
Cleaning tasks					1	1	1	Working in confined spaces. Often stooped over or kneeling. Involves some awkward lifting	
Walking - all of site			1	1		2	5	Most mills are built on multi-levels with lots of stairs, also lots of broken boards, fillets that people trip over - trips and falls during normal tasks	
								Lots of sprained ankles, unevens surface etc	
Notes: MSD's greatly reduced by 2 hrly rotations (35)									

Appendix 4

- Initial mill communication letter
- Mill management consent letter
- Mill employee information sheet
- Consent forms for employee and company

COHFE
Centre for Human Factors and Ergonomics

19 November 2001

(Employer Address)

Dear

Re: Musculoskeletal Disorders in the Sawmilling Industry

Further to your telephone communications with Marion Edwin (ergonomist) regarding the research currently being undertaken within the sawmilling industry, we provide the following information.

Background

COHFE[1], and before it LIRO, have long undertaken ergonomics, safety and health research in the New Zealand Forest Industry. Attention has focused almost exclusively upon silviculture and harvesting, in line with government objectives and industry concerns, while little or no research has considered health and safety risks for the wood processing sector. COHFE's current contract with the Foundation for Research Science and Technology (FRST) has however been realigned to include wood processing alongside our forest programme.

Anecdotally, we are aware of ergonomics, safety and health problems in the wood processing industry, particularly in the area of musculoskeletal disorders (strains/sprains, occupational overuse etc.), lacerations and slips trips and falls. This is further illustrated through a summary of ACC claims data (1994/5 – 1998/9)[2]. Health and safety concerns are however difficult to prioritise in the New Zealand industry as no one body collates injury and incident data to a sufficiently detailed level, and there is little or no New Zealand research that has sought to identify key risk factors for wood processing work.

[1] COHFE is a part of Forest Research, and has offices in Rotorua and Albany.
[2] Analysis of ACC Claims Data 1994/5 – 1998/9, Martin Laurs (2000).

Study Aims and Process

This study is concerned with identifying key musculoskeletal disorder risk areas in the sawmilling industry, and designing and evaluating methods for reducing the level of risk and subsequent injuries. Results from the recent accident register survey (based on data from the 37 mills that participated) indicate that the most problematic work areas appear to be work on the green (or dry) sorting table, and the variety of tasks requiring stacking, lifting, and handling of timber, including saw operations. Preliminary data analysis identifies back injuries as the most prevalent musculoskeletal injury at 37% of reported injuries, and shoulder, arm, wrist and hand problems combine to form a further 36% of injuries.

The next step in the study is for us to assess some of these tasks in a small sample of mills. This will involve spending some time on site observing, measuring, and speaking to staff involved in the tasks concerned. From this data we will then work with each of the mills to develop a range of possible interventions. These will then be honed by the participating sites and the researchers into a site-specific list. The researchers will work with each site on the implementation of the interventions and their effectiveness will be formally evaluated in the months following. As this is a government-funded study, the only commitment required of each mill will be a limited amount of staff time during the occasions when we are on site, and the costs of any interventions that the mills choose to adopt.

As with the survey data, all information collected will be treated confidentially. A summary of overall results from the study will be made available to the industry but with the participating mills remaining anonymous.

Request

As this is a national study, mills from both the South Island and the North Island have been selected for the on site work assessing the problem task areas, and developing, implementing and evaluating interventions. As discussed, we would like the opportunity to work with (mill name deleted for confidentiality) for this research, and seek approval for this to commence as soon as possible. David Tappin and Marion Edwin will begin this on-site work in the Canterbury/West Coast region on Wednesday 21 and Thursday 22 November. Following management approval to commence, we will be in contact to make more specific plans.

If you have any questions regarding the process and outcomes of this study, please contact either:

Marion Edwin (Ergonomist contracted to COHFE) 03 312 7175, mobile 025 626 1300, or
David Tappin (COHFE Ergonomist) 09 415 9850.

Yours sincerely

Marion J Edwin
Ergonomist contracted to COHFE

David Tappin
COHFE Ergonomist

AUCKLAND Building 69, Enterprise Centre, Massey University Campus, P.O. Box 300-540, Albany Auckland Telephone 09 415 9850 Facsimile 09 415 9028
ROTORUA Forest Research Campus, Sala Street, Private Bag 3020, Rotorua Telephone 0800 737 327 Facsimile 07 343 5528

COHFE
Centre for Human Factors and Ergonomics

25 February 2002

(employer address)

Dear

Musculoskeletal Disorders (MSD's) in Sawmills Research - Information

As per our contact of last year, we wish to continue the research we are carrying out within the sawmill sector, and to obtain your formal consent to continue with this research in your workplace.

COHFE is carrying out Public Good Science Fund (PGSF) funded research within the sawmill sector of the wood processing industry. As a part of this process, Marion Edwin, the South Island based ergonomist contracted to COHFE to complete this work, is also completing work towards a Masters in Ergonomics degree through Massey University. Marion's contact phone number is 03 312 7175 or 025 626 1300, email Marion.OT.Erg@xtra.co.nz, or postal via PO Box 38076, Christchurch). Marion's university supervisor for this work is Associate Professor Stephen Legg (Massey University, phone 06 350 5799 x 2786, email S.J.Legg@massey.ac.nz, or postal via Massey University, Private Bag, Palmerston North), and co-supervisor is David Tappin, the principal COHFE ergonomist working on this research project (phone 09 415 9850, email david.tappin@COHFE.co.nz, or postal via PO Box 300 540, Albany, Auckland).

The first step (completed last year) entailed the identification of MSD risk areas via an Accident Register Survey and data gathered from industry on suspected primary injury causes. This has determined that our target area is green/dry/machine stress grading/round table or chain tasks.

As discussed previously, COHFE now wishes to undertake a series of assessments in your mill to gather data on a wide range of factors and aspects of the work environment. This will include task completion methods, worker characteristics, forces required to move timber from the table/chain, plant design and layout, and worker comfort and effort whilst completing timber pulling and handling duties. This baseline data will allow the identification of aspects of the task that, for your mill, could be improved to reduce the musculoskeletal risks associated with the task.

The time required onsite for these initial assessments is estimated to be 1-2 days. While some of the data-gathering will require workers to be off-line for short periods of time to interact with the researcher/s and complete assessment tasks, other data gathering tasks are not disruptive, and others are carried out whilst they are working. Data gathering will take place via pencil and paper recording, worker interviews, video recordings of workers completing tasks for later analysis of movements, photographic recordings, and some physical assessments (strength tests) with employees. Individual employees will first be invited to participate, and their consent sought prior to participating in the study.

Following the initial assessment, ergonomists will identify a range of changes or modifications that may reduce MSD injury risks, and will then continue to work with your mill over several months to develop appropriate strategies to address these factors. It is hoped that a number of improvements that will enhance health and safety for your work area will result.

Further to the initiation of changes, further assessments (mid-2002) will be carried out to allow analysis of MSD risk factors in order to determine the overall benefit of any changes made. Whilst

the information gathered via this process we hope will be of immediate value to your mill, the sawmilling industry as a whole will benefit from the industry reports and recommendations that will result. Information regarding the factors that lead to MSD's in this high-injury industry will be identified, and a range of appropriate methods to reduce MSD risk factors outlined.

Throughout this process the identification of your sawmill as a participant in this study will remain confidential to the researchers. Results and reports that are published, and the thesis to be completed by Marion Edwin, will not identify your mill as a participant. The mills participating will simply be identified as 'South Island' or 'North Island' sawmills. All researchers/supervisors involved with this project will abide by the various confidentiality agreements that are in place between parties. Video tapes and photographs in which workers could be identified will not be used in any way other than as raw data for the researcher's use. All information/records will be held in secure premises.

We appreciate your making your work site and employees available to us for this study. We advise that you and your company retains the following rights:

- to decline to participate
- to refuse to answer any particular questions
- to withdraw from the study at any time
- to ask any questions about the study at any time during participation
- to provide information on the understanding that you/your company's name will not be used unless you give this permission to the researcher
- to be given access to a summary of the findings of the study when the study is concluded.

We therefore ask that you give your consent for your company's further participation in this research, as per the attached consent form. Employees will be given this information, invited to participate, and asked to sign similar consent forms prior to their participation.

Thank you for your time/your company's time on this research project to date. We look forward to continued fruitful work with you and your employees.

Yours sincerely

David Tappin COHFE Ergonomist

Marion Edwin Ergonomist contracted to COHFE

COHFE
Centre for Human Factors and Ergonomics

25 February 2002

Information Sheet

Musculoskeletal Disorders (MSD's) in Sawmills Research

Following our contact last year with your sawmill, we wish to continue the research we are carrying out within the sawmill sector, and to obtain your formal consent to participate in this research. The information given below explains the main aspects of the research project.

COHFE is carrying out Public Good Science Fund (PGSF) funded research within the sawmill sector of the wood processing industry. As a part of this process, Marion Edwin, the south island based ergonomist contracted to COHFE to complete this work, is also completing work towards a Masters in Ergonomics degree through Massey University. Marion's contact phone number is 03 312 7175 or 025 626 1300, email Marion.OT.Erg@xtra.co.nz, or postal via PO Box 38076, Christchurch). Marion's university supervisor for this work is Associate Professor Stephen Legg (Massey University, phone 06 350 5799 x 2786, email S.J.Legg@massey.ac.nz, or postal via Massey University, Private Bag, Palmerston North), and co-supervisor is David Tappin, the principal COHFE ergonomist working on this research project (phone 09 415 9850, email david.tappin@COHFE.co.nz, or postal via PO Box 300 540, Albany, Auckland).

The first step of this research work (completed last year) entailed the identification of MSD risk areas via an Accident Register Survey and data gathered from industry on suspected primary injury causes. This has determined that our target area is green/dry/machine stress grading/round table or chain tasks.

COHFE now wishes to undertake a series of assessments in your mill to gather data on a wide range of factors and aspects of the work environment. This will include task completion methods, worker characteristics, forces required to move timber from the table/chain, plant design and layout, and worker comfort and effort whilst completing timber pulling and handling duties. This baseline data will allow the identification of aspects of the task that, for your mill, could be improved to reduce the musculoskeletal risks associated with the task.

The time required onsite for these initial assessments is estimated to be 1-2 days. While some of the data-gathering will require workers to be off-line for short periods of time to interact with the researcher/s and complete assessment tasks, other data gathering tasks are not disruptive, and others are carried out whilst you are working. Data gathering will take place via pencil and paper recording, worker interviews, video recordings of workers completing tasks for later analysis of movements, photographic recordings, and some physical assessments (strength tests) with employees. We invite all table/chain employees to participate, and seek your consent to do so prior to participating in the study.

Following the initial assessment, ergonomists will identify a range of changes or modifications that may reduce MSD injury risks, and will then continue to work with your mill over several months to develop appropriate strategies to address these factors. It is hoped that a number of improvements that will enhance health and safety for your work area may result.

Further to the initiation of changes, further assessments (mid-2002) will be carried out to allow analysis of MSD risk factors in order to determine the overall benefit of any changes made. Whilst the information gathered via this process we hope will be of immediate value to your mill, the sawmilling industry as a whole will benefit from the industry reports and recommendations that will result. Information regarding the factors that lead to MSD's in this high-injury industry will be identified, and a range of appropriate methods to reduce MSD risk factors outlined.

Throughout this process the identification of you, and your sawmill as a participant in this study will remain confidential to the researchers. Results and reports that are published, and the thesis to be completed by Marion Edwin, will not identify you or your mill as a participant. The mills participating will simply be identified as 'South Island' or 'North Island' sawmills. All researchers/supervisors involved with this project will abide by the various confidentiality agreements that are in place between parties. Video tapes and photographs in which workers could be identified will not be used in any way other than as raw data for the researcher's use. All information/records will be held in secure premises.

We appreciate the time and information that you make available to us for this study. We advise that you retain the following rights:

- to decline to participate
- to refuse to answer any particular questions
- to withdraw from the study at any time
- to ask any questions about the study at any time during participation
- to provide information on the understanding that your name will not be used unless you give this permission to the researcher
- to be given access to a summary of the findings of the study when the study is concluded.

We therefore invite you to participate, and ask that you give your consent for your further participation in this research, as per the attached consent form.

Thank you for your time on this research project to date. We look forward to continued fruitful work with you.

Yours sincerely

David Tappin COHFE Ergonomist

Marion Edwin Ergonomist contracted to COHFE

COHFE
Centre for Human Factors and Ergonomics

MUSCULOSKELETAL DISORDERS IN SAWMILLS RESEARCH

Consent Form (Employee)

I have read the Information Sheet and have had the details of the study explained to me. My questions have been answered to my satisfaction, and I understand that I may ask further questions at any time.

I understand I have the right to withdraw from the study at any time and to decline to answer any particular questions.

I agree to provide information to the researcher on the understanding that my name will not be used without my permission. (The information will be used only for this research and publications arising form this research project).

I agree/do not agree to the use of video recording for the purpose of worker movement analysis and understanding of the functions of the table/chain work area being investigated.

I agree/do not agree to the use of photographic recording for the purpose of worker movement analysis and understanding of the functions of the table/chain work area being investigated.

I agree to participate in this study under the conditions set out in the Information Sheet.

Signed: ______________________________

Position: ______________________________

Name: ______________________________

Date: ______________________________

COHFE
Centre for Human Factors and Ergonomics

MUSCULOSKELETAL DISORDERS IN SAWMILLS RESEARCH

Consent Form (Company)

I have read the Information Sheet and have had the details of the study explained to me. My questions have been answered to my satisfaction, and I understand that I may ask further questions at any time.

I understand that I/my company have the right to withdraw from the study at any time and to decline to answer any particular questions.

I/my company agrees to provide information to the researcher on the understanding that my/my company's name will not be used without my permission. (The information will be used only for this research and publications arising form this research project).

I agree/do not agree to the use of video recording for the purpose of worker movement analysis and understanding of the functions of the table/chain work area being investigated.

I agree/do not agree to the use of photographic recording for the purpose of worker movement analysis and understanding of the functions of the table/chain work area being investigated.

I agree to participate in this study under the conditions set out in the Information Sheet.

Signed: ______________________________

Position: ______________________________

Name: ______________________________

Date: ______________________________

Appendix 5

- Worker interview worksheet
- Dynamometer calibration report
- Discomfort Rating Scale
- Manual Handling Hazard Control Record

13. Worker Interview, Anthropometric Data, Strength Measurement

Date: Mill Number:

Name: Identifying number:

1. Date of birth __/__/__
2. Gender (circle) Male Female
3. Weight ________
4. Height ________
5. Handedness (circle) Right Left Ambidextrous (both hands equally)
6. Job title ______________________________
7. How long have you been working in this job, at this work site
   Years ____ Months ____ (Weeks ____)
8. Have you worked elsewhere doing similar work? (circle) Yes No
9. Total length of time doing similar work before starting at this site? (circle)
   Months 1-2 Years 3-4 Years 5-9 Years 10 years or more
10. On average, how many hours a week do you work (including overtime but excluding main meal break)? ________ hours
11. Nutrition/Drinks Breakfast

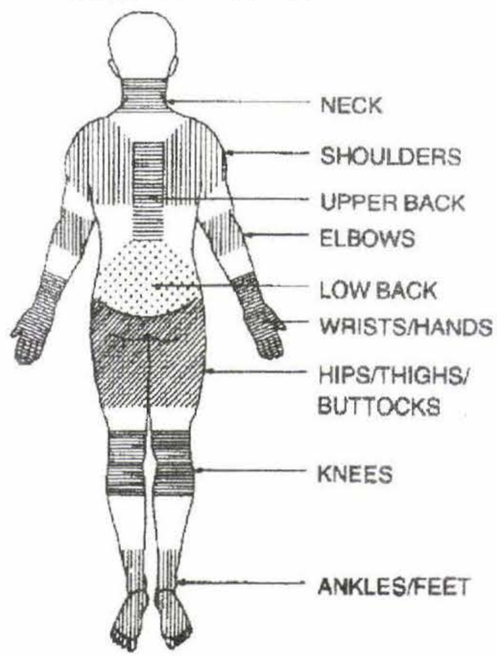
    Lunch/snacks

    Dinner
12. PPE used vs preferred, comments:
13. Easiest/hardest work tasks, comments:
14. Training - key factors, comments:
15. Rest breaks/fatigue, comments:
16. Improvements to design/function of table, comments:

Body Map

Have you at any time during the last 12 months had trouble (such as ache, pain, discomfort, numbness) in:	Have you had trouble during the last 7 days:	During the last 12 months have you been prevented from carrying out normal activities (e.g. job, housework, hobbies) because of this trouble:
1. Neck No [ ] Yes [ ]	2. Neck No [ ] Yes [ ]	3. Neck No [ ] Yes [ ]
4. Shoulders No [ ] Yes [ ] right Yes [ ] left Yes [ ] both	5. Shoulders No [ ] Yes [ ] right Yes [ ] left Yes [ ] both	6. Shoulders No [ ] Yes [ ]
7. Elbows No [ ] Yes [ ] right Yes [ ] left Yes [ ] both	8. Elbows No [ ] Yes [ ] right Yes [ ] left Yes [ ] both	9. Elbows No [ ] Yes [ ]
10. Wrists/hands No [ ] Yes [ ] right Yes [ ] left Yes [ ] both	11. Wrists/hands No [ ] Yes [ ] right Yes [ ] left Yes [ ] both	12. Wrists/hands No [ ] Yes [ ]
13. Upper Back No [ ] Yes [ ]	14. Upper Back No [ ] Yes [ ]	15. Upper Back No [ ] Yes [ ]
16. Lower Back No [ ] Yes [ ]	17. Lower Back No [ ] Yes [ ]	18. Lower Back No [ ] Yes [ ]
19. One or both hips/thighs/buttocks No [ ] Yes [ ]	20. One or both hips/thighs/buttocks No [ ] Yes [ ]	21. One or both hips/thighs/buttocks No [ ] Yes [ ]
22. One or both knees No [ ] Yes [ ]	23. One or both knees No [ ] Yes [ ]	24. One or both knees No [ ] Yes [ ]
25. One or both ankles/feet No [ ] Yes [ ]	26. One or both ankles/feet No [ ] Yes [ ]	27. One or both ankles/feet No [ ] Yes [ ]

NB: Body sections are not sharply defined and certain parts overlap. You should decide for yourself which part, (if any) is, or has been, affected.



Anthropometric Data (+/- 5mm)

Gender M F
Est. ethnicity Eur Mao PI
Hand R/L/A
Age -
Footwear -

Stg Eye Ht -
Stg Shoulder Ht -
Stg Elbow Ht -
Stg Hip Ht -
Stg Knuckle Ht -
Span -
Bideltoid Width -
Acrom Grip Lgth -
Hand Lgth -
Hand Brdth -

Dynamometer Data (pull upwards gradually)

Arm lift (Chain with elbow at 90, hold under)
1 ____
2 ____
3 ____

Torso lift (Chain 1st link, heels off back 38)
1 ____
2 ____
3 ____

Leg Lift (Chain 1st link, heels at 0, feet out)
1 ____
2 ____
3 ____

Independent Scales Ltd

100a Hayton Road
P.O Box 8098
Christchurch
Tel: (64) (3) 338-4384
Fax: (64) (3) 338-2275
(025) 325607
independentscales@clear.net.nz

ISO 9002 SGS

Client	Optimise Limited	**Make/Model**	JAMAR Dynmometer
Address	P O Box 38076	**Serial #**	12890238
	CHRISTCHURCH	**TMU #**	Not Applicable
Phone	03-3127175	**Capacity**	300kg
Location		**Tare Capacity**	Not Applicable
Contact	Marion Edwin	e=1kg	Class IIII

Checks & tests	**P**	**F**
Zero	✓	
Discrimination	N/A	
Sensitivity	N/A	
Price Comp	N/A	
Verification mark	N/A	

Repeatability	**40/60% 150kg**	**90/100% 300kg**
Test 1	150kg	300kg
Test 2	150kg	300kg
Test 3	150kg	300kg
Test 4		
Test 5		
Test 6		

Eccentricity or Rolling Test

P	*F*	*P*	*F*
	N/A Kg		
P	*F*	*P*	*F*

Weights

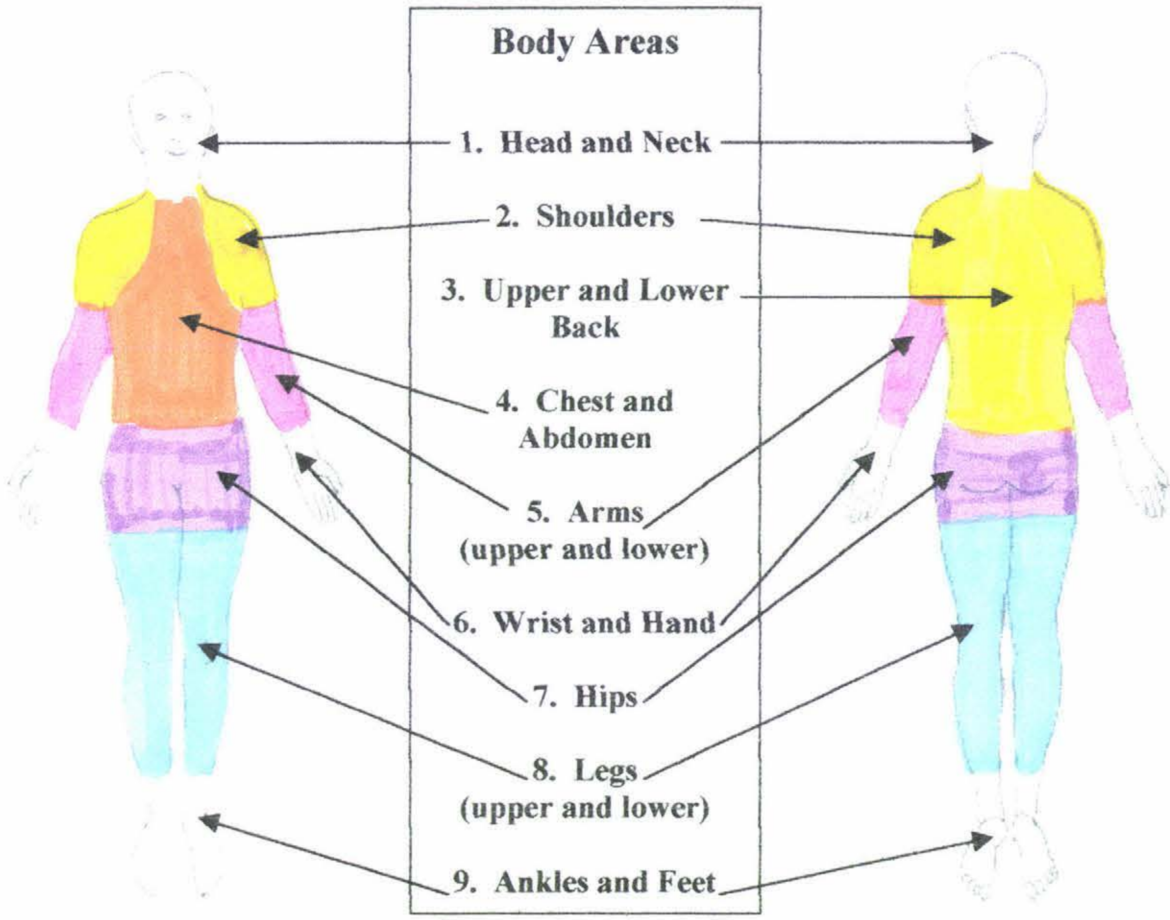
Test Loads	Test Weight ID	Test Weight Kg	Indicated Weight Kg	Error	P	F
Min Cap	105	10kg	10kg		✓	
Chg in MPE	Trailer Set	50kg	49kg	- 1kg	✓	
Chg in MPE		200kg	200kg		✓	
Max Cap		300kg	302kg	+ 2kg	✓	
		150kg	150kg		✓	
		100kg	100kg		✓	
		250kg	251kg	+ 1kg	✓	

Comments

Stamped		Date Start	22/02/02
Certified		Date Next Due	22/02/03
Non Complying			
Non Trade	6925		

Signature [signature] Date Finish 22/02/02 Job # 7201

Discomfort Rating Scale



Comfort Ratings

How do you rate the comfort of your (see above) **body area?**

1	2	3	4	5
Very Comfortable	Comfortable	Acceptable	Uncomfortable	Very Uncomfortable

Manual Handling Hazard Control Record

Task Details

1 Task name:
………………………………………………………

Area: ……………………………………………………………

Assessor: …………………………………………………

Date of assessment: ………/………/……..

Others consulted:
……………………………………………

…………………………………………………………………
.

2 Sketch with dimensions (Optional)

3 Record the results of your:

Review of the company records: (e.g. hazard register, accident investigations, early reports of discomfort)

…………………………………………………………………
.

…………………………………………………………………
.

…………………………………………………………………
.

…………………………………………………………………

…………………………………………………………………
.

…………………………………………………………………
.

Consultation with employees: (Talk to the people who do the task or who were injured doing it; get them to mime the task actions.)

…………………………………………………………………

…………………………………………………………………

…………………………………………………………………

…………………………………………………………………

…………………………………………………………………

Observation of the manual handling task: (Watch the employees doing the task, video the task. Describe the manual handling aspects of the task by writing down its steps.)

…………………………………………………………………

…………………………………………………………………

…………………………………………………………………

…………………………………………………………………

…………………………………………………………………

…………………………………………………………………

…………………………………………………………………

Task duration or cycle time:……………………………

Number of repetitions per shift: ……………………….

Forces exerted (per cycle) e.g. Lifting 16kg bags, pushing with a force of 20kg for 3 metres. ………………………………

…………………………………………………………………

Hazard Identification

4 Are any of these factors present in the task?

	No	Yes
Twisted, stooped, awkward, asymmetrical postures	❑	❑
Fixed, sustained, rigid, prolonged postures	❑	❑
Unvaried, repetitive movements	❑	❑
Sudden, uncontrolled or jerky movements	❑	❑
Handling or reaching away from the body	❑	❑
Using high or sustained force	❑	❑
Handling heavy or awkward loads	❑	❑
Whole body vibration or upper limb vibration	❑	❑
Handling that goes on for too long without a break	❑	❑

5 Is one or more of the boxes in Question 4 ticked 'Yes'?

Yes ❑ **go to Questions 7 – 11 and find the risk score for the task**

No ❑

6 If there is no evidence that there is hazardous manual handling, stop here. Review again according to your hazard review schedule.

Sign off - Name: ……………………

Date: ……./……../……..

Risk Score

7 Find the load score: The load score is the muscle force applied by the worker. It may be the weight of the object handled or you may need to measure the forces applied with a spring balance or a force gauge – or make an estimate. If several people do the task, the score should reflect the ability of the least able.

Men	Women	Load Score
< 10 kg	< 5 kg	1
10 – 19 kg	5 – 9 kg	2
20 – 29 kg	10 – 14 kg	4
30 – 39 kg	15 – 24 kg	7
40 +	25 +	10

Report the Load Score here → [ ] A

8 Find the posture and workplace layout score: Observe the postures adopted. Take an average value if necessary or use numbers between the ones shown.

	Posture Score
Trunk upright, no twisting, load close to body, standing or walking a few steps only.	1
Some bending forward or twisting, load close to body, sitting, standing or walking for a longer distance.	2
Bending far forward or close to the floor, slightly bending and twisting the trunk, load far from the body or above shoulder height, sitting or standing.	4
Bending far forward and twisting the trunk, load far from the body, below the knees or above shoulder height, unstable posture while standing, crouching or kneeling.	8

Report the Posture/Workplace Layout Score here → [ ] B

9 Find the work conditions and environment score:

	Environment Score
Good conditions, with sufficient space, no obstacles, level and solid floor surface, good lighting, able to get a good grip on the load.	0
Restricted workspace (area < 1.5 m^2), restricted postural stability (floor uneven, soft, slippery, steeply sloping).	1

Report the Environment Score here → [ ] C

10 Find the time score: Find the time score from the greatest of either the number of repetitions of the task or the time spent doing it during the shift.

Repetitions per shift	Total time per shift	Time Score
< 10	< 30 min	1
10 – 40	30 min – 1 hr	2
40 – 200	1 – 3 hrs	4
200 – 500	3 – 5 hrs	6
> 500	> 5 hrs	8

Report the Time Score here → [ ] Time

Add the three scores in boxes A, B and C → Sum [ ]

11 Multiply box **'Sum'** by box **'Time'** to get the risk score. → [ ]

Decide the significance of the Risk Score. Follow the arrow and consult the table. If the risk score is 10 or more you should carry out the Contributory Factors Assessment at question 12.

Less than 10 ❑ Complete question 6 and you are finished, **unless** there is the risk that a single high force action could cause harm.

10 or more ❑ **Complete the remainder of this checklist.**

Contributory

12 Tick any contributory factors that are present in the task. Transfer each factor that you tick to Question 13. For example, if you ticked 'Handling over long distances', write 'T3' in Column A of Question 13. See the pages listed in the Code of Practice for Manual Handling for solutions for each factor.

A Load (Solutions page 29)

- L1. Heavy loads handled/high forces required ❑
- L2. Bulky, unwieldy ❑
- L3. Unpredictable ❑
- L4. Uneven in weight distribution ❑
- L5. Unstable or unbalanced ❑
- L6. Blocks vision ❑
- L7. Difficult to grip, greasy, slippery ❑
- L8. Handle size, position or shape ❑
- L9. Very hot or cold, or hazardous ❑
- L10. Person or animal ❑
- L11. Sharp edges ❑
- L12. Other ❑

B Environment (Solutions page 30)

- E1. Floor slippery, uneven or cluttered ❑
- E2. Area slopes or has steps ❑
- E3. Hot, cold, humid, outdoors, windy, wet ❑
- E4. Poor air quality ❑
- E5. Noisy ❑
- E6. Poor lighting, glare, gloomy ❑
- E7. Insufficient or confined space ❑
- E8. Other ❑

Guidance on the Meaning of the Risk Score

Risk Score	*Urgency and type of control measure*
< 10	**Injuries are unlikely unless there are infrequent high force actions. Monitor the task from time to time.**
10 - 24	**Injuries may result for less resilient people. Workplace re-design is recommended for them.**
25 - 49	**Injuries are possible for trained and fit people. Workplace re-design is recommended to control the contributory factors identified.**
50 +	**Injuries are likely regardless of the strength and fitness of employees. Elimination of the task or workplace re-design is a priority.**

Factors Assessment

C People (Solutions page 30)

- P1. Too few staff to do the work ❑
- P2. Low skill, untrained, new ❑
- P3. Low strength or fitness ❑
- P4. Special considerations ❑
- P5. Inappropriate footwear, clothing or personal protective equipment ❑
- P6. Less resilient people ❑
- P7. People work by themselves ❑
- P8. Fatigued ❑
- P9. Poor employee commitment to health and safety ❑
- P10. Other ❑

D Task (Solutions pages 30-32)

- T1. Large horizontal/vertical reaches ❑
- T2. Reaching above shoulder or below mid-thigh ❑
- T3. Handling over long distances ❑
- T4. Repetitive movements with no or few breaks ❑
- T5. Awkward, twisted or restrained postures ❑
- T6. Freedom of movement restricted ❑
- T7. Unpredictable, fast or unexpected movements ❑
- T8. Uncontrolled/invariable work pace ❑
- T9. Standing for a long time ❑
- T10. Handling in a seated position ❑
- T11. Squatting, kneeling or crouching ❑
- T12. Handtools are poorly designed ❑
- T13. Handling requires two or more people ❑
- T14. Mechanical handling aids used without training ❑
- T15. Personal protective equipment, special clothing or footwear makes task awkward ❑
- T16. Vibration ❑
- T 17. Other ❑

E Management (Solutions pages 32-33)

- M1. Insufficient rest breaks ❑
- M2. Involves piece work or other incentive schemes ❑
- M3. Job involves shift-work and/or unsociable hours ❑
- M4. Too few staff if busy, sickness, deadlines ❑
- M5. Poor maintenance of tools, equipment, etc. ❑
- M6. Staff are not involved in the selection, purchase or trialing of equipment ❑
- M7. Poor organisational communication ❑
- M8. Communication is compromised because people are separated by distance, protective equipment or by working in a confined space ❑
- M9. Task organisation ❑
- M10. Health and safety are not important to the company ❑
- M11. Other ❑

Controls

13 In Column A, write the number of each contributory factor you ticked in Question 12. Indicate the importance of the factor by circling one of Low, Medium or High in Column B. Write controls in Column C (one to each row) and estimate their cost and impact in Columns D and E. Circle Yes or No in Column F to indicate whether or not the control measure will be actioned. Use a separate sheet if necessary.

A. Link to Contributing Factor	**B. Risk** (Low, Medium or High)	**C. Controls:** What are the possible solutions for controlling this risk posed by this factor? Transfer the control number to Column A, Question 14, if you will action it.	**D. Cost of control** (Low, Medium or High)	**E. Impact of control** (Low, Medium or High)	**F. Action** Yes or No
	L M H	**1**	L M H	L M H	Yes No
	L M H	**2**	L M H	L M H	Yes No
	L M H	**3**	L M H	L M H	Yes No
	L M H	**4**	L M H	L M H	Yes No
	L M H	**5**	L M H	L M H	Yes No
	L M H	**6**	L M H	L M H	Yes No
	L M H	**7**	L M H	L M H	Yes No
	L M H	**8**	L M H	L M H	Yes No

Action Plan

4 Starting with the most important, write the number for each control you decide to action in Column A. Indicate the term of the solution and the method of control in Columns B and C. Write the action plan, responsibilities and completion dates in the last three columns.

A. Control number – from Question 13, Column C	**B. Term.** Short, medium or long term?	**C. Method.** Will the control eliminate, isolate or minimise the hazard?	**D. Action plan** (How is the control measure going to be implemented and how will training be given to affected employees?)	**E. Person assigned**	**F. Date** for completion
	S M L	E I M			
	S M L	E I M			
	S M L	E I M			
	S M L	E I M			
	S M L	E I M			

Monitoring and Evaluation

15 Does the task pose a significant hazard?

Yes ❑ **go to Question 16**

No ❑ **go to Question 18**

If the task poses a significant hazard, **and** if you do not eliminate or isolate it you are required to monitor the health of the employees exposed to the hazard, with their consent and in relation to the hazard.

16 Which method of monitoring will be used to follow the musculoskeletal health of the people doing this task?

Talking with employees ❑ Discomfort reporting system ❑ Questionnaire surveys ❑ Periodic health assessments ❑

17 How frequently will this monitoring be carried out? (Evidence that this monitoring has been carried out should appear in the appropriate health and safety records for audit purposes.)

Continuously ❑ Daily ❑ Weekly ❑ Monthly ❑ Quarterly ❑ Every 6 months ❑ Annually ❑

18 Say how you will evaluate the effectiveness of the controls.

Control Number	Type of evaluation *	Frequency	Who will confirm that the evaluation plan has been actioned?

* **Suggested methods:** Tracking: injury rates, injury severity, incidents reported, discomfort reported and sickness absence; a repeat hazard identification; general H&S audits; evaluating the quality of the product, the process efficiency or staff morale; cost/benefit analyses.

Appendix 6

- Mill 12 interview data
- Mill 12 timber statistics
- Mill 12 pack size charts
- Mill 12 force measure data
- Mill 12 REBA data
- Mill 12 Manual Handling Risk Score

Interview Data 12 270202														
Subj #	Age	Gend	Weight	Height	Hand	Time in Job	Experience	Work Hrs	**Nutritional**	**PPE Used**	**Hardest/easiest**	**Training**	**Rest Breaks**	**Improvements**
1	22	m	84	178	r	7 mths	5-9 yrs	42	Good breakfast, no lunch, large dinner. 2 coffees breakfast, 6-7 cups coffee during day, +1.5 litres of water during warm/hot days	Leather apron, as per training, Bilateral wrist braces, gloves as provided	hardest with bigger boards and when mill fast, and when less skilled workers on	Use weight of board, push board down so it slides off with own weight, wait for timber to come to you, use whole body not just arms	ok	Repair and maintenance of chain, keeps coming off and is dangerous. Other chain styles better - bike chain style with nylon under/on sides
2	18	m	75	180	r	3 mths	0	45	No breakfast, 1-2 coffees and smoke, 2 pies am tea and same for lunch, may buy something for tea or not have any. Drinks about 4 1.5 liter bottles of coke/water per day	left wrist brace (sore from previous fisheries job), gloves as provided when on chain - not stripping	Hardest is pushing oaded trolleys out	Throw the boards, don't get in the way, watch and learn	Hard to get to shops and back for food during tea break	Fix chain that keeps breaking and repair trolleys
3	26	m	65	178	r	6mths	8 mths	42	No breakfast, coffee at 10 am and about 5 other cups during day, no lunch, big dinner. May drink 1-1.5 litres of coke or water during the day.	gloves as provided, doesn't wear apron here as doesn't feel it is needed, uses different method	limited workspace is hard, not using all the chain seems dangerous	throw boards as if passing a rugby ball, hold it as little as possible, let the wood do the work, work within your capacity only	Hard to get coffee and then get to carpark (where they smoke) and back in 15 minutes	Increase space between workers on chain, maintenance of chain, improve pusing of trolleys - putting grooves in concrete, hydraulic stacker system
4	21	m	90	178	r	6weeks	2 months	42	3 slices toast, orange juice for breakfast. 3 double sandwiches for lunch, no snacks, large dinner. Drinks about 3 litres water during day, little coffee/coke	Gloves as provided, wears bilat wrist braces for pulling and stripping, to help support wrists and decrease pain.	Bigger timber and when mill going fast is hardest. Difficult if not enough room between stacks etc. Is easier with enough people working on chain.	Don't 'flick' with wrists, keep them straight, use shoulders more.	ok	Have enough people on the line, kep mill at the right speed for the number of people working on chain.
5	20	m	80	?	r	8mths	0	43	No breakfast, 2 coffees only. 6 double sandwiches for lunch cheese/vegemite etc. Biscuits for am/pm tea, big meal at night, drinks 2-3 x 1.5 litres water during the day	Gloves as provided. Also right wrist brace (purchased own). Doesn't wear leather apron as feels no need	Handle timber as though throwing a rugby ball, grasp, throw and guide in with hands. Get into a work rhythm. Pushing trolleys out when full is hardest part of job. Likes to work on faster section at front of chain.	ok. Rotate daily for balance with heavy/light timber.	ok	maintain trolleys, ? Able to control speed of chain.
6	28	m	68	170	r	1mth	0	42	4 weetbix for breakfast and energy drink can. Lunch 2 double sandwiches and 2 pieces fruit, large dinner. Drinks about 2-3 litres per day.	Gloves as provided. 10 days until worn out.	Rotations one day table one day stripping ok, prefers table work as day goes faster. Timber size, not too bad (but not yet doing lots of heavy timber as still fairly new)	Don't jam fingers/hit others with timber. Slide timber don't lift/carry unnecessarily. ? Benefit of leather aprons and training to use them.	ok. Notices he is tired after days work, goes to bed early.	not sure
7	19	m	82	170	r	2mths	0	41	No breakfast, just 1 cup coffee. May have sandwich for morning tea. 2 double sandwiches for lunch, large dinner meal. Drinks 3 coffees and varying amounts of coke during day .	Gloves ok, a little hard to break in. last 5-8 days. If stripping they don't wear as fast. Wouldn't wear apron as prefers old clothes	hardest task is pushing trolley out, 2 people needed. Difficult when really busy /working fast. More space better.	Pull and 'throw' timber. Stand at the side (side on to chain)	Difficult to get over to tea room, get coffee, and get over to table 'off-site' where they are not prevented from smoking	Mechanise, harder to keep up the pace at the front of the chain.
8	36	m	98	180	r	6mths	0	41	Breakfast is something he takes out of family shop on way to work - salad roll/mince pie/pasta and a coffee. Lunch is similar, with snacks of fruit or biscuits, full dinner. Drinks 2-3 litres of water per day.	Gloves as given. Last about 1 week, fairly comfortable. Leather apron not used but may save clothes. May need hard hats at front end due to timber sometimes catching up and flying off.	Harder when working with mill at full speed. Bending when stripping is also really difficult. Trolleys hard to push out 2-3 tons of timber etc in total	Throw the timber and guide it into place	ok, maybe could take short rests (5 mins) every hour	Modify trolleys. Warm-up before starting. Take 5 mins rest breaks per hour.
9	29	m	82	190	r	9mths	0	42	Breakfast 4-5 weetbix and fruit, with .5 litre of milk. No am/pm tea snacks, Drinks approximately 1 litre per day while working. May have apple/banana for lunch, or nothing. Large dinner with 1-2 litres beer.	Gloves last well, reasonably comfortable and good protection for both stripping/pulling. Gets 4-6 weeks wear when at front 'pushing' and stripping.	Hardest to work on chain. Finds pressure of speed/teamwork difficult, likes more paced work with good focus so he can think about other things. Easier if can trust a good team of people. Easier to work at more relaxed pace. Ned to be strong to find work easy. Awareness of others critical, and more space is easier to work in.	Watch and learn	ok	Improve storage of fillet sticks. Forklift moving in and out is dangerous and stacks sometimes tip etc. Hard Hat necessary at front of chain. Fix resaw from making snare ups.Pushing timber at front of chain a redundant job?

10	24	m	72	182	r	2days	5-9 years	40	2 pieces toast and a coffee for breakfast. Morning tea is 2 sandwiches and coffee, lunch apple and 2 sandwiches, afternoon tea cold drink/coke. Large dinner. Drinks 4-5 litres of water per day.	Uses wrist braces for support. Gloves would be imporved by buckle across the back to tighten them	Stacking irregular sizes is hardest	Slide the timber off to make it easier, don't flick wrists.	ok	Use full length fillets, short pices a nuisance to work with. Water fountain handy would be good.
11	31	m	75	172	r	8mths	3-4 years	40	Very large coffee (750 ml) and a cigarette for breakfast, biscuits for morning tea, 2 double sandwiches for lunch, coffee and cig. Afternoon tea, large meal at night. May have a can of coke during day, no water though unless it is really hot. (NB is mostly forklift driver rather than working on chain)	0	working on chain is hard. Pushing resaw timber and sorting it out is difficult. When timber is sticking out fromm chain it is easier to grasp hold of.	Trial and error learning is important. Rugby throw of timber into place on the stack then control/slide it in.	ok. Rest breaks ok when on forklift, is harder tor est enough if on chain.	maintainenace of chain, and improve trolley design - solid wheel base and wheels without bearings.
12	32	m	90	178	r	9mths	0	45	No breakfast, fruit for am tea and lunch with 1 cup of coffee during day. Afternoon tea lunch and chips, big dinner. 2 litres of water during day.	Gloves ok, comfortable. ?Hard hats, but thinks it is too hot.	hardest is pulling big timber.	Training? - left to leading hand. Not used to using leather apron.	ok	Need 4 more trolleys. Relief pack at end of chain for second packi for commonly produced size, relieves the first pullers from overwork. Was half day rotiations now mostly one day rotations. Resaw timber tangles up on chain and causes problems. Space issues - extra stripping bay outside currently. wants to have enough space to bring it back under cover - ? needs to shorten chain a little to fit this in.

Mill 12 Timber Statistics

Greenchain production for week 25 February 2002 to 1 March 2002

Timber Size (mm)	Timber items / packet (width x height)	Date/Total number of packets					Total items pulled/stacked per day				
		25 Feb /57	26 Feb /63	27 Feb /83	28 Feb /79	1 Mar /36.5	25 Feb	26 Feb	27 Feb	28 Feb	1 Mar
100 x 25	253 (11 x 23)	8	13	7	9	6	2024	3289	1771	2277	1518
150 x 25	168 (7 x 24)	28	10	20	17	7	4704	1680	3360	2856	1176
100 x 40	154 (11 x 14)	5	4	2			770	616	308		
200 x 40	78 (6 x 13)	1	3	23	1	5	78	234	1794	78	390
100 x 50	121 (11 x 11)	2	23	6	5	12	242	2783	726	605	1452
90 x 60	120 (12 x 10)	5	10				600	1200			
200 x 25	126 (6 x 21)	2		5	3		252		630	378	
150 x 40	98 (7 x 15)	2		2			196		196		
250 x 40	64 (4 x 16)	4		18	11	3	256		1152	704	192
210 x 20	155 (5 x 31)				9	3.5				1395	543
150 x 50	136 (8 x 17)				12					1632	
210 x 42	100 (5 x 20)				12					1200	
Total packets pulled/stacked per week		318.5									
Total items pulled/stacked per day							9122	9802	9937	11125	5271
Total items pulled per worker (7 workers average)							1303	1400	1420	1589	753
Total items pulled/stacked per week							45257				

Two other weeks of greenchain production

Weekly Greenchain Production Mill 12					
Timber Size (mm)	11-17 Feb 02 Total number of packets (338)	18-24 Feb 02 Total number of packets (287)	Timber items / Packet (width x height)	11-17 Feb 02 Total items pulled/ stacked	18-24 Feb 02 Total items pulled/ stacked
75 x 50	14		168 (14 x 12)	2352	
85 x 24		4	*300 (12 x 25)		1200
85 x 85		17	84 (12 x 7)		1428
100 x 25	32	42	253 (11 x 23)	8096	10626
100 x 40	15	18	154 (11 x 14)	2310	2772
100 x 50	28	32	121 (11 x 11)	3388	3872
100 x 100		10	66 (11 x 6)		660
130 x 45	7	31	*104 (8 x 13)	728	3224
130 x 97	40	32	*48 (8 x 6)	1280	1536
150 x 20	6		210 (7 x 30)	1260	
150 x 25	44	66	168 (7 x 24)	7392	11088
150 x 32	1		133 (7 x 19)	133	
150 x 40	11	7	98 (7 x 15)	1078	686
150 x 42	3		105 (7 x 15)	315	
150 x 50	14		84 (7 x 12)	1176	
185 x 23	16		*150 (6 x 25)	2400	
185 x 46	10		*78 (6 x 13)	780	
200 x 25	22	17	88 (4 x 22)	1936	1496
200 x 32	2		*76 (4 x 19)	152	
200 x 40	27	5	78 (6 x 13)	2106	390
210 x 20	4		150 (5 x 30)	600	
250 x 25	2		100 (4 x 25)	200	
250 x 40	9	4	64 (4 x 16)	576	256
255 x 23	15	2	*112 (4 x 28)	1680	224
255 x 46	16		*52 (4 x 13)	832	
Total items pulled/stacked per day				**40770**	**39458**

*Numbers of boards per stack estimated from figures given as not included in pack size data sheet

(MTM 12)

Fillet Pack Sizes

Export Size	Width	Height	Domestic Size	Width	Height
120 x 12	10	33	255 x 12	5	38
150 x 12	8	33	185 x 20	6	31
85 x 17	14	33	210 x 20	5	31
150 x 17	8	33	75 x 25	15	27
90 x 18	13	32	100 x 25	12	27
150 x 18	8	32	150 x 25	8	27
75 x 21	15	30	200 x 25	6	27
75 x 24	15	28	225 x 25	5	27
75 x 30	15	24	250 x 25	5	27
85 x 38	14	21	100 x 32	12	23
60 x 40	19	20	150 x 32	8	23
75 x 40	15	20	200 x 32	6	23
80 x 40	15	20	100 x 40	12	20
60 x 60	19	15	150 x 40	8	20
85 x 85	14	12	180 x 40	6	20
250 x 40	5	20	200 x 40	6	20
x			75 x 50	15	17
180 x 12	6	38	100 x 50	12	17
210 x 12	5	38	150 x 50	8	17
216 x 13.5	5	36	75 x 75	15	13
257 x 13.5	4	36	100 x 75	12	13
75 x 15	15	35	100 x 100	12	10
120 x 15	10	35	250 x 40	5	20
150 x 15	8	35	90 x 24	13	27
90 x 60	13	15	60 x 24	19	27
120 x 60	10	15	125 x 50	10	17

? 200 x 100 5 5

Green Sawn Pack Sizes

Export Size	Width	Height	m3	Domestic Size	Width	Height	m3
120 x 12	9	48	2.488	255 x 12	4	51	2.497
150 x 12	7	50	2.520	185 x 20	6	28	2.575
180 x 12	6	48	2.488	210 x 20	5	30	2.520
210 x 12	5	50	2.520	75 x 25	14	24	2.520
216 x 13.5	5	43	2.508	100 x 25	11	23	2.530
257 x 13.5	4	45	2.498	150 x 25	7	24	2.520
120 x 15	9	39	2.527	200 x 25	5	25	2.500
150 x 15	7	40	2.520	225 x 25	5	22	2.475
85 x 17	12	36	2.497	250 x 25	4	25	2.500
150 x 17	7	35	2.499	100 x 32	11	18	2.534
90 x 18	12	32	2.488	150 x 32	7	19	2.554
150 x 18	7	33	2.495	200 x 32	5	20	2.560
75 x 21	14	28	2.470	100 x 40	11	14	2.464
75 x 24	14	25	2.520	150 x 40	7	15	2.520
75 x 30	14	20	2.520	180 x 40	6	14	2.419
85 x 38	12	16	2.481	200 x 40	5	16	2.560
60 x 40	18	14	2.419	75 x 50	14	12	2.520
75 x 40	14	15	2.520	100 x 50	11	11	2.420
80 x 40	13	15	2.496	150 x 50	7	12	2.520
60 x 60	18	10	2.592	75 x 75	14	8	2.520
85 x 85	12	7	2.428	100 x 75	11	8	2.640
~~125 x 50~~ 130 x 30	9	17	2.462	100 x 100	11	6	2.640
~~85 x 32~~ 90 x 60 / 40 x 60	12	10	2.592	250 x 40	4	16	2.560
120 x 60	9	10	2.592	255 x 28	4	22	2.513
30 x 30	36	19	2.462	~~90 x 60~~	~~12~~	~~10~~	
75 x 15	14	40	2.500	125 x 50	9	11	2.475

Force Measure (Kilograms) Position 1 (near start of first/fast chain section)				
Board Number	Pull Number 1	Pull Number 2	Pull Number 3	Mean
A1	5.75	6.00	5.95	5.90
A2	8.20	9.00	9.05	8.75
A3	9.05	9.50	9.55	9.37
A4	7.15	7.65	8.60	7.80
A5	5.70	5.40	5.95	5.68
A6	7.75	7.25	7.35	7.45
A7	8.30	8.85	8.90	8.68
A8	8.00	7.20	7.50	7.57
B1	15.25	17.30	16.10	16.22
B2	20.50	21.85	20.75	21.03
B3	17.40	16.90	15.75	16.68
B4	17.15	15.60	16.95	16.57
B5	12.80	11.70	10.40	11.63
B6	10.20	11.35	10.85	10.80
B7	11.20	11.20	10.90	11.10
B8	11.75	13.15	13.10	12.67

Force Measure (Kilograms) Position 2 (Near end of first/fast chain section)				
Board Number	Pull Number 1	Pull Number 2	Pull Number 3	Mean
A1	6.05	6.65	6.60	6.43
A2	7.95	8.05	7.85	7.95
A3	8.55	8.35	8.55	8.48
A4	7.60	8.15	7.60	7.78
A5	4.20	3.85	3.85	3.97
A6	8.00	7.65	8.25	7.97
A7	9.00	8.15	8.20	8.45
A8	7.40	7.60	7.55	7.52
B1	12.95	12.65	11.95	12.52
B2	10.15	11.45	10.35	10.65
B3	12.55	12.85	13.00	12.80
B4	15.95	12.40	13.10	13.82
B5	16.85	18.30	18.80	17.98
B6	14.60	15.90	17.05	15.85
B7	12.60	12.30	11.65	12.18
B8	13.40	12.90	13.40	13.23

Force Measure (Kilograms) Position 3 (Midpoint of second/slow chain section)				
Board Number	Pull Number 1	Pull Number 2	Pull Number 3	Mean
A1	6.70	7.15	7.00	6.95
A2	7.65	7.10	7.55	7.43
A3	8.60	8.45	8.90	8.65
A4	8.35	8.95	8.05	8.45
A5	5.70	5.80	5.80	5.77
A6	6.45	6.75	6.40	6.53
A7	7.30	7.95	8.75	8.00
A8	6.00	5.65	5.65	5.77
B1	17.95	17.90	18.00	17.95
B2	20.95	22.40	22.35	21.90
B3	16.40	16.65	16.55	16.53
B4	18.35	18.40	19.00	18.58
B5	12.65	12.00	11.40	12.02
B6	12.90	13.55	13.40	13.28
B7	11.55	10.70	11.05	11.10
B8	13.30	13.65	13.45	13.47

Mill 12 – REBA Data

Subject description	Task description	REBA Score	Working Sheet Number	Comments	REBA Risk Level
Above 50th %ile male, experienced	25 x 150 mm x 4 m				
	Reach to grasp board from **chain** with right hand	**6**	1		Med
	Begin to throw board to **stack**	**6**	2		Med
	Placing board on **pack**	**3**	3		Low
	Beginning to throw board onto **first layer** of pack	**5**	4		Med
	Throwing board out and onto **first layer** of pack	**11**	5	Much right arm action and trunk bending	Very High
	Placing board onto **first layer** of pack	**5**	6		Med
	Grasping board from **chain** with left hand	**10**	7	Much left arm action and spinal bending	High
	Pulling board across to **mid-layer/mid board** position on pack	**6**	8		Med
	Straightening board on pack	**7**	9		Med
	Grasping board from chain and starting to pull	**8**	10		High
	Throwing board onto a post-fillet layer on stack	**7**	11		Med
	Placing board on post-fillet layer on pack	**4**	12		Med
	Picking up fillet sticks from under chain	**10**	13	Bending and reaching and risk of getting caught by belt/hit by timber	High
	Pushing out trolley (with another person)	**12**	14	Bracing legs against chain and applying high force	Very High
Below 50th%ile male, inexperienced	25 x 150 mm x 4 m timber				
	Grasping board from table and beginning pull	**9**	1	Bending forward and arm action	High
	Pulling board across onto stack	**8**	2	Arms with high action	High
	Placing board onto pack	**5**	3		Med
	Grasping board from table	**5**	4		Med
	Sliding and holding board to move it to stack	**9**	5		High
	Pushing board into place on pack	**7**	6		Med
	Grasping board from table	**9**	7		High
	Throwing board up onto top layer of stack	**8**	8	Tiptoeing for extra height, shoulder elevation	High
	Lining board up on top layer of pack	**7**	9		Med
	Grasping board from table	**9**	10		High
	Moving board down onto 2nd/3rd layer on stack	**9**	11	Trunk bend is extreme	High
	Aligning board on pack	**10**	12		High
	Pushing trolley out	**5**	13	Very high forces though little back/arm effort measured here	Med

Mill 12 - Manual Handling Risk Score

The risk score was calculated as below:

7 Find the load score: The load score is the muscle force applied by the worker. It may be the weight of the object handled or you may need to measure the forces applied with a spring balance or a force gauge – or make an estimate. If several people do the task, the score should reflect the ability of the least able.

The load score varies depending on the timber dimension being worked with. For the most common (smaller) board sizes, I estimate that a load score of 2 is indicated. For the largest common board sizes, I estimate that a load score of 4 is indicated. For the intermittently handled largest board sizes, I estimate that a load score of 10 is indicated.

Men	Women	Load Score
< 10 kg	< 5 kg	1
10 – 19 kg	5 – 9 kg	2
20 – 29 kg	10 – 14 kg	4
30 – 39 kg	15 – 24 kg	7
40 +	25 +	10

Report the Load Score here → **2, 4,10** A

8 Find the posture and workplace layout score: Observe the postures adopted. Take an average value if necessary or use numbers between the ones shown.

Usually working with slight bending and twisting of the trunk, though varies depending on individual anthropometrics and task.

	Posture Score
Trunk upright, no twisting, load close to body, standing or walking a few steps only.	1
Some bending forward or twisting, load close to body, sitting, standing or walking for a longer distance.	2
Bending far forward or close to the floor, slightly bending and twisting the trunk, load far from the body or above shoulder height, sitting or standing.	4
Bending far forward and twisting the trunk, load far from the body, below the knees or above shoulder height, unstable posture while standing, crouching or kneeling.	8

Report the Posture/Workplace Layout Score here → **4** B

9. Find the work conditions and environment score:

Score	Environment
Good conditions, with sufficient space, no obstacles, level and solid floor surface, good lighting, able to get a good grip on the load.	0
Restricted workspace (area < 1.5 m^2), restricted postural stability (floor uneven, soft, slippery, steeply sloping).	1

Report the Environment Score here → **1** C

10 Find the time score: Find the time score from the greatest of either the number of repetitions of the task or the time spent doing it during the shift.

Repetitions per shift	Total time per shift	Time Score
< 10	< 30 min	1
10 – 40	30 min – 1 hr	2
40 – 200	1 – 3 hrs	4
200 – 500	3 – 5 hrs	6
> 500	> 5 hrs	8

Report the Time Score here → **8** Time

Add the three scores in boxes A, B and C → Sum **7, 9, 15**

11 Multiply box **'Sum'** by box **'Time'** to get the risk score. **56, 72, 120**

Guidance on the Meaning of the Risk Score	
Risk Score	*Urgency and type of control measure*
< 10	Injuries are unlikely unless there are infrequent high force actions. Monitor the task from time to time.
10 - 24	Injuries may result for less resilient people. Workplace re-design is recommended for them.
25 - 49	Injuries are possible for trained and fit people. Workplace re-design is recommended to control the contributory factors identified.
50 +	**Injuries are likely regardless of the strength and fitness of employees. Elimination of the task or workplace re-design is a priority.**

Appendix 7

- Mill 12 Summary of Assessment Findings
- Mill 12 Recommendations for Reduction of Manual Handling Risks

Mill 12

Summary of Assessment Findings

Contents

Mill 12

Summary of Assessment Findings

Greenchain, Trolley, Packet and Workspace Dimensions

Chain/table geometry: The greenchain consists of two chain tables, one a faster moving section of 16.5 metres in length (3680mm width) placed ahead of a slower length of 39.5 metres (3050mm width). Thus there is a total chain length of 56 metres. The first shorter chain table is 920mm height to the top of the chains, and the second slower chain table is 905mm to the top of the chains. There are 4 chains operating per table, though at the assessment visit in February one (third chain, slower table) was not functioning, reportedly due to the chain having stretched and consequently frequently coming off the drive mechanism. The chain is a classic link-chain design, with links of 70mm x 40mm outside measurements. They run in gutters on top of the table and return also in gutters below the table. A means of 'taking the slack' on chains that are gradually stretching/loosening is reportedly being sought. Chains observed to come off with reasonable frequency and impact on table and mill functioning. Unclear methods of stopping the chain/lockout appeared to be in use.

Chain speed: The faster section of chain runs at 1 minute 23 seconds per 10 metres, and the slower section at 2 minutes and 39 seconds per 10 metres.

Trolley-table distance: Pack ends were measured at between 1400 and 1800 mm from the table edge, with the timber overhanging the table edge by approximately 300mm. Thus the distance between the end of the timber on the table and the end of the packet is approximately 1100 – 1500mm.

Packet Sizes: Packet height varies between 505mm and 1050mm, with the most commonly pulled timber dimension (150 x 25 mm) at 725 mm total height. Packs have 2.5 m3 of timber, and the number of boards in them reflects this. Total packet height given includes 50 mm for two fillet strips. Timber is of approximately 4 metres in length.

Trolleys: Trolleys in use (a total of 12) are of several designs. The overall height ranged from 357mm to 560mm, with lower trolleys preferred for use. Trolleys are approximately 3650mm long and 1370mm wide with several bearers that timber rests on. Some trolleys are easier to push than others, and it was noted that these trolleys had wide wheel rims (50mm) and a rubber rim on the wheel. These rolled easily and did not damage the concrete surface. Other trolleys had narrower wheels (25 mm) without rubber rims, and these damaged the concrete surface making their use even more difficult. Many of the bearings on these wheels were completely destroyed. Some trolleys had bent axles, reportedly due to lateral damage from the forklift. The weight of a packet of timber was reported as between 2.5 and 2.8 ton.

Trolley wheel mountings in some cases looked as if they could be altered for a lower trolley height.

Main findings: ***Total greenchain length 56 metres, total height 905 and 920mm. Four chains operating per table, with maintenance concerns regarding chain stretching and replacement when it comes off.***
Chain speed 1 min 23 secs per 10m for first table, and 2 mins 39 secs per 10m for second table.
Distance between table and packet ends between 1400 and 1800mm.
Packet heights between 505 and 1050mm, most commonly stacked timber packs at 725mm.
12 Trolleys, with heights between 357 to 560mm, with differing design, structural strength and task suitability noted. Poorly maintained. Lower trolleys preferred.

Timber Statistics

For the week of 25 Feb – 1 March 45,257 boards were handled, and the previous two weeks saw 40,770 and 39,460 boards pulled and stacked. This represents 9051, 8154 and 7892 boards per day, or 1293, 1165 and 1127 boards per worker, with an average of 7 workers pulling and stacking each day.

Taking these figures, the following table of estimated outputs per worker has been developed. This is based on the recorded amount of timber pulled on the two days of the assessment, and figures from the two weeks prior.

Estimated boards pulled and stacked per worker			
Boards per day	**Boards per hour**	**Seconds per board**	**Boards per minute**
1000	125	28.8	2.3
1100	137.5	26.2	2.3
1200	150	24	2.5
1300	162.5	22.2	2.7
1400	175	20.6	2.9
1500	187.5	19.2	3.1
1600	200	18	3.3

Video analyses allowed some data to be gathered on actual work pace. Thus the work pace of one board in 9.3, 11.5, and 7.6 seconds was observed during a reasonably slow work period, and one board in 7.0, 9.6, and 10.4 seconds during a faster and steadier period when some additional workers were on the chain. Periods of downtime were also observed where no boards were stacked for some time, trolleys were moved, and mill hold-ups waited for. Depending on the pace/dimensions of timber coming from the mill some workers will have more than others to stack. Downtime (mill not operating) may impact significantly on work pace, with records showing that the mill may operate for between 6 and 7.75 hours most days. Therefore should the mill only be operating for 6 hours on a day when 1165 boards are pulled per worker, the work pace would increase from 146 boards per hour (2.4 boards per minute, 25 seconds per board) to 194 boards per hour (3.2 boards per minute, 18.7 seconds per board).

Resawn timber is handled twice by greenchain workers. It is pulled and stacked before going back into the mill to be sawn to half the thickness, and is stacked again following this. An easier means of redirecting timber to resaw would potentially reduce the amount of stacking required.

Main findings: ***Calculations as above indicate that approximately 1200 boards are handled daily by each greenchain worker, at an average pace of approximately 2.5 boards per minute should they work consistently over 8 hours. The accuracy of these calculations would be enhanced by consideration of mill downtime and other reasons for lost productivity.***

Environmental data

Noise: The results of the June 1991 noise assessment appear to have been misinterpreted. The recommendations are:

- That Grade 2 hearing protection (ear plugs or ear muffs) is mandatory for those in the first chain position and further down the chain, whether or not the mill or radio are on.
- That the person working at the top of the chain (pusher) should wear Grade 3 hearing protection (ear muffs).

Lighting: Lighting levels in the green chain area are particularly dim on cloudy days, or early in the morning/late evening. These were measured at 45-82 lux near the back wall, and 350 to 415 lux on the stacking side of the chain area, at 8.00 am on a cloudy February day. Lighting levels for general purpose areas such as storerooms are suggested to be between 80-170 lux, and for packing/despatch tasks between 200-250 lux (Kroemer and Grandjean 1997). Thus a review of lighting levels may be indicated given early work shifts over winter months.

Floor surface: The narrow/broken trolley wheels have caused damage to the concrete surface further inhibiting the movement of trolleys. Steel bolts from the previous location of the chain motor remain in place, protruding several centimetres and forming a tripping hazard behind the table. Fillet sticks are loosely stored under the table collecting grit and sawdust and spilling out into the walkway at times. Grit and dust are a hazard given semi-exposed building design with wind likely to blow dust about.

Main findings: ***Hearing protection for greenchain workers requires reviewing. Lighting levels at the greenchain indicate possible need for review. Floor surface damage and hazards require addressing.***

Nordic Musculoskeletal Questionnaire (NMQ)

Results conclude that in the last 12 months (prior to assessment) discomfort was experienced by greenchain workers (n=12) as below:

- 25% neck,
- 33% one or both shoulders,
- 33% one or both elbows,
- 83% one or both wrists,
- 25% upper back,
- 58% lower back,
- 17% hips/thighs/buttocks,
- 17% knee,
- 25% ankles/feet.

Over the previous 7 days (prior to assessment) discomfort was experienced by greenchain workers as below:

- 8% both shoulders,
- 16% one or both elbows,
- 49% one or both wrists,
- 17% upper back,
- 8% lower back,
- 8% hips/thighs/buttocks,
- 8% knee,
- 8% ankles/feet.

Over the last 12 months (prior to assessment) some discomfort was experienced that prevented worker participation in normal activities as below:

- 17% due to shoulder discomfort,
- 25% due to lower back discomfort,
- 8% due to hip/thigh/buttock discomfort,
- 8% ankle/foot discomfort.

Main finding: ***musculoskeletal discomfort is common among this group of greenchain workers – particularly wrist discomfort - with some limitation of normal capacity to complete daily activities resulting.***

Lifting strength testing - using dynamometer

Comparison of data gathered with that reported by Keyserling, Herrin and Chaffin, 1978, determined that:

Leg lift — all workers had 50th %ile or above strength, with 75% of workers 90th%ile or above

Arm lift — 66% of workers had 50th%ile or above arm lift strength, 25% of these with 75th%ile strength.

Main finding: ***That the workforce population employed at this mill is relatively strong for this leg and arm lift.***

Anthropometric Data

Data collected form the worker group correlates with that for the New Zealand population, as given in NZ Anthropometric Estimates, (Slappendel and Wilson, 1992). Thus this NZ data can be used for relevant design considerations.

Main finding: ***NZ Anthropometric estimates suitable for use in design considerations with worker population.***

Borg Rating of Perceived Exertion (RPE) Scale

Indications are that experienced workers perceive lower levels of exertion than less experienced workers, though further data gathering would be needed to validate this. Workers reported greater exertion at the end of the day than at the beginning. The scale used included ratings for: very, very light; very light; fairly light; somewhat hard; hard; very hard; very, very hard.

Main finding: ***Workers perceived lower levels of exertion at the start of the day (very, very light – fairly light) compared to the end of the day (very light – very hard.***

Discomfort Rating Scale

Two workers reported discomfort in the morning, and four workers reported discomfort in the last afternoon work period.

Main finding: ***Discomfort levels increase throughout the work day***

Interviews

Nutrition: 50% of workers interviewed report having an insubstantial breakfast (often no food, just coffee) before commencing this physical work, and varying fluid intake during the day.

Personal Protective Equipment (also from observation): 42% of workers used one or two wrist braces, believing that these assisted their comfort and protected from injury. One worker used a leather apron for clothing and tissue protection while handling timber. All workers used the gloves as provided and they were generally felt to provide adequate protection, with one comment that they would be better with a strap across the back of the hand to improve the fit. Fit of gloves was observed to be poor, with workers experiencing gloves coming off as they are working, and frequently needing to pull gloves back on to their hands. Hearing protection worn consistently only at the 'pusher' position at the front of the line, but not by others. Steel capped boots worn as standard.

Hardest/easiest work tasks: Timber pulling was reported to be more difficult with:

Large board sizes
Mill going very quickly
Fewer skilled workers available
Inadequate space between stacks
Stacking irregular sized timber
Handling resaw timber

It was said to be easiest when:

Able to work in a good rhythm (no stop/start)
Adequate workers on chain
Trustworthy team of workers

The most difficult task was reportedly pushing full (but requiring repair) trolleys out.

Training: Key factors for ease in timber handling and learning the necessary work skills were:

Use the weight of the board, push it down so it slides off by itself
Wait for the timber to come to you on the chain
Use your whole body, not just your arms
Throw the boards like a rugby ball
Don't 'flick' with your wrists
Work within your capacity
Rotate work positions
Don't lift/carry unnecessarily, slide it
Throw the timber and then guide it into place
Use a leather apron so hip/thigh can assist with guiding/lifting boards, and to keep boards closer

Rest Breaks: 33% of workers reported some difficulty gaining adequate rest and rehydration/nutrition within the 15 minute breaks.

Improvements: Maintenance of the chain and repair of existing trolleys was a key improvement identified by many workers. Other suggestions included provision of a drinking water supply nearby, a means of controlling chain speed, regular rest breaks, alternative means of storing fillet sticks, preventing resawn timber from causing snare-ups, provision of additional trolleys, increased task rotations, and provision of extra trolleys.

Main findings: ***Some workers have inadequate nutrition for the physical work required of them during the work day.***
Wearing of personal protective equipment is consistent regarding glove wear and steel-capped boots, but inconsistent and perhaps poorly researched regarding hearing protection and apron wear. Glove requirements could be further researched. Many workers prefer to use wrist braces whilst working.

The most difficult task was pushing out full trolleys and working with large boards or when working very quickly.
Some key training factors appear to exist.
Rest break length is perhaps inadequate for workers to gain rest and nutrition.
Primary area for improvement felt by workers to be chain and trolley maintenance.

Task Rotations

It was reported that rotation of tasks is usually half daily. The general plan is that each worker will complete alternate days stripping. The decision on who does what tasks is based on worker skills, mill output/pace and therefore work skills required, discomfort/fatigue complaints, and the previous rotation of each worker, and is made by the leading hand or team leader. It was however noted that rotations were largely being done on a daily basis, with some changes of position on the chain only. The rotation system is largely informal and not recorded.

Main finding: ***Rotation system is informal and though theoretically based on half days, has actually become daily. Thus a reduction in the task variability available to workers has occurred.***

Rapid Upper Body Assessment (REBA)

The very high scores (indicating that action is necessary *now*) were for tasks including:

- Pushing a full trolley out
- Throwing a board out onto the first layer of a packet

The high scores (indicating that action is necessary *soon*) were for tasks including:

- Pulling a board from the table from too far away (not using feet)
- Picking up fillet sticks from under chain
- Pulling and lifting boards onto tops of packets
- Placing/aligning boards on first/lower layers of packets

Main findings: ***A number of tasks were identified using this assessment tool as having a high risk of injury. Using this analysis the tasks requiring immediate attention are pushing full trolleys and throwing the boards onto the first layer of the packet. Requiring attention also are handling boards on the lower layers of packets, pulling boards from the table from too far away, picking up fillet sticks, and putting boards onto the top of packets.***

Force Measure Data

The force required to initiate horizontal movement from the chain of the most commonly pulled timber size (150 x 25 x 4000mm) averaged 7.4 kg. The force required to initiate horizontal movement of the most commonly pulled larger timber dimension (200 x 40 x 4000mm) averaged 14.6 kgs. These figures represent the horizontal 'break-out' force only and additional lifting and carrying, timber directional and control forces, and additional actions to keep timber moving also occur. Similar measures have been taken from varying table/chain types, and demonstrate some appreciable difference in table/chain design.

Force Measure Comparison All mills

Mill Number	Timber Dimensions	Table Type	Green/Dry	Mean Break-out Force (Kilograms)
Mill 43	90 x 45mm x 4.8m	Roller chain	Dry	1.00
	240 x 45mm x 6.0m	Roller chain	Dry	3.44
Mill 17	125 x 40mm x 3.6	Flat chain with cleats	Dry	4.88
	300 x 50mm x 3.0 - 3.6m	Flat chain with cleats	Dry	11.60
Mill 30	150 x 50mm x 3.8 - 6.0m	Round table with timber base	Wet (anti-sapstain)	17.62
	100 x 75mm x 5.4 - 5.8m	Round table with timber base	Wet (anti-sapstain)	24.27
	200 x 25mm x 4.8m	Round table with timber base	Wet (anti-sapstain)	20.63
	Various other dimensions	Round table with timber base	Wet (anti-sapstain)	10.92 - 27.88
Mill 12	150 x 25mm x 4.0m	Chain link	Wet	7.38
	300 x 50mm x 3.0 - 3.6m	Chain link	Wet	14.61

Main finding: ***The break-out forces required to initiate horizontal movement of timber from this chain is 7.4 kg for 150 x 25 x 4000mm boards, and 14.6 kgs for 200 x 40 x 4000mm boards.***

Manual Handling Risk Score

The risk score was calculated as below:

7 Find the load score: The load score is the muscle force applied by the worker. It may be the weight of the object handled or you m need to measure the forces applied with a spring balance or a force gauge – or make an estimate. If several people do the task, the score should reflect the ability of the least able.

The load score varies depending on the timber dimension being worked with. For the most common (smaller) board sizes, I estimate that a load score of 2 is indicated. For the largest common board sizes, I estimate that a load score of 4 is indicated. For the intermittently handled largest board sizes, I estimate that a load score of 10 is indicated.

Men	Women	Load Score
< 10 kg	< 5 kg	1
10 – 19 kg	5 – 9 kg	**2**
20 – 29 kg	10 – 14 kg	**4**
30 – 39 kg	15 – 24 kg	7
40 +	25 +	**10**

Report the Load Score here → 2, 4,10 A

8 Find the posture and workplace layout score: Observe the postures adopted. Take an average value if necessary or use numbers between the ones shown.

Usually working with slight bending and twisting of the trunk, though varies depending on individual anthropometrics and task.

	Posture Score
Trunk upright, no twisting, load close to body, standing or walking a few steps only.	1
Some bending forward or twisting, load close to body, sitting, standing or walking for a longer distance.	2
Bending far forward or close to the floor, slightly bending and twisting the trunk, load far from the body or above shoulder height, sitting or standing.	**4**
Bending far forward and twisting the trunk, load far from the body, below the knees or above shoulder height, unstable posture while standing, crouching or kneeling.	8

Report the Posture/Workplace Layout Score here → **4** B

9. Find the work conditions and environment score:

	Environment Score
Good conditions, with sufficient space, no obstacles, level and solid floor surface, good lighting, able to get a good grip on the load.	0
Restricted workspace (area < 1.5 m^2), restricted postural stability (floor uneven, soft, slippery, steeply sloping).	1

Report the Environment Score here → **1** C

10 Find the time score: Find the time score from the greatest of either the number of repetitions of the task or the time spent doing it during the shift.

Repetitions per shift	Total time per shift	Time Score
< 10	< 30 min	1
10 – 40	30 min – 1 hr	2
40 – 200	1 – 3 hrs	4
200 – 500	3 – 5 hrs	6
> 500	> 5 hrs	**8**

Report the Time Score here → 8 **Time**

Add the three scores in boxes A, B and C → **Sum** **7, 9, 15**

11 Multiply box **'Sum'** by box **'Time'** to get the risk score. **56, 72, 120**

Guidance on the Meaning of the Risk Score	
Risk Score	*Urgency and type of control measure*
< 10	**Injuries are unlikely unless there are infrequent high force actions. Monitor the task from time to time.**
10 - 24	**Injuries may result for less resilient people. Workplace re-design is recommended for them.**
25 - 49	**Injuries are possible for trained and fit people. Workplace re-design is recommended to control the contributory factors identified.**
50 +	**Injuries are likely regardless of the strength and fitness of employees. Elimination of the task or workplace re-design is a priority.**

Mill 12

Recommendations for Reduction of Manual Handling Risks

Contents

Mill 12

Recommendations for Reduction of Manual Handling Risks

Goals

The primary task reviewed for this research project is the pulling and stacking of timber from the greenchain. Thus whilst greenchain workers also complete timber filleting tasks, this has not been reviewed at this time. Recommendations are made based on their likely impact on decreasing musculoskeletal risks for your mill area, as per assessment findings. Some findings that have less immediate bearing on musculoskeletal injury risk but have relevance to general health and safety factors (workplace cleanliness, lighting, noise) are included for your general consideration.

It is hoped that your mill may be able to action at least one of the recommended changes (preferably more) with researcher assistance as required, so that a review of musculoskeletal risk factors can occur. It is expected that some recommendations will require further discussion, trials and decision-making to determine the best solution for your work area.

Discussion

Forces acting as timber is pulled from the table and placed in the packet are various. Assessment methods were selected to measure relevant aspects of these tasks.

For each board pulled from the table there is initial inertia to overcome, momentum and possibly lifting to transfer the timber onto the packet, and some force required to slow/move the timber into place on the packet. The total physical effort required to achieve this is dependent on the dimension and weight of the timber, the degree of friction between the timber and the table/other timber, the distance between the table and the packet, and the work technique used.

Task elements where physical effort is required appear to be:

- Overcoming the inertia of the timber to get it moving off the table.
- Building sufficient momentum to effect timber transfer off the table and onto the packet (pulling the timber horizontally and possibly pushing downwards to employ gravity as the board moves off the table, or additional lifting to move the board into a position higher than the table).
- Maintaining momentum of the timber as it moves perpendicular to the direction of table travel (through applying extra 'pulls' on the timber or physically lifting and transferring it).
- Requiring extra velocity and height to manoeuvre the timber over fillets/bearers (first board of first layer and each layer after the placement of fillets).
- Applying force to guide and/or stop the timber in the correct place on the packet.
- Applying additional force to lift or lever the board into place (when it falls off the side of the packet)

The effort required will also not be consistent or entirely predictable, due to differing timber 'adhesion' to the table, variable chain or roller condition, contact with other timber lengths and board breakage.

A number of recommendations for the configuration of the timber transfer workspace (table, trolleys, packet placement, fillet stick storage etc) follow. These are suggested starting points for further refinement through trials, and require operational verification before the actual heights and ranges can be determined as suitable. Following this are recommendations for addressing redundant timber handling, gloves, task rotations, training, maintenance issues, workplace cleanliness, lighting and noise.

Table height

Recommendation 1: Height to top of chains/rollers - 920 mm. An adjustable table height would however be ideal. The range could be between 785 and 1045 mm (based on 2.5th percentile female and 97.5th percentile male elbow heights (plus footwear allowance and minus 200 mm elbow clearance).

This is based on the following assumptions:

- Fixed table height is most likely to be provided.
- People choose to grip boards somewhere between their elbow and knuckle height, to avoid either too much elbow flexion and shoulder elevation, or forward bending.
- The heavy nature of the task means that an appropriate work surface height is 200 mm below standing elbow height (static anthropometric data). This lower work surface accounts for the dynamic nature of this work. Workers often stand with their legs apart so that they can apply forces effectively and this consequently lowers their elbow height.
- New Zealand Anthropometric Estimates (Slappendel and Wilson, 1992) data is representative of user populations.
- 45-60 year old females have not been included for consideration as none were present in the worker populations sampled.

All measurements in mm, 35 mm footwear allowance, rounded down to nearest 5 mm	Elbow height plus footwear allowance minus 200 mm working clearance below elbow			Knuckle and elbow heights plus footwear allowance	
	5th percentile	50th percentile	95th percentile	Knuckle height - elbow height range (5th and 95th percentiles)	Mid-distance knuckle-elbow (easy reach)
19-45 year old males	870	950	1025	805 - 1150	980
45-60 year old males	860	930	1000	795 - 1130	960
19-45 year old females	800	870	940	775 - 1070	920

- 2.5th percentile female (19-45 year olds) knuckle and elbow heights plus footwear = 705 to 985 mm, which a table height of 920 mm would accommodate.
- 97.5th percentile male (19-45 year olds) knuckle and elbow heights plus footwear = 875 to 1245 mm, which a table height of 920 mm would accommodate.

Recommendation 2: Incline the table bed.

Inclining the table bed will help reduce the amount of inertia before the timber starts moving, and the amount of energy necessary to gain momentum. There is obviously an ideal range at which the inertia is substantially reduced, but the boards remain stationary until the pulling force is applied. The degree of tilt would require trial for each table and surface type.

Table heights at the mills surveyed were:

Mill 43 (dry table)	850 mm
Mill 30 (green/round table)	600-850 mm
Mill 17 (dry table)	970 mm to top of rail, 890 mm to chain surface
Mill 12 (green table	905 mm old section, 920 mm new section

Timber overhang

Recommendation 3: Timber should overhang the table edge by 750 - 1000 mm.

Having more timber over the front edge should allow:

- Workers to position themselves closer to the load with feet further under the board and less bending.
- Workers able to position themselves to use less spinal rotation when handling boards as they are able to step behind or in front of the board.
- Reduce the inertia and the overall weight to be pulled as a greater amount of the timber's weight is already past the fulcrum on which it is balanced (i.e. the table edge/rail/rollers), creating better board control and decreased effort.
- Reduce the force required to tip the board downwards (where this is done to gather board speed quickly as it is transferred).
- The optimum amount of overhang is likely to vary with mill and table design, other functions (docking, grading etc) occurring at the table and also depends on where timber is being transferred too.

Timber overhang at the mills surveyed were:

Mill 43	760 mm
Mill 30	100 mm back from table edge to 300 mm over table edge
Mill 17	35 mm
Mill 12	200-400 mm

Breakout Force Decrease

Recommendation 4: That tables are designed to minimise the horizontal pull force to move timber from table to packet. This appears to be reduced most significantly by the use of a roller chain system.

The mean break out forces for all chains measured was lowest with a roller chain. (See 'Summary of Assessment Findings', page 9). Whilst timber dimensions/lengths and wet/dry nature must also be taken into account, the solid timber round table required the greatest forces, and other flat chain or chain link tables required more force than the roller chain, but less than the wooden round table.

Timber end (on table) – packet distance

Recommendation 5: The distance between the end of the timber as it rests on the table to the end of the packet should be 1100-1400 mm.

This is based on male and female arm spans, and should enable the transfer to occur without excessive lateral spinal movement or twisting, stepping, or hitting the timber end or packet. This distance is affected (both positively and negatively with regard to musculoskeletal disorders) by:

- How far the timber needs to be transferred up or down the table to the appropriate packet.
- Length of the timber (longer lengths may need more room to gather sufficient momentum, shorter lengths may need less room so that the timber is not totally supported by the worker).
- Speed of the table (less space between the table and packet reduces task cycle time).
- Amount of traffic in the transfer area (how much extra space is required for tasks other than timber pulling).
- Height of the packet(s) in relation to the table (may need more space if the transfer is onto a packet higher than the table).
- How many packets there are (especially for round tables)

Timber end to packet end distance in the mills surveyed were:

Mill 43	1100-1400 mm
Mill 30	1600-3300 mm
Mill 17	900-1250 mm
Mill 12	1400-1800 mm

Maximum height for final row in packet

Recommendation 6: The overall height of the second to last layer of timber in the packet (therefore the height to which the last layer is lifted to) should be 920 mm – the same as the recommended table height.

Transfer of common and large dimension timber (from the table to the packet) should not require timber to be moved to a height significantly greater than that of the table. Transferring timber up to the packet is working against gravity and requires greater effort and a greater risk of injury as a result.

- This height is a function of the floor height of the area packets in, the total packet height, and trolley/bearer height. Achieving the same height as the table may require modification to any or all of these elements.
- The largest proportion of timber handling should occur between elbow and knuckle heights.
- Additional forces to lift the timber against gravity should not be required.
- To reduce the difficulty getting the first pieces of timber in place on the trolleys/bearers, a 'landing pad' to bounce timber along may assist. (As is done for the remaining timber in the stack).

Recommendation 7: Lower the trolley height to allow the total packet height (to top of second to last layer) to be equal to or less than the table height.

Recommendation 8: Decrease the overall height of the timber packets (make them wider and shorter), to decrease the height stacked too.

Recommendation 9: Use a 'landing pad' on the trolleys/bearers to bounce the timber along to reduce the effort required for positioning the first layer of timber.

Total packet heights on trolleys/bearers in the mills surveyed were:

Mill 43	no higher than the table
Mill 30	estimated 300 mm above table
Mill 17	packet height 530-770 mm and new trolley height 380 mm (old trolley 480 mm) above the floor that workers stand on when pulling and stacking. Total packet heights 910-1150 mm (new trolleys) and 1010-1250mm (old). Therefore total packet height is often higher than the table/rail (970mm).
Mill 12	commonly pulled timber (150 x 25 mm) packet height 725 mm , trolley height 360 mm, total height 1085 mm. Some packets 505 – 1050 mm total and trolleys between 360 and 560 mm height. Therefore total packet height on the trolley is often higher than the table (905/920).

Lateral Workspace Requirement

Recommendation 10: That the packet width plus 1020 mm (elbow span for 95th percentile male) is considered the minimum for packet/trolley spacing. For a packet width of 1200 mm, the overall lateral workspace requirement would therefore be 2220 mm for each single-worker workstation.

Adequate workspace should be provided at each packet for timber to be safely and easily handled, without workers feeling cramped or restricted in timber handling methods. For packets where two workers consistently work together, the lateral spacing should be increased.

Recommendation 11: That for packets where two workers consistently work together, that the overall lateral workspace requirement is packet width plus 2 x 1020 (elbow span for 95th percentile male). Thus for a packet of 1200 mm, the overall lateral workspace requirement will be 3240 mm, for a dual worker workstation.

The overall chain length should therefore allow this spacing for each trolley.

Trolley Design

Recommendation 12: That trolleys are built with structural stability and strength adequate for their purpose.

Trolleys should be built to withstand possible lateral movement if knocked by forklifts/cranes. Particularly they should have suitable wheels and bearings. Wheels should not damage the flooring surface and the trolley should move smoothly with minimal force. Trolleys should be maintained to ensure they remain functional and safe to use.

Fillet Stick Storage

Recommendation 13: That fillet sticks are stored within easy reach, and in such a way that it is easy to clean around them.

Fillet sticks are 'stored' under the front edge of the table and are obtained by bending and reaching under the chain. Whilst broken sticks are used for filleting, the collection of sticks under the table is haphazard and spread some distance, and includes other garbage and sawdust build-up.

Fillet stick storage at a better height and within easier reach of workers would be ideal. This should reduce the time taken for obtaining fillets, will make it physically safer and easier to reach them and will make it easier to clean under the chain area. Fillet sticks that are too small or damaged to use should be disposed of.

Redundant Handling

Recommendation 14: Alter the system for handling resawn timber.

Timber for resaw requires stacking when it first comes from the mill, then is sent back through resaw. The resawn timber then falls onto the timber coming from the main mill and creates frequent 'snarl ups'. These are time-consuming and somewhat dangerous for the workers that must sort it out, and can create greenchain stoppages. The additional handling of timber that is resawn is also costly in terms of worker time, and increases the amount of timber that must be pulled each day (without a production increase), and the trolley required for the first stack takes additional space on the greenchain.

Glove Design

Recommendation 15: That gloves are provided that have good fit and protection suitable for all workers.

Gloves should meet the following specifications:

- Chemical protection from timber treatments (if present)
- Timber splinter protection
- Sufficient 'feel' and 'tactile feedback' for the task(s)
- No restriction to hand postures and movements required for tasks
- No significant increase in the muscle effort/grip force (through glove inflexibility) required to achieve these hand postures and movements
- No contribution to the occurrence of localised physical discomfort through direct pressure, movement over skin or irritation
- Must be good enough for workers to stay within existing cycle time and acceptable quality parameters on a sustainable (absence of physical discomfort) basis.
- Sizes of gloves must enable 95% (2.5th - 97.5th percentile ranges) of both existing and potential user populations to achieve a comfortable, snug fit when undertaking the tasks for which it is intended.
- Should be of a construction that permits local modification of the glove when users need it (i.e. when the functional dimensions of their hand(s) are outside the percentile range stated above, or between glove sizes, or finger amputations exist).
- Should not get uncomfortably hot (or cold) when being worn for these tasks.
- Should not cause the wearer's hand(s) to sweat excessively where this could require increased muscle effort to overcome.
- Should be sufficient to withstand normal operating conditions (e.g. donning/doffing) throughout the design life of the glove system without affecting other aspects of performance.
- Should be accepted by those working in the industry as a viable alternative to other gloves and/or bare hands.
- All sizes and configurations must be available without significant delay.
- Should be considered affordable by sawmill operators.

At this mill it was noted that gloves had poor fit and adjustment, with a tendency to slip off workers hands. They were however noted to be cost effective, and to offer adequate splinter protection with adequate thermal comfort.

Task Rotations

Recommendation 16: That the rotational system is formalised and consistently adhered to, with at least 4 rotations through varied work tasks per day.

Regular rotation of workers through tasks that use different muscles and actions and is at a different level of physical intensity reduces the risks of musculoskeletal injury. Regular rotation also allows new workers to adjust to the task requirements with greater ease. Given that some workers report limited ability to gain rest and adequate nutrition within the two 15 minute breaks particularly, there may be some value in considering using two longer work breaks (30 minutes), instead of one 30 minute, and two 15 minute breaks. This would require further investigation. This work pattern lends itself to 6 rotation periods per day. One of the benefits is that for workers that have perhaps missed a substantial breakfast, they have the opportunity to eat at an earlier time during the day, enhancing their resulting physical performance. Others will choose to eat two smaller 'lunches', but all will have the opportunity for a longer physical rest from the work being performed.

Using the existing work breaks, rotations could occur on the following schedule:

7.30 – 8.45	1.15 hrs
8.45 – 10.00	1.15 hrs
tea break	
10.15 – 12.00	1.45 hrs
lunch	
12.30 – 1.45	1.15 hrs
1.45 – 3.00	1.15 hrs
tea break	
3.15 – 4.30	1.15 hrs
Total	8.00 hrs

Rotations should alternate between heavy or intense to light or slow work tasks. It is suggested that a whiteboard or other visible schedule system is used (and paper recording so previous days schedules can be tracked), and would be controlled by the team leader or leading hand. It is suggested that regular swapping between filleting and stacking occur. Rotations will also depend on worker skill levels. E.g. new and inexperienced workers may not cope well with more than one rotation on a heavy timber stacking task before needing to be rotated into a light task area, though a more experienced worker could manage a heavy task, followed by a medium task.

Training

Recommendation 17: That key safe work methods for pulling and stacking timber are covered at induction followed by buddy training with an experienced operator.

Key work methods and issues appear to be:

- Wait for the timber to come to you on the chain.
- Walk in close to the timber to grasp it from the table, avoid bending forward and over-reaching with stationary feet.
- Move your feet in the direction the timber is to move in, walk with it.
- Keep a wide base of support (feet apart) for stability.
- Use knee and hip action to reduce bending and twisting with the back.
- Develop left and right handed work methods to share the workload and reduce overuse problems.
- Work with wrists as straight as possible.
- Use gravity to best advantage, push the timber down and allow the timber to slide onto the stack.
- Use a 'throw' (as if passing a rugby ball) to provide the impetus for timber movement.
- Once the timber is moving, guide it into place on the stack.
- Use an apron and also guide the timber onto the stack with the hip/thigh to share the workload with the hands.
- Use the apron's protection to allow the thigh to act as an additional leverage point for handling timber that has fallen off the side of the stack.
- Place the first board of the layer on one side of the stack and then slide other boards with greater ease/speed alongside this guide board. (If working two to a stack the guide board is usually placed centrally).
- Learn to 'throw' and 'bounce' boards into place over bearers and fillet sticks, but also use the 'guide board' principle if possible.
- An alternative to throwing the first board over fillet sticks is putting the first board of the post-fillet layer on top of the pre-fillet layer, then having a team member lift the end of this board up so that fillet sticks can then be placed under. This gives a short work break, a stretch, a reason for some teamwork, and avoids the awkward first board post-fillet throw.
- Avoid lifting and placing of boards, rather they should be slid/supported on the table or stack, and 'thrown' and 'guided'.
- Regularly swap between heavy or intense stacking tasks and lighter or slower tasks.
- Allow new/inexperienced workers to gradually develop the strength and technique required for heavy/larger timber handling, and the speed/coordination required for more frequent handling of smaller timber dimensions.
- Develop a smooth and relaxed work rhythm.
- Work within your capacity.
- Stretch before and during work.
- Report discomfort early and ensure that some action is taken to accommodate this.
- Eat/drink according to the nature of the job. It is very physical work, and to perform well and avoid injury it is suggested that all workers eat healthily including breakfast, adequate snacks and lunch, and drink plenty of water during work.

Aprons: Aprons are used for several purposes. They protect the clothing from sap/resin build up and from damage from catching on rough timber. Aprons also allow the soft tissues of the body to be protected from splinters or bruising from the boards. Used well, aprons appear to allow the timber to be kept closer to the body in handling, thus reducing the forces acting on the back and arms. Apron use was observed to encourage a skilled worker to use leg and hip flexion rather than back flexion when stacking into the lowest stack positions.

Two styles of apron were seen in use. Thicker leather aprons allow greater body protection and timber is observed to be 'slid across/against' the leather aprons confidently and without risk of injury. Heavy plastic aprons appear to only protect the clothing, and workers using these were not observed to slide the timber across/against the aprons in the same way as those using leather aprons.

These key work method/training points should also be added to and altered following trial. Work method issues should not be seen as the only method for reducing musculoskeletal injuries. Workplace design and other factors (as per this report) should be considered and addressed accordingly.

Maintenance System

Recommendation 18: The maintenance system should allow all necessary repairs to be identified, communicated and tracked, so that all repairs and maintenance requests are systematically and effectively dealt with. Specifically, repairs to the chains should occur so that they are all functioning and the tensioning issues are addressed

An informal maintenance system without any form of documentation does not allow for review of reasons for downtime/tracking of breakdowns, creates confusion about what has been requested and when, and can cause workers to make the assumption that requests have been noted, when they may not have been. Workers may also assume that 'management doesn't care' if problems take some time to be rectified, so feedback to work teams is indicated. Informal systems also mean that safety issues can easily be overlooked, as critical 'keep the mill operating' issues take precedence. From a musculoskeletal injury perspective, poor maintenance of equipment can create the need for extra forces to move poorly maintained equipment, high stress as workers must frequently conduct running repairs on faulty equipment, and feelings of frustration and fear that at times dangerous maintenance problems must be constantly faced.

Recommendation 19: Remove the bolts protruding from the floor at the rear of the chain.

Recommendation 20: Review chain stoppage/lockout systems and communication issues.

Workplace Cleanliness

Recommendation 21: That the work area at the chain is swept and tidied regularly.

Keeping the sawdust cleared and broken fillet sticks etc removed will reduce both the risks of eye injury (as the building is exposed to winds), and risks related to slips and trips.

Noise

Recommendation 22: That the results of the June 1991 noise assessment are accurately followed.

The recommendations were:

- that Grade 2 hearing protection (plus or muffs) is mandatory for those in the first chain position and further down the chain, whether or not the mill or radio are on
- that the person working at the top of the chain (pusher) should wear Grade 3 hearing protection (ear muffs).

Lighting

Recommendation 23: That lighting levels at the greenchain be increased.

Lighting levels for general purpose areas such as storerooms are suggested to be between 80-170 lux, and for packing/despatch tasks between 200-250 lux (Kroemer and Grandjean 1997). On an cloudy February morning at 8 am lighting at the rear, mill end of the chain was 45 lux, through to 82 lux at the far end. The stacking side of the chain was between 350 and 415 lux at this time. This issue is relevant given early morning starts in winter.

Appendix 8

- Mill 17 interview data
- Mill 17 timber statistics
- Mill 17 pack specification tables
- Mill 17 force measure data
- Mill 17 REBA data
- Mill 17 Manual Handling Risk Score

Interview Data 17 130302														
Subj #	Age	Gend	Weight	Height	Hand	Time in Jot	Experienc	Work Hrs	Nutritional	PPE Used	Hardest/easiest	Training	Rest Breaks	Improvements
1	35	M	95	180	R	15 mths	6 mths	44	4 weetbix and 1 coffee for breakfast, cake/biscuits for morning tea, and 1 coffee, Sandwiches and coffee for lunch, full evening meal	Doesn't usually wear gloves, eye protection if grading or using saw, steelcapped boots, earplugs. Heavy plastic aprons may be worn to protect clothing.	Unloading task is hardest, handles everything, and very physical especially on big timber. Unloader gets slower over 5-6 packs being unloaded.Timber size, small timber is faster, large timber is heavier, both good/bad points.	Get the timber on top of the bar and use it as a lever. Pull timber and slide it along the stack. Ensure that the far board on the stack is in place for the other boards to slide alongside. May be easier with the table/stack distance closer, preference	Better with 2 longer breaks during day, rather than 2 short and one long break. Rotations 1.5 hourly are good.	Extra step all the way along in trolley area (that the trolleys fit under, reduce height of rails, automatic unloader, rollers on edge of bar would be even easier, pit stacker would be better with mechanical block to move the front edge of export packs closer to the
2	21	F	63	163	L	15 mths	NA	44	Breakfast is coffee and cigarette, morning tea 2 minute noodles and coffee, lunch is salad roll, fruit and coffee, full dinner at night. Also drinks about 2 litres of water per day.	safety boots, glasses in strapping and docking areas, hard hat where needed, and apron may be necessary to protect form antisapstain (only if working on green table, not on dry table).	Unloading is hardest, handle all timber, sets the pace for others. Trys to fill every cleat on table.	Fairly informal, don't lift the timber, use the rail and balance it, point it down and let the weight of the timber do the work, learn to manage the 'bounce' of the timbe when throwing it onto the stack. Slide it on, longest pieces to the outside of the pack.	Rotations 1.5 hrly are good.	Move tally board so have more trolley space. ?distance/length marker for grader to make it easier.
3	36	F	92	158	R	4yrs and 2 mths	NA	44	Toast and rice bubbles and 2 hot drinks, morning tea is coffee, Lunch is fruit and sandwich with one tea or cold drinks. Drinks 1.5 litres of water on days that aren't too cold and if busy. Large evening meal.	Boots, no earmuffs as they give her a headache, only wears them until her head hurts,. Uses Showa gloves as these are best fit.	Easiest task is pulsling and stacking timber, hardest is the unloader, handling each piece of timber. Bigger timber is more difficult. Pit stacking at the end is hard on back as you work in front of the	No special tricks, everyone is different has own pattern and rhythm. No wpecific method, work form left or right depending on preference.	1.5 hrly rotations are good, particularly if been on tough jobs.	Fix the design of the unloader, so don't have to lift up over the ridge and throw onto the table. (automate). Chain start-up is very squeaky ? Maintenance. Speed is supposed to be reasonalbe set and steady, but is
4	51	M	92	180	R	16 yrs	3-4 years	44	Breakfast is 4 slices toast, 1 large cup of tea. First break has sandwich (2 slices), fruit and cake and 2 cups of tea, second break has sandwich and fruit and 2 cups of tea. Has full meal at nights.	Earmufs, gloves (polyester with resin pattern), when they get older they get softer and mat up (and less splinters get through). These last 3-4 days to 10 days. They are breathable.	Grading has high cognitive demand, must consider grade, trimming length etc. Is a grading manual with criteria, is skilled and experienced job. Hardest to work with timber on chain in awkward place, work that is fast is hard. Weasiest is pulling off when most is going to the pit stacker. Can use stop button if backlog builds. Worse with pressure to get an order out. Grader areas also stressful as are	Grading is on the job and book lessons. Walk behind the timber, silly questions are better than silly mistakes philosophy, fillet stick spacing and pack sizing are learnt. Buddy training is good. Throw timber to stack it.	Good breaks, not so many that get lethargic, but 10 minute tea breaks inadequate with this work.	? Lighting levels for visibility to grade. Unloader has been modified and therefore jams more than it should. Breaks fillet sticks (costly). End of boards catch on lugs when pulling them off the chain, use rail to keep the boards clear. ? Look into lug height vs rail relationshop, and consider chain speed issues also. Noted that rollers will not work if pulling off to a pack on an angle (falls off)
5	49	M	74	1.65	R	1 yr	NA	44	Breakfast is 1 cup of tea and 4 slices of toast, morning tea is 2 sandwiches, 8 crackers and some fruit with 2 cups of tea, lunch is 2 sandwiches, 2 cakes and a banana with 2 cups of tea. Drinks 750 mls juice during the day also, and has full dinner at night.	Prefers orange Showa type gloves as feels they have better protection. The more fluffy/woolly ones are more comfortable but have less protection. Wears hard hat all the time and earmuffs.	Grading is mentally demanding, unloader is the most physically demanding. Heavy timber (rimu) is harder to pull and stack. Pit stacker is quite good but can be demanding. Hard to pull bigger sizes back and along the table. Fillet sticks is easiest though most monotonous.	Lift board over bar, sharp throw with one hand onto stack, use boards on the apck to support and guide it into place, carry as little board weight as possible. He preferes to work lookin up the table to timber that is coming, some prefer either left/right throw hand.	Rotations ok.	New trolleys with steel wheels, need 2-3 people to push them sometimes. Need to have various heights to suit different worker heights, rails for trolleys are dangerous, need to be cut down, risk of ankle etc damamge.? Walkway across combine with scissor hoist on trolleys.
6	55	M	90	173	R	20 yrs	10 yrs	44	Breakfast 3 weebix, 1 coffee and another coffee when he gets here. Morning tea biscuits and 2 cups of tea, lunch is several sandwiches and a banana and 2 cups of tea. May drink water during the day if it is hot. Full dinner at nights.	Wears safety boots, hard hat, earplugs and an apron to protect clothing.	hardest work is with bigger timber, easier in pit stacking than pulling off timber. Recognises that he does not work/move as fast as he used to.	Feels that you should adjust yourself to use your strongest side to pull timber off. Use whole body not just arms.	Finds half hour break almost too long.	Thinks that table should be lower to work from. Thinks the rail is there to stop him jamming his fingers, was not aware of other purpose for it. Finds it easier to move timber downhill onto trolleys.
7	54	M	73	170	Amb	6 yrs	1-2 yrs	44	Breakfast is bacon, sausage, potatoes or weetbix/muesli and toast with 3 cups of tea or coffee. Has no morning tea snacks, lunch is 6 sandwiches and fruit, and at least 1 litre during the day. Has full dinner.	Wears glasses, earplugs/muffs and boots, plus hard hat where required. Aprons are optional to keep clean, but this work is quite clean. Timber used to be more rough/raggedy and ripped clothing more, not so bad now (rimu more rough).	Work is fairly constant, not really much difference between big and small timber sizes. Hardest with pressure to get a lot of timber through/chain going faster.	Training is best with 'watch and see' approach he thinks. Buddy training is good, walk with the timber, don't overuse your back (what Precious McKenzie said).	Breaks ok.	Having the bar along the side was a breakthrough. It stopped people carrying the weight of the timber, by sliding it off over the bar. Need to lift it off over the lugs too, and for back care reasons.

Mill 17 Timber Statistics

Date (* = Friday)	Total packs per day	Total m3 per day	Piece tally per day	Hours table operating	Estimate of timber items unloaded and stacked per worker (given 7 workers)	Timber items unloaded and stacked per hour of table operation
29.10.01		81	5785	4.8		1205
30.10.01		72	5349	4.8		1114
31.10.01		62	7940	5.9		1346
01.11.01		86	4613	4.2		1098
02.11.01		41	3031	2.9		1045
05.11.01		67	6650	3.9		1705
06.11.01		55	2390	2.3		1039
07.11.01		37	1699	2.5		739
09.11.01		75	4757	4.0		1189
12.11.01		78	6571	4.9		1341
13.11.01		67	5747	5.0		1149
14.11.01		95	5844	5.1		1146
15.11.01		95	4729	5.0		946
16.11.01		91	4288	4.5		953
19.11.01		91	5390	5.0		1078
20.11.01		68	7288	5.0		1458
21.11.01		67	6778	5.0		1357
22.11.01		117	3915	5.3		739
23.11.01		76	3662	5.3		691
26.11.01		109	5330	5.0		1066
27.11.01		79	5325	4.9		1087
28.11.01		63	3499	3.3		1060
29.1.01		69	7621	5.6		1361
30.11.01		90	6458	5.0		1292
04.12.01		81	4197	4.3		976
05.12.01		55	4588	3.8		1207
06.12.01		76	3239	3.7		875
07.12.01		57	3175	3.2		992
10.12.01		70	6417	5.0		1283
11.12.01		104	5713	5.0		1143
12.12.01		91	6571	5.4		1217
13.12.01		70	5586	4.5		1241
14.12.01		71	3125	3.2		977
17.12.01		144	7059	6.0		1177
18.12.01		60	5513	4.6		1198
19.12.01		79	5178	4.3		1204
20.12.01		55	5744	4.1		1401
21.12.01		33	3074	2.2		1397
07.01.02		76	5037	4.4		1145
08.01.02		74	6796	5.2		1307
14.01.02		68	7548	5.8		1301
15.01.02		112	6000	5.1		1176
16.01.02		76	6456	5.0		1291
17.01.02		46	6088	4.5		1353
18.01.02		61	4957	4.7		1055
21.01.02		72	6938	5.5		1163
22.01.02		90	4477	4.9		914
23.01.02		62	5388	4.9		1100
24.01.02		58	3932	3.8		1035
25.01.02		87	3781	4.1		922
28.01.02		70	6734	4.8		1403
29.01.02		56	6283	4.9		1282
30.01.02		46	5769	4.4		1311
31.01.02		37	4568	3.7		1235
1.2.02*	42	52.8	4753	3.9	679	1219
4.2.02	46	68.8	4835	4.7	691	1029
5.2.02	37	44.7	5571	4.6	796	1211
7.2.02	63	64.6	8948	3.9	1278	2294
8.2.02*	42	58.8	3568	3.4	510	1049
11.2.02	50	48.9	3965	4.1	566	967
12.2.02	58	60.5	2810	3.1	401	906
13.2.02	35	46.3	3091	3.3	441	937
14.2.02	41	60.4	3247	3.6	464	902
15.2.02*	49	51.5	2789	2.8	398	996
18.2.02	33	43.4	4300		614	
19.2.02	46	55.5	4479		639	
20.2.02	38	34.6	5252		750	
25.2.02	53	67.5	6230		890	
26.2.02	38	54.3	4980		711	
27.2.02	45	51.9	5983		855	
28.2.02	43	55.7	4472		639	
11.3.02		42	5019		717	
12.3.02		108	5321		760	
13.3.02	48	80	4020		574	
14.3.02	49	68.09	4057		580	

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Pack Specification Manual

Issue	Contents	Section	Page
3	Export Pack Dimensions	3.1	2 of 2

Pack Dimensions	WIDTH (mm)	HEIGHT(mm)	LENGTH (m)
EXPORT	700 WIDE	750 HIGH	5.70

N° of Pieces in Pack Bottom	EXPORT		FILLET STICK PLACING		HEIGHT
TIMBER SIZE	On Flat	On Edge			
50x25	14	0	9	9	27
50x40	14	0	5	5	16
50x50	14	0	5	5	15
75x17	10	0	13	13	40
75x19	10	0	12	12	37
75x25	10	0	9	9	27
75x32	10	0	7	7	22
75x40	10	0	5	5	16
75x50	10	0	4	4	13
75x75	10	0	2	3	10
100x17	7	0	13	13	40
100x19	7	0	12	12	37
100x25	7	0	9	9	27
100x32	7	0	7	7	22
100x40	7	0	5	5	16
100x50	7	0	4	4	13
100x75	7	0	2	3	10
100x100	7	0	2	2	7
125x19	6	0	12	12	37
125x25	6	0	9	9	27
125x32	6	0	7	7	22
125x40	6	0	5	5	16
125x50	6	0	4	4	13
150x19	5	0	12	12	37
150x25	5	0	9	9	27
150x32	5	0	7	7	22
150x40	5	0	5	5	16
150x50	5	0	4	4	13
200x19	3	6	12	12	37
200x25	3	4	10	10	27
200x40	3	2	5	5	16
200x50	3	2	4	4	13
250x25	2	8	10	10	27
250x40	2	5	8		16
250x50	2	4	6		13
300x25	2	4	13		27
300x40	2	2	8		16
300x50	2	2	6		13

Mill 17

Pack Specification Manual

Issue	Contents	Section	Page
2	Domestic Pack Dimensions	4.1	2 of 2

Pack Dimensions	WIDTH (mm)	HEIGHT	LENGTH (m)
DOMESTIC	1020 for 17mm thick 1070 for other sizes		5.69

N° of Pieces in Pack Bottom	DOMESTIC		FILLET STICK PLACING		HEIGHT
TIMBER SIZE	On Flat	On Edge			
50x25	19	0	8	9	25
50x40	19	0	4	6	16
50x50	19	0	4	4	12
75x17	14	0	10	10	30
75x19	14	0	8	10	28
75x25	14	0	8	9	25
75x32	14	0	6	8	20
75x40	14	0	4	6	16
75x50	14	0	4	4	12
75x75	14	0	2	3	8
100x17	10	0	10	10	30
100x19	10	0	8	10	28
100x25	10	0	8	9	25
100x32	10	0	6	8	20
100x40	10	0	4	8	16
100x50	10	0	4	4	12
100x75	9	0	2	3	8
100x100	10	0	2	2	6
125x19	8	0	8	10	28
125x25	8	0	5	10	25
125x32	8	0	5	10	20
125x40	8	0	4	8	16
125x50	8	0	3	6	12
150x19	7	0	8	10	28
150x25	7	0	8	9	25
150x32	7	0	5	10	20
150x40	7	0	6	5	16
150x50	7	0	4	4	12
200x19	7	0	4	4	12
200x25	5	0	8	9	25
200x40	5	0	5	6	16
200x50	5	0	4	4	12
250x25	4	0	12		25
250x40	4	0	8		16
250x50	4	0	6		12
300x25	3	0	13		25
300x40	3	4	8		16
300x50	3	3	6		12

Force Measure (Kilograms) Position 1					
Board Number	Pull Number 1	Pull Number 2	Pull Number 3	Mean	Moisture content
A1	4.65	4.95	5.05	4.88	
A2	4.80	4.95	4.70	4.82	
A3	3.85	3.70	3.35	3.63	
A4	4.00	4.10	4.05	4.05	
A5	6.90	7.30	6.90	7.03	
A6	5.85	5.70	5.30	5.62	
A7	5.35	5.35	5.40	5.37	
A8	3.50	3.60	3.85	3.65	
Mean for A boards				4.88	
B1	17.55	17.40	17.55	17.50	10.9
B2	14.15	14.20	14.40	14.25	12.1
B3	10.15	10.60	10.25	10.33	12.2
B4	12.35	11.55	11.40	11.77	12.1
B5	10.45	9.95	9.65	10.02	10.6
B6	13.70	13.50	13.05	13.42	9.3
B7	8.15	8.05	8.10	8.10	10.7
B8	7.95	7.35	7.00	7.43	12.2
Mean for B boards				11.60	

Force Measure (Kilograms) Position 2					
Board Number	Pull Number 1	Pull Number 2	Pull Number 3	Mean	Moisture content
A1	5.60	5.95	5.95	5.83	15.8
A2	4.70	4.90	4.85	4.82	11.6
A3	3.50	3.45	3.50	3.48	11.9
A4	4.55	4.65	4.70	4.63	10.7
A5	6.60	7.15	7.10	6.95	12.8
A6	5.80	4.65	4.95	5.13	14.9
A7	4.95	5.00	5.00	4.98	15.1
A8	3.40	2.90	3.10	3.13	10.3
Mean for A boards				4.87	

Board sizes A = 125 x 40 mm, 3600 mm lengths
B = 300 x 50 mm, 3000 - 3600 mm lengths

Board A Overall Mean	4.88
Board B Overall Mean	11.60

Mill 17 – REBA Data

Subject description	Task description	REBA Score	Working Sheet Number	Comments	REBA Risk Level
Over 50th %ile male, inexperienced	**Unloader** ?100 x 50 mm timber				
	Grasping board at **unloader**	**5**	1	Spinal twisting, feet restricted by table edge	Med
	Levering board across step by pushing down end (**unloader**)	**8**	3		High
	Throwing board onto chain by levering off the far end of the board **(unloader)**	**6**	2		Med
	Picking short board up from **table**	**3**	41		Low
	Putting short board onto 2nd layer of **stack** on trolley	**4**	42		Med
	Pushing full trolley out (with another person)	**11**	27		Very High
Less than 50th%ile male, experienced	**Pit stacker** ?100 x 50 mm timber				
	Reaching forward to grasp board from top of chain near **pit stacker**	**9**	4		High
	Pulling board back to lever it into position on **pit stack**	**8**	5		High
	Sliding board into **pit stack** position	**4**	6		Med
Approx 50th%ile male, inexperienced	**Table/stacking** ?100 x 50 mm timber				
	Pulling board from **table**	**11**	7	Standing too far away, bend and reach	Very High
	Reaching to grasp board from **table**	**6**	13		Med
	Lifting/pulling board from **table**	**9**	14		High
	Pulling board from **table and onto stack**	**9**	8		High
	Feeding board onto **stack**	**6**	9		Med
Over 50th%ile male, experienced	**Grader** – putting grade mark on board end with chalk	**7**	10		Med
	Reaching to grasp/turn board with left hand for **grading**	**6**	11		Med
	Reaching out for skill saw to **cut/dock board** end	**7**	12	Skill saw hits chest/arms/head when swinging after use	Med
	Pit stacker – reaching for board from chain	**5**	38	Step at left prevents optimal foot placement	Med
	Levering board across onto **pit stack**	**9**	39		High
	Placing board onto **pit stack**	**5**	40		Med
Under 50th%ile female, experienced	**Unloader** ?100 x 50 mm timber				

	Reaching for board with right hand at **unloader**	**11**	15	Leaning forward and reaching to board	Very High
	Unloader pulling board back with right arm	**8**	16	Stabilising with left hand/arm on top of buffer	High
	Unloader, pulling board back for levering over to table	**11**	17	Spinal twisting	Very High
	Unloader, applying leverage downward force to lift board far end over to table	**11**	18		Very High
	Unloader, board being swung over	**10**	20		High
	Unloader, lifting front end of board up and over the edge	**10**	20		High
	Unloader, throwing the board onto the chain	**8**	21		High
	Unloader, picking up board in left hand	**10**	22	Works with legs abducted for greater stability, also anchors against edge of table	High
	Unloader, applying downwards force to lever board over	**10**	23		High
	Feeding timber onto **stack**	**7**	31		Med
	Lifting board onto **stack**	**8**	32		High
	Throwing board out onto **stack** and feeding in	**11**	33	Trunk bent, arms at full reach, heavy and awkward load	Very High
	Grasping board from **table** with left hand	**6**	28		Med
	Two hands to pull board from **table**	**8**	29		High
	Flinging board out with right hand towards **stack**	**8**	30		High
	Aligning board end on **stack**	**11**	34	Full bend	Very High
	Placing board onto **stack**, first layer	**10**	35	Full bend, straight legs	High
	Lifting board up and feeding on to approximately 12th layer of **stack**	**7**	36	Considerable shoulder elevation	Med
	Lifting board to approximately 13th layer on **stack**	**7**	37		Med
Less than 5th%ile male, experienced	**Pit stacker** ?100 x 50 mm timber				
	Pit stacker, reaching with left hand to grasp board from top of chain	**5**	24		Med
	Pit stacker, pulling board back with left hand	**9**	25		High
	Placing board onto **pit stack**	**5**	26		Med

REBA Risk Levels

- Negligible (REBA Score 1)
- Low (REBA Score 2-3)
- Medium (REBA Score 4-7)
- High (REBA Score 8-10)
- Very High (REBA Score 11-15)

Mill 17 – Manual Handling Risk Score

The risk score was calculated as below:

7 Find the load score: The load score is the muscle force applied by the worker. It may be the weight of the object handled or you may need to measure the forces applied with a spring balance or a force gauge – or make an estimate. If several people do the task, the score should reflect the ability of the least able.

The load score varies depending on the timber dimension being worked with, and whether a male/female worker. For the smaller/short board sizes, I estimate that a load score of 1 is indicated (men) and 2 (women). For the larger/longer board sizes, I estimate that a load score of up to 10 is indicated (women) and 4 (men).

Men	Women	Load Score
< 10 kg	< 5 kg	1
10 – 19 kg	5 – 9 kg	2
20 – 29 kg	10 – 14 kg	4
30 – 39 kg	15 – 24 kg	7
40 +	25 +	10

Report the Load Score here → 1,2,4,10 A

8 Find the posture and workplace layout score: Observe the postures adopted. Take an average value if necessary or use numbers between the ones shown.

Usually working with slight bending and twisting of the trunk, though varies depending on individual anthropometrics and task.

	Posture Score
Trunk upright, no twisting, load close to body, standing or walking a few steps only.	1
Some bending forward or twisting, load close to body, sitting, standing or walking for a longer distance.	2
Bending far forward or close to the floor, slightly bending and twisting the trunk, load far from the body or above shoulder height, sitting or standing.	4
Bending far forward and twisting the trunk, load far from the body, below the knees or above shoulder height, unstable posture while standing, crouching or kneeling.	8

Report the Posture/Workplace Layout Score here → 4 B

9. Find the work conditions and environment score: (Flooring/work area restricted in some work stations)

	Environment Score
Good conditions, with sufficient space, no obstacles, level and solid floor surface, good lighting, able to get a good grip on the load.	0
Restricted workspace (area < 1.5 m^2), restricted postural stability (floor uneven, soft, slippery, steeply sloping).	1

Report the Environment Score here → 1 C

10 Find the time score: Find the time score from the greatest of either the number of repetitions of the task or the time spent doing it during the shift.

Repetitions per shift	Total time per shift	Time Score
< 10	< 30 min	1
10 – 40	30 min – 1 hr	2
40 – 200	1 – 3 hrs	4
200 – 500	3 – 5 hrs	6
> 500	> 5 hrs	8

Report the Time Score here → 8 *Time*

Add the three scores in boxes A, B and C → **Sum** **6, 7, 9, 15**

11 Multiply box **'Sum'** by box **'Time'** to get the risk score. **48, 56, 72, 120**

Guidance on the Meaning of the Risk Score	
Risk Score	***Urgency and type of control measure***
< 10	Injuries are unlikely unless there are infrequent high force actions. Monitor the task from time to time.
10 - 24	Injuries may result for less resilient people. Workplace re-design is recommended for them.
25 - 49	**Injuries are possible for trained and fit people. Workplace re-design is recommended to control the contributory factors identified.**
50 +	**Injuries are likely regardless of the strength and fitness of employees. Elimination of the task or workplace re-design is a priority.**

Appendix 9

- Mill 17 Summary of Assessment Findings
- Mill 17 Recommendations for Reduction of Manual Handling Risks

Mill 17

Summary of Assessment Findings

Contents

Mill 17

Summary of Assessment Findings

Archival Data

Hazards and health and safety factors are covered at induction. Whilst many other factors are noted, manual handling factors are not specifically identified in this hazard management process. This workplace maintains a focus on health and safety and endeavours to be proactive in managing risks and increasing productivity.

Accident register data is kept and analysed at this workplace. Some recent incidences included problems from the uneven flooring over the trolley railings, fillet sticks flying up, rollers at the unloader causing timber to fly back and jam fingers, and one case of hand strain from handling timber (grader) and some back problems from general bending and twisting activities.

Several pay steps exist, with movement through the pay steps based on performance etc.

Main findings: ***Manual handling risks not covered fully. General proactive approach to health and safety management.***

Drychain, Trolley, Packet and Workspace Dimensions

Chain/table geometry: Total table length is just over 17 metres. This includes where the unloader places timber onto the table and the grader works through to the area where the two table hands stack timber and the end position where the pit stacker stacks the bulk of the timber. The table has a total of 7 chains across its 6 metre width and is 890 mm high.

Chains have cleats/lugs that separate the timber, with these cleats being of two styles. Cleats are between 95 mm and 115mm in height from the table surface. Cleats are reportedly necessary on the chains to separate the timber and allow the tallying process to occur.

Board position at the table edge is determined by a guide positioned just beyond the grader, allowing the timber to overhang the table edge by 35 mm.

A rail exists along the front edge of the table from just beyond where the grader works to near the end of the table. The rail is at 970 mm overall height (80 mm taller than the table edge) and it protrudes 200 mm out from the table edge. It is used to rest the timber on at a position above cleat height, thus making the pulling and stacking process somewhat easier. The rail does however mean that the worker must first reach over and lift up the timber, and must quickly pull it and push down on the timber end to free the board from the cleats, so that the board is not dragged along the table by the cleats.

Unloader: Timber is tipped from the unloader onto a platform that allows fillet sticks to fall through (they sometimes fly up). The unloader operator must take these boards and move them over onto the chain, doing so by pulling the boards back then levering them over the barrier onto the table. Rollers exist to move the boards closer to the operator to reduce

reaching and bending. The unloader operator handles each piece of timber that goes onto the table, and the work pace of this person dictates overall output.

Grader: The grader must visually inspect each board (turns the board over) to determine the grade and then marks the board. The grader will at times use the skill saw to dock boards of damaged areas. The chain may be stopped to allow this to happen.

Chain speed: The chain has a variable speed control, and was observed to run at 22.5 seconds over 10 metres at its fastest (2 seconds per board), 23.3 seconds per 10 metres at a 'moderate speed', and 27 seconds per 10 metres (2.5 seconds per board). Board size and therefore ease of handling issues dictate the work speed selected by the work team. The chain is controlled by start/stop controls at several points along the table length and the speed controls are near the grader.

Trolley-table distance: Pack ends were measured at between 900 and 1250 mm from the table edge, with the timber overhanging the table edge by approximately 35 mm. Thus the distance between the end of the timber on the table and the end of the packet is approximately 860 – 1220 mm. A rail is 200 mm from the table edge, and 80 mm above table height.

Packet Sizes: Packet height domestic - varies between 530mm and 660mm and export - between 660 and 770 mm. Total packet height estimated includes 20 mm for two fillet strips. Packet size for export is given generally as 700 mm wide, 750 mm high and 5.7 metres long. Packet size for domestic markets is given generally as 1070 mm wide (except for 17 mm thick timber which is 1020 mm wide) and height variation as above, and length around 5.7 metres also.

Trolleys: Trolleys in use are of two main designs. The overall height of the new trolleys is 860mm, with several old wooden trolleys at around 960 mm. One prototype new trolley is at 1030mm but was determined to be too high for comfortable use. Trolleys are this height to accommodate the 480mm step up to the flooring alongside the table. The new trolleys are not solid approximately 3-4 metre long models as the old ones, but are actually two separate bearers, each travelling on 4 x 150 mm diameter nylon wheels. These run on right angles steel rails attached to the floor. Accident reports indicate several incidences where these trolleys have tipped when fully laden. Trolleys are however lightweight and manoeuvrable, and can be lifted across railings to different positions as required.

Main findings: ***Total dry table length 17 metres, total height 890 mm with bar height at 970 mm. Seven chains operating, with cleats of approximately 100mm to space timber to allow tallying. Cleats cause timber to be pulled along the table, and the rail was installed to allow boards to be quickly lifted free of the cleats to reduce this problem.***
Chain speed is variable but without actual speed indicators. Observed to move at between 2 and 2.6 seconds per board. Chain speed variance is usually a function of timber size and at time grading needs. The team selects to work faster with smaller timber dimensions.
Distance between table and packet ends approximately 860 to 1250 mm.
Packet heights between 530 and 770mm, and between 700 and 1070 mm wide.
Trolley heights largely at 860 mm some 960, and one trolley at 1030 mm. New trolley design of two separate bearers on 4 wheels though with some tipping problems indicated. Trolleys must compensate for the 480 mm step up to the flooring at the table.
Unloader and grader handle all timber items, pit stacker stacks the majority of timber. Two table hands, and tallybox operator, fillet sticks person, and strapper, crane operator.

Timber Statistics

On review of figures from end October 2001 to end February 2002, and taking into account the time when the table was not operating each day, the following mean/range figures were determined. This area keeps good track of any downtime on the chain for productivity enhancement purposes.

	Boards stacked per hour	Boards stacked per minute	Seconds per board
Mean	1156	19.27	3.11
High	2294	38.23	1.57
Low	739	12.32	4.9

Unloading and grading requires handling of each item of timber, and the pit stacker handles much of the timber from the table.

Main findings: ***A mean of 1156 boards are stacked every hour from the dry chain, at an average pace of approximately 19.27 boards per minute and 3.11 seconds per board.***

Environmental data

Noise: Verbal reports indicate that full noise testing has been completed for this area, with mandatory hearing protection not required, though available if desired. Impact noise occurs as the timber falls at the unloader and radio noise, intercom communication and chain noise (squeaking) are consistent.

Lighting: Lighting levels as measured mid-day on a cloudy February day were upwards of 500 lux in the general work area. Between 650 lux (nearest to the grader) and 900 lux (mid-table) was measured for the length of timber that the grader must view. As the grader must rapidly complete visual grading tasks, good lighting is essential. The CIBS Code for Interior Lighting (1984) recommends 750 lux for timber inspection activities, with the comment that directional lighting may be useful. The lighting level closest to the grader could therefore be slightly improved to reach this level. The mirror hanging at the grader's right (for tally purposes) is perhaps blocking some of the light at this point closest to the grader.

Floor surface: The work area beside the table is a wooden platform. There are steps up to this at several points from the lower concrete flooring area that the trolleys are on. Trolley rails create a hazard (with recent slip/trip incidents), and flooring modifications are being considered. A step down into the work area of the pit stacker exists. Steps up to the tallybox.

Main findings: ***Hearing protection is not mandatory. Lighting levels are adequate though may require review for the grader. Floor surface hazards require addressing regarding the trolley rails that must be crossed over if not using the wooden walkway near the table.***

Nordic Musculoskeletal Questionnaire (NMQ)

Results conclude that in the last 12 months (prior to assessment) discomfort was experienced by dry table workers (n=7) as below:

- 43% neck,
- 57% one or both shoulders,
- 29% one or both elbows,
- 72% one or both wrists,
- 14% upper back,
- 57% lower back,
- 57% hips/thighs/buttocks,
- 29% knee,
- 43% ankles/feet.

Over the previous 7 days (prior to assessment) discomfort was experienced by dry table workers as below:

- 29% neck
- 28% one or both shoulders,
- 14% both elbows,
- 29% lower back,
- 29% hips/thighs/buttocks,
- 14% knee,
- 14% ankles/feet.

Over the last 12 months (prior to assessment) some discomfort was experienced that prevented worker participation in normal activities as below:

- 14% due to lower back discomfort,
- 14% due to hip/thigh/buttock discomfort,
- 14% due to knee discomfort,
- 14% ankle/foot discomfort.

It is also noted that this group of workers consisted of 4 males between the ages of 49 and 56 years, one mid-30's male, and two females (mid 30's and early 20's). The somewhat older age group reported a number of injuries that were pre-existing (arthritis, old injury pain etc) and that have impacted on the discomfort reports. Only one worker did not have an old or recent significant injury causing discomfort. It could be interpreted that this workload is not that heavy if these workers can in fact sustain the effort satisfactorily.

Main finding: ***musculoskeletal discomfort is common among this group of dry table workers, with some limitation of normal capacity to complete daily activities resulting. Discomfort in some instances relates to pre-existing conditions.***

Lifting strength testing - using dynamometer

Comparison of data (n = 5) gathered with that reported by Keyserling, Herrin and Chaffin, 1978, determined that:

Leg lift — 80% of workers had 75th percentile or above leg lift strength and 20% 25th percentile strength

Arm lift — 80% of workers had less than 50th percentile arm lift strength, 20% with less than 25th percentile strength.

Main finding: ***That the workforce population employed at this mill is relatively strong for the leg lift, but relatively weak for the arm lift.***

Anthropometric Data

Data collected form the worker group correlates with that for the New Zealand population, as given in NZ Anthropometric Estimates, (Slappendel and Wilson, 1992). Thus this NZ data can be used for relevant design considerations.

Main finding: ***NZ Anthropometric estimates suitable for use in design considerations with worker population.***

Borg Rating of Perceived Exertion (RPE) Scale

Workers reported somewhat greater exertion at the end of the day than at the beginning. The scale used included ratings for: very, very light; very light; fairly light; somewhat hard; hard; very hard; very, very hard. Further data gathering required to strengthen validity of possible interpretations.

Main finding: ***Workers perceived lower levels of exertion at the start of the day (very, very light – somewhat hard) compared to the end of the day (very light – hard.***

Discomfort Rating Scale

Two (out of 7) workers reported discomfort in the morning and in the afternoon, from pre-existing injuries more than specific work related discomfort. Apart from specific injury sites most workers felt comfortable or acceptable whilst working both during both the morning and afternoon periods. One worker developed right wrist discomfort whilst pit-stacking in the last work period of the day.

Main finding: ***Reported discomfort levels related largely to existing injuries, with reports of acceptable comfort otherwise.***

Interviews

Nutrition: Most workers interviewed reported having a substantial breakfast and meals during the day and at night, and additional fluid intake during the day to counter the physical workload with related fluid loss.

Personal Protective Equipment (also from observation): Some workers use a plastic apron for clothing protection while handling timber (it was noted that pinus radiata is not as 'rough' as rimu). Most workers used one of the various glove types available, with selection largely based on fit, comfort during use, and protection. All gloves used were of knit fabric types. Showa (rubber coated palm/digits) gloves were reportedly best fit for females. Males used two other knit styled gloves, one with a fully rubberised palm/digits design and the other with a rubberised 'webbing' over the palm/digits. Hearing protection worn by some workers to protect reduced hearing, or for general auditory comfort. One worker finds earmuffs to be uncomfortable and this reduces the time earmuffs are worn for. Hard hats and safety glasses worn by all workers at appropriate workstations. Steel capped boots worn as standard.

Hardest/easiest work tasks:
Hardest work when:
- Unloading, as handling all timber
- Unloading, especially when large timber sizes
- Table going faster
- Grading task with high cognitive demand and particularly difficult when table going fast
- When pressure for output and speed of work
- Having to move timber up/down length of table

Easiest work when:
- Work is constant (no stop/start)
- Working in pit stacker
- Working in fillet sticks

Training: Key factors for ease in timber handling and learning the necessary work skills were:
- Get the timber on top of the bar and use it as a lever
- Slide the timber on the rail/stack, don't lift/carry
- Get a 'guide board' in place on the side of the stack, then slide others along side
- Keep stack close to table
- Use the weight of the board - push it down so it slides off by itself
- Learn to manage the 'bounce' of the timber to control it
- Develop your own pattern and rhythm, and left/right/both sides work preferences
- Walk behind the timber
- 'Throw' the boards onto the stack
- Use your whole body, not just your arms/back

No formal training system/method exists for timber handling, but is done by a more experienced team member working with newer team members. 'Precious McKenzie' has been involved previously, carrying out lifting training onsite.

Rest Breaks: Most workers find that 30 minute breaks are adequate. Allows good rest and time to get food, but not so long that hard to 'get started again. Rotations of 1.5 hours are good, especially if on a hard job.

Improvements: An extra step all the way along at trolleys to make it easier up/down. Reduce the height of the rails over the floor, consider walkway across. Trolley wheels with easy-push design. Consider scissor hoists on trolleys. Have an automated unloader system/modify unloader so fillet sticks don't catch and timber handling unnecessary. Place rollers on rail edge. Have a mechanical block on pit-stacker to move the front edge of export packs closer to the table end. Move tally board further away so have more trolley space for stacking (?grader space). Maintenance of squeaky chain. Keep chain speed steady and 'reasonable'. Modify cleats so boards don't catch.

Main findings: ***Most workers maintain good nutrition and fluid intake. Wearing of personal protective equipment is consistent for glove wear, hearing protection, eye protection, and steel-capped boots. Glove requirements could be further researched. The most difficult task is working at the unloader. Some key training factors appear to exist. Rest break length is adequate for workers to gain rest and nutrition. Primary areas for improvement felt by workers to be the unloader and trolley rails/pushing ease issues.***

Task Rotations

The rotation system is formalised and based on 1.5 hourly rotations (with one 1.0 hour rotation after the lunch break). A total of 6 rotations per day. Work shifts are from 6.30 am to 4.00 pm, with a 30 minute break 9.30 – 10.00 am, and 1.00 – 1.30 pm. Rotations are managed by the team leader and is based on sharing of the physically demanding tasks, physical capacities/injury awareness, skill and training of workers, work demands of current task. A formal system documenting worker skill level for tasks operates, so not all workers are able to complete all jobs. Tally box and grading particularly. As the team leader works with the team at most times, changes can be made within the allocated tasks if required, for many and various reasons. However the basic outline of regular rotations is adhered to. Overall teamwork and coordination is important within this workplace.

Rotation positions are fillet sticks, unloader, grader, table stacker (2 positions), pit stacker, floater/strapping and wrapper. The crane operator and despatch person are a part of the team but not of the rotation system.

Main finding: ***Rotation system is formal, based on 1.5 hourly rotations and task demands, skill level of workers and worker capacity. Team work is necessary in this work area and appears to function well.***

Rapid Upper Body Assessment (REBA)

The very high scores (indicating that action is necessary *now*) were for tasks including:

- Pushing a full trolley out
- Working at the unloader, especially if leaning too far forward to pick up boards
- Pulling boards off the table whilst standing too far away
- Throwing a board out onto the first layer of a packet and aligning it

The high scores (indicating that action is necessary *soon*) were for tasks including:

- Pulling back and levering boards at the unloader and pit stacker
- Reaching for boards at the pit stacker
- Lifting and pulling boards from the table
- Pulling and lifting boards onto packets, especially high ones
- Placing boards on first/lower layers of packets
- Unloader lifting front of board and throwing onto the chain

Main findings: ***A number of tasks were identified using this assessment tool as having a high risk of injury. Using this analysis the tasks requiring immediate attention are pushing full trolleys, working at the unloader, pulling boards form the table (from standing too far away) and throwing/aligning the boards on the first layers of the packet. Requiring attention also is reaching for boards at the pit stacker.***

Force Measure Data

The force required to initiate horizontal movement from the chain of the most commonly pulled timber size (125 x 40 x 3600mm) averaged 4.88 kg. The force required to initiate horizontal movement of the most commonly pulled larger timber dimension (300 x 50 x 3000 - 3600mm) averaged 11.6 kgs. These figures represent the horizontal 'break-out' force only and additional lifting and carrying, timber directional and control forces, and additional actions to keep timber moving also occur. Similar measures have been taken from varying table/chain types, and demonstrate some appreciable difference in table/chain design.

Force Measure Comparison All mills

Mill Number	Timber Dimensions	Table Type	Green/Dry	Mean Break-out Force (Kilograms)
Mill 43	90 x 45mm x 4.8m	Roller chain	Dry	1.00
	240 x 45mm x 6.0m	Roller chain	Dry	3.44
Mill 17	125 x 40mm x 3.6	Flat chain with cleats	Dry	4.88
	300 x 50mm x 3.0 - 3.6m	Flat chain with cleats	Dry	11.60
Mill 30	150 x 50mm x 3.8 - 6.0m	Round table with timber base	Wet (anti-sapstain)	17.62
	100 x 75mm x 5.4 - 5.8m	Round table with timber base	Wet (anti-sapstain)	24.27
	200 x 25mm x 4.8m	Round table with timber base	Wet (anti-sapstain)	20.63
	Various other dimensions	Round table with timber base	Wet (anti-sapstain)	10.92 - 27.88
Mill 12	150 x 25mm x 4.0m	Chain link	Wet	7.38
	300 x 50mm x 3.0 - 3.6m	Chain link	Wet	14.61

Main finding: ***The break-out forces required to initiate horizontal movement of timber from this chain is 4.88 kg for 125 x 40 x 3600mm boards, and 11.6 kgs for 300 x 50 x 3000 - 3600mm boards.***

Manual Handling Risk Score

The risk score was calculated as below:

7 Find the load score: The load score is the muscle force applied by the worker. It may be the weight of the object handled or you may need to measure the forces applied with a spring balance or a force gauge – or make an estimate. If several people do the task, the score should reflect the ability of the least able.

The load score varies depending on the timber dimension being worked with, and whether a male/female worker. For the smaller/short board sizes, I estimate that a load score of 1 is indicated (men) and 2 (women). For the larger/longer board sizes, I estimate that a load score of up to 10 is indicated (women) and 4 (men).

Men	Women	Load Score
< 10 kg	< 5 kg	1
10 – 19 kg	5 – 9 kg	2
20 – 29 kg	10 – 14 kg	4
30 – 39 kg	15 – 24 kg	7
40 +	25 +	10

Report the Load Score here → 1,2,4,10 A

8 Find the posture and workplace layout score: Observe the postures adopted. Take an average value if necessary or use numbers between the ones shown.

Usually working with slight bending and twisting of the trunk, though varies depending on individual anthropometrics and task.

	Posture Score
Trunk upright, no twisting, load close to body, standing or walking a few steps only.	1
Some bending forward or twisting, load close to body, sitting, standing or walking for a longer distance.	2
Bending far forward or close to the floor, slightly bending and twisting the trunk, load far from the body or above shoulder height, sitting or standing.	4
Bending far forward and twisting the trunk, load far from the body, below the knees or above shoulder height, unstable posture while standing, crouching or kneeling.	8

Report the Posture/Workplace Layout Score here → 4 B

9. Find the work conditions and environment score: (Flooring/work area restricted in some work stations

	Environment Score
Good conditions, with sufficient space, no obstacles, level and solid floor surface, good lighting, able to get a good grip on the load.	0
Restricted workspace (area < 1.5 m^2), restricted postural stability (floor uneven, soft, slippery, steeply sloping).	1

Report the Environment Score here → 1 C

10 Find the time score: Find the time score from the greatest of either the number of repetitions of the task or the time spent doing it during the shift.

Repetitions per shift	Total time per shift	Time Score
< 10	< 30 min	1
10 – 40	30 min – 1 hr	2
40 – 200	1 – 3 hrs	4
200 – 500	3 – 5 hrs	6
> 500	> 5 hrs	8

Report the Time Score here → 8 Time

Add the three scores in boxes A, B and C → Sum **6, 7, 9, 15**

11 Multiply box **'Sum'** by box **'Time'** to get the risk score. **48, 56, 72, 120**

Guidance on the Meaning of the Risk Score	
Risk Score	*Urgency and type of control measure*
< 10	Injuries are unlikely unless there are infrequent high force actions. Monitor the task from time to time.
10 - 24	Injuries may result for less resilient people. Workplace re-design is recommended for them.
25 - 49	**Injuries are possible for trained and fit people. Workplace re-design is recommended to control the contributory factors identified.**
50 +	**Injuries are likely regardless of the strength and fitness of employees. Elimination of the task or workplace re-design is a priority.**

Mill 17

Recommendations for Reduction of Manual Handling Risks

Contents

Mill 17

Recommendations for Reduction of Manual Handling Risks

Goals

The primary task reviewed for this research project is the pulling and stacking of timber from the dry chain, and the associated tasks completed by these workers. Recommendations are made based on their likely impact on decreasing musculoskeletal risks for your mill area, as per assessment findings. Some findings that have less immediate bearing on musculoskeletal injury risk but may have relevance to task performance (lighting) are included for your general consideration.

It is hoped that your mill may be able to action at least one of the recommended changes (preferably more) with researcher assistance as required, so that a review of musculoskeletal risk factors can occur. It is expected that some recommendations will require further discussion, trials and decision-making to determine the best solution for your work area.

Discussion

Forces acting as timber is pulled from the table and placed in the packet are various. Assessment methods were selected to measure relevant aspects of these tasks.

For each board pulled from the table there is initial inertia to overcome, momentum and possibly lifting to transfer the timber onto the packet, and some force required to slow/move the timber into place on the packet. The total physical effort required to achieve this is dependent on the dimension and weight of the timber, the degree of friction between the timber and the table/other timber, the distance between the table and the packet, and the work technique used.

Task elements where physical effort is required appear to be:

- Lifting the boards over the rail.
- Overcoming the inertia of the timber to get it moving off the table.
- Building sufficient momentum to effect timber transfer off the table and onto the packet (pulling the timber horizontally and possibly pushing downwards to employ gravity as the board moves off the table, or additional lifting to move the board into a position higher than the table).
- Maintaining momentum of the timber as it moves perpendicular to the direction of table travel (through applying extra 'pulls' on the timber or physically lifting and transferring it).
- Requiring extra velocity and height to manoeuvre the timber over fillets/bearers (first board of first layer and each layer after the placement of fillets).
- Applying force to guide and/or stop the timber in the correct place on the packet.
- Applying additional force to lift or lever the board into place (when it falls off the side of the packet).

The effort required will also not be consistent or entirely predictable, due to differing timber 'adhesion' to the table, variable chain (or roller) condition, variable table speed, contact with other timber lengths and board breakage.

A number of recommendations for the configuration of the chain and table, the timber transfer workspace, the unloader and trolleys follow. These are suggested starting points for further refinement through trials, and require operational verification before the actual heights and ranges can be determined as suitable. Following this are recommendations for addressing table speed and flooring modifications, training, gloves, and other factors such as manual handling risk identification and lighting.

Table height

Recommendation 1: ***Height to top of chains/rollers - 920 mm. An adjustable table height would however be ideal. The range could be between 785 and 1045 mm (based on 2.5th percentile female and 97.5th percentile male elbow heights (plus footwear allowance and minus 200 mm elbow clearance).***

This is based on the following assumptions:

- Fixed table height is most likely to be provided.
- People choose to grip boards somewhere between their elbow and knuckle height, to avoid either too much elbow flexion and shoulder elevation, or forward bending.
- The heavy nature of the task means that an appropriate work surface height is 200 mm below standing elbow height (static anthropometric data). This lower work surface accounts for the dynamic nature of this work. Workers often stand with their legs apart so that they can apply forces effectively and this consequently lowers their elbow height.
- New Zealand Anthropometric Estimates (Slappendel and Wilson, 1992) data is representative of user populations.
- 45-60 year old females have not been included for consideration as none were present in the worker populations sampled.

All measurements in mm, 35 mm footwear allowance, rounded down to nearest 5 mm	Elbow height plus footwear allowance minus 200 mm working clearance below elbow			Knuckle and elbow heights plus footwear allowance	
	5th percentile	50th percentile	95th percentile	Knuckle height - elbow height range (5th and 95th percentiles)	Mid-distance knuckle-elbow (easy reach)
19-45 year old males	870	950	1025	805 - 1150	980
45-60 year old males	860	930	1000	795 - 1130	960
19-45 year old females	800	870	940	775 - 1070	920

- 2.5th percentile female (19-45 year olds) knuckle and elbow heights plus footwear = 705 to 985 mm, which a table height of 920 mm would accommodate.
- 97.5th percentile male (19-45 year olds) knuckle and elbow heights plus footwear = 875 to 1245 mm, which a table height of 920 mm would accommodate.

At this table the need to use the high rail to clear the boards from the cleats must be considered alongside the issue of table height. Cleat removal from some chains, and reduction of the height of cleats will reduce the need for the rail to be as high as it is, and may reduce the need for the rail at all. The function of the cleats is to ensure board spacing for tally purposes, and adjustments should be possible providing this function is maintained. The rail is currently functioning to increase some of the forces required to remove timber from the table while reducing others.

Recommendation 2: ***Removal of cleats from the first, fourth, sixth and seventh chains.***

Recommendation 3: ***Remaining cleats to be reduced in height to 20 – 30 mm.***

Recommendation 4: Reduction of rail height. Ideally this will be to the same height as the top of the table/chain, but this will be dependent on cleat adjustments made.

Recommendation 5: Incline the table bed.

Inclining the table bed will help reduce the amount of inertia before the timber starts moving, and the amount of energy necessary to gain momentum. There is obviously an ideal range at which the inertia is substantially reduced, but the boards remain stationary until the pulling force is applied. The degree of tilt would require trial for each table and surface type.

Table heights at the mills surveyed were:

Mill 43 (dry table)	850 mm
Mill 30 (green/round table)	600-850 mm
Mill 17 (dry table)	970 mm to top of rail, 890 mm to chain surface
Mill 12 (green table	905 mm old section, 920 mm new section

Timber overhang

Recommendation 6: Timber should overhang the table edge by 750 - 1000 mm.

Having more timber over the front edge should allow:

- Workers to position themselves closer to the load with feet further under the board and less bending.
- Workers able to position themselves to use less spinal rotation when handling boards as they are able to step behind or in front of the board.
- Reduce the inertia and the overall weight to be pulled as a greater amount of the timber's weight is already past the fulcrum on which it is balanced (i.e. the table edge/rail/rollers), creating better board control and decreased effort.
- Reduce the force required to tip the board downwards (where this is done to gather board speed quickly as it is transferred).
- The optimum amount of overhang is likely to vary with mill and table design, other functions (docking, grading etc) occurring at the table and also depends on where timber is being transferred too.

At this table the current very small timber overhang causes workers to work with increased spinal flexion and greater spinal rotation to move boards. This particularly effects the unloader, who must reach over the table to pick up all boards. The unloader supports/stabilises often with one hand on the table edge as they pull back and lever each board over onto the table. This creates considerable spinal rotation forces and is a high risk manual handling activity, and also creates the risk of fingers being jammed or hit by boards moving forward on the rollers.

Recommendation 7: Review the overall functions and operations at the unloader. This may include different configurations of rollers/roller speeds to move timber forward and then onto the chain.

Timber overhang at the mills surveyed were:

Mill 43	760 mm
Mill 30	100 mm back from table edge to 300 mm over table edge
Mill 17	35 mm
Mill 12	200-400 mm

Breakout Force Decrease

Recommendation 8: That tables are designed to minimise the horizontal pull force to move timber from table to packet. This appears to be reduced most significantly by the use of a roller chain system.

The mean break out forces for all chains measured was lowest with a roller chain. (See 'Summary of Assessment Findings', page 10). Whilst timber dimensions/lengths and wet/dry nature must also be taken into account, the solid timber round table required the greatest forces, and other flat chain or chain link tables required more force than the roller chain, but less than the wooden round table.

At this table the horizontal pull is not the only action required to move timber from the table as the presence of the rail above the table edge means that the boards must also be lifted over and onto the rail.

Timber end (on table) – packet distance

Recommendation 9: The distance between the end of the timber as it rests on the table to the end of the packet should be 1100-1400 mm.

This is based on male and female arm spans, and should enable the transfer to occur without excessive lateral spinal movement or twisting, stepping, or hitting the timber end or packet. This distance is affected (both positively and negatively with regard to musculoskeletal disorders) by:

- How far the timber needs to be transferred up or down the table to the appropriate packet.
- Length of the timber (longer lengths may need more room to gather sufficient momentum, shorter lengths may need less room so that the timber is not totally supported by the worker).
- Speed of the table (less space between the table and packet reduces task cycle time).
- Amount of traffic in the transfer area (how much extra space is required for tasks other than timber pulling).
- Height of the packet(s) in relation to the table (may need more space if the transfer is onto a packet higher than the table).
- How many packets there are (especially for round tables)

If the timber is allowed to overhang the table (Recommendation 6) the consequent reduction in distance to the packet end can be modified by moving the packets/trolleys slightly further away.

Timber end to packet end distance in the mills surveyed were:

Mill 43	1100-1400 mm
Mill 30	1600-3300 mm
Mill 17	900-1250 mm
Mill 12	1400-1800 mm

Maximum height for final row in packet

Recommendation 10: The overall height of the second to last layer of timber in the packet (therefore the height to which the last layer is lifted to) should be 920 mm – the same as the recommended table height.

Transfer of common and large dimension timber (from the table to the packet) should not require timber to be moved to a height significantly greater than that of the table. Transferring timber up to the packet is working against gravity and requires greater effort and a greater risk of injury as a result.

- This height is a function of the floor height of the area packets in, the total packet height, and trolley/bearer height. Achieving the same height as the table may require modification to any or all of these elements.
- The largest proportion of timber handling should occur between elbow and knuckle heights.
- Additional forces to lift the timber against gravity should not be required.
- To reduce the difficulty getting the first pieces of timber in place on the trolleys/bearers, a 'landing pad' to bounce timber along may assist. (As is done for the remaining timber in the stack).

Recommendation 11: Consider lowering the trolley height or using height adjustable scissor lifts to allow the total packet height (to top of second to last layer) to be equal to or less than the table height.

Recommendation 12: Decrease the overall height of the timber packets (make them wider and shorter), to decrease the height stacked too.

Recommendation 13: Use a 'landing pad' on the trolleys/bearers to bounce the timber along to reduce the effort required for positioning the first layer of timber.

The 'landing pad' concept would reduce the effort and difficulty required to place the first boards/layer on the trolley particularly, and could be combined with a means of preventing the trolleys from tipping when being moved fully loaded.

Total packet heights on trolleys/bearers in the mills surveyed were:

Mill 43	no higher than the table
Mill 30	estimated 300 mm above table
Mill 17	packet height 530-770 mm and new trolley height 380 mm (old trolley 480 mm) above the floor that workers stand on when pulling and stacking. Total packet heights 910-1150 mm (new trolleys) and 1010-1250mm (old). Therefore total packet height is often higher than the table/rail (970mm).
Mill 12	commonly pulled timber (150 x 25 mm) packet height 725 mm , trolley height 360 mm, total height 1085 mm. Some packets 505 – 1050 mm total and trolleys between 360 and 560 mm height. Therefore total packet height on the trolley is often higher than the table (905/920).

Lateral Workspace Requirement

Recommendation 14: ***That the packet width plus 1020 mm (elbow span for 95th percentile male) is considered the minimum for packet/trolley spacing. For a packet width of 1200 mm, the overall lateral workspace requirement would therefore be 2220 mm for each single-worker workstation.***

Adequate workspace should be provided at each packet for timber to be safely and easily handled, without workers feeling cramped or restricted in timber handling methods. For packets where two workers consistently work together, the lateral spacing should be increased. Recommendation 14 applies to the situation where each worker is only handling timber for one stack. Recommendation 15 applies to the situation where two workers consistently work stacking timber onto the same stack. Recommendation 16 applies where one worker consistently stacks on to several different adjacent stacks. It is not recommended that workers 'cross over' each others work spaces to stack in different areas due to the risk of being hit by timber as it is pulled from the table. It is important that adequate space exists between stacks for the necessary movement between with intermittent timber handling, but that stacks are not spaced so far apart that additional travel up and down the table occurs.

Recommendation 15: ***That for packets where two workers consistently work together, that the overall lateral workspace requirement is packet width plus 2 x 1020 (elbow span for 95th percentile male). Thus for a packet of 1200 mm width, the overall lateral workspace requirement will be 3240 mm, for a dual worker workstation.***

Recommendation 16: ***That for situations where one worker stacks timber onto two or more adjacent packets, that the overall lateral workspace requirements should be a minimum of 610 mm clearance each side of the outside packets (so 1020mm space to the next packet as both workers must have clearance). For between packet spacing, if the total packet height on the trolley is less than 980 mm (5th percentile female elbow height plus footwear allowance and minus 20 mm clearance) the between packet clearance should be 550 mm (95th percentile female hip breadth plus clothing/movement clearance allowance). For between packet spacing where the total packet height on the trolley is above 980 mm, the between packet clearance should be 620 mm (95th percentile male bideltoid breadth plus clothing/movement clearance allowance).***

The overall chain length should therefore allow this spacing for each trolley.

Pit-Stacker Operations

Recommendation 17: ***That the position of the step at the pit-stacker is modified to allow the pit-stacker operator to get closer to the timber that is coming off the chain and to therefore avoid over-stretching.***

Recommendation 18: ***That the pit stacker is modified to allow narrower timber packets to be stacked closer to the end of the table. This will reduce the distance timber is moved from the table onto the packet and will therefore be both more efficient and physically easier.***

Trolley Design

Recommendation 19: ***That trolleys are modified to reduce the risk of tipping when being pushed out with a full packet. This will require lengthways stabilisation.***

Recommendation 20: ***That trolleys are modified to provide a 'landing pad' to reduce the distance and leverage forces required for throwing/placing the first row of timber. This may need to drop away to allow the crane to pick up the packet.***

Trolleys should be built to withstand the range of forces they are subjected to. Particularly they should have suitable wheels and bearings, and the wheels should move smoothly with minimal force even when fully loaded. Trolleys should not tip or be otherwise unstable, a risk with this workplace as the trolleys are high to accommodate the step up to the flooring alongside the table. Trolleys should be maintained to ensure they remain functional and safe to use. Trolley design that reduces the force necessary for placing the first row of timber is ideal.

Table Speed

Recommendation 21: ***Determine the table speed that is appropriate for key tasks (various timber types/dimensions) and develop a method of controlling this via a 'speed indicator' control. Consciously consider work pace/table speed as a factor in manual handling risk management.***

Recommendation 22: ***Determine the maximum sustainable and effective work pace for the timber grader, as this is most likely to limit the overall table speed.***

The existing 'faster/slower' controls do not allow for clear determination and selection of work pace. Team disagreement may therefore occur as to an appropriate work pace, and some key personnel (grader, tally person) may be at risk of increased errors due to too fast a work pace.

Fillet Stick Storage

Recommendation 23: That existing (but unsuccessful) fillet stick holders are modified so that fillet sticks are stored within easy reach.

While fillet stick holders exist they are not suitable for the purpose, and are therefore unused. Some fillet sticks are 'stored' along the front edge of the table and are obtained by bending down to pick them up. This poses a tripping and a manual handling hazard. Other fillet sticks are stored near the pit-stacker and table hands must walk along to pick them up. This slows the work pace and increases the risk of injury from walking around other timber handlers. Existing fillet stick holders do not work adequately for the purpose and require modification.

Fillet stick storage at a better height and within easier reach of workers would be ideal. This should reduce the time taken for obtaining fillets, will make it physically safer and easier to reach them and will make it easier to clean under the chain area.

Glove Design

Recommendation 24: That gloves are provided that have good fit and protection suitable for all workers.

Gloves should meet the following specifications:

- Chemical protection from timber treatments (if present)
- Timber splinter protection
- Sufficient 'feel' and 'tactile feedback' for the task(s)
- No restriction to hand postures and movements required for tasks
- No significant increase in the muscle effort/grip force (through glove inflexibility) required to achieve these hand postures and movements
- No contribution to the occurrence of localised physical discomfort through direct pressure, movement over skin or irritation
- Must be good enough for workers to stay within existing cycle time and acceptable quality parameters on a sustainable (absence of physical discomfort) basis.
- Sizes of gloves must enable 95% (2.5th - 97.5th percentile ranges) of both existing and potential user populations to achieve a comfortable, snug fit when undertaking the tasks for which it is intended.
- Should be of a construction that permits local modification of the glove when users need it (i.e. when the functional dimensions of their hand(s) are outside the percentile range stated above, or between glove sizes, or finger amputations exist).
- Should not get uncomfortably hot (or cold) when being worn for these tasks.
- Should not cause the wearer's hand(s) to sweat excessively where this could require increased muscle effort to overcome.
- Should be sufficient to withstand normal operating conditions (e.g. donning/doffing) throughout the design life of the glove system without affecting other aspects of performance.
- Should be accepted by those working in the industry as a viable alternative to other gloves and/or bare hands.
- All sizes and configurations must be available without significant delay.
- Should be considered affordable by sawmill operators.

At this mill several varieties of gloves were used, with females preferring a smaller fitting glove. They appeared to offer adequate splinter protection with adequate thermal comfort. One worker with a digit amputation cut off the 'spare' finger on the glove to prevent it's catching, but with resultant loss of splinter protection.

Training

***Recommendation 25:** That key safe work methods for pulling and stacking timber are covered at induction followed by buddy training with an experienced and skilful operator. Consider use of a training video highlighting key work methods and techniques.*

Key work methods and issues appear to be:

- Wait for the timber to come to you on the chain.
- Walk in close to the timber to grasp it from the table, avoid bending forward and over-reaching with stationary feet.
- Move your feet in the direction the timber is to move in, walk with it.
- Keep a wide base of support (feet apart) for stability.
- Use knee and hip action to reduce bending and twisting with the back.
- Develop left and right handed work methods to share the workload and reduce overuse problems.
- Work with wrists as straight as possible.
- Use gravity to best advantage, push the timber down and allow the timber to slide onto the stack.
- Use a 'throw' (as if passing a rugby ball) to provide the impetus for timber movement.
- Once the timber is moving, guide it into place on the stack.
- Use a leather apron and also guide the timber onto the stack with the hip/thigh to share the workload with the hands.
- Use the apron's protection to allow the thigh to act as an additional leverage point for handling timber that has fallen off the side of the stack.
- Place the first board of the layer on one side of the stack and then slide other boards with greater ease/speed alongside this guide board. (If working two to a stack the guide board is usually placed centrally).
- Learn to 'throw' and 'bounce' boards into place over bearers and fillet sticks, but also use the 'guide board' principle if possible.
- An alternative to throwing the first board over fillet sticks is putting the first board of the post-fillet layer on top of the pre-fillet layer, then having a team member lift the end of this board up so that fillet sticks can then be placed under. This gives a short work break, a stretch, a reason for some teamwork, and avoids the awkward first board post-fillet throw.
- Avoid lifting and placing of boards, rather they should be slid/supported on the table or stack, and 'thrown' and 'guided'.
- Regularly swap between heavy or intense stacking tasks and lighter or slower tasks.
- Allow new/inexperienced workers to gradually develop the strength and technique required for heavy/larger timber handling, and the speed/coordination required for more frequent handling of smaller timber dimensions.
- Develop a smooth and relaxed work rhythm.
- Work within your capacity.
- Stretch before and during work.
- Report discomfort early and ensure that some action is taken to accommodate this.
- Eat/drink according to the nature of the job. It is very physical work, and to perform well and avoid injury it is suggested that all workers eat healthily including breakfast, adequate snacks and lunch, and drink plenty of water during work.

For a video, task techniques to show variations in handling different timber sizes, suit different builds, rest muscle groups, and carry out specific actions such as bouncing boards over fillets and replacing boards that fall off the packet should be covered. Incorrect techniques and practices could also be highlighted with an explanation as to why they are undesirable. Emphasis should be placed on the fact that the timber transfer task is sustainable with good technique, comfortable work pace, regular rotations and good workspace layout. However, occasional events such as boards falling off, dragging boards back, stopping timber suddenly, sustained rapid work pace etc, can be hazardous and may be overlooked. A video should

recognise individual differences in acceptable work technique, and this should be included in the training. This could include: applying high force at the start and then guiding the board only, getting the board going and then applying force as they guide it, getting the board going and tipping it to get momentum, using backhand (if able) to reduce exposure.

Aprons: Aprons are used for several purposes. They protect the clothing from sap/resin build up and from damage from catching on rough timber. Aprons also allow the soft tissues of the body to be protected from splinters or bruising from the boards. Used well, aprons appear to allow the timber to be kept closer to the body in handling, thus reducing the forces acting on the back and arms. Apron use was observed to encourage a skilled worker to use leg and hip flexion rather than back flexion when stacking into the lowest stack positions.

Two styles of apron were seen in use. Thicker leather aprons allow greater body protection and timber is observed to be 'slid across/against' the leather aprons confidently and without risk of injury. Heavy plastic aprons appear to only protect the clothing, and workers using these were not observed to slide the timber across/against the aprons in the same way as those using leather aprons.

These key work method/training points should also be added to and altered following trial. Work method issues should not be seen as the only method for reducing musculoskeletal injuries. Workplace design and other factors (as per this report) should be considered and addressed accordingly.

Manual Handling Risk Factor Identification and Control

***Recommendation 26:** That manual handling risk factors are clearly identified in the health and safety manual and task description documents pertaining to this work area. Use of the ACC WorkSmart Back Plan and related documents including the manual Handling Hazard Control Record may assist with this process.*

Floor surface

***Recommendation 27:** That a more even flooring surface across the trolley railings is installed.*

The existing flooring surface is hazardous but must frequently be navigated by workers in this area. Current options to travel across the work area are to walk behind the workers at the table and risk being hit by timber as it is stacked, or to negotiate the uneven flooring across the trolley rails. Provision of a safer and easier to navigate walkway area would reduce injury risks.

Lighting

***Recommendation 28:** That lighting levels are increased to 750 lux for the area immediately in front of the grader. This may be achieved by altering the position of the mirror used for tally purposes or the addition of another light source.*

The recommended lighting level for timber inspection tasks is given as 750 lux (CIBS Code for Interior Lighting, 1984), but for the grader was measured at between 650 and 900 lux.

Flying Fillet Sticks

***Recommendation 29:** That the issue of airborne fillet sticks/parts of fillet sticks at the unloader is reviewed and appropriate actions taken.*

Appendix 10

- Notes regarding intervention application Mill 12
- Notes regarding intervention application Mill 17

Notes regarding intervention application Mill 12 (following presentation of recommendations in May 2002)

June 2002

Email contact with the Operations Manager identified that changes made in response to the study recommendations were:

- Most of the trolleys have been lowered
- 'Landing pads' being trialed on the trolleys
- Trolleys are spaced wider apart for greater work space
- Maintenance reporting system improved with a 'Fix it' book
- Lighting levels have been increased
- Ear plugs are being tried
- More rotation of staff through the day handling various timber sizes

August 2002

A brief onsite visit was made with the following findings (report/observation) regarding changes made:

Trolleys

- All excepting one trolley was at lower height as recommended, and with wheels replaced (rubber rims, and broader rims) and maintained as required.
- Half of the trolleys had 'landing pads' installed, with staff indicating that these assist with throwing out the larger sized boards particularly.
- Trolleys spaced a little further apart.

Board Overhang

- Tending to have 'pusher' make the timber overhang about 500mm from the table edge

Rotations

- Daily formal rotations between chain and filleting, and team on the chain made more regular informal swaps between light/heavy work tasks. Found that variation in timber flow can make a more formal system awkward. Relies on teamwork. Training for rotations a part of induction.

Use of aprons

- Team members using leather aprons to work

Maintenance

- Additional maintenance personnel hired
- System for maintenance requests improved

Hearing protection

- Trialed earplugs, did not like them so plan to move to earmuffs

Resaw system

- Resaw system reviewed and now working better, with less timber tangles, so therefore less stressful for whole team

Housework

- More regular cleaning of work area
- Fillet sticks stored more tidily/clean

Injury reports

- 4 months of injury reports shows no musculoskeletal injuries related to green chain work

Still plan to improve storage of fillet sticks; water cooler installation (being arranged); and to improve the stop/start safety system for the chain, and to finish off installation of 'landing pads' on all trolleys
Did not plan to follow up on inclining the table bed due to engineering difficulties, and some limitation to table changes due to other building plans.

Would appreciate the industry doing something about producing a video covering safe timber pulling techniques, and the training of more experienced timber handling personnel. Training materials (video/manual) should suit the needs of smaller mills.

It was reported that fewer workers had sore wrists, and felt that this was due to care to work with rotations, teamwork, production planning avoiding the very heavy timber and aiming at greater consistency in work flow, and having two packets of the 'busiest' timber dimensions. It was noted that with less workers, the same output was being achieved. This meant that workers were completing and were more confident of a greater output, and they earned more. They were generally feeling more satisfied with their work situation. Workers were achieving 15% better pay with this higher output.

March 2003

Telephone contact was made with the Operations Manager for an update on the changes made and to inform of forthcoming regional sawmilling meeting being organised by OSH. Changes were reportedly:

- Work organisation factors - now aware of need for steady pacing of work at the table, less pushed, slower work. Also some downturn in the industry so less pressure for output and lower worker numbers.
- Trolley changes made are still beneficial
- Training of new workers – allowing newcomers time to train into the role and build skills and expertise.

Approval for photos without identifiers to be used in presentations.

Notes regarding intervention application Mill 17 (following presentation of recommendations in May 2002)

May 2002

Reported that since assessment, had already progressed with:

- Cutting down trolley rails so they were a lower profile
- Higher focus on housekeeping so trolleys less likely to catch on fillet sticks etc and tip
- A support/stabiliser strut has been added to trolleys in an effort to reduce tipping incidents

Requested at this visit that I take time to speak with green chain personnel to make comment on their work area along the same lines as the reported recommendations for the dry chain area. Comments made at brief walkthrough included:

- Total packet height of timber on trolleys was generally lower than table height
- May benefit from concept of 'landing pad' on trolleys, already low trolleys in use, and appeared keen to trial this
- Leather aprons only used by some workers, and reportedly not for anything other than clothing protection – not aware of possible benefits of leather aprons in reducing effort, easier method

June 2002

Telephone follow up indicating that the following changes had been or were in the process of being made in the dry chain area:

- Cleat height reduced to 19 mm, considering removing some cleats completely in future
- Ongoing discussion about benefit of rail along table length vs removal of rail. Workers not keen to remove it completely, though in agreement at this stage that it could be lowered
- Plan to install step along length of the platform to make it safer/easier to get up/down to trolley area
- Trolleys – discussion about whether a system of height adjustment can be devised. Landing pad concept may suit in the future when the system alters a little
- Timber overhang on table edge is related to the rail issue. May be able to have the rail height at just over the chain height, and have timber overhang greater so that timber reaches the worker already with it's end up on the rail, but hanging over so easier to grasp
- Working on identification and documentation of manual handling hazards

A brief article from the ergonomist was included in the regular worksite newsletter.

July 2002
Telephone contact with leading hand:

- Unable to do anything further with trolley changes as changes to forklift/crane use in this area impact
- No changes to timber overhang/rail issue, is still working with team members to have them accept the benefit of change – may agree to trial no rail for half of the table length. Reminded about the reasons for removing the rail and the benefit of increasing the overhang, which appeared to have been forgotten

August 2002
Onsite visit to review changes made since recommendations (report and observation):

1 – Table/chain

- Cleats cut down. Reported that this does not make much change to the task by itself, needs rail to be lowered to make the most difference – per report.

3 – Workspace geometry

- Team members decided not to alter the timber end on the table to packet end distance formally, remains as personal preference
- Have a maximum of two persons working on one packet (used to be three so was workspace/safety issue)
- Pit stacker step unable to be moved as a motor is in the way under the step
- Still plan to modify pit-stacker machinery for narrower packets closer to the table end
- Fillet stick holders in the process of being replaced with functional items

4 – Trolleys

- Putting steel wheels on trolleys to reduce sticking and tipping, reportedly much easier to push full trolleys
- Increased housekeeping vigilance to keep sticks off trolley rails
- Stabilisers added to trolleys for lengthways stability
- Alteration to system forklift/crane so can not put other trolley system changes into action at this stage

5 – Table speed

- Grader now much more involved with process of selecting table speed, and reportedly have 'clarified' the speeds preferred

6 – Flooring

- Cut rails down for trolleys rather than installing flooring/walkway

7 – Training

- Have completed some 'best method' training with workers
- Working on new personnel being better trained, keen on producing a video for this purpose

8 – Gloves

- Greater range of glove sizes made available, and worn by all workers now (some chose not to wear them previously)

9 – Other factors

- Working on better manual handling hazard identification
- Signs moved by grader, and better lighting apparently resulted – though additional lux level readings would need to be taken to verify this
- Noise level may have increased with radio on, will review noise dose over 8 hours

No changes made to unloader. This work task is the main limiting factor to the overall productivity of the dry table.

Productivity has increased by 20m3 per day or more, reportedly due in the main to the presence of a forklift which means that work does not have to stop while the crane is waited for, and two workers not needed to push the trolley out. Also now doing bigger runs of one timber size, which means that more can be stacked off onto more trolleys, so is faster.

Barriers to change noted - worker attitudes and inflexibility (work team with a number of older workers very fixed in ways and beliefs). Also some changes are complex and costly, but may be able to be actioned with future plan to move entire dry-table area. (Required as longer table required due to increased demand for length-sorted timber. Would include in new table area (perhaps within 6 months) an automatic unloader, and the various specifications provided at assessment, including trolley spacing and height, etc.

May 2003

Telephone contact to review progress and inform of forthcoming regional meeting with sawmilling focus, organised by OSH:

- Rail along table has been lowered to equal table height, with workers reportedly finding this easier to use
- New dry table area at planning stage, with the guidelines as per the recommendations being included in the design
- Plan to remodel the unloader machinery to stop the need to handle all timber 'over the edge'
- A number of new employees with only 2 experienced workers.

Approval given for use of photographs, without identifiers, to be used in presentations.

Appendix 11

- Reports written from this work

1. Edwin, M., Tappin, D. & Bentley, T. 2002. *Musculoskeletal Disorders in the New Zealand Log Sawmilling Industry.* Proceedings of the 11th Conference of the New Zealand Ergonomics Society, 14 and 15 November 2002. Wellington. (pp 112-117)

2. Tappin, D., Edwin, M. & Moore, D. 2003. *Sawmill Accident Register Records – Main Findings of a Survey from 37 Mills.* COHFE Report, 4(5)

3. Tappin, D., Edwin, M. & Bentley, T. 2003. *Musculoskeletal Disorders in Sawmilling: ergonomics work systems assessments and suggested interventions.* COHFE Report, 4(6)

4. Tappin, D., Edwin, M., Bentley, T. & Ashby, L. 2004. *Addressing Musculoskeletal Disorders in the New Zealand Log Sawmilling Industry.* Contemporary Ergonomics. McCabe, P. (ed.). (pp 212-216)