Hancock Forest Management®

A Division of Hancock Timber Resource Group, A Manulife Asset Management Company

INTERIM BEST PRACTICE GUIDELINE

CABLE ASSISTED STEEP SLOPE HARVESTING

2016

Special acknowledgment for industry contributions to this and previous BPG's must go to:

- Chris Hancock, Electrical and Machinery Services Ltd, Rotorua, New Zealand
- Denis Smith, Tasman SV Consulting Engineers, Auckland, New Zealand
- Lars Rosewarne, Rosewarne Cable Loggers Ltd, Whangarei, New Zealand
- Ross Wood, Wood Contracting Ltd, Nelson, New Zealand

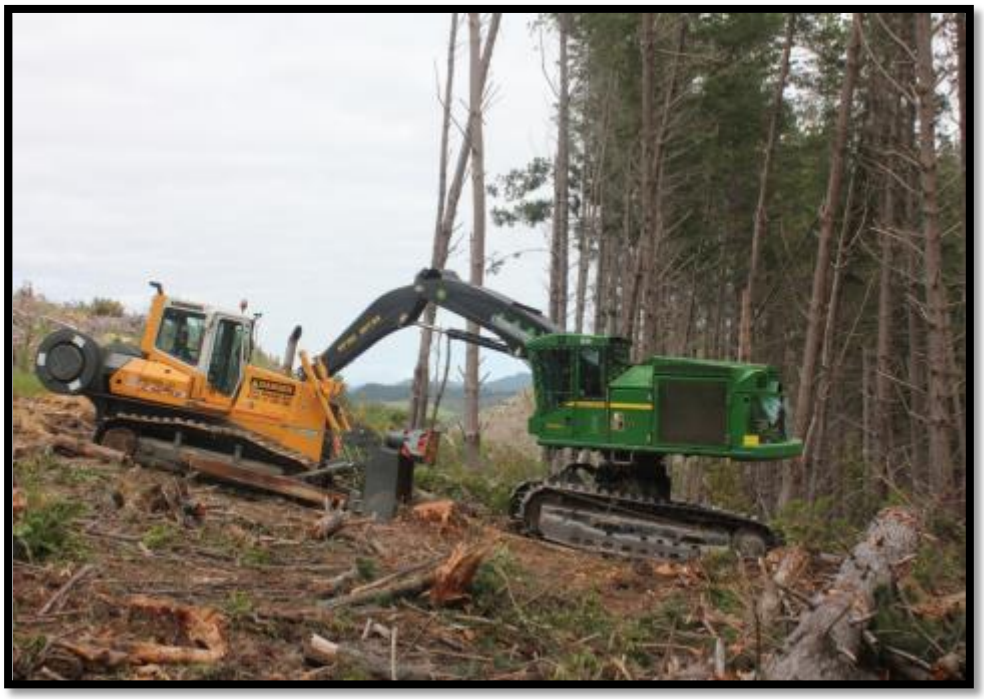

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Photo front page: Stokes Logging operating an EMS Tractionline system and TigerCat 855C.

Photo this page. Rosewarne Cable Harvesting twin drum cable assist tractor and JD909 (2014).

1 Contents

Grimmer Logging single drum cable assist tractor (2014)

2 INTRODUCTION

- Steep slope cable assisted harvesting systems are designed to provide health and safety, environmental, and productivity benefits in commercial logging operations on steep slopes up to 50°.
- By definition a steep slope cable assisted system is the sum total of an anchor, including though not necessarily, a machine providing cable assistance, the machine (plant) receiving the assistance (ie harvesting / extraction machine), all associated rigging, and any ancillary safe work practices or procedures that have been specifically developed, tested, and demonstrated to be safe when operating on slopes up to a predetermined maximum (i.e. 50°).
- The steep slope cable assisted system may be used for mechanical felling, bunching, shovel logging, log extraction (forwarding/skidding) or a combination of these functions, and can be used in conjunction with traditional cable logging operations or ground based operations.
- The wire rope between the machine and the anchor point is used to provide tractive assistance when the machine is travelling up or down slopes.
- These guidelines aim to provide for operations where the winch may be mounted on the harvester / base machine or the machine anchor.
- The machine shall not be operated on slopes that exceed a maximum specified by the system manufacturer (or their agent), a Chartered Professional Engineer (CPEng), or the principal contractors self-imposed restrictions.
- Each steep slope cable assisted harvesting system operating within HFMNZ managed estate is required to comply fully with these Best Practice Guidelines and also the Ministry of Business, Innovation, and Employment (MBIE) *2013 Approved Code of Practice for Safety and Health in Forest Operations* (ACOP).
- Steep slope cable assisted harvesting systems operating within HFMNZ managed estates must have Safe Working Procedures specific to the type of activity that is being undertaken.
- The system may have applications for other mechanised operations on steep slopes.

Photo: PJ and MJ Olsen Ltd (King Country Harvesting) operating an EMS Tractionline and CAT522B Harvester

3 THE STEEP SLOPE CABLE ASSISTED HARVESTING SYSTEM

3.1 Steep Slope Cable Assisted Harvesting system components:

1) Human – operator/principal/crew
2) Environment – physical/climate
3) Machines and materials
4) Administration and procedures

<table>
<tr><td colspan="2">Administration and Procedures
➢ Steep Slope Cable Assisted Harvesting Safe Operating Policy
➢ Steep Slope Cable Assisted Harvesting Safe Operating Procedures including Emergency Procedures</td></tr>
<tr><td>Stakeholders
➢ HFMNZ
➢ Principal
➢ Operator
➢ Crew</td><td>Environment
➢ Physical – slope, soil, crop trees, hazards
➢ Climate</td></tr>
<tr><td colspan="2">Machines and materials
➢ Base Machine
➢ Winch or winches
➢ Wire rope and rigging
➢ Anchor points</td></tr>
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4 SAFE WORKING PROCEDURES

Every harvest area is required to have documented **Safe Working Procedure** in place before the Steep Slope Harvester (SSH) can commence any work.

4.1 Parts of a Safe Working Procedure

Harvest Area Work Plan	**SSH Safe Working Policy**	**A SSH Risk Matrix** (as per ACOP 6.4.5)
SSH Hazard Identification And Management Controls (as per ACOP 6.4.5)	**Machine Maintenance And Inspection** (as per ACOP 6.4.5)	**Rigging Register**
Operator Fatigue Plan (as per ACOP 6.4.5)	**Working Alone Procedures** (as per ACOP 6.4.5)	**Traffic Control and General Signage Procedures**
Emergency Plan (as per ACOP 6.4.5)		

5 MACHINES AND MATERIALS

5.1 The Base Machine

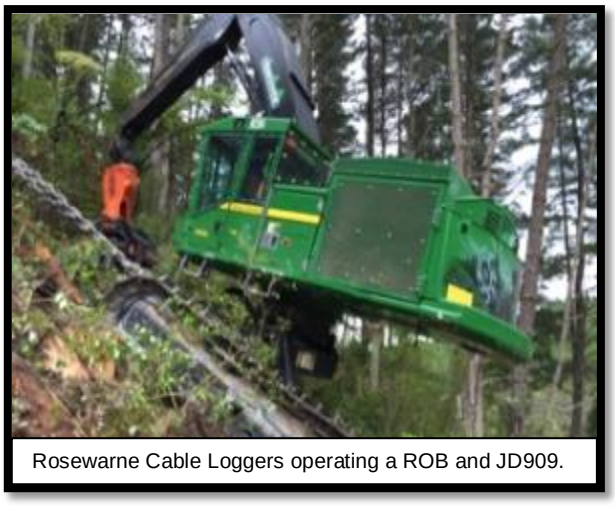
5.1.1 Typical base machine options:

a) Factory built self-levelling tracked harvester

b) Factory built non-levelling (fixed) tracked harvester

c) Modified tracked harvester

d) Factory built forwarders / skidders



Rosewarne Cable Loggers operating a ROB and JD909.

The following are **mandatory requirements** for all SSH base machines working in HFM NZ managed forests:

i. Compliant purpose built ex-factory forestry cab or a cab designed, fitted, and certified (ROPs FOPs and Ops) in NZ.

ii. Guarding package that protects the mechanical operation of the base machine - and winch if on board.

iii. Extended (>50mm) single grouser track shoes for tracked machines and chains or bands for rubber tyred machines.

iv. A certified heavy duty towing hitch that is engineered to withstand a full range of vertical and horizontal forces across a range of angles.

v. Have an over-riding and functional braking system in the event of loss of machine power.

vi. Have an emergency back-up system incorporated into the operation to ensure stability of the mobile plant should the winch, wire rope, or anchor fail (as per ACOP sect. 6.4)

vii. Must be designed and tested to operate continuously on a predetermined maximum slope angle ie up to 30-40-50°.

viii. Incorporate safety redundancies into remote control systems that accommodate radio frequency (RF) latency, fade, or drop-out. Ideally redundancies will combine both procedures to minimise occurrence (i.e. maximise line of site between RC devices; avoid standing trees (signal absorption) and technological fail-safes (i.e. cut-outs) in the event of signal fade or failure.

ix. Have an inclinometer fitted that measures track / tyre angle at all times.

x. Have a fully integrated/automatic fire suppression system or where a suppression system is not fitted there is a minimum 2kg Dry Powder plus a 9/10 litre water or 9/10 litre foam fire extinguisher charged and available for immediate use.

xi. Have a minimum of two and a preference for three, emergency access and egress points '*each on different faces*' on the cab of the mobile plant. Each exit must be able to be opened from both inside and outside the machine.

xii. Have a 19mm polycarbonate or equivalent front window.

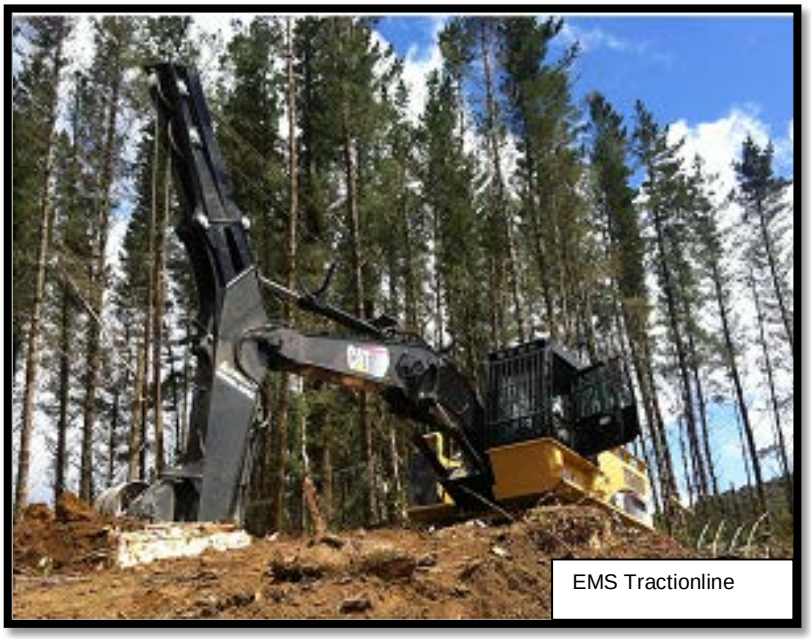
xiii. Manufacturers of cable assist systems should refer to AS1418.2 1997 Serial Hoists and Winches, Section 6 - Creeper Power Winches, when seeking CPEng Certification.

5.2 The Winch or Winches

SSH systems may be operated by a single or dual winch system with multiple energy sources (i.e. mechanical, hydrostatic and / or electric).

The winch or winches must meet the following requirements:

- Shall have a pre-set maximum line pull (safe working load) that does not exceed 33% of the breaking load of the wire rope fixing the base machine to the anchor.
- The base machine must be capable of receiving live rope tension / load status at the base machine, from the machine anchor, or ideally both. The physics attributable to pulleys may exist when ropes meet resistance (i.e. bind on obstruction/s) potentially leading to false representation of true rope tension at the base machine. Using blocks rather than object (i.e. stumps) will maximise rope life and control resistance.
- Shall have an auto-stop mechanism in case of catastrophic loss of energy or mechanical failure.
- An auto-stop mechanism that is triggered when wire rope spools off the drum is recommended.
- Will have emergency stop procedures tailored to the energy source being used.
- The attachment points of all winches and tow hitches must carry Chartered Professional Engineering certification.
- Have an auto stop mechanism designed to engage when a minimum number of wire rope wraps (ie 3 or 4 wraps) remain on the winch drum is recommended.


EMS Tractionline

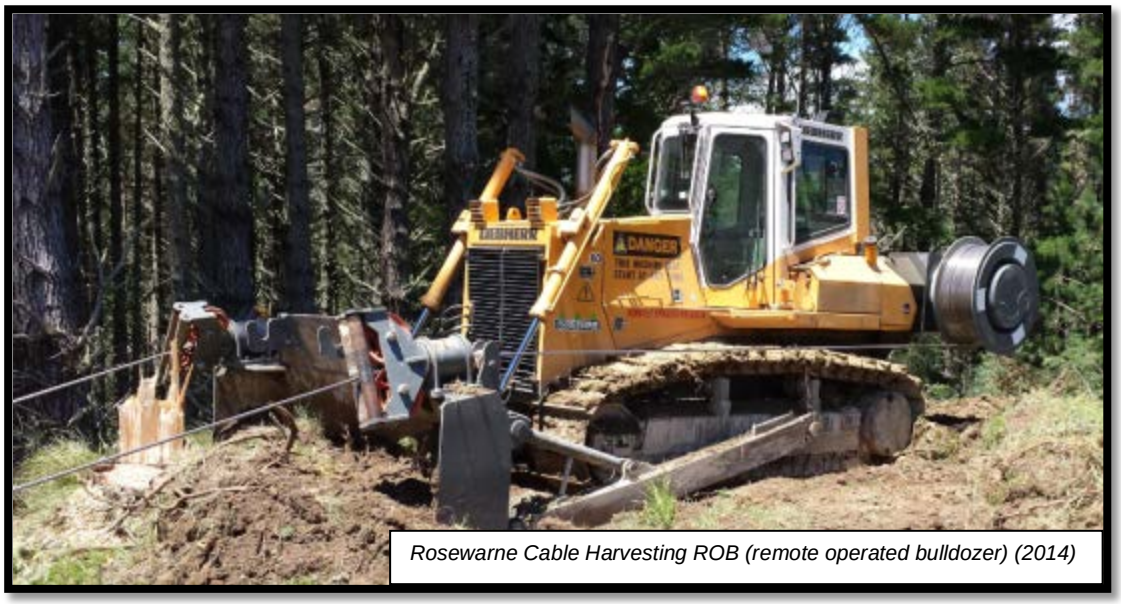
- Have a measuring system that records and relays to the base machine the amount of rope having left the drum and the amount remaining on the drum is recommended.
- Have a manufacturers time based maintenance / service regime for winch drums, planetary/s, and all other permanent parts (i.e. tension monitors, tunnels, rollers, fair leads, etc.).

5.3 Wire Rope and Rigging

The wire rope and rigging must comply with the following requirements:

i. A Rigging Register is required identifying each of the various components being used in Cable Assisted System.
ii. The register will include each items replacement or retest dates and should include procedures for testing critical equipment including what to measure (i.e. final link in chain), how to measure (using digital calliper's) , and rules for replacement (i.e. remove chain link with 4mm metal fatigue from new).
iii. The register will state the Maximum Breaking Load (MBL), Safe Working Load (SWL), and Safety Factor (SF) of each item in the system.
iv. For suitable wire rope care and maintenance, inspection and discard refer to ISO 4309:2010. Wire rope care should include the time interval (in hours) when to end for end ropes and a time interval to test with rigour (i.e. electromagnetically) and / or discard.
v. The MBL of the wire rope/s must exceed the maximum operating weight of the base machine.
vi. Shock loading wire rope and rigging will reduce their useful life. Manufacturers and operators of cable assist systems should aim to minimise shock loading wherever possible.
vii. The maximum SWL is calculated by applying a SF of 3:1 to the breaking load of the wire rope/s. A practical allowance from new must be incorporated on all system parts (i.e. wire ropes, shackles, chain) to cover normal deterioration encountered in day to day wear and tear. A system just meeting a 3:1 SF at new will, once in service, quickly fall below the 3:1 minimum threshold. A controlled allowance will allow the SWL to remain working at or above 3:1 for a period of time. After which a monitoring / replacement program will ensure all parts in the system meet the minimum thresholds.
viii. If a sheave is used an additional sheave factor will be applied in accordance with Table 4.2 in the *Cable Logging Handbook* (1983) - See **Appendix 4** for Table 4.2.
ix. Anchor strop strength must be equal or greater than that of the winch rope.
x. All shackles must have a SWL greater than that of the wire rope.
xi. All rope eyes must be married and spliced with a minimum of three tucks per strand.
xii. Swaged eyes must be formed by an approved wire rope company.
xiii. Where practical consider using a 2nd white metal pressed ferrule, a slave ferrule, to maintain the bond / holding strength of the primary ferrule where the ferrule runs into blocks / sheaves.
xiv. There shall be no knots tied in any ropes used for this purpose.
xv. Equaliser blocks and strops will have an identified and documented SWL
xvi. All wire rope and rigging must be visually checked daily.

5.4 Anchor Points – Machines, stumps, deadmen



Rosewarne Cable Harvesting ROB (remote operated bulldozer) (2014)

Typical anchor point options:

a) Factory built tracked machine anchor – tractor/excavator/other

b) Modified tracked machine anchor – tractor/excavator/other

c) Stumps and Deadman

All anchor points shall be compliant with the relevant sections on Anchors in the Approved Code of Practice for Safety and Health in Forest Operations (ACOP 14.3 & 14.6).

5.4.1 Machine anchors

- Machine anchors must comply with the ACOP for mobile anchors (ACOP 14.6).
- Should include a purpose built tension monitor to relay information back to SSH.
- Recommended that all anchors are fitted with an electronic anchor movement alarm (i.e. break away switch) that can alert the SHH operator of anchor winch stability issues.
- Rope departure angles, vertically and laterally, make a significant contribution to anchor stability. Cable assist operating procedures should incorporate the optimum, maximum, and known circumstances that should be considered when managing vertical and lateral rope departure angles.
- Recommended that operating procedures identify the optimum relationship between the track frame and the rope departure angle to maximise stability.
- For excavators an optimal angle between boom and stick (i.e. 90-110) and how to optimally secure / position the bucket should be articulated and actively managed.

- Experience has proven that the departure point for wire ropes leaving the anchor should be a low as practical to the ground. It is strongly advised that departure points for excavators should not be mounted on the boom.
- Conditions that may require further machine security / stabilisation (i.e. tying back) measures may be encountered and should be identified in the hazard assessment process.

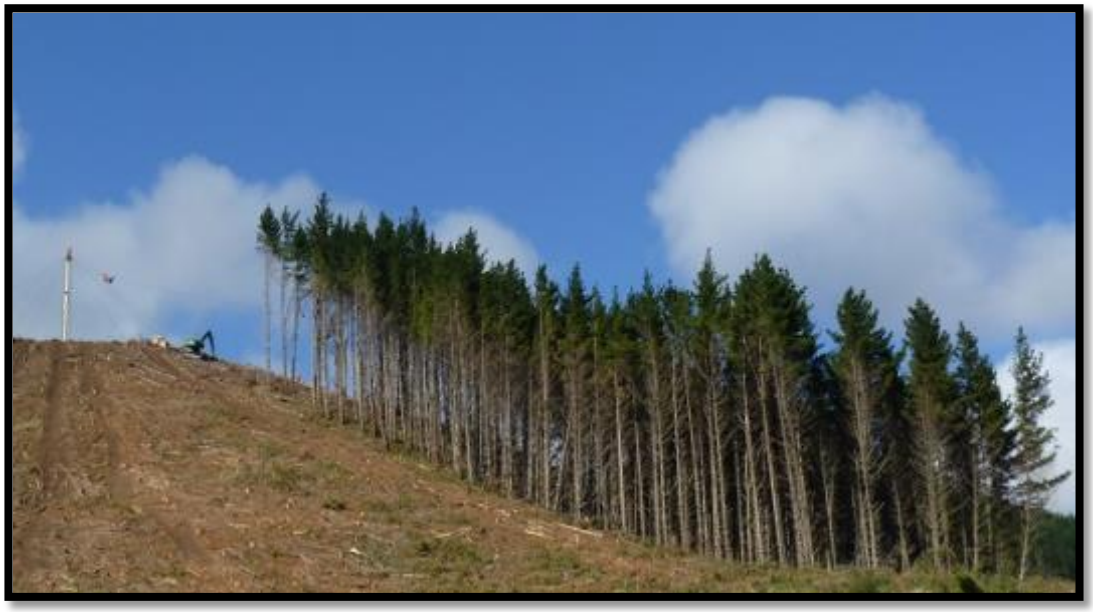
5.4.2 Stumps

Where tree stumps are used for anchorage points they must meet the following requirements:

- Comply with all relevant requirements of section 14.3 of the ACOP.
- Minimum stump diameter of 500mm
- A stump monitor alarm must be fitted to the anchor stump, for operator notification in case of stump movement.

5.4.3 Deadman

- Deadman, when used, must comply with section 14.3.5 of the ACOP.



6 OTHER SAFETY FEATURES

In addition to the forestry compliant guarding package the base machine must be fitted with the following safety equipment and features.

a) Minimum of four point harness (lap 75mm + shoulder 50mm) seat belt

b) A cab capable of operating at noise levels less than of 85 dBA. Personal hearing protection is compulsory where noise levels exceed 85 dBA.

c) A heating and ventilation control system in the cab to maintain operating ambient temperatures between 15 and 25 Celsius

d) A secure place to secure all water and food containers.

Where applicable an Interpine GPS / slope mapping software and associated tablet hardware is strongly recommended.

7 MACHINE MAINTENANCE, INSPECTION, AND OPERATION

- The operator must carry out a daily operational check of the SSH prior to the commencement of operations.
- No loose and / or dangerous material shall be carried in the cab.
- All machinery must be operated with the doors closed.
- No person shall get on or off a moving machine, or ride on an excavator not fitted with proper seating: “no seat - no ride”
- The cable assist machine and the machine being assisted shall be serviced and maintained to the manufacturer’s specifications, recommendations and instructions.
- When a machine is shut down or left unattended with engine running all attachments shall be resting on the ground and in a safe position.
- All harvester heads shall be locked or supported and the cutting unit de-energised when any maintenance is being carried out.
- The operator or mechanic must ensure there is zero energy in all parts of the machine prior to commencing any repair work on the machine.
- Service records will be available for inspection.
- Each month the entire length of the rope will be inspected for wear and damage.

- All sensors, alarms, and controls fitted by the manufacturer must be monitored and in working condition.
- An example of a Daily Checklist is included in *Appendix 2.*

8 STAKEHOLDERS

8.1 Hancock Forest Management

- Prior to any SSH operation commencement the Supplier Principal must provide their local HFM office with a copy of their SSH System and Safe Operating Procedures and obtain written approval from HFM to operate the system.
- HFM will undertake comprehensive audits of the SSH system annually
- The audit criteria used will be developed in partnership with HFM suppliers.

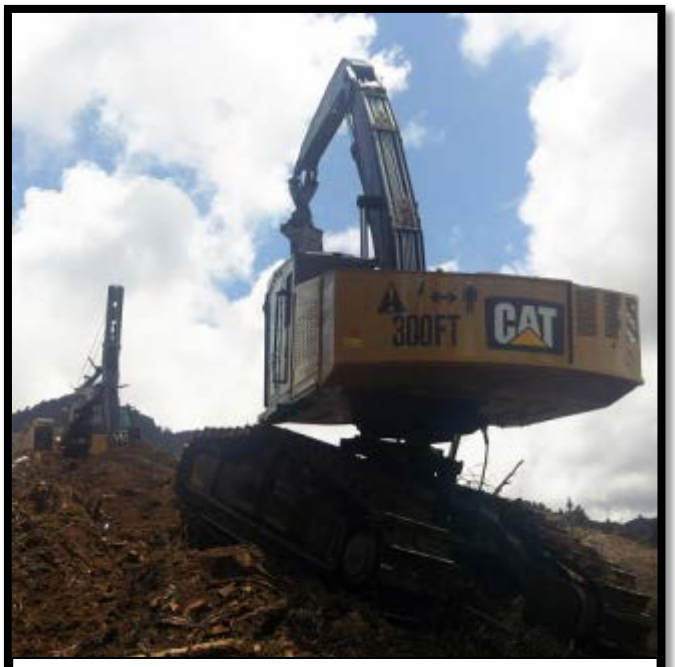


Photo: PJ and MJ Olsen Ltd operating an EMS Tractionline and CAT522B Harvester

8.2 The Operator

- The operator must be suitably trained or under supervised training.
- The operator will be deemed competent, in writing, and will undertake safe behavioural observations (SBOs) at regular predetermined time intervals i.e. monthly.
- Induction - as a minimum requirement, the operator will have spent 20 working days operating the Steep Slope base machine on slopes less than a predetermined angle (i.e. <22) before undertaking any further training on slopes exceeding 22 .

- A fully trained operator will hold the following NZQA Unit Standards:

i. 6935 Operate an excavator based tracked machine in a forestry situation.
ii. 24590 Operate a self-levelling machine in a forestry situation
iii. 6947 Bunch tree lengths for extraction or processing.
iv. 6941 Demonstrate knowledge of forest mechanised harvesting and
v. 6945 Fell trees using a mechanised harvesting machine
vi. 1231 Prepare wire ropes for harvesting operations
vii. 22994 Demonstrate knowledge of factors that affect the performance of forestry workers
viii. 17771 Carry out lineshifts in a cable harvesting operation using a mobile tailhold machine

8.2.1 Operator fatigue Plan

The Steep Slope Harvester operator has a responsibility to maintain their personal fitness for work and to not operate the machine when known to be fatigued.

The following may assist in the development of a fatigue management plan:

- The operator will undergo training in fatigue recognition prior to commencement of operation.
- A minimum 12-hour break must be provided between work shifts.
- The operator shall not work more than 6 successive days.
- The operator must take a minimum of a 15-minute break every 3 hours.

9 HAZARD IDENTIFICATION AND RISK MANAGEMENT CONTROLS

It is the responsibility of the Principal Harvesting Contractor to ensure hazard identification is undertaken with the operator, and any other employee(s) who may be associated with the Steep Slope Harvester operation.

Hazard identification for Steep Slope Harvesting should include consideration of the following issues. N*B: This is not an extensive list of hazards, but a guide to common hazards.*

An example Hazard Identification and control plan is provided in **Appendix 2**.

9.1 Machine Stability Factors

- Anchor security
- Slope & Slope Length
- Terrain Stability / Classification
- No go zones (red), assisted (tethered) only zones (orange), unassisted zones (green)

9.2 Ground conditions:

- Rocks, Outcrops, Tomos
- Soil strength – soil type, soil moisture (hard/soft/saturated), soil depth

9.3 Climate and Weather

- Season/month/day/ forecast
- Precipitation – rain, snow, sleet
- Fog
- Electrical storms
- Sun-strike

9.4 Pre-Existing and Post-Harvest Debris/Vegetation

- Heavy vegetation
- Windthrow
- Slash / trees
- Oversize wood

9.5 Worker Isolation - Time for Assistance to Reach Operator

- Rope length
- Terrain
- Distance to road/clearing

9.6 Mechanical Factors

- Design limitations of plant, rope and rigging.
- Physical limitations of plant, rope and rigging.

9.7 Environmental Impact

When operating a cable assisted system in low strength soils (ie erodible geology / wet soils) or wet weather there is the potential for the cable assisted machine to damage soils, contribute to slope instability, or negatively impact waterways.

It is the responsibility of the supplier in conjunction with the operator to define those areas within the harvest area that may be mechanically worked on each day so as to ensure compliance with the HFMNZ Environmental Management Standards (EMS) and any relevant resource consent conditions or Regional/District council rules. If necessary consult with your HFMNZ supervisor.

Woods Logging single drum cable assist tractor with JD909 (2013)

Plan to harvest areas of high environmental risk when conditions are optimum and use mitigation tools such as corduroy and slash to increase the operating window and reduce any potential negative impact like rutting and compaction.

Rehabilitation of disturbed areas including uncontrolled ruts and excavations used to secure the anchor should be undertaken as soon as practical.

Worth emphasising is that often no other machine is capable of safely traversing the same slope as a cable assisted base machine. As such rehabilitation should be undertaken immediately - as you go.

10 WORKING ALONE PROCEDURES

A written Working Alone Procedure including a No Response Action Plan must be generated and continuously applied when working alone.

It is the employer's responsibility to assess the hazards posed to any employee working alone and to take all practical measures to control those hazards. The employer will supply a means of communication to notify an emergency situation or to summon assistance.

It is the employee / operator's responsibility to;

- Ensure that someone knows of their whereabouts.
- Communicate their plans to someone (point of contact)
- Have an RT or cell phone for communication.
- Make regular check-ins (Minimum once per hour) with a contact person.
- Not to change plans without informing the point of contact first.

Response time to a SSH operator working alone should be no longer than 30 minutes. If the response time is likely to be greater than 30 minutes then a buddy should be provided.

11 EMERGENCY PLAN

- Emergency procedures and response should be as per the Crew Emergency Response Procedures.
- A SSH operating across multiple crews operates under the emergency plan for the site being actively worked.
- In the event of an emergency occurring, ensure emergency services are contacted and dispatched as soon as practical.
- An emergency procedure sticker is to be prominently displayed on the worksite and displayed in all vehicles and machines
- Emergency location co-ordinates must be current for each work site.

12 INCIDENT REPORTING

Supporting the on-going development and success of cable assist systems requires the sharing of knowledge and experiences. Whether it is owners, operators, technicians, engineers, planners, trainers, or regulators we are all seeking to improve the safety and efficiency of cable assist systems.

The incident reporting system in place for HFM NZ continues to be the preferred vehicle for sharing operational experiences and improvements. The limited list below shows examples, there are more, of areas of interest for HFM that if they were to occur HFM would expect the supplier to lodge an Incident Report.

- when a mechanism primarily aimed as a fail-safe is triggered ie machine kill switch / drum overspool switch / number of wraps left on drum, etc.
- any event where the operator invokes an emergency stop
- when an anchor moves (bucks / slides / rolls)
- when one or both tracks lift off the ground - potential rollover / rollover
- the felling machine slips / slides more than half the length of the machine
- any rope, rigging, or rigging accessory that almost breaks or fails completely.
- a tree or object that falls on or strikes a rope or machine
- any event that could be construed as shock loading
- when an intermediate support (ie high stump) fails
- when an operator abandons the machine
- when an operator resigns from operating steep slope machines

13 APPENDIX 1: Sample Hazard Identification and Control

Hazard	Management control methods
Entering the cut-over	Without cable assist – **Risk**: Machine rollover; **Likelihood**: High; **Consequence**: high ◊ With cable assist - Risk: Machine rollover Likelihood: High Consequence: medium / low ◊ Determine soil strength (ie wet / dry soil, fill or hard soil, etc) and ensure that available traction assistance is sufficient for the situation. ◊ Points of weight transfer between machines are points of highest risk. Identify where the transfer will occur and control the transfer. ◊ Pre-tension ropes to ensure support is immediately available prior to entering the cut-over. ◊ Before entering the cut-over ensure the rope departure / arrival angle (vertical and horizontal) will be maintained within manufacturer's guidelines at all times. ◊ Operator to secure the 4 point harness seatbelt and stow any loose items before moving out of the designated safe area.
Cable assist machine being pulled over	**Risk**: Machine rollover **Likelihood:** High. **Consequence:** High ◊ Plan to succeed. Pre-plan travel and work patterns, designate risk based on hazard assessment, identify safe areas, share your plan. ◊ No person shall be in the machine providing the assistance at any time that the machine being assisted is tethered and moving. ◊ Before entering the cut-over ensure the rope departure / arrival angle (vertical and horizontal) will be maintained within manufacturer's guidelines at all times. ◊ Secure the anchor to manufactures or best practice guidelines. ◊ Continuously monitor rope angle, rope vertical orientation (rope in the air adds weight), rope binds. ◊ Monitor the break-away alarm for movement of the anchor machine.

Remote Control Machine guidance interrupted	**Risk**: Signal failure (radio fade and drop-out) of remote control guidance system. **Likelihood**: High. **Consequence**: Low ◊ Standing trees absorb electronic signals (sound waves) and can dampen signal strength and clarity. ◊ Plan to keep the distance between remotely connected machines as clear of standing trees as possible. ◊ Take advantage of hard objects (ie rocks) to bounce / reflect the signal. ◊ Consider installing radio frequency signal range extender technology to maintain line of site or counter signal absorption.
Unauthorised access or approach to a remote operated machine	**Risk**: Unauthorised person/s access or approach a remote operated machine; **Likelihood**: Low; **Consequence**: Low ◊ Ensure remote operated machine is clearly identified as being unmanned and remote controlled. ◊ Make sure all machines have a stand clear distance clearly marked. ◊ Ensure all physical hazards such as accessible moving parts (ie winch drums) are highlighted / marked so that any movement is obvious. ◊ Ensure remote operated machine is configured to lock-out unauthorised attempts to move or control the machine.
Sticks/Branches entering Cab	With/Without cable assist: **Risk**: cab penetration; **Likelihood:** low; **Consequence**: high **Eliminate** by design and fitting of purpose-built cab and guarding (ie 19mm Marguard laminate front windscreen.). **Minimise** potential hazards by: ◊ Pulling trees down past the excavator when shovel logging and keeping the boom-side of the excavator between the cab and the tree (this method may have limitations as it potentially reduces visibility for the operator, which is vital on steeper slopes) ◊ Keep the tree as far away as possible from the cab; while maintaining awareness of machine stability when pushing tree away from the cab. ◊ Machine doors will be securely closed during operations ◊ No tree shall be pulled by the head unless the tree stays below cab height throughout the full manoeuvre

Stumps and logs can upset stability, or throw a track	With/Without cable assist: **Risk**: uncontrolled moving objects impact unprotected workers or plant; **Likelihood**: high; **Consequence**: high **Minimise** ◊ Cut stumps off low to the ground ◊ Avoid walking the excavator over high stumps ◊ Place stumps away from travel line if they are lying on top of the ground. ◊ Position machine being assisted optimally before engaging cable assist. A small amount of assistance provided at the wrong time may cause an upset condition.
Undergrowth can hide hazards such as holes and wind thrown trees	With/Without cable assist: **Risk**: uncontrolled moving objects impact unprotected workers or plant; **Likelihood**: high; **Consequence**: high **Minimise** ◊ Operator walks the felling area prior to the commencement of work each day to identify potential hazardous sites ◊ Clear undergrowth off the excavator travel line with the felling head/grapple before proceeding ◊ Lift and shift rather than walk over fallen trees.
Solid Rock surfaces may lead to a loss of traction	Without cable assist: **Risk:** Machine rollover / slide **Likelihood**: High **Consequence**: high With cable assist: **Risk**: Machine rollover / slide; **Likelihood**: medium; **Consequence**: medium / low **Minimise** ◊ The operator shall avoid walking the excavator over solid rock surfaces while felling, shovel logging or traversing. ◊ The operator **must never** walk the excavator on solid rock surfaces at any time on slopes greater than 20 °, unless on a previously formed road, track or firebreak.

Working uphill can cause instability risks	Without cable assist – **Risk**: Machine rollover; **Likelihood**: High; **Consequence**: high With cable assist - **Risk**: Machine rollover; **Likelihood**: High; **Consequence**: medium / low **Minimise** ◊ On slopes between 20 and 30 degrees° the operator has the option of holding the boom in front of the excavator provided it is low to the ground surface, to assist climbing and reduce instability risks. ◊ On slopes greater than 30 degrees the boom must be facing downhill at all times when walking the excavator. ◊ Ensure the boom is facing the correct / optimum direction before engaging the winch.
Working across slope	Without cable assist – **Risk**: Machine rollover; **Likelihood:** High; **Consequence**: high With cable assist - **Risk**: Machine rollover **Likelihood**: High; **Consequence**: medium / low ◊ When sidling care should be taken to avoid stumps and ground depressions. ◊ Limited sidling should be done on slopes greater than 26 degrees. ◊ Before working (felling / shovelling) tracks should be faced vertically in line with the predominant slope.
Hazards causing loss of rope / rigging integrity	With cable assist – **Risk**: Machine rollover; **Likelihood**: medium; **Consequence**: medium / low ◊ Ensure all parts of the system are designed and maintained to deliver a minimum 3:1 factor of safety. ◊ Ensure maintenance, visual checks, toolbox / hazard ID , are conducted as specified (ie daily) ◊ Where there is a situation that the rope or rigging is damaged for any reason then cable assist operations are to stop and the rope or rigging repaired or replaced immediately.

Lifting trees alters the centre of gravity, and is particularly hazardous on steep slopes.	Without cable assist – **Risk**: Machine rollover; **Likelihood:** medium / high; **Consequence**: high With cable assist – **Risk**: Machine rollover; **Likelihood**: medium / low; **Consequence**: medium / low **Minimise** ◊ Rule of thumb is to never lift trees higher than necessary off the ground. ◊ Aim to reduce the reach when working as 1) the slope increases and / or 2) the weight of the object/s being moved increases. ◊ On slopes greater than 26 degrees trees shall not be lifted more than 3 metres above ground level.
Wind thrown trees are a slip and topple hazard	**Minimise** ◊ Remove wind thrown trees from the line of travel. ◊ Remove high stumps from the line of travel ◊ Avoid root bowls or fill these with slash or dirt before walking through them on slopes up to 20 degrees. ◊ Avoid all root bowls on slopes greater than 20 degrees.
Falling debris	With/Without cable assist: **Risk**: uncontrolled moving objects impact unprotected workers or plant; **Likelihood**: high; **Consequence**: high Falling debris may be dislodged by the anchor rope, causing damage to machine or operator **Minimise** ◊ The operator must remain in the stationary cab for 30 seconds before dismounting and then check for falling debris from up slope.
Standing trees or stumps used for rope deflection fail	With cable assist - **Risk:** Machine rollover / shock loading; **Likelihood:** medium; **Consequence:** medium / low ◊ Plan to use certain trees or stumps to deflect ropes rather than rely on chance. ◊ Deflection pressures can dislodge stumps and other hazards (ie rocks, stumps) and fell standing trees. ◊ Observe the points of deflection and if necessary actively change the set-up, including the anchor position, to avoid shock releases – be pro-active. ◊ The operator should move the machine being assisted into a clear area (at least 1.5 tree lengths) before exiting the cab. ◊ Before exiting the cab the operator must identify potential falling tree hazards.

Operator mounting or dismounting the machine may slip	**Risk:** fall injury; **Likelihood:** medium; **Consequence**: medium / high Operator getting on and off the machine may slip, resulting in slip, trip or fall injuries **Minimise** ◊ When getting on or off the machine the operator must always maintain 3 points of contact, and ◊ Wear appropriate safety footwear, and ◊ Maintain hand holds and steps in good condition ◊ Dismounting from the high side of the cab is preferred.
Unsecured equipment in the cab may be hazardous.	◊ The cab must be free of all loose equipment that could injury an operator of in the event of a roll over. Items such as fire extinguishers shall be held securely in a holder, all other tools are to be outside of the cab or in a lock up tool box.
Inexperienced Operator	◊ Ensure new operator has been inducted, provided suitable training and supervision, and completed time in seat (min. 20 days) in low risk conditions prior to working in medium / high risk conditions. ◊ Undertake a SBO before deeming the operator competent and able to advance to medium / high risk environments.
Operator fatigue	**Risk**: sub-optimal decision making; **Likelihood:** High; **Consequence**: high ◊ Ensure the operator is well hydrated and rested ◊ Operator to consider restricting activities involving higher risk to times of the day when they are most alert (ie first 3 hours of the morning). ◊ Set-up robust processes to monitor and measure operator wellbeing at regular intervals
Increased aerial hazards risk to manual fallers	**Risk:** increased aerial hazards to manual fallers; **Likelihood:** High; **Consequence:** high ◊ The machine operator, the manual faller, and the site foreman pre-plan the cutting pattern or zones that the manual and mechanical fallers should work within. ◊ Machine operators to avoid where possible increasing the number of and, risk associated with, aerial hazards (ie hang-ups and widow makers) that will be encountered by manual fallers at a later date. ◊ Manual fallers entering an area previously visited by a harvester must have heightened awareness of increased aerial hazards. ◊ Some areas will contain too many uncontrolled hazards for a manual faller and should not be attempted.

14 APPENDIX 2: Sample Daily Check List for Steep Slope Felling Operations

Operator :	**Date from: To:**
Felling Machine :	

Start-up Check list	**✓ ok - ✗ not ok**						**Inspection Results - Comments**
	M	T	W	T	F	S	
Rope and fittings							
Eye splice							
Rope wear							
Shackles							
Hammer Locks							
Anchor strops 7/8”							
Ferrules							
Winch and fairlead							
Fairlead roller damage							
Oil leaks							
Hose wear							
Feed out working							
Guide on gear							
Parked correctly							
Communication							
Work plan							
Radios							
Remote control system							

Upper Structure							
Oil Levels							
Radiator fluid							
Hydraulic level							
Oil leaks							
Engine exhaust							
Hand rails							
Guarding Damage							
External cooler							
Undercarriage							
Slew bearing							
Rollers							
Sprockets							
Idlers							
Oil leaks from underneath							
Turret bolts							

15 APPENDIX 3: 2016 Cable Assisted Steep Slope Harvesting Audit

For Cable Assisted Steep Slope Harvester and their Mobile Anchors

CONTRACTOR NAME AND CREW #			
DATE OF AUDIT		**HAREA**	
AUDITOR/S		**FOREST**	
SYSTEM		**ROAD**	

	Enter Machine Type and Operator's name	Harvesting Machine	Anchor
	HAZARD MANAGEMENT AND RISK CONTROL		
1.	Is there a cable assisted steep slope safety management system on site and a copy on file with HFM?		
2.	Is the cable assist system (mobile anchor, harvester, and connections) certified by a Chartered Professional Engineer as being safe to operate on the cutover?		
3.	Is there evidence that the operator undertakes a risk assessment of the felling area to determine hazards and controls?		
4.	Is there evidence of a slope hazard assessment being undertaken that identifies rocks, holes, bluffs, drop-offs, and slope angle that could lead to shock loading?		
5.	Is there evidence of an environmental hazard assessment being undertaken that identifies weather, soil type, topography, waterways, and other natural hazards that could contribute to machine instability, system failure (rope and attachments) or operator distress?		

6.	Is there evidence of a hazard assessment that identifies risks to rope and mechanical integrity? For Example: Hazards that could impact the machine to machine interface include but are not limited to rope integrity (internal and external wear), winch brakes and lock-outs, mounting and fitting failure, hydraulic/mechanical failure, electronic failure including remote control interface).		
7.	Does the operator actively manage risk to themselves and other persons? Are there, for example, clearly identified machine no go zones (machines/men), no persons working downhill of a machine or within 2 tree lengths, there are minimum keep out zone in metres (ie 70m) and/or within a predetermined distance of working ropes and/or within the bight of any rope?		
	OPERATOR /OPERATING PRACTICES		
8.	Does the operator hold the relevant NZQA Unit Standard/s for the tasks being undertaken ix. 6935 Operate an excavator based tracked machine in a forestry situation. x. 24590 Operate a self-levelling machine in a forestry situation xi. 6947 Bunch tree lengths for extraction or processing. xii. 6941 Demonstrate knowledge of forest mechanised harvesting and processing. xiii. 6945 Fell trees using a mechanised harvesting machine xiv. 1231 Prepare wire ropes for harvesting operations xv. TBD DKO cable secured excavator operational capabilities and limits. xvi. 22994 Demonstrate knowledge of factors that affect the performance of forestry workers xvii. 17771 Carry out line shifts in a cable harvesting operation using a mobile tailhold machine		
9.	Is there a training plan for operator development?		
10.	Is there evidence of Safe Behavioural Observations being conducted on the operator at intervals specified in SMS?		
11.	Can the operator demonstrate how the two tree length rule is being managed and measured?		

12.	Ask the operator to define the mean tree height for the harvest area. Did he get it correct?		
13.	Does the operator ensure no one is working directly in front or behind machine during in-haul?		
14.	When walking uphill does the operator keeps the boom either facing directly uphill or directly downhill in a fully extended position with the felling head as low as possible?		
15.	When walking downhill does the operator keeps the boom facing downhill?		
16.	Does the operator avoid turning and or travelling on side slopes?		
17.	When felling up, down, or across slope the operator undertakes pre-felling machine stabilisation measures including slipping counter measures (ie on stumps, rope lock-outs, machine facing up and down slope), limits over reaching, and has the felling head firmly attached to tree?		
18.	Does the operator have clear knowledge of the Comprehensive Faller Management Plan and the breaker out safe retreat plan and knows their part within either of those plans?		
	EXTERNAL INSPECTION		
19.	Are tracks are in good condition and cleats exceed the minimum (50mm)?		
20.	Are guards in place to protect physical entry to pulleys, shafts, and belts? Are guards undamaged and secure?		
21.	Is the felling head / processor / grapple in good condition?		
22.	Is the battery secure & maintained?		
23.	Is there any significant oil leaks or in-cab fumes?		
24.	Is the bush pan is in good condition / clear of debris?		
25.	Is the harvesting head or processor grounded when stationary?		
26.	Are all heads / hydraulics locked during maintenance (physically locked)?		

	CAB INSPECTION		
27.	Are there any dangerous items in the cab?		
28.	Do door latches close correctly and securely?		
29.	Is the hydraulic lock out working?		

30.	Is the **4 point webbing harness** (min. 75mm lap and 50mm shoulder) working (check that retractables retract), in use, and in good condition?		
31.	Are there non-slip pads / surface on foot pedals?		
32.	Are there two points of access and egress (emergency access) from machine cab?		
33.	Are all lights fitted for night work in working order?		
34.	Are all steps and grab rails secure and in a stable condition?		
35.	Are the windows clean and offer good clear vision?		
	COMMUNICATION SYSTEM		
36.	Are all fitted communication systems (radios, alarms, remote controls, remote diagnostics, cameras) in working order?		
37.	Have predetermined call in times been executed and recorded?		
	SAFETY LABELS		
38.	Is a warning sign / sticker for occupational overuse syndrome (OOS) visible?		
39.	Is a hazard warning sign / sticker for overhead power lines visible?		
40.	If in-cab noise levels are >85db is there a hazard warning sign for hearing damage)?		
41.	Is a chain shot warning sign / sticker visible?		
	FOPS/COPS/ROPS		
42.	Are the FOPS, COPS, ROPS, OPS fitted certified (correct structure for machine use)?		
43.	Do FOPS = ISO 8083 and ROPS = ISO 8082 and OPS = ISO 8084, OPS with Polycarbonate = ISO 8084/12117?		
44.	Are all alterations certified by the manufacturer, agent, or certified engineer?		
	NOISE		
45.	Is the in-cab noise level below 85 dBA? If no, is the operator wearing hearing protection?		
	FIRE SUPPRESSION		
46.	Is the fully integrated automatic fire suppression system (if fitted) 1) charged and 2) has been professionally checked within the last 12 months?		

47.	Is there is a 2kg (or >) Dry Powder plus a 9 / 10 litre water or 9 / 10 litre foam fire extinguisher charged and available for immediate use – **Cut-over machine** only?		
	CHAIN SHOT – MECH PROCESSING AND / OR FELLING **(main saw and / or topping saw)**		
48.	Is there an active Chain Shot Management Plan in place?		N/A
49.	Can the operator describe the danger zone and any controls in place to minimise risk (ie zones, maintenance, de-energising)?		
50.	Is the machine fitted with a minimum 19mm polycarbonate or equivalent front window?		
51.	Are all broken chains measured and an incident report generated when links are found to be missing?		
52.	Is there a chain catcher is in place and is in working order?		
53.	Is there a chain shot guard is in place and in working order?		
54.	Has the chain currently fitted or replacement chains on site been repaired more than 2 times?		
55.	Does chain stretch not exceed recommended limits (check with MPT)?		
56.	Are chain cutters of equal length?		
57.	Is the chain sufficiently lubricated?		
58.	Does the chain have any broken straps, cutters, or tangs?		
59.	Is the chain tension being actively managed (ie <3mm)?		
60.	Are all replacement rivets spun not hammered?		
61.	Is there any evidence of loose rivets?		
62.	Is there evidence the operator undertakes regular / correct maintenance of the guide bar – rail depth, spread (is square), wear pattern (ie being turned), nose defects, etc.		
63.	Is the drive sprocket aligned with guide bar grooves?		
64.	Is the drive sprocket wear inside tolerances?		

	OPERATOR FATIGUE		
65.	Is there evidence the operator has been inducted into the HSE working procedures, safe working limits of machine/s, felling techniques, and on-going safety management of machine/s?		
66.	Is there an operator fatigue management plan that considers state of mind, confidence levels, options to time-out/retreat, and timing of breaks?		
67.	Is there evidence that the options to manage fatigue available to the operator are being used?		
68.	Ask the operator to explain/demonstrate how he manages workplace fatigue ie break intervals, food and fluid, uses an observer or works with another, and how he recognises signs of fatigue.		
69.	Does the operator have sufficient healthy food and fluids available given the weather conditions?		
70.	Ask the operator to explain and demonstrate how they recognise stress as a contributing factor to fatigue and how they are managing stress. Stress could come from a number of areas – production pressure, terrain, hazards, workplace dissatisfaction, or home, etc.		
	EMERGENCY RESPONSE		
71.	Do the planned counter measures / emergency actions the operator plans to take in a slide / fall situation match the emergency procedures?		
	MAINTENANCE		
72.	Is their machine maintenance (completed maintenance and fault reports) documentation on site?		
73.	Is the current inspection certification posted in cab or on the machine?		
74.	Is the machine switched off during maintenance (unless specified otherwise by the manufacturer)?		
75.	Is the machine generally kept tidy?		
	ROPES AND RIGGING		
76.	Is there a Rigging Register outlining the various components listed in their Steep Slope Assisted Felling & Bunching Harvesting System and is it in line with the CPE report?		
77.	Does the register state the Safe Working Load (SWL) and Breaking Strain of all ropes and rigging?		

78.	Is there a documented visual wire rope inspection and maintenance program and is it being undertaken periodically as per the SMS? Is there a program to proof (ie electro-magnetically) test or replace the rope at periodic intervals?		
79.	Is the wire (winch) rope of a suitable size, length & condition for the purpose?		
80.	Ask the operator for the safe loading limits (min. 3:1 design factor) for the winch rope. Did the operator get them correct?		
81.	Are running ropes in good condition (ie no kinks, broken strands, crush damage, corrosion extending into the core, cross-overwear)?		
82.	Are all rope shackles and swivels of appropriate size (min 3:1 design factor) and in good condition?		
83.	Do all shackles (hanging shackles) have grommets fitted?		
84.	Are all splices in good condition and absent of cut splices?		
85.	Is the tension monitor present and working?		
86.	Is there evidence that the wire rope and rigging tension is being restricted to 33% (3:1 design factor) of its breaking load at all times? **Note**: A system with components that when new just make 3:1 is unlikely to maintain minimum design factors once operational.		
87.	Are all controls that identify and manage loading (ie clutches, tension monitors, alarms, etc) working?		
88.	Are ropes spooling onto drums correctly (ie no crossover or crushing)?		
89.	Are any ropes tied off to standing trees?		
90.	Are all blocks and sheaves of an appropriate size and in good condition?		
	ANCHORS		
91.	Is the anchor (including any blocks) stability / position security tested and checked each time the anchor is repositioned?		
92.	Are any ropes across a road flagged when positioned less than 6 metres from the road surface in a slack position?		
93.	Are backline stumps of suitable size and secure? Are stumps notched correctly?		

94.	Are deadman placed correctly (ie ropes equal & tight, shackle facing right way)?		
95.	Do any guyropes attached to machines have correct rope attachment (suitably engineered attachments)?		
	MOBILE TAIL HOLDS		
96.	Are correct rope anchoring methods (suitably engineered attachments) being used?		
97.	Is the position of the anchor stable: • tractor blade depth = ½ the blade (where possible) • excavator bucket depth = minimum ¾ the bucket • excavator exiting rope angle is within operating procedure limits • tractor exiting rope angle is within operating procedure limits		
	WORKING ALONE PROCEDURE		
98.	Is there a working alone procedure and can the operator verbally identify the process?		
	ENVIRONMENTAL IMPACTS		
99.	Is there evidence of unacceptable rutting / channelling / gouging?		
100.	Is there evidence of strategies that minimise disturbance (ie single pass) on confluence zones?		
101.	Is rehabilitation (cut-outs, slash) being undertaken as they go?		
	INCIDENT REPORTING		
102.	Is there evidence of a commitment to incident investigation and reporting		

COMMENTS

16 APPENDIX 4: Sheave Diameter and Bending Fatigue

In cable logging, wire ropes operate over sheaves and around drums, and bending the rope requires a considerable effort. The sharper the bend the greater the force required, and if the bend is too sharp, the rope is permanently damaged. The passage of a rope around a sheave causes increased tension in outer wires and reversed loading on inner wires. This combination of load stress and bending stress *is* commonly the cause of rope damage and failure.

It is recommended that sheave diameter should be twenty times the rope diameter, but in cable systems the weight of the blocks and sheaves means that except for the lead blocks, a compromise has to be reached so that blocks can be man-handled around the logging setting. For most skyline and highlead systems using 19-26 mm haul back and mainropes, sheave diameters of 20-30 cm are used.

Table 4.2 gives the strength for ropes bent around sheaves of a given diameter as compared with the same rope when straight.

TABLE 4.2 STRENGTH EFFICIENCY UNDER STATIC LOAD

When sheave diameter is:	Efficiency of rope is:
10 times rope diameter	79% of strength of straight rope
12 times rope diameter	81% of strength of straight rope
14 times rope diameter	86% of strength of straight rope
16 times rope diameter	88% of strength of straight rope
18 times rope diameter	90% of strength of straight rope
20 times rope diameter	91% of strength of straight rope
24 times rope diameter	93% of strength of straight rope
30 times rope diameter	*95%* of strength of straight rope

Information above extracted from: *Table 4.2. Cable Logging Handbook, NZ Logging Industry Research Association Inc, 1983.*