NSW GOVERNMENT | Trade & Investment Mine Safety

Investigation report

Investigation into a fatal collision between a Caterpillar 793D haul dump truck and a Toyota Landcruiser at Ravensworth open cut mine on 30 November 2013

Report prepared by the NSW Mine Safety Investigation Unit for the Secretary of NSW Trade & Investment

March 2015

Published by NSW Department of Trade and Investment, Regional Infrastructure and Services

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Report written: November 2014

More information

NSW Mine Safety Investigation Unit

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1. Executive summary

Incident overview

At 11.50 pm on Saturday, 30 November 2013, 38-year-old Ingrid Forshaw, a trainee plant operator employed by TESA Mining (NSW) Pty Ltd, was fatally injured while working at the Ravensworth open cut mine, near Singleton NSW (Ravensworth mine). Ms Forshaw suffered fatal injuries when the Toyota Landcruiser she was driving collided with and was run over by the front right-hand side wheel of a haul dump truck (Caterpillar 793D), weighing approximately 351 tonnes (including 186 tonnes of coal).

Ms Forshaw had earlier parked the haul truck she was operating at a stockpile and collected a Landcruiser that was parked at the stockpile by another operator at the start of the shift. Ms Forshaw was driving to collect other workers and go to a crib (meal) break.

The truck operator was hauling coal along the 9th haul road (a main haul road in the Narama area). As he approached the T-intersection with the stockpile ramp (8th ramp) he saw the Landcruiser travelling down the 8th ramp. As the truck operator approached the T-intersection he saw the Landcruiser enter the 9th haul road to his right and then he lost sight of it.

At the time, vehicles approaching the T-intersection on the 8th ramp were required to give way to vehicles on the 9th haul road.

The Landcruiser driver turned right onto the 9th haul road into the path of the truck. The truck and Landcruiser collided and Ms Forshaw was crushed inside the Landcruiser and died immediately from multiple injuries.

Figure 1. Photograph of simulation taken by investigators at Ravensworth mine on 2 December 2013.

Contributory factors

The Landcruiser operated by Ms Forshaw entered the path of the truck. It is possible that Ms Forshaw:

- recognised the presence of the intersection, but was not able to detect the truck
- observed the truck, but misinterpreted the road environment presented and what was required.

The combination of a range of factors is likely to have contributed to the incident. These include:

- the interaction of light and heavy vehicles on haul roads at the mine created opportunity for vehicle collisions
- some aspects of the intersection design and signage did not meet Ravensworth mine's guidelines and/or ARRB best practice
- the height of the windrows may have restricted Ms Forshaw's line of sight from the Landcruiser while travelling in a westerly direction down the 8th ramp, making it difficult to see the truck on the 9th haul road approaching the intersection
- the background lighting near the intersection had the potential to disorientate or confuse drivers approaching the intersection on the 8th ramp. The background lighting may have adversely affected Ms Forshaw's ability to detect a moving vehicle on the 9th haul road with accuracy and certainty.
- The presence of the water ponding may have been a contributory factor in the incident if it had distracted Ms Forshaw and/or led to reflection of the secondary lighting and vehicle headlights off the water's surface causing glare and confusion.
- the poor visibility of the truck due to the obscured front bumper lights and the recessed right side low beam light may have contributed to the incident by limiting the visibility of the truck that night. Due to the height of the truck and its close proximity to the intersection, the lack of light coming from the bumper lights would have made it difficult for Ms Forshaw to see the truck.
- the absence of other illumination devices on the truck to enhance the visibility of the front, top and side of the truck would have made it difficult to detect it while travelling down the 8th ramp and at the intersection
- the limited field of vision of the truck operator meant that the operator could not see the Landcruiser when it was positioned in the truck's blind spot in order to take evasive action
- there were no proximity or collision avoidance systems installed on the truck or Landcruiser to warn the operators of the presence of the other vehicle
- there was an over-reliance on administrative controls to manage heavy and light vehicle interactions at Ravensworth mine.

Recommendations

The incident highlights the importance of having an effective risk management program in relation to the interaction of light vehicles and heavy vehicles at open cut mines. The following recommendations are advanced to improve industry safety and reduce the likelihood of similar incidents occurring in the future.

When considering the recommendations below, mine operators are reminded of their obligation to take a combination of measures to minimise the risk, if no single measure is sufficient for that purpose.

Recommended practice for industry

- Consider separation of light vehicles and heavy vehicles on haul roads.
- Consider alternatives to the use of light vehicles for personnel transport while heavy vehicles are being operated on haul roads.
- Consider the use of traffic management systems which manage vehicle interactions at intersections, i.e. traffic signals, warning lights and hard barriers.
- Ensure appropriate road grades, lines of sight, windrow heights, speed limits and signage at intersections.
- Consider the location and impact of background lighting and its potential to disorientate or confuse operators while driving on haul roads and at intersections.
- Consider dedicated haul road and intersection lighting and ensure lighting is adequate.
- Ensure haul roads and intersections are adequately maintained on a regular basis.
- Consider the visibility of heavy vehicles and in particular haul trucks during night operations. Consideration should be given to the location, cleanliness and operation of vehicle lighting and the use and positioning of reflective materials, to enhance visibility of the vehicle.
- Consider the use of proximity detection and collision avoidance systems on light vehicles and heavy vehicles.
- Ensure daily inspections of haul roads and intersections are carried out by a competent person.
- Undertake regular documented surface transport management audits and risks assessments on all mine roads and intersections, which consider both day and night operation.

Contents

2. Purpose of report

This report concerns the investigation into the fatal collision outlined above, and was prepared for the Secretary of NSW Trade & Investment. It presents information from the investigation conducted by the department's Investigation Unit into the cause and circumstances of the incident and makes recommendations to enhance industry safety.

The purpose of this report is to assist the Secretary, as regulator of the work health and safety legislation at mines, to learn about the incident and to share information with the industry and the community so that steps can be taken to improve industry safety and to prevent incidents of a similar nature happening in the future.

3. Background to investigation

The department's Investigation Unit

The Investigation Unit investigates the nature, cause and circumstances of major incidents in the NSW mining and extractives industry.

Its role is to carry out a detailed analysis of incidents to ensure that lessons can be applied for the safety of workers at mines, and to give effect to the department's Enforcement Policy.

The unit is autonomous within the department and reports to the Secretary. It is located separately from the department's Mine Safety Operations inspectorate and is not involved in the activities of the inspectors, or the day-to-day inspection of mines.

Legislative authority to investigate

The investigation was conducted under the *Work Health and Safety Act 2011* (*WHSA*). Investigators had authority to conduct an investigation into this matter because the incident occurred at a coal workplace regulated by the department.

The department's response to the incident

The department received notification of the incident from the mine. Upon receipt of notification, the local inspector of coal mines from the department issued a Non-Disturbance Notice requiring preservation and non-disturbance of the scene and attended the scene until investigators arrived.

In accordance with departmental policy, the incident was automatically referred to the Investigation Unit for investigation. Investigators attended the incident scene and were present when Ms Forshaw was recovered from the Landcruiser. Investigators observed the incident scene and took control of the scene once officers from the NSW Police Force Hunter Valley Local Area Command and the NSW Police Forensic Services Group left the scene.

Investigation activities

The investigation activities included:

- incident scene photography
- conducting simulations of the incident (daytime and night)
- reviewing incident CCTV footage
- observing functionality testing of the truck and obtaining relevant documentation via statutory notice
- observing lighting testing on the truck and obtaining relevant documentation via statutory notice
- interviewing workers
- engaging an automotive consultant to examine the Landcruiser

- arranging testing of oils taken from the Landcruiser
- obtaining plans of the incident site
- issuing statutory notices to Ravensworth Operations Pty Ltd to obtain information and documents
- issuing statutory notices to TESA Mining (NSW) Pty Ltd to obtain information and documents
- issuing statutory notices to WesTrac Pty Ltd to obtain information and documents
- issuing statutory notices to individuals to obtain information and documents
- obtaining rainfall data from the Bureau of Meteorology
- obtaining records from NSW Police Force via statutory notice
- engaging consultants to conduct a road safety audit.

The Investigation Unit published an information release on 23 December 2013, which contained preliminary details about the incident.

At the time of writing this report, the investigation into the cause and circumstances surrounding the incident was ongoing.

4. Ingrid Forshaw

Ms Forshaw was aged 38 at the time of the incident.

Ms Forshaw had not previously worked in the mining industry. Her prior work was in the areas of logistics and hospitality. Ms Forshaw completed an Associate Diploma of Business in 1995 and in 2009 completed an OH&S consultation course and obtained a forklift licence.

Ms Forshaw completed an application for a mining traineeship with the Skilled Group Limited group of companies on 5 June 2012. On 6 February 2013, Ms Forshaw was offered fixed term employment by TESA Mining (NSW) Pty Ltd (see company details in Section 8, below), in the position of trainee in Certificate III Surface Extraction Operations at Xstrata Ravensworth Surface Operations (trainee plant operator). Ms Forshaw accepted the offer of employment on 13 February 2013. Ms Forshaw's traineeship began on 18 February 2013.

5. Ravensworth mine

Ravensworth mine is on Lemington Road at Ravensworth in NSW, which is approximately 28 km north-west of Singleton. The mine consists of two active open cut mining areas; the Narama Mine (began in 1990s) and the Ravensworth North Mine (began in 2012). Narama Mine, a strip mine, uses a dragline for overburden removal and truck and loader operation to mine coal. Ravensworth North Mine uses truck and shovel.

Coal is stored in stockpiles and crushed on the mine site. It is then conveyed to Macquarie Generation for domestic consumption (power generation at Liddell and Bayswater power stations) or to the Ravensworth Coal Processing Plant for processing and export via an export conveyor.

In 2012, 103 new production and 24 new maintenance employees were engaged, taking the total site employees to about 300. The 2013 plan for the mine involved recruiting 190 new employees (including redeployments, trainees, and experienced operators) throughout the year, with 110 new employees targeted between January and March 2013. There was a staged delivery program for over 500 million dollars of mining equipment from 2012 to 2015 including 23 CAT 797 trucks and 35 CAT 789 trucks.

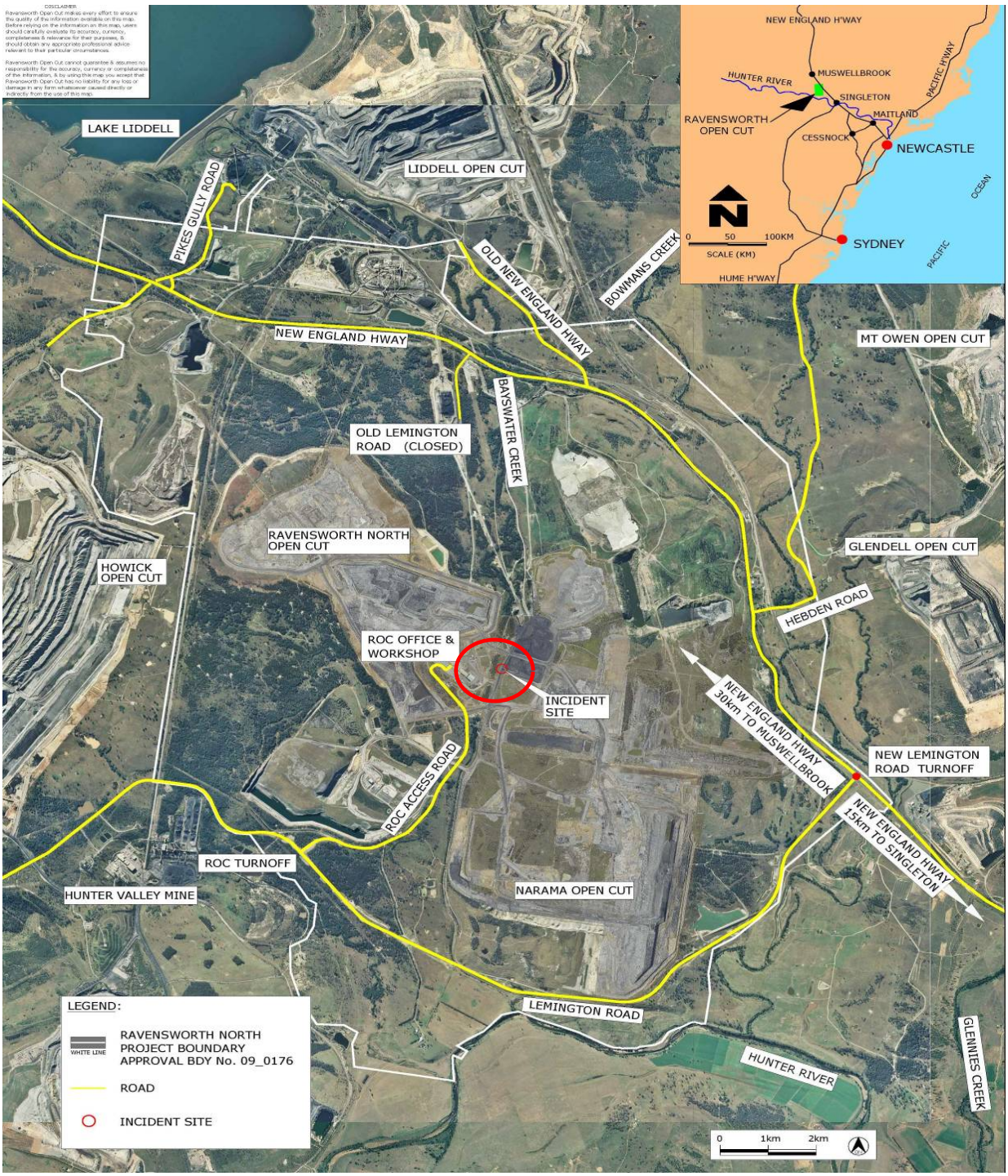
The production target for 2013 was waste (overburden and partings) at 45.1 Mbcm (Million bank cubic metres) and ROM (run of mine) coal at 8.1 Mtonnes (Million tonnes). A challenge identified by the mine with regard to resources was managing the operational ramp up, ensuring training, resources, systems and processes were in place to enable the site to achieve its targets and goals.

As at 30 November 2013, there were about 436 people employed to work at Ravensworth mine (about 171 contractors). There were two production shifts per day, seven days per week. The Lemington, Bayswater, Broonies and Ravensworth coal seams were being mined and the average haul loads per shift for November 2013 was 755 loads of waste and 112 loads of coal across the mine. Ravensworth mine produced 8,639,853 ROM tonnes of coal in 2013.

Mining lease details

The incident site was within Mining Lease 1683 (ML 1683) which was held by Cumnock No 1. Colliery Pty Limited and ICRA Cumnock Pty Ltd. ML 1683 was granted on 7 February 2013 pursuant to the provisions of the *Mining Act 1992* for 21 years.

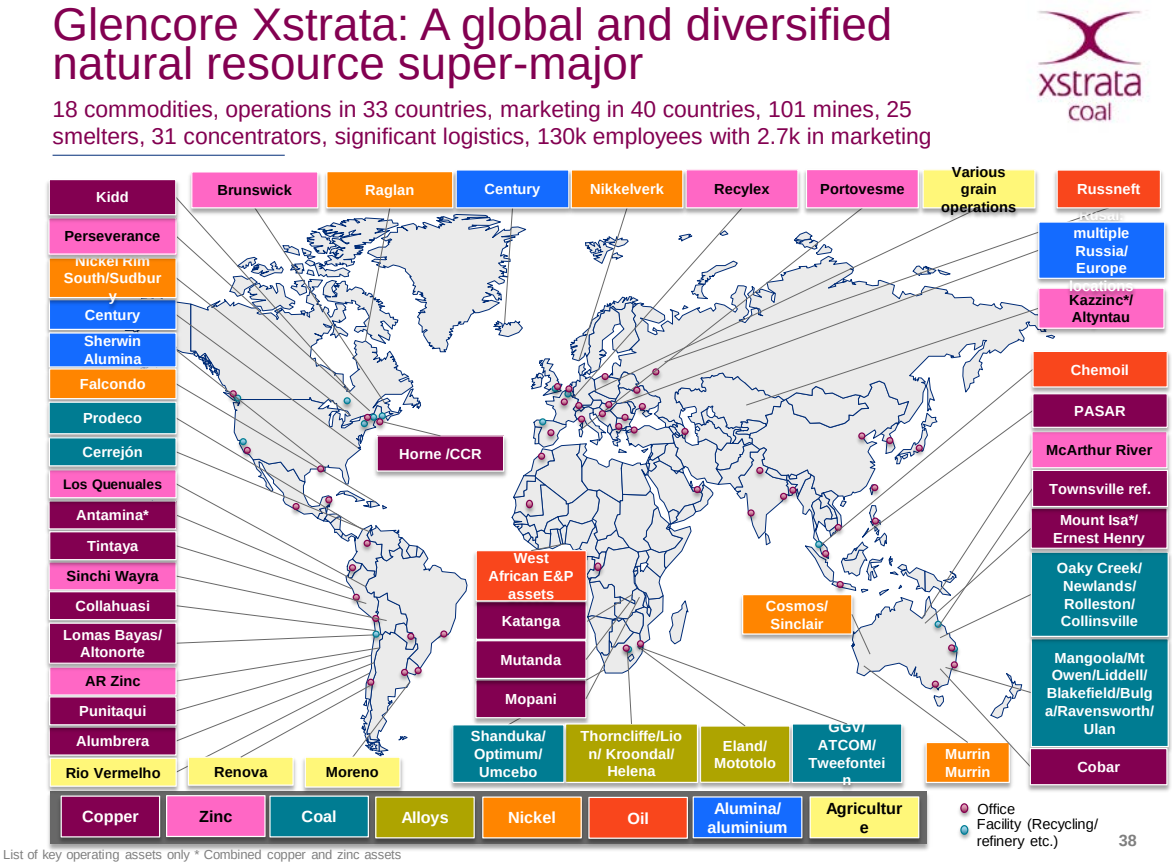
Figure 2. Locality plan (cropped for report) of the mine depicting the incident site.



6. Mine ownership and management

Ravensworth mine was owned by Glencore Xstrata PLC (now Glencore PLC). Ravensworth Operations Pty Ltd (ROPL) was responsible for the day-to-day management of the mine. Figure 3 provides an illustration of Glencore Xstrata's international business.

Figure 3. A slide from a Ravensworth mine presentation in February 2013.



7. Mine risk management

Glencore Xstrata implemented a SafeCoal initiative in 2009. As part of this, a suite of 12 fatal hazard protocols were developed and issued to the business in May 2010. The fatal hazard protocols provided the minimum systems and conditions for the management of fatal hazards at every coal assets – Australia, Glencore operation.

The mine's Sustainable Development Management Operating System (SDMOS) provided an overview of how the fatal hazards were managed.

According to the system, the mine was committed to performing risk assessments to evaluate the controls for the fatal hazard protocols, the legislated major hazards and any risk that had the potential to cause multiple fatalities.

Fatal hazard protocols - mobile equipment

Fatal hazard protocol number 3 - mobile equipment, required that:

- a risk assessment be conducted to identify the risks associated with mobile equipment including the interaction of heavy and light vehicles and pedestrians
- a traffic management plan be developed, implemented and maintained

- operations make rules that relate to safe travelling and parking distances
- operations construct and maintain safety berms/windrows that consider the height, density, material type and profile to act as an effective barrier
- wherever possible, consideration be given to the separation of heavy and light vehicles, particularly around workshops and stockpiles.

The fatal hazard critical control register for mobile equipment in place at the time of the incident listed the following controls:

- effective mobile equipment management plan
- inspections and monitoring
- behavioural (safety) observations (incorporates critical controls fatigue management, pre-start inspections, transport rules, planned task observations, drug and alcohol testing)
- engineering standards (designed fit for use)
- competency (training and competency)

Surface transport management plan

The interaction between haul trucks and light vehicles at open cut mines is a well-known hazard. Section 35 of the *Coal Mine Health and Safety Act 2002* (CMHSA) required that the operator of a coal operation establish and maintain major hazard management plans (MHMP). Clause 30 of the *Coal Mine Health and Safety Regulation 2006* set out the required content of MHMPs in relation to hazards arising from the use and operating environment of plant used for the transport of people or materials on the surface part of the operation (transport). It required that provisions be made for; the conditions under which transport may be used, transport being used within design parameters, design of roadways, maximum speeds, steps to ensure transport was safe, and interaction of heavy and light transport.

At the time of the incident the mine had a surface transport management plan (STMP) in place to address the requirements of the legislation and the requirements of fatal hazard protocol number 3 - mobile equipment. The STMP stated that it provided direction to mine personnel and contractors so that hazards associated with surface transport were identified, evaluated and eliminated or controlled to an acceptable level. Sections of the STMP are summarised under the headings below (not all sections are covered).

Competency

Personnel are not permitted to operate equipment unless they are trained and authorised as competent to operate the specific class of equipment in accordance with the training and competency management plan.

Pre-operational safety inspections

Mine-owned vehicles and equipment being driven and operated in the mine must have an appropriate pre-operational safety inspection on each shift prior to use, which includes testing of brakes. This is to be carried out by a walk-around inspection using a checklist for the vehicle being used.

Communication

A two-way radio must be available in all vehicles or equipment operating within the mine area. Positive communication must be adhered to as per the two-way radio protocol positive communication.

Operating in adverse weather conditions

Operators must drive to suit road and weather conditions and give way to vehicles carrying out road maintenance. Where rainfall has commenced, operators must consider the rapid change in road surface friction, curves and bends on the haul road and interaction issues associated with

the wet environment. The equipment operators in consultation with the mining supervisors shall cease work where conditions are no longer considered safe.

After a rainfall event, equipment being operatied shall return to work after the mining supervisor has inspected the work area. The mining supervisor, in conjunction with the operators engaged in the work area, shall determine when it is safe to resume mining operations after conducting a group SLAM (risk assessment), upon which a staged return to work will commence.

Traffic control

Unless otherwise specified in the STMP, NSW road rules apply. Vehicle operators and drivers must obey all signs and traffic rules. The maximum speed limit for main haul roads and access roads is 60 kilometres an hour or as sign posted.

Road design

All haul roads and ramps are to be designed and constructed in accordance with the ROC road design and construction guidelines.

The guidelines provided the specifications and requirements for the design, construction and maintenance of roadways at the mine. It covers minimum requirements for width, gradient, sight distance, superelevation, cross fall, drainage, intersections, berms and windrows, delineations, and signage for all roadways.

The STMP provides that wherever possible an analysis should be conducted to segregate light vehicles and heavy mobile equipment to minimise potential risk from interaction.

Risk assessments

The STMP referred to the mine broad brush risk assessment and the mobile equipment risk assessment, which identified operational surface transport hazards that have the potential to result in injury or fatality.

The assessment, dated 6 October 2010, was attached to the STMP. For the activity of driving light vehicles on haul roads it identified the hazard of collision with heavy vehicle and control measures as “exhibit reflective flag or red light/flashing orange beacon (see Section 10, for further information regarding visibility devices on Landcruisers).

The mobile plant risk assessment report dated 11 July 2012 described the potential for collision between light and heavy equipment due to vision and communication issues. Associated preventative controls were authorisation of personnel, STMP (road rules), pre-start inspections, competency-based training, equipment introduction to site, road design standards, vehicle standards, speed limits, road maintenance and signage, operations management and communication.

8. TESA Mining (NSW) Pty Ltd

TESA Mining (NSW) Pty Ltd (TESA) provided skilled labour, technical professional personnel, project management and training services to the black coal mining industry.

TESA was wholly owned by the TESA Group Pty Ltd and the ultimate holding company was Skilled Group Limited (Skilled Group).

According to its annual report 2013, Skilled Group was the largest provider of workforce solutions in Australia, employing more than 50,000 skilled Australians per year, and one of the largest employers of apprentices and trainees in the country. The range of services offered by Skilled Group included both onshore and offshore total workforce management, flexible labour solutions and project-based workforce solutions.

A supply contract between Ravensworth mine and TESA provided that TESA would supply the mine with suitably qualified and competent temporary labour.

Site specific safety management plan

The “TESA Mining Site Specific Safety Management Plan - Xstrata Ravensworth” (SMP) was applicable to the tasks that were performed by TESA at the mine.

All TESA employees were required to work in accordance with mine plans, standards, procedures, rules and policies. TESA employees were also required to comply with applicable TESA policies and procedures while performing work at the mine. Where a difference in company standard arose between TESA and the mine, the strictest standard applied.

The SMP stated that TESA would conduct a workplace risk assessment (WRA) at the mine before employee placement and undertake regular site inspections to assist with ensuring a safe place of work.

The most recent WRA before the incident was completed on 28 October 2011. The WRA was a checklist form for “industrial” worksites. The form had a section for mining, which covered the following for open cut mining:

- Are safety management plans in place?
- Is there evidence of adequate procedures (risk assessment) for blasting including adequate communication of blasting schedules?
- Are there adequate strata systems in place? (i.e. for window heights, dump locations).
- Are employees able to control incoming natural light?
- Are site transport rules in place to allow movement of people and equipment?
- Are there adequate communication channels/procedures between parties?
- Are there appropriate work platforms and ladders around machinery/vehicles, adequately guard railed where required?
- Are employees demonstrating adherence to traffic rules procedures on site? (i.e. speed limit, distance between plant and machinery, interaction between heavy and light vehicles).
- Are road conditions in satisfactory condition? (e.g. wet/dryness, gradient, turning space, potholes/uneven)?

All questions were answered (ticked “yes”) in the affirmative with brief comments beside some of the tick boxes. The WRA due on 28 October 2013 was delayed and the next WRA was conducted on 28 March 2014.

A safe work method statement (SWMS) dated 18 September 2009 was written pursuant to the CMHSA Division 6 – Duties of contractors, for the provision of supplementary labour for mine site workforce. The SWMS was one page in length and contained bullet points regarding training required and roles and responsibilities. The broad brush risk assessment in effect at the time of the incident was completed on 11 November 2009. With regard to machinery operation, risks identified were:

- not familiar with or appointed to machine
- unaware of site policies and procedures
- machine interaction/collisions
- unfamiliar with work area
- strains, sprains, jarring, vibration
- unplanned movement
- fatigue.

The controls identified for the above risks were:

- recognition of prior learning
- trained, assessed, and appointed to site requirements

- attend pre-start meeting
- reiterate safety awareness through safety toolbox talks, safety observation
- follow site isolation procedures and fundamentally stable park rules
- present fit for work
- TESA account manager adhere to fatigue management policy when rostering shift.

The last TESA site inspection before the incident was conducted on 30 October 2013. In the month of November 2013, two safety observations (both regarding operation of dump trucks hauling waste) were completed on 26 November and one (regarding operation of loader) on 28 November.

9. The Toyota Landcruiser

The Toyota Landcruiser that was involved in the incident was bought by Xstrata Cumnock Management Pty Ltd from Chatswood Toyota on 15 May 2012 and delivered to ProMine Singleton.

The vehicle was delivered to Ravensworth mine on 21 June 2012.

Vehicle details

Vehicle make: Toyota Landcruiser Workmate V8 turbo diesel 5 seat M/T wagon.

Year model: February 2012 (Model No: VDJ76R-RKMNYQ).

GVM weight: 3000 kg.

Vehicle modifications

The following were inclusions at the time of purchase of the Landcruiser; towbar (no wiring), 4x ROH Track2's/Mud terrain T (tyres), digital clock, reverse camera, air-conditioning, and steel bull bar. ProMine Contracting Pty Ltd (ProMine) carried out all of the mine site modifications required by the mine. The vehicle commissioning check sheet indicated the following modifications were made by ProMine:

Mechanical

- oil pressure switch relocation mod
- fire extinguisher bracket (9 kg) fitted to rear barn door
- wheel nut indicators fitted to all wheels
- door check straps fitted to all four passenger doors
- front mud skirt fitted to bulbar
- front canvas seat covers fitted
- rear canvas seat covers fitted
- pintle hook adaptor & pintle hook fitted
- mine specific id signage & reflective tape
- Ravensworth Operations safety information stickers to dash
- tare / gvm sticker on right hand front guard

Electrical

- 12 volt jump start plug fitted to bulbar
- 2-way radio fitted with ANI code entered with unit ID
- 1.5 meter reflective flag fitted with LED light tip
- roof mounted light rack front & rear
- unit ID triangle mounted to rear light rail with LED beacon
- circuit breaker box mounted in glove box with correct labelling
- main circuit breaker mounted in enclosure in engine bay
- all auxiliary wiring mechanically protected in harnessflex & secure

Maintenance

Ravensworth mine's light vehicle maintenance and repair procedure, which applied to the Landcruiser, required light vehicles to be serviced every 5000 kilometres or three weeks, whichever occurred first. Examination of documents produced by the company under statutory notice revealed that three weekly services were conducted up until late December 2012 and from January 2013 services were conducted every four weeks.

The Landcruiser's last six monthly brake test was performed on 20 September 2013. The brake report printout contained the following data:

Speed = 35.3 km/h

Stopping distance= 12.1 m

Decel avg= 0.40 g

Decel max= 0.52 g

MFDD= 4.07 m/s²

The last four weekly service of the Landcruiser was completed at 11.30 pm on 28 November 2013 (48 hours before the incident). Records for that service stated the following work was carried out:

- hand brake overhaul
- new rear rotor and rear brake pads
- replace hand brake cable
- replace leaf springs, bushes, pins and shackles
- replace all shock absorbers
- tighten bull bar

The odometer reading on 28 November 2013 was 80399 kilometres.

A defect report for the Landcruiser dated 4 December 2013 showed that at the time of the incident the Landcruiser had two defects that had not been actioned, damaged mud guards (cosmetic only) and the air conditioner vents were not blowing onto the dash.

Light vehicles at the mine

Figure 4. Photograph of a similar vehicle, taken by investigators at the mine on 2 December 2012.

The Xstrata operators manual (used at the mine) for generic light vehicles, stated that light vehicles were essential to the smooth operation of the mine. They were used primarily for transporting personnel and operators to and from the place of work for deployment, crib times, and for changing machine operations.

The STMP detailed in section 7 provided guidance regarding minimum rules and controls to manage hazards arising from the operation of light vehicles on site.

Conditions of use of light vehicles

The STMP provided that no person should operate a light vehicle on the mine site unless that person held a current NSW driver licence or equivalent, a site driving permit and the vehicle was roadworthy.

The STMP required that when in the mining supervisor's district (i.e. on haul roads) all vehicles below three metres in height exhibit a reflective flag or a red light on a pole to a minimum height of three metres and at all times use a flashing orange beacon (see Figure 4). All vehicles and mobile equipment used on the site were also required to clearly display a unique reflective vehicle identification number to facilitate positive communications and have a two way radio.

Apart from a reversing camera, light vehicles were not fitted with any electronic proximity detection or collision avoidance systems.

Safe operation of light vehicles

The STMP stated that all personnel must present fit for work and must not be under the influence of any type of substance when operating any plant or equipment on site. As detailed in section 7, operators were required to complete a pre-operational safety inspection on mine owned light vehicles on each shift prior to use.

The pre-operational safety inspection checklist for light vehicles required the following things be checked:

Category 1: Do not operate machine - have faults rectified

- major fuel, oil, water leaks
- fire extinguisher
- equipment damage
- indicator lights
- cab glass, mirrors
- warning systems
- wheel nuts, studs
- seats / seat belts
- two-way radio
- reverse alarm
- park / service brake
- steering
- flag
- flashing lights

Category 2: Contact supervisor and maintenance personnel for information

- tyres
- horn
- window wipers
- gauges
- air conditioning
- lights
- AM/FM radio
- clean cab
- first aid kit

Mobile phones

Mobile phones were prohibited from use during operation of any vehicle at Ravensworth mine, except where a hands-free device was being used.

Fatigue

The fatigue management procedure described the controls to be used at the mine for the risks associated with fatigue related incidents.

The procedure set out fatigue control requirements for hours of work, as follows:

Work hours	Fatigue control requirements
Up to 14.5 hours	Individual should assess his/her own fitness for duty.
14.5 to 16.5 hours	At the discretion of the supervisor following an informal risk assessment with the employee.
16.5 to 18 hours	Requires approval of the relevant department manager on completion of a documented risk assessment involving the employee and their Supervisor.
Beyond 18 hours	Requires approval from the mine manager and will only be allowed in an emergency.
Maximum hours in a 7-day period	No person should work more than 72 hours unless a documented risk assessment is completed and approval is given by the department manager or operations manager.
Maximum rostered hours averaged over a four-week period	Rostered hours for normal production and maintenance work are not to exceed 72 hours per week averaged over four weeks.
Maximum days worked in each two week period	Shifts should be arranged so that employees are afforded at least two days off in a two week cycle.
Breaks between consecutive shifts	No person should work on more than two consecutive occasions within one week without a break between shifts of at least 10 hours.

Overtime could not be worked on a day immediately before a rostered night shift, and the maximum amount of overtime available per month was 34.8 hours.

10. The Caterpillar 793D haul dump truck

The Caterpillar 793D haul dump truck involved in the incident was owned by Glencore Glendell Mine (Glendell). It was sold new by WesTrac Pty Ltd (WesTrac) to Glendell on 31 March 2008. It

was maintained by WesTrac for Glendell.The truck was transferred to Ravensworth mine in July 2013. An equipment introduction to site checklist was completed on 31 July 2013.

Machine details

Machine model:	Caterpillar 793D.
Serial number:	FDB00592.
Engine:	CAT 3516B high displacement EUI quad turbocharged and aftercooled diesel engine.
Rated power:	1801 KW @ 1,750 rpm.
Gross machine operating weight:	383 749 kg.
Nominal payload capacity:	218 tones.

Figure 5. Photograph of a similar Caterpillar 793D haul truck taken by investigators on 2 December 2013.

Standard equipment

Vital information management system

The Caterpillar 793D had VIMS (vital information management system). This system records electronic data from various switches and sensors installed on the machine and enabled the maintenance department to view data off-board. It had a message centre to notify the operator of an event and a keypad for operator interaction.

The system monitors vital parameters, such as engine oil pressure, steering pressures, brake pressures or temperatures and payload. If a fault is triggered, an action alarm is activated in the cabin, requiring a response from the operator. This system has four levels of severity ranging from a “notification” to “shut down safely”. These levels were 1, 2, 2S and level 3 respectively. If activated, level 3 triggers a snapshot which electronically captures all data channels for a period of five minutes before an event and one minute after (six minutes).

Dealer provided options

The following were dealer provided options selected by Glendell:

Access systems

- ladder access & controls
- anti-slip decking

Operator's station

- seating
- corrosion protection

Cabin & body

- gas bonnet struts
- component labelling

Electrical

- engine shutdown
- jump start receptacle
- isolators
- circuit protection
- shovel light switch modification
- back up alarm
- emergency shut down
- reverse camera
- additional lhs reverse lights
- air condition service points
- electric horns
- insulation under batter lids
- clearance lights
- ladder down indicators
- loading light switch modification
- front lighting
- front indicators
- led isolation indicators
- cabinets and junction boxes

Communication devices

- radio AM/FM/CD
- two-way radio
- modular mine system

Fuel, lubrication & cooling systems

- radiator pressure relief
- service centre
- overflow protection
- grease system
- radiator cap
- fuelling point
- engine oil sight glass
- transmission remote mount sight glass
- fuel tank sight glass
- sight glass covers installed
- hydraulic housing

Fire systems

- fire protection

Wheel & brake

- mudguards

Ancillary

- stainless steel wash bottle
- payload RHS plug cover
- component lifting
- turbocharger heat shields
- air system

Maintenance

The haul truck was maintained by WesTrac onsite at Ravensworth mine. The service history and records were recorded in the Caterpillar Service Information Management System (SIMS). Component changes and preventative maintenance records were managed onsite using AMT (asset management tool) as the mine maintenance management system.

Records obtained via statutory notices indicated that services were carried out on the truck at Ravensworth mine on the following dates:

- 16 August 2013 - 250 hour inspection checks.
- 1 September 2013 - 2000 hour lubrication service.
- 12 September 2013 - 250 hour inspection checks.
- 27 September 2013 - 500 hour lubrication service.
- 10 October 2013 - 250 hour inspection checks.
- 25 October 2013 - 1000 hour lubrication service.
- 6 November 2013 - 250 hour inspection checks.
- 20 November 2013 - 250 hour inspection checks.

At the time of the incident the following defects had not been repaired

- reverse camera not working (reported 5/9/13)
- start isolator light broken allowing water into isolator box (reported 19/10/2013)
- remove broken bolts on valve stem cover (23/10/2013)
- handrail behind cab damaged and hitting tray (reported 19/10/2013)
- dump body cracking above back of rear wheels on bolsters (reported 29/11/13)
- hydraulic tank cracked near front mount (approx. 200 days old)

Use of Caterpillar 793D haul dump trucks at the mine

Ravensworth mine used different makes and models of haul dump trucks, the Xstrata operator manual (used at Ravensworth mine) for generic haul trucks stated that “haul trucks are extremely large pieces of equipment and have limited operator vision, thus making the potential to cause considerable damage if involved with an accident/incident”.

The STMP detailed in section 7 provided guidance regarding minimum rules and controls to manage hazards arising from the operation of vehicles on site.

The provisions regarding mobile phones and fatigue discussed in section 10 applied to the use of haul dump trucks at Ravensworth mine. The headings below focus on the use of the Caterpillar 793D (CAT 793D) haul dump trucks at the mine.

Risk assessments

An operational risk assessment of the CAT 793Ds bought by Glendell (including the truck) was conducted in February 2008 at the request of WesTrac. The risk assessment did not consider any hazards that may be peculiar to a particular scenario at site, that is, the risk assessment did not consider the operational environment at Glendell.

Ravensworth mine engaged consultants to carry out studies and reviews in June 2012 as part of introducing ultra-class equipment into the mining operation (including CAT 793Ds). The goal of this process was to identify any controls that could require additional work as part of the transition.

One of the identified key incident types most impacted with the change to ultra class equipment introduction was mobile equipment, traffic and equipment movement. Contributing causes identified were:

- human error - with increases in numbers of personnel on site; unfamiliarity with new equipment; changed tasks related to the new gear, and; changed supervisory / training requirements
- equipment - due largely to increased size and capacity
- controlled work environment - with implications for site communication (radio traffic), modified mine designs and variations to road network(s).

For an incident caused by interaction between light and heavy equipment the preventative controls identified by the review were;

- authorisation of personnel
- road rules
- pre start inspections
- competency based training
- introduction of equipment to site
- road design standards
- vehicle standards
- speed limits
- road maintenance and signage
- implement communication systems and processes

A risk assessment was conducted at the mine on 8 July 2013 regarding the introduction to site of new earth moving equipment, including CAT 793Ds, to assist in managing operational changes that may be required. The risk assessment assumed that specific operational risk assessments would be conducted at a later date to address specific risks associated with the use of individual equipment types and models.

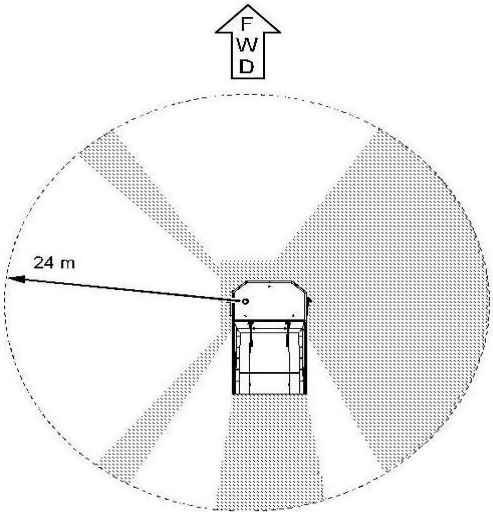
The mobile plant risk assessment report dated 11 July 2012 (discussed in section 7), incorporated the same preventative controls regarding interaction between heavy and light vehicles as the June 2012 review. No other risk assessment reports specific to CAT 793Ds had been identified at the time of writing this report.

Restricted visibility

The operator and maintenance manual for a CAT 793D stated the following with regard to restricted visibility:

“The size and the configuration of this machine may result in areas that cannot be seen when the operator is seated. Illustration 1 provides an approximate visual indication of the areas of significant restricted visibility. Illustration 1 indicates the restricted visibility areas at ground level inside a radius of 24.00 m (78.74 ft) from the operator on a machine without the use of optional visual aids. This illustration does not provide areas of restricted visibility for distances outside a radius of 24.00 m (78.74 ft).”

Figure 6. Illustration 1, extracted from Operation and maintenance manual of Caterpillar 793D Note: The shaded areas of illustration 1 indicate the approximate locations with significant restricted visibility.



Optional visibility aids

The operator and maintenance manual for the CAT 793D stated the machine may be equipped with optional visual aids that may provide visibility to some of the restricted visibility areas. According to Ravensworth mine, the truck was equipped with a reversing camera as an optional visible aid. Apart from the reversing camera, the truck was not equipped with any electronic proximity detection or collision avoidance systems or any other visibility aids.

Pre-operational safety inspection

The pre-operational safety inspection checklist for heavy vehicles required the following things be checked:

Category 1: Do not operate machine- have faults rectified

- major fuel, oil, water leaks
- fire extinguisher charged in green
- equipment damage
- indicator lights
- cab glass, mirrors
- warning systems
- bent rock ejectors
- seats/seat belts
- two-way radio
- reverse alarm
- park/service brake
- wheel nuts/studs
- retard - operational
- chassis/structure

Category 2: Contact supervisor and maintenance personnel for information

- tyres/tracks
- air filter indicators
- hand rails/steps/walkways
- pins retainers
- grease system/liners
- air leaks
- minor leaks
- cab seals
- window wipers
- gauges
- air conditioning
- lights
- fuel level
- AM/FM radio
- reversing camera
- clean cab

Leica fleet management system

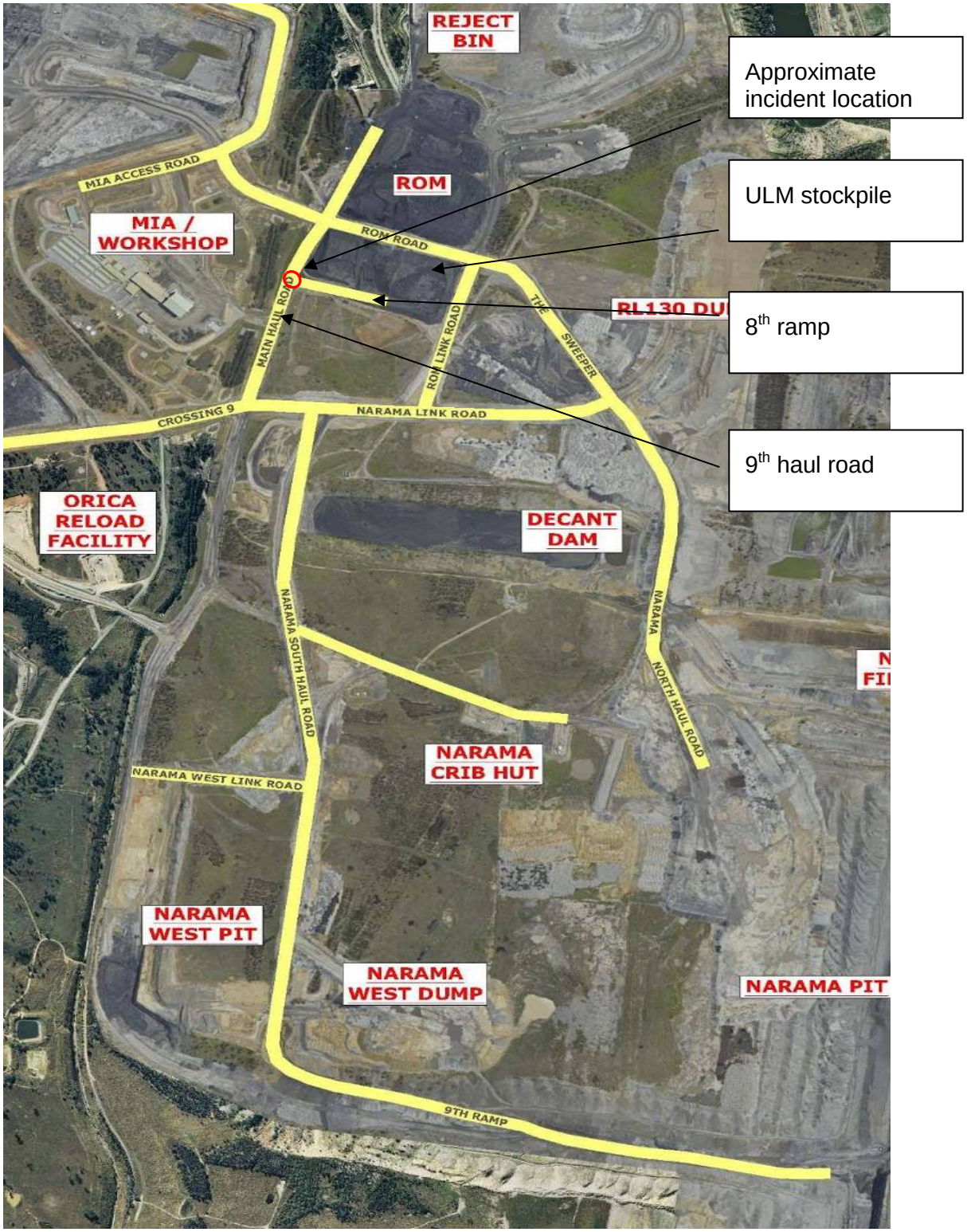
The truck was fitted with the Leica fleet management system (LFMS), which consisted of a GPS that recorded geographical location. The LFMS had the following functionality:

- capture of material movements through truck counts/loads
- accurate recording of machine activities (automatic and operator influenced)
- machine health information
- operator messaging
- record the speed of the GPS unit attached to plant as the plant moves about the mine

11. The incident site

The incident occurred on the 9th haul road, near the T-intersection (the intersection) of the 8th ramp and the 9th haul road in the Narama area (see Figure 7).

Figure 7. Extract from the mine's mine roads plan.



Figures 8 and 9 are photographs of the intersection (note: the orange mobile lighting tower in Figure 8 was put in that position following the incident, there were no lighting towers near the intersection at the time of the incident).

Figure 8. Photograph of the intersection from the 8th haul road taken by investigators on 1 December 2013.

Figure 9. Photograph of the intersection from the 9th haul road taken by investigators on 1 December 2013.

The intersection and the 8th ramp were built between 25 July 2012 and 19 August 2012. The 8th ramp was modified between 24 August 2013 and 22 September 2013 when a coal ramp to the stockpile was established. Before July 2012, there was an intersection and haul road further north.

The characteristics of the intersection, the 8th ramp and the 9th haul road at the time of the incident are discussed below.

Intersection control

The intersection was controlled by the 8th ramp having to give way to the 9th haul road. Figures 10, 11 and 12, below depict the “GIVE WAY” signs located at the intersection on the 8th ramp and “KEEP LEFT” signs in the medians on the 9th haul road and the 8th ramp.

Figure 10. Plan of signs provided by Ravensworth mine (cropped for report).

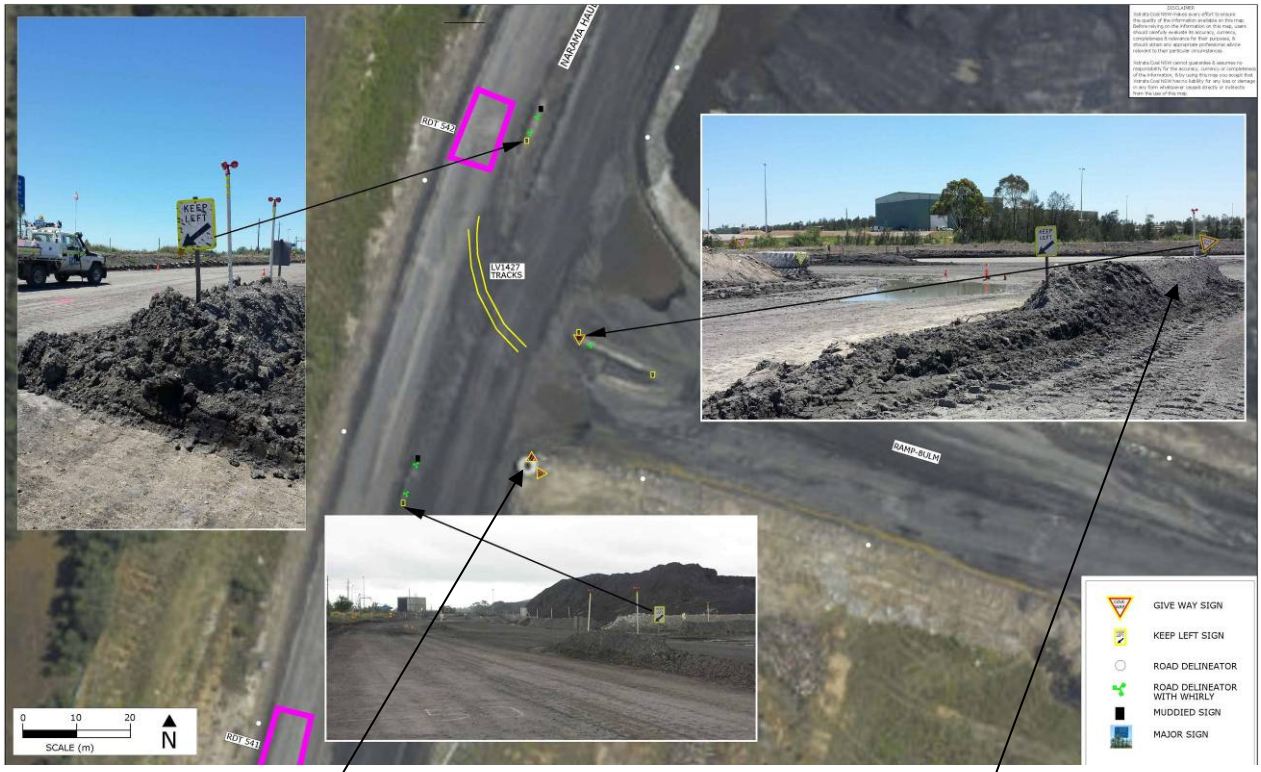


Figure 11 (left) and Figure 12 (right). Photographs taken by investigators on 1 December 2013

Speed limit

Speed limits applied, with a maximum speed limit on the 8th ramp and 9th haul road of 60 kilometres an hour.

Road width

The 9th haul road had a width ranging from 27 to 28 metres. The 8th ramp had a width ranging from 28 to 30 metres.

Road gradient and crossfall

The 9th haul road had a 1% gradient for 450 metres (uphill in a northerly direction). The 8th ramp had an 8.4% gradient for 197 metres (downhill in a westerly direction), and 3% gradient (downhill) for the final 134 metres to the intersection.

The 9th haul road had a constant crossfall ranging from 2.2 - 3.0% and the 8th ramp had a constant crossfall ranging from 2.5 - 3.0%

Windrow height

The roadside windrow heights on the 9th haul road (south east 'corner') were:

- 1.3 metres at the intersection
- 2.0 metres at 10 metres from the intersection
- 0.8 metres at 50 metres from the intersection

The median windrow height (the southern median to the intersection) ranged from 0.7 - 1.05 metres (see Figure 10, above).

The roadside windrow heights of the 8th ramp (south east 'corner') were:

- 2.0 metres at 100 metres from the intersection
- 2.4 metres at 80 metres from the intersection
- 1.9 metres at 60 metres from the intersection
- 2.7 metres at 40 metres from the intersection
- 2.0 metres at 30 metres from the intersection
- 1.7 meters at 10 metres from the intersection
- 1.3 metres at the intersection

The centre median windrow height at the intersection on the 8th ramp ranged from 1.4 metres - 1.6 metres (see Figures 10 and 12, above).

Figures 13 and 14 are photographs taken on the 8th ramp looking towards the windrow on the 8th ramp (note: the haul truck and mobile lighting plant in Figures 13 and 14 were not it that position at the time of the incident).

Figure 13. Photograph of windrow on 8th ramp taken by investigators at the mine on 1 December 2013.

Figure 14. Photograph of windrow on 8th ramp taken by investigators on 1 December 2013.

Delineation

Figure 10 (above) shows the position of delineators (guideposts) marked with white dots along the 9th haul road and the 8th ramp.

Lighting

No direct artificial lighting was provided at the intersection. Secondary background lighting at the intersection is discussed in Section 14 (below).

Inspections

The open cut examiner for the Narama area completed inspections of the Narama area sometime after 7.10 pm on 30 November 2013 and again sometime after 9 pm. The open cut examiner observed the intersection and stated there were no major hazards on the 8th ramp or problems in the area.

The mining superintendent inspected the Narama area on 27 November 2013 between 8.30 am and 11 am. The inspection report noted that "recent rain had some areas wet". The report did not specify which areas.

The manager of mining engineering (mine manager) and the operations manager, inspected the Narama area on 29 November 2013 between 7.15 am and 11 am. The manager of mining engineering noted in regard to haul road and ramp that "signage in place, appears safe." There was no reference to which haul road and ramp was being referred to.

The statutory inspection report completed by the open cut examiner for the night shift on 30 November 2013, commented generally about the Narama area as follows (there is no indication whether the comments applied to specific haul roads and ramps or other areas):

- haul road and ramp: Exceptions observed - "very wet"
- access signs/roads delineation: Exceptions observed - "as per site standard"
- ramp conditions/windrows: Exceptions observed - "very wet"
- lighting/visibility: Exceptions observed - "ok"

12. The incident

About 11.46 pm on Saturday, 30 November 2013, Ms Forshaw parked the haul truck she was operating at the ULM stockpile and collected the Landcruiser which had been parked at the ULM stockpile by another operator at the start of the shift. Ms Forshaw was operating the Landcruiser to collect other workers and go to crib (meal) break.

About 11.49 pm the haul truck operator was hauling coal in a northerly direction along the 9th haul road, he saw the Landcruiser travelling down the 8th ramp (in a westerly direction). As the truck operator approached the intersection he saw the Landcruiser enter the 9th haul road then he lost sight of the Landcruiser.

About 11.50 pm the Landcruiser travelled across the 9th haul road onto the left-hand side of the road into the path of the truck on its right-hand side (the blind side). The truck and Landcruiser collided and Ms Forshaw was crushed inside the Landcruiser and died immediately from multiple injuries.

There were no eye witnesses to the incident other than the truck operator.

CCTV

CCTV footage that captured the incident was provided to investigators by Ravensworth mine via statutory notice. The footage came from a camera a considerable distance from the incident site.

At 11.50:04 pm (time on the footage) the truck came into view travelling north on the 9th haul road. At 11.50:31 pm the Landcruiser came into view travelling west down the 8th ramp. The

Landcruiser appeared to slow around the end of the 8th ramp before continuing through the intersection onto the 9th haul road and into the path of the truck at 11.50:45 pm.

Chronology of events

6.46 pm - Ms Forshaw logged onto ROCs system.

6.55 pm - Ms Forshaw attended a 10 minute pre-shift briefing delivered by her supervisor.

Ms Forshaw was delegated a haul truck on the ULM stockpile. Ms Forshaw's task was to operate the haul truck. A loader operator was to load her truck with coal at the ULM stockpile and she was to haul the coal to the coal bin and unload and repeat the process.

The briefing form noted that hazards and risks associated with the activities was "wet, blocky material."

7.07 pm - Radio call made by operator 1 to the supervisor advising that the crew (which consisted of four operators, two loader operators and two haul truck operators, one of which was Ms Forshaw) were taking the Landcruiser. Operator 1 then transported the operators to their designated vehicles and then drove the Landcruiser up the ULM stockpile ramp and parked the Landcruiser behind a berm near a lighting plant, then got into his loader.

8.00 pm - (approximately) One of the loaders broke down so operator 1 moved his loader to where the broken down loader was operating, leaving the Landcruiser behind were it had been parked earlier.

8.41 pm - Radio call made by Ms Forshaw to washery control saying that the coal bins had been on red light for around 10 minutes.

8.47 pm - Radio call made by Ms Forshaw to dispatch - Ms Forshaw was reassigned to a different loader.

10 pm - Ms Forshaw hauled a load of coal to the Broonies stockpile and unloaded it.

10.12 pm - Ms Forshaw hauled a load of Bayswater coal to the park up area.

11.39 pm - The truck left a loader heading towards the BR Stockpile.

11.41 pm - Operator 1 received a radio call from the supervisor telling him to go to crib.

11.41 pm - Radio call made by operator 1 to Ms Forshaw asking her to collect the Landcruiser from the ULM stockpile.

11.44 pm - Ms Forshaw left the ROM park up area and drove her truck to the ULM stockpile.

11.46 pm - Ms Forshaw arrived at the ULM stockpile and her haul truck was parked up.

11.50:04 pm - Ms Forshaw collected the Landcruiser and travelled down the 8th ramp, a distance of about 400 metres.

11.50:45 pm - The Landcruiser entered the intersection, travelled across the 9th haul road and then collided with the truck.

11.51:29 pm - First emergency call made by operator of the truck.

11.51:53 pm - Second emergency call made by operator of the truck

11.52:58 pm - The supervisor requested mines rescue to attend the scene.

11.53:20 pm - Another supervisor requested the crew first aider to attend the scene.

The crew first aider attended the scene and noted that Ms Forshaw had no pulse and had injuries incompatible with life.

The open cut examiner and the Mines Rescue crew arrived at the incident scene within 5 to 10 minutes of the incident occurring.

13. Examination of the circumstances of the incident

Incident simulations

Investigators conducted a range of incident simulation activities at the incident site. These simulations involved positioning light vehicles along the 8th ramp at 10 metre increments approaching the intersection to simulate Ms Forshaw's path of travel. The truck was positioned at 50 metre increments along the 9th haul road to simulate its path of travel. Simulations were conducted during day and night time conditions. These simulations provided valuable insight into the incident.

Figure 15. Photograph taken by investigators from truck operator's cabin (passenger seat) at Ravensworth mine on 2 December 2013. The truck was positioned at the center of the intersection. Note the significant blind spot on the right-hand side of the truck and the Landcruiser direction of travel (red arrow).

Figure 16. Photograph taken by investigators on 5 December 2013. The light vehicle is positioned in the truck's blind spot on the right-hand side of the truck simulating the right-hand turn made by Ms Forshaw.

Investigators made the following observations during the simulations: The Landcruiser could not be seen when it was positioned in the truck's blind-spots. The lack of clearance/side lighting and reflective material on the truck made it difficult to detect at night. Lines of sight from the Landcruiser were obscured by the 8th ramp windrow in numerous places, making it difficult to see the truck on the haul road. The absence of direct artificial lighting and the impact of secondary (incidental) lighting from the mine infrastructure area (MIA) at the intersection caused background glare.

Figure 17. Screenshot from video taken by investigators on 5 December 2013. Taken from inside a light vehicle (passenger side) on the 8th ramp stockpile near the intersection.

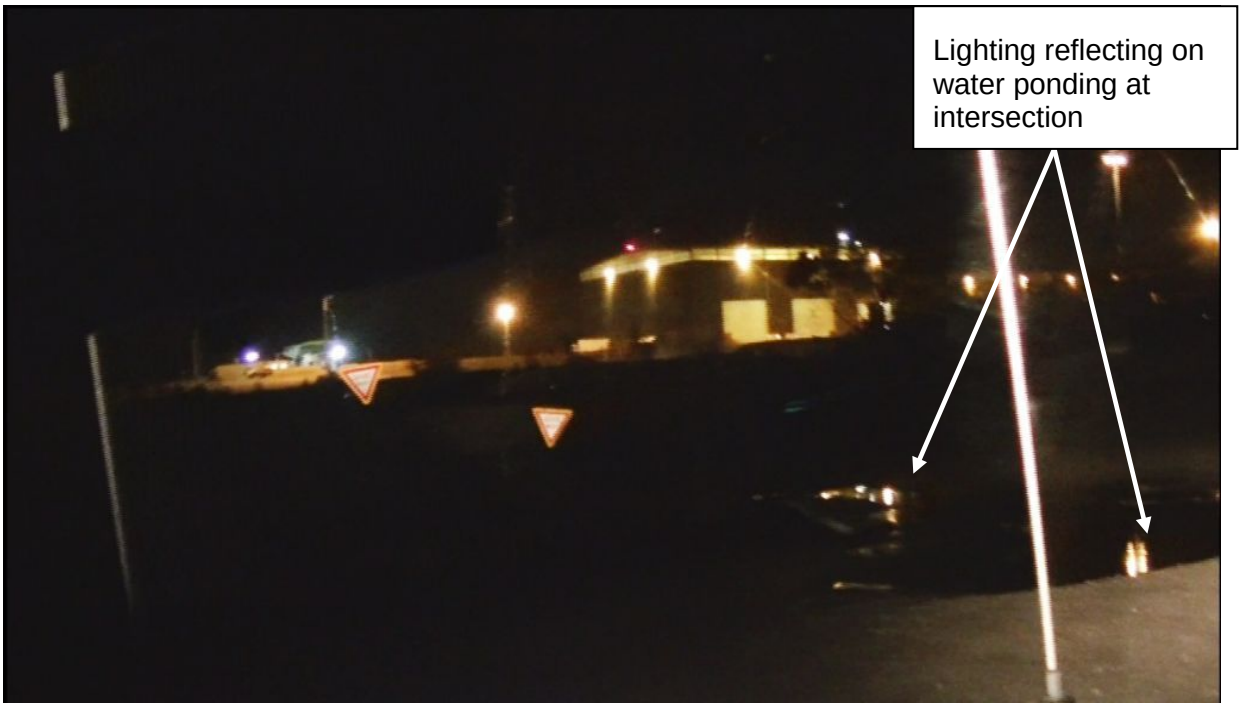
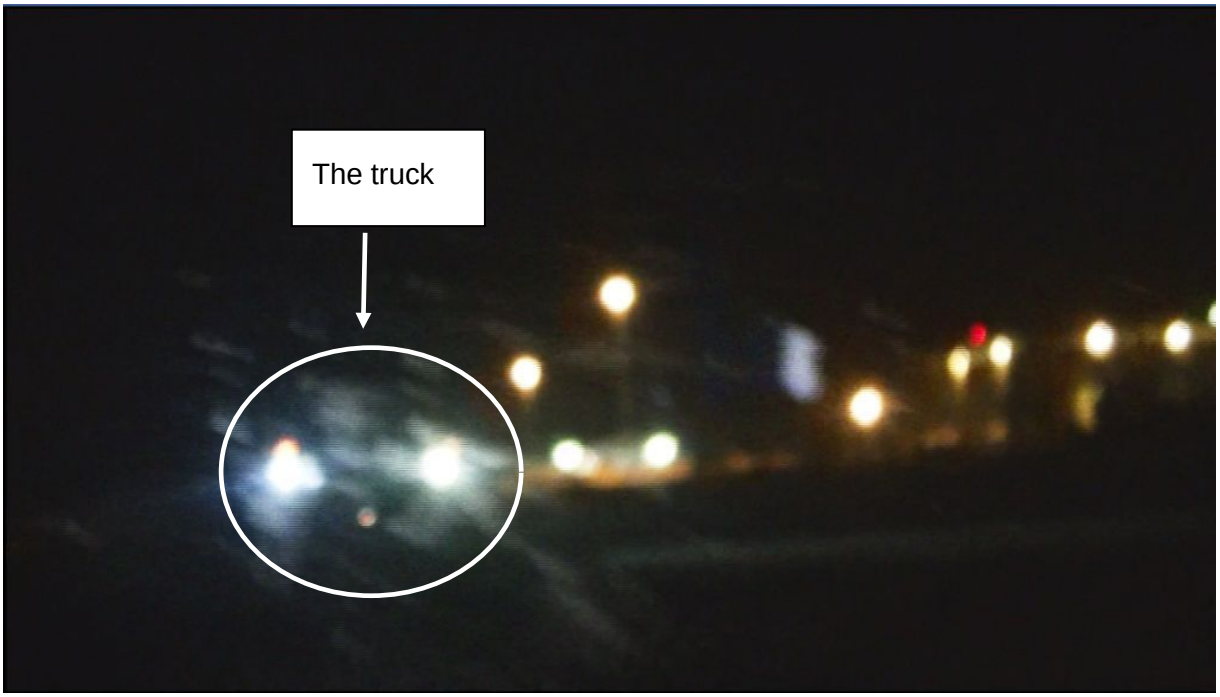


Figure 18. Screenshot from video taken by investigators on 5 December 2013 from inside a light vehicle travelling through the intersection. The truck was positioned on the haul road 50 metres from the intersection. Workshop lighting is visible in the back ground.



Tyre marks / vehicle path

Figure 19

Figure 20

Figure 21

Figures 19, 20, and 21. Photographs of the tyre marks of the Landcruiser at the incident site taken by investigators at the mine on 1 December 2013.

Observation of the Landcruiser tyre marks indicated that Ms Forshaw travelled about 30 metres from the intersection across the 9th haul road. There was no indication of skidding, braking, or swerving prior to collision. However, at the point of collision (see Figure 21), skidding of the Landcruiser tyres was evident for a distance of 19 metres to the point where the truck stopped with the Landcruiser trapped under its front right-hand side tyre.

The Toyota Landcruiser

Pre-operational safety inspection

A pre-operational safety inspection was not completed on the Landcruiser at the start of the night shift on 30 November 2013. Operator 1 stated in interview that he did a quick walk around of the Landcruiser before operating it (on night shift on 30 November 2013), he said it was clean and there was no mud on the windows. Operator 1 did not identify any issues with operating the Landcruiser at the start of the shift.

The pre-operational safety inspection book in the Landcruiser had a last entry dated 28 November 2013. That entry for the Landcruiser recorded that there was a defect identified with the handbrake (refer to Section 10). The only other inspection completed for the Landcruiser in that book was for day shift on 27 November 2013. No defects were identified in that entry (earlier entries in the book related to other light vehicles).

The mine was unable to locate any other completed pre-operational safety inspection sheets for the Landcruiser between 23 November 2013 and 30 November 2013. It was noted that radio logs indicated that the Landcruiser was operated on 29 November 2013 but the relevant operators were unable to be identified.

Automotive consultant report

The department engaged an automotive consultant to comment on impact progression and the pre-impact condition of the Landcruiser. The automotive consultant examined the Landcruiser on 26 February 2014, 12 and 27 May 2014, and 10 July 2014.

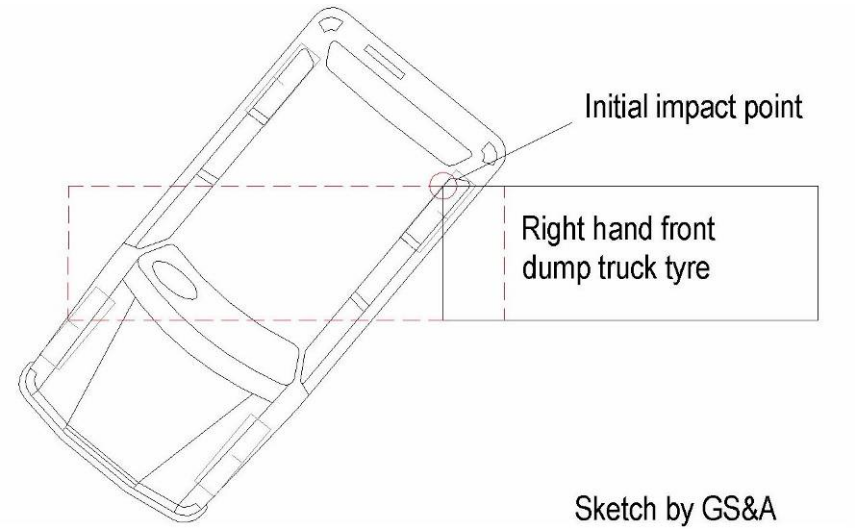
Figure 22. Photographs of the Landcruiser taken by investigators at the Newcastle Police holding yard on 8 January 2014.

The findings and opinions of the consultant are summarised below[1]:

Point of impact

The most probable point of initial impact on the Landcruiser would have occurred near the turret seam just forward of the door pillar (rear passenger side). Figure 23, is an unscaled sketch of a plan view of the most probable point of impact.

Figure 23. Unscaled sketch of a plan view of the most probable impact point



Windows, windscreen wipers, ventilation system, cargo barrier

The only window glass not broken was the pane from the right-hand rear door. Measurements of the distance from the window sills down into their door glass channel, which connects to the winder mechanism, implied that all four door windows were in the closed position.

Evidence did not indicate the windscreen wipers were being used. The wiper rubbers were in a satisfactory condition. The dash was destroyed making it impossible to identify if the ventilation system had been activated and its configuration.

The vehicle was equipped with a cargo barrier, although the barrier was crushed ,it prevented cargo from going into the cabin (the vehicle was carrying insufficient cargo, not of a type, to restrict visibility).

Lights

Examination of light globe filaments (a recognised method of establishing if lights were on immediately before or at the time of impact) revealed that the headlights were on low beam and the tail lights were on

Controls

While the ignition lock assembly was crushed, the key appeared to be in the on position. The broken light switch was found and was in the on position. The brake and accelerator pedal pads were not abnormally worn and access to them did not appear to be impeded by any obstructions.

[1] G. Senz, Report on Condition of Damaged Toyota Landcruiser, LV 1427, 10 September 2014.

Braking

Examination of the light globe filaments showed that the large diameter brake light filament was still neatly coiled, evidencing that the Ms Forshaw was not attempting to brake immediately prior to the time of initial impact.

Removal of the vacuum supply hose on 27 May 2014 revealed the booster still had what appeared to be a full vacuum charge, supporting the opinion that Ms Forshaw had not depressed the brake pedal after engine stoppage. The ability to hold vacuum for so long also confirmed that the booster valving was not damaged and the engine mounted vacuum pump must have been functioning normally.

Other findings regarding the braking system were:

- the left-hand and right-hand rear brakes had been recently serviced
- the left-hand front brake and right-hand front brake were correctly assembled and had been operating normally
- rear brake pads were in an unsatisfactory condition
- an unprofessional repair had been performed on both rear brakes
- other than the unprofessional repair, the hydraulic brake system operation could not be faulted
- brake fluid condition was not a contributory factor
- the left park brake drum had been recently machined and appeared to have been operating normally.

Steering and suspension

- The steering shaft did not display abnormal joint wear.
- Power steering fluid condition did not indicate the vehicle had lost steerage.
- Front suspension and steering linkages were in a satisfactory pre-impact condition.
- The vehicle had been fitted with after-market off road type springs and shock absorbers.
- There was evidence of recent rear suspension repairs.

Tyres

- Three of the four tyres were deflated by wheel crushing, the left-hand front tyre deflated from a valve stalk failure.
- Tyre deflation did not occur before impact.
- Tyre tread condition on all four tyres did not contribute to the incident causation.

Transmission and driveline

Damage to the transmission gear lever and the four wheel drive selector lever prevented identification of pre-impact transmission and transfer case selection.

Examination of the front axle drive train revealed both wheel hubs were engaged to enable four wheel drive had it been selected. Testing confirmed that drive was not lost via a catastrophic clutch failure.

Drive through the front wheels and the rear axle was possible before impact.

Engine

The engine cooling fan was jammed against the engine intake ducting. The fan condition indicated that the blade had most probably stopped or was virtually stationary when the intake duct moved onto it, suggesting the cooling fan had stopped by the time the engine bay was crushed.

Engine bay destruction included smashing the engine's left-hand camshaft cover. The number four fuel injector was broken as a result of secondary damage. Examination of the exhaust camshaft and its lobe lubricator pipe confirmed that the engine had already stopped before the camshaft cover was smashed.

There was no visible evidence of excessive exhaust soot present in the exhaust tail pipe and nearby surfaces, thereby signifying that the engine had been operating normally leading up to the incident.

Diesel engines have an inherent problem in that they can readily run on almost any combustible fumes including crankcase fumes or oil. The possibility that excessive crank case fumes created a problem was ruled out because the engine was not abnormally worn and did not have the potential to produce sufficient crankcase fumes to affect engine operation.

Splatter staining near and inside the air filter outlet confirmed a small volume of muddy water had entered the engine intake but a tidemark was not present, therefore the volume of water was insufficient to have affected engine operation.

Inspection of the fuel filter's sediment bowl did not reveal evidence of visible water contamination. The fuel was of normal colouration and odour.

There was physical evidence present to confirm that the engine was stopped when the truck crushed the engine bay, no evidence was found to suggest the engine either lost power or was uncontrollable at the time of initial impact with the truck. Evidence pointed to the engine being stalled by the trucks right-hand front tyre trapping the Landcruiser's left-hand rear wheel moments after initial impact.

Engineering Investigation Unit examination

Officers from the NSW Police Force Engineering Investigation Unit carried out an examination of the Landcruiser on 26 February 2014 at Newcastle Police holding yard. The examination revealed no mechanical defects or component failure which may have contributed to the incident occurring. All of the damage detected on the motor vehicle was consistent with collision impact.[2]

CCTV

The CCTV captured the Landcruiser travelling in a westerly direction on the 8th ramp. The Landcruiser's headlights and a flashing light were observable. The Landcruiser appeared to slow around the end of the 8th ramp (at the intersection) before travelling into the path of the truck. The lights of the Landcruiser then became blocked from view by the truck.

The Caterpillar 793D haul dump truck

Pre-operational safety inspection

The truck operator completed both an electronic (through the LFMS) and paper pre-start check form for the truck at the start of the night shift on 30 November 2013. There were no category 1 faults noted (see Section 11), a category 2 fault of "no reverse camera" was noted. It was also noted that there were scuffs and side wall cuts to tyres.

Workshop pre-incident

At 8.30 pm the truck operator took the truck to the workshop in response to fault messages regarding the "brake filter" and the "harness".

Work order details stated that the brake filter was changed and the machine test operated, but the fault stayed active with the new filter. The harness was tested for fault. The truck was at the workshop for around an hour.

[2] NSW Police Force , Vehicle Examination Expert Certificate (27 February 2014).

Within about 10 minutes of the truck leaving the workshop the fault messages returned and the truck operator took the truck back to the workshop (around 9.50 pm).

The truck operator stated that a WesTrac employee checked the truck over again and said that everything was okay to run the truck. The truck left the workshop at 10.10 pm.

Vital information management system data

On 1 December 2013, VIMS data was downloaded from the truck by a WesTrac employee.[3] The data was analysed with the following results:

- A snapshot existed in the memory file from a level 3 event activated by a low engine oil level alarm on 30 November 2013 at 11.57:18 am.
- A manual snapshot was triggered by maintenance via a keypad command “EREC” on 1 December 2013 at 07.12:03 am.
- When the incident between the truck and the Landcruiser occurred, there was no fault activated with the truck, so no event was recorded.
- Interpretation results showed the truck ignition key may have been switched on for a period of time (longer than 6 minutes) after the incident occurred and before the “EREC” command was activated by maintenance as there was no electronic data recorded.
- The payload status was still in “loaded mode” and showing 186.2 tonnes.

Leica fleet management system data

Position and speed data was not sent continuously for vehicles on the LFMS but recorded at 30 second intervals and stored temporarily on the machine until transferred to a central database. This transfer occurred approximately every eight minutes.

On the night of 30 November 2013, the last received data containing GPS position data from the truck was at 11.49 pm and the speed of the truck at that point was 35 kilometres an hour. The data recorded up to 11.50 pm was incomplete and not ready for transfer and was lost when the truck was electrically isolated during the initial response to the incident.

Therefore, the speed the truck was travelling about 11.50 pm on 30 November 2013 was not available through any of the equipment monitoring data.

CCTV

The CCTV camera that captured the incident was directed towards the ROM bins (north of the intersection). At the point the truck (left side) initially came into view on the 9th haul road there was a lighting tower (about 250 metres from the intersection) in the vicinity, therefore the front lighting of the truck could not be distinguished, then only the rear of the truck was visible. Consistent rear lighting of the truck can be seen, it appears as though the rear lights brighten momentarily (presumably from the application of the brake) as the truck approaches the intersection with the 8th ramp. After the Landcruiser enters the truck’s path, the rear lighting brightens again until the truck appears to stop.

Repairs following incident

As a result of the collision, the steering oil cooler lines under the truck on the right-hand side were damaged, when the Landcruiser contacted them. These were replaced, so the machine could be moved after the initial investigation at the incident scene was complete. The system required 143 litres of hydraulic oil added post repair. Total system capacity is 265 litres.

The brakes and steering functions were also tested dynamically at that time with no fault found.

[3] WesTrac response to s 155 Notice *WHSA*, 27 March 2014, items 1&5.

Functional testing

On 5 December 2013, two WesTrac employees carried out a 250hr PM (preventative maintenance) inspection on the truck. The operational checks included lights for correct function and the braking system for correct operation. All operational checks conducted showed that the machine was in sound mechanical condition. Observations made during the inspection were as follows:

- The access handrail was bent reward, contacting the isolation box, preventing full access to all of the isolators.
- Some superficial damage was evident on the right-hand front bumper section, where initial contact was made with the Landcruiser. This carried through under the machine on the right hand side with minimal damage sustained.
- Position two tyre outer sidewall (RHS) had evidence of a heavy impact, no tyre damage was sustained.
- The grease lubrication hose that attaches to the left-hand side outer steering cylinder ball stud grease cap was broken.
- A small hydraulic oil leak was evident from the front of the hydraulic tank (see Section 11).
- The reverse lamp that attaches to the underside of the offside rear view mirror was not operating (see Section 11).
- The position 1 wheel bearing compartment oil level was low.
- The position 2 wheel bearing compartment had evidence of water in the oil.
- Orientation on both of the rear strut top mounting pins was incorrect. This is generally not an issue; however the pin can break through the lubrication hole as the load point has changed.
- There was an aftermarket (Vision Brand) LED installed to the low beam position on the RHS (offside) of the truck. It was recessed into the front fender and not flush with the front panel of the front fender (see Figure 24).

Lighting and visibility devices

The truck was fitted with six forward-facing headlights. The lights were configured with two pairs of lights at high level (immediately below the operator's cab access deck level) one pair on the left, the other on the right side of the vehicle, and two lights in the bumper at low level (see Figure 25).[4]

The lights can be configured by the operator in the following arrangements:

- bumper lights only
- bumper lights and low beam lights
- bumper lights and low beam lights and high beam lights

The truck operator stated that he had the bumper lights and low beam lights on at the time of the incident. This was unable to be verified by the CCTV footage.

The bumper lights on the truck were heavily obscured by mud (see Figure 26) at the time of the incident.

All other lights fitted to the truck, being load-cell indicator (which did not appear to be working at the time of the incident) and other task lights contribute a negligible amount of luminance.

[4] Ninox ST Pty Ltd Lighting Engineering, Evaluation of Vehicle Lights- Ravensworth Truck 542, 24 December 2013, pg 5.

Figure 24. RHS (below left) and LHS (below right) front lighting (low beam and high beam) of truck. Photographs taken by investigators on 5 December 2013.

Figure 25. Photograph of truck taken by investigators at ROC on 2 December 2014.

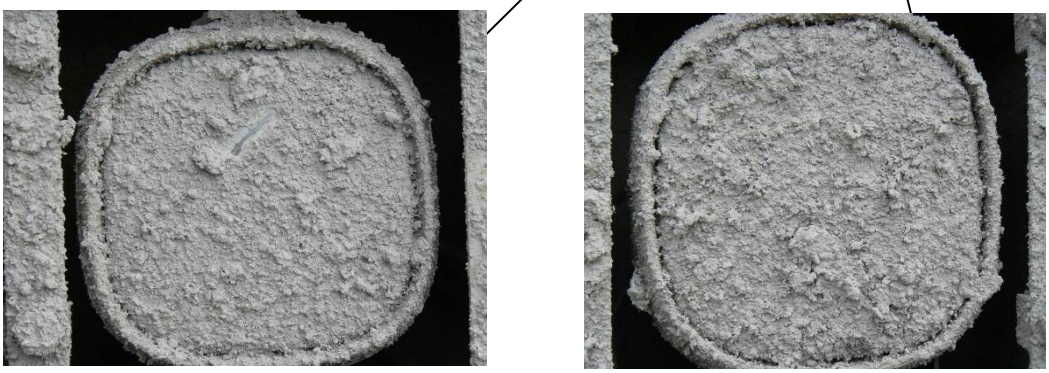
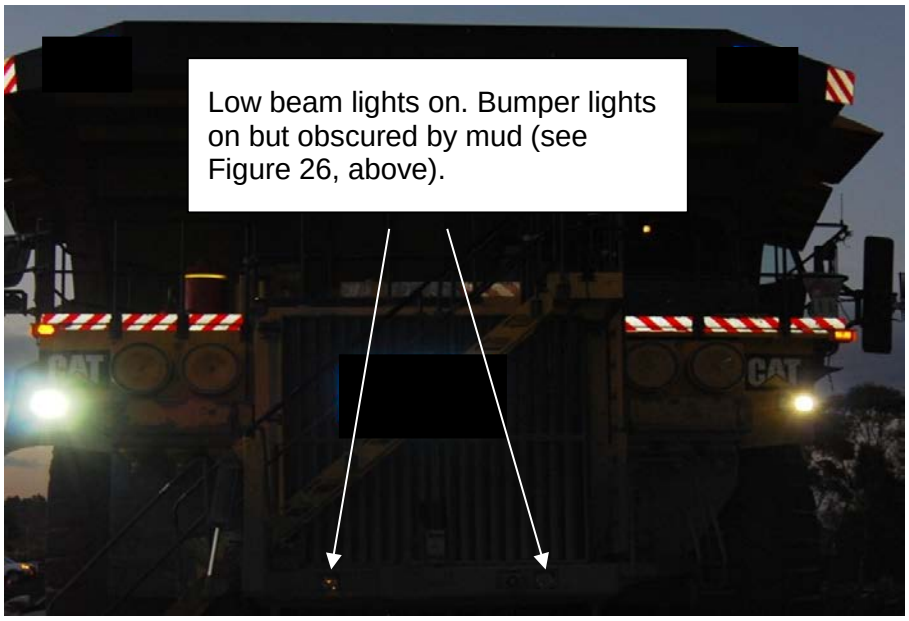


Figure 26. RHS (above left) and LHS (above right) front bumper lights of truck. Photographs taken by investigators on 2 December 2013.

Figure 27. Photograph of the truck taken by investigators on 1 December 2013 at 5 am when the truck was first started after the incident. Low beam lights and bumper lights were on.



Investigators observed during the night time simulations of the incident on 5 December 2013 using the truck, that the recessed right hand side low beam light lens could not be seen from certain angles on the right-hand side of the truck.

Work environment factors

The intersection

ARRB Group Ltd (ARRB) was engaged by the department to provide an independent report on road environment factors relating to the incident. ARRB conducted a desktop study of the intersection against Ravensworth mine standards and 'ARRB best practice' (best practice) based on Safe System principles (see Section 15), in lieu of a recognised national standard (also discussed later in the report). ARRB observations with regard to the intersection type, geometry, control and transient characteristics at the time of the incident are summarised below. [5]

Road condition

The haul roads had been constructed using locally available natural materials (i.e. they were not sealed with a bituminous or concrete running surface) and were moderately wet and "tacky" due to rainfall on the preceding day.

Intersection geometry

The selection of a T-intersection was considered appropriate for the location and operational requirements. The geometry of the intersection was in accordance with Ravensworth mine standards and best practice.

Speed management

ARRB suggested a maximum speed limit of 50 kilometres an hour for haul roads and 30 kilometres an hour for ramps.

Road width

[5] ARRB Group Pty Ltd, Contract Report: Investigation into a vehicular incident at Ravensworth Open Cut Coal Mine on 30 November 2013, 9 September 2014.

The width of the 9th haul road (27-28 metres) was narrower than the Ravensworth mine standards for a CAT 797 F truck (30 metres) and best practice (29.3 metres).

The width of the 8th ramp (28-30 metres) was slightly narrower in places than the Ravensworth mine standards for a CAT 797 F truck (30 metres) and generally met best practice (29.3 metres).

Road gradients and crossfall

The transverse profile of the 9th haul road was provided by a constant crossfall (2.2 – 3.0%), which was consistent with Ravensworth mine standards and best practice.

The transverse profile of the 8th ramp was provided by a constant crossfall (2.5 – 3.0%) which was substantially consistent with Ravensworth mine standards and consistent with best practice.

Windrows

The 9th haul road windrow heights were below the minimum height of 2.01 metres (half the wheel height) based on a CAT 797 F required by both Ravensworth mine standards and best practice. The tapered windrow heights (within 10 metres of intersection) were 2.0 metres, which were higher than the Ravensworth mine standard of 1.0 metres and best practice of 1.2 metres. Median windrow heights were below the minimum heights within both the Ravensworth mine standards and best practice.

The 8th ramp windrow heights varied considerably, being approximately 0.7 metres above the 2.01 metre requirement in places, and 0.3 metres too low up to 10 metres from the intersection. The windrows for the final 10 metres to the intersection (1.7 metres) were higher than both the Ravensworth mine standard (1.0 metres) and best practice (1.2 metres). Median windrow heights generally met the Ravensworth mine standard of 1.5 metres, but exceeded the best practice of 1.2 metres.

Signage

The absence of termination/sight boards was not consistent with Ravensworth mine standards or best practice.

Existing signs and location were consistent with Ravensworth mine standards and best practice. The size of signs did not comply with best practice.

Delineation

The provision of guideposts and whirlybirds substantially complied with both Ravensworth mine standards and best practice.

Intersection control

The intersection was controlled by a ‘GIVE WAY’ sign on the 8th ramp. According to best practice, for a haul road with a speed limit of 60 kilometres an hour, a sight distance of 115 metres or better from a distance of seven metres from the intersection was required for the intersection to have a ‘GIVE WAY’ control. The sight distance from a light vehicle at 10 metres from the intersection was 150 metres; therefore it exceeded the best practice minimum requirement.

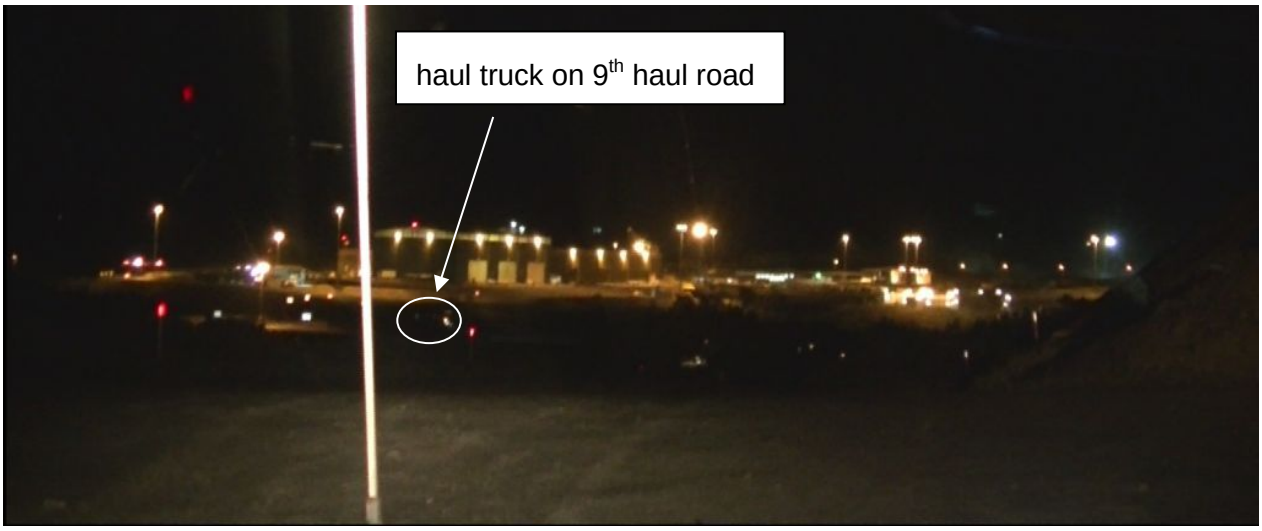
However, the windrow heights and the 3% downhill gradient at the intersection on the 8th ramp had the potential to reduce the actual line of sight from the light vehicle, such that only the top half of the haul truck could be seen. This part of the truck did not have lights and had only minimal retro-reflective taping applied (see Figure 25, above).

Also, the location and size of the ‘GIVE WAY’ signage on the 8th ramp did not provide optimum warning to drivers approaching the intersection.

Lighting

The incident occurred in the hours of darkness and as mentioned above no direct artificial lighting was provided at the intersection. There was secondary (background) lighting from the mine infrastructure area (MIA) in the vicinity of the intersection (see Figure 28, below).

Figure 28. Screenshot from video taken by the investigators on 5 December 2013, Taken from inside a light vehicle (passenger side) on the 8th ramp stockpile looking west toward the MIA.



Information from operators indicated that the background lighting of the intersection had the potential to disorientate or confuse drivers approaching the intersection on the 8th ramp, which may in turn adversely affect a driver's ability to detect a moving vehicle on the 9th haul road with accuracy and certainty. Reference was made to taking additional care at the intersection to detect whether the lights in vision were stationary or moving, as per a vehicle.

Weather

Rainfall data provided by the mine recorded 22.8 millimetres of rain between 8.10 am and 10.25 am on 29 November 2013, and 6.2 millimetres of rain between 4.10 pm and 9.30 pm on 29 November 2013. No rain was recorded on 30 November 2013.

Water at intersection

Water ponding was clearly present at the south-eastern 'corner' of the intersection (described as being 'laying water' and 'at the bottom of the ramp') by an operator (see Figure 29, below). ARRB considered that the potential for any surface water to pond at this location was foreseeable given the combination of gradients and crossfalls at the location.

Management of the mine indicated that water across the intersection was an anticipated occurrence, such as during and after rain events and the road had a spoon drain across the intersection, requiring all vehicles to slow down on their approach. The water ponding remained unresolved at the time of the incident. This appears to be inconsistent with the local standard for haul road maintenance which stated *'Repairs to any defective section of roadway shall take place as soon as practical* [sic]*'* (ref. Section 6.1 of RDCG).

Figure 29. Photograph taken of incident site by investigators on 1 December 2013.

Level of interaction between light vehicles and heavy vehicles

Up to the time of the incident there had been 361 loads of waste and 38 loads of coal hauled on the night shift on 30 November 2013.

There were around 66 operators from Crew 3 (Narama and Ravensworth North) operating various types of equipment including excavators, dozers, graders, and haul dump trucks.

Human factors

The truck operator's account

The truck operator recognised the intersection and the presence of the Landcruiser on the 8th ramp. The operator saw the Landcruiser get to the bottom of the ramp and saw the Landcruiser entering the intersection. The truck operator assumed the Landcruiser would pull up and once the truck went past, pull in behind the truck. The truck operator then lost sight of the Landcruiser.

The field of vision of the truck operator was restricted due to the truck blind spots (see Section 11).

Hours of work

In the seven day period before the shift on which the incident occurred, Ms Forshaw worked the following shifts/hours:

- 25 November - day shift (12 hours)
- 26 November - day shift (12.45 hours)
- 27 November - day shift (rostered overtime - training day) (7.30 hours)
- 29 November - night shift (12.45 hours)

Total of 45 hours.

In the seven day period before the shift on which the incident occurred the truck operator worked the following shifts/hours:

- 25 November - day shift (12.30 hours)
- 26 November - day Shift (12.15 hours)

Total of 24.45 hours.

The truck operator reported that he had between six and eight hours sleep on the night before the night shift of the incident. He also reported that he had two-and-a-half hours' sleep in the afternoon before the start of the night shift.

The truck operator stated that he felt “quite good” physically around the time just before the incident.

Drug and alcohol results

No alcohol was detected in Ms Forshaw’s body from samples taken during the post mortem examination. The samples taken were unsuitable for testing for drugs.

Ms Forshaw was subjected to random drug and alcohol urine screens at the mine on 19 February 2013 and 22 February 2013. No drugs or alcohol were detected in the screens.

No drugs were detected in blood and urine samples taken from the truck operator following the incident. The truck operator was subjected to a random drug and alcohol urine screen at the mine on 8 April 2013 and no drugs or alcohol were detected.

Mobile phone records

NSW Police obtained the mobile telephone records for Ms Forshaw’s mobile telephone number and the truck operator’s mobile telephone number for 30 November 2013. No phone calls were initiated or received by either of the mobile telephone numbers at or around the time of the incident. Further, no text messages were received or sent to or from either of the mobile telephone numbers at or around the time of the incident.

It should be noted that the relevant mine policy allowed the use of mobile telephones on hands-free devices. However, the phone records identify they were not being used by either operator when the incident occurred.

Safety management system factors

Hierarchy of controls

The WHSA requires a duty holder to eliminate risks to health and safety, so far as is reasonably practicable and if it is not reasonably practicable to eliminate such risks, to minimise them.

A duty holder, in minimising risks to health and safety, must implement risk control measures in accordance with clause 36 of the *Work Health and Safety Regulation 2011 (*WHSR). Clause 36 requires that the duty holder must minimise risks, so far as is reasonably practicable, by doing one or more of the following:

- Substituting (wholly or partly) the hazard giving rise to the risk with something that gives rise to a lesser risk.
- Isolating the hazard from any person exposed to it.
- Implementing engineering controls.
- If a risk then remains, the duty holder must minimise the remaining risk, so far as is reasonably practicable, by implementing administrative controls.
- If a risk then remains, the duty holder must minimise the remaining risk, so far as is reasonably practicable, by ensuring the provision and use of suitable personal protective equipment.

The control measures implemented by Ravensworth mine with regard to the interaction of heavy and light vehicles are outlined in Section 7 above. Under the headings below, the mine control measures are considered against the WHSA hierarchy of controls with regard to the circumstances of the incident and available controls. Personal protective equipment was not considered due to the nature of the incident.

Elimination and substitution

Light vehicles and heavy vehicles at the mine were operated by operators on multi-purpose haul roads and ramps. Segregation (separation) of light and heavy vehicles was not provided on haul roads and ramps in the operating environment.

Engineering controls/isolation

Both the truck and Landcruiser had a reverse camera (although the reverse camera on the truck was not working at the time of the incident or for some time before the incident). Neither the truck nor the Landcruiser had any other proximity detection device or collision avoidance system installed (see Section 15).

The characteristics of the 8th ramp and 9th haul road are set out above, no traffic lights or hard barriers were provided at the intersection (i.e., boom gates).

Administrative

The STMP and RDCG are outlined in Section 7 above and discussed with regard to "work environment factors" above. The following points are noted:

- Positive communication between vehicles was not required at intersections.
- A pre-operational inspection of the Landcruiser was not conducted.

Training

Ms Forshaw was passed as competent and authorised to operate light vehicles on 25 February 2013 (7 days after starting at Ravensworth). The trainer commented that Ms Forshaw completed all the requirements of the course both theory and practical and had a detailed mine site tour, as well as understanding all the safe work procedures. Ms Forshaw's NSW driver licence was sighted.

Ms Forshaw's training evidence record card indicated she had been a passenger with a mentor in a light vehicle on three occasions (site tour on 25/2/13, and unspecified on 26/2/13 and 28/2/13), and that she had operated a light vehicle with a mentor present on four occasions as follows:

- 28/2/13 - from crib hut
- 5/3/13 - to haul truck
- 5/3/13 - from crib hut
- 7/3/13 - to excavator
- 7/3/13 - from crib hut

Competency records for Ms Forshaw indicated she was competent to operate CAT 789C haul dump trucks (trained 4/3/13).

The truck operator was competent to operate the following vehicles as at 30 November 2013:

- Light vehicles (trained 6/12/12)
- CAT 789C haul dump truck (trained 26/1/13)
- CAT 789D haul dump truck (trained 18/2/13)
- CAT 793D haul dump truck (trained 7/11/13)

The night shift on 30 November 2013 was the first time the truck operator had been assigned to operate a CAT 793D following his training on that model on 7 November 2013. According to the truck operator, the CAT 793D were a similar truck to the CAT 789 models that he had operated numerous times, but they were wider and carried more tonnage. The truck operator's training on the CAT 793D consisted of a theory assessment and operating the truck for 'a few' haul loads with a trainer.

Communication

The transfer of information at the mine occurred via quarterly training days, monthly communication sessions, fortnightly letters, pre-shift meetings, noticeboard announcements, and kiosks.

A presentation at the November 2013 quarterly training days (November QTD) noted that from 289 hazards/improvements raised up to that point in 2013, roads were the top hazard which accounted for 12% of hazards raised (35 reports). Windrows were the equal second top hazard accounting for 8% of hazards raised (23 reports).

A presentation on light vehicle interactions was given at the November QTD. The topic of light vehicle interactions was selected following a number of light vehicle incidents that had occurred on site in the preceding weeks, including a rollover on 8th September 2013 and unplanned movement at the workshop on 9th October 2013, to which the operations manager stopped all work on site and discussed the incidents with workers. The mine management team had also received and reviewed a safety alert detailing an incident involving a bulldozer and light vehicle collision at Mount Arthur Coal Mine on 18 October 2013.

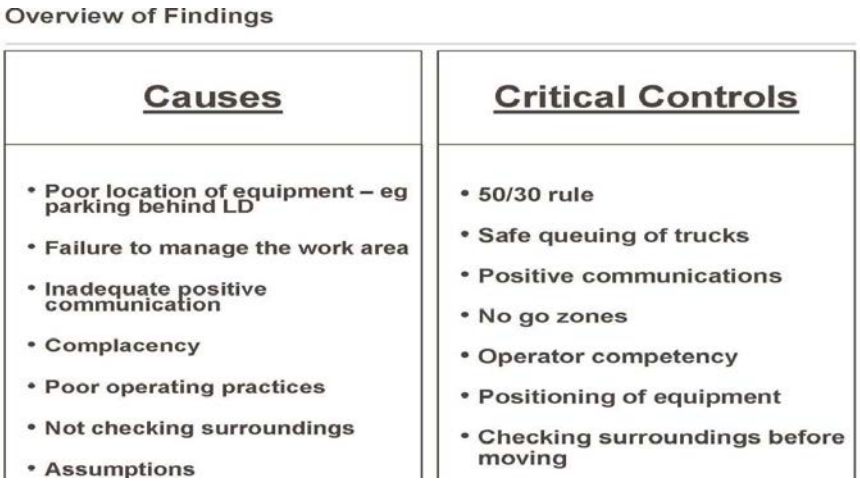
The presentation consisted of photographs of a number of incidents involving light vehicles, including a photograph from the Blackwater open cut mine fatality in 1997 involving a water truck and a light vehicle, and photographs of the Mount Arthur Coal incident. A video was shown of a story regarding a dump truck and light vehicle incident at Newmont Boddington Gold Mine in Perth.

The following incidents at Ravensworth mine between 2010 and November 2013 were listed in the presentation:

- 19/01/11 – Landcruiser reversed into Landcruiser in car park
- 26/01/11 – Landcruiser collided with dozer ripper box when the vehicle was being towed
- 22/02/11 – Near Miss between Landcruiser and dozer
- 18/07/11 – Landcruiser failed to give way in a Loader circuit on haul road
- 19/08/11 – Two contractor light vehicles contacted each other when leaving CHP area
- 28/09/11 – Landcruiser drove through a stop sign onto the haul road
- 03/02/12 – Landcruiser backed into Landcruiser bullbar in car park
- 26/10/12 – Dozer pushed rocks over bench and hit the Landcruiser parked below
- 10/01/13 – Landcruiser and dozer (trainee) near miss
- 08/09/13 – Landcruiser overturned on haul road
- 07/10/13 – Contact between two maintenance light vehicles outside workshop

A presentation on heavy vehicles interactions (collisions and near-misses) was also given at the November QTD. A number of incidents from 2012 and 2013 were listed and the findings presented are extracted in Figure 30, below.

Figure 30. Extract from Ravensworth mine presentation regarding heavy vehicle interactions.



It is noted that Ms Forshaw attended the November QTD on 27 November 2013. The truck operator did not attend the November QTD.

Contributory factors

The Landcruiser operated by Ms Forshaw entered the path of the truck. It is possible that Ms Forshaw:

- recognised the presence of the intersection, but was not able to detect the truck
- observed the truck, but misinterpreted the road environment presented and what was required.[6]

The combination of a range of factors is likely to have contributed to the incident. These include:

- the interaction of light and heavy vehicles on haul roads at ROC created opportunity for vehicle collisions
- some aspects of the intersection design and signage did not meet ROC guidelines and/or ARRB best practice
- the height of the windrows may have restricted Ms Forshaw's line of sight from the Landcruiser while travelling in a westerly direction down the 8th ramp making it difficult to see the truck on the 9th haul road approaching the intersection
- the background lighting near the intersection had the potential to disorientate or confuse drivers approaching the intersection on the 8th ramp. The background lighting may have adversely affected Ms Forshaw's ability to detect a moving vehicle on the 9th haul road with accuracy and certainty
- the presence of the water ponding may have been a contributory factor in the incident if it had distracted Ms Forshaw and/or led to reflection of the secondary lighting and vehicle headlights off the water's surface causing glare and confusion
- the poor visibility of the truck due to the obscured front bumper lights and the recessed RHS low beam light may have contributed to the incident by limiting the visibility of the truck that night. Due to the height of the truck and its close proximity to the intersection, the lack of light coming from the bumper lights would have made it difficult for Ms Forshaw to see the truck
- the absence of other illumination devices on the truck to enhance the visibility of the front, top and side of the truck would have made it difficult to detect the truck whilst travelling down the 8th ramp and at the intersection
- the limited field of vision of the truck operator meant that the operator could not see the Landcruiser when it was positioned in the truck blind spot in order to take evasive action.
- there were no proximity or collision avoidance systems installed on the truck or Landcruiser to warn the operators of the presence of the other vehicle
- there was an over-reliance on administrative controls to manage heavy and light vehicle interactions at Ravensworth mine.

[6] ARRB Group Pty Ltd, Contract Report: Investigation into a vehicular incident at Ravensworth Open Cut Coal Mine on 30 November 2013, 9 September 2014.

14. Safety observations

Safe system principles

The Safe system principles adopted by ARRB in considering the road environment at Ravensworth mine was explained by the concept 'Safe Road Users driving at Safe Speeds in Safe Vehicles on Safe Roads and Roadsides', i.e. the components are complementary and considered as inputs to a system which can determine the ultimate outcome, rather than being seen in isolation.

It is recognised within the safe system that:

- humans (road users) make mistakes on road networks and should not 'pay' with their life for doing so
- the human body has only limited tolerance to impact forces.

ARRB has had great success in applying both the long-standing and emerging safe system principles of road network safety and road safety engineering to a range of private sector road networks. This has included assisting many mine owners / operators to rationalise and reduce risk on their haul road networks within open cut mining operations.

Road design and construction standards and guidelines

Open cut mine sites are unique operating environments with many different functions and uses taking place, with a diverse range of vehicles (in terms of size, performance, fields of view etc.) and vulnerable road users. Their interactions and the risks associated with such interactions need to be understood, and knowledge, skills and experience applied.

ARRB noted that definitive industry standards and guidelines do not currently exist in this technical area, either internationally or within Australia. Many documents have been developed, either by individual mines or mining companies which all tend to vary in terms of coverage and the level of road safety, traffic engineering and traffic management knowledge and experience displayed.

Reliance on human behaviour

Due to the lack of engineering controls that were in place regarding the circumstances of the incident, a high reliance was placed on administrative controls which in turn place a high reliance on human behaviour. The causes identified for a number of heavy vehicle interactions at Ravensworth mine in 2012 and 2013 all relate to human behaviour (see Figure 30). Also, all of the critical controls identified were administrative controls which rely on human behaviour.

Human error is a well-known characteristic of human behaviour that cannot be completely eliminated but systems of work can be made more robust. Technologies are available which offer another layer in the process of minimising risks.

Proximity detection and collision avoidance systems

The role of proximity detection systems and collision avoidance systems has been highlighted in recent years. MDG 2007 (February 2014) the *Guideline for the selection and implementation of collision management systems in mining* has been developed for use by coal mines, metalliferous mines and quarries. It provides guidance for an operator to select and implement a suitable system for their operation as well as providing consistency across the mining industry.

MDG 2007 states that a collision management system needs to provide additional layers of protection to reduce the risk of collision interaction where other types of controls are not effective or impractical to apply. It is not intended that the system replaces existing administrative controls (e.g. induction, training etc.) but will be elevated within the hierarchy of controls to ensure that the risks associated with interactions are minimised.

Many mining operations are exploring the potential of introducing proximity detection. The benefits of avoiding predictable human errors in respect to positioning around machinery by warning personnel or slowing/stopping machinery movements can provide an engineering solution to a hazard (or unwanted event).

Guidelines for heavy vehicle lighting and reflective material

The *Guideline for Mobile and Transportable Equipment for Use in Mines* (MDG 15) (March 2002) was compiled to assist manufacturers, purchasers, owners, operators, site contractors and the department's mining inspectorate when assessing safety aspects of mobile and transportable equipment used at mines, including surface coal mines.

Section 3.11.3 Reflectors/lights, requires that adequate reflectors, reflective tape and/or lights shall be provided on all equipment to make it readily visible from any direction and hence reduce the likelihood of a collision. This includes but is not limited to:-

a) lights or reflectors visible from the side arranged in strips to assist in identifying the length of the equipment (this applies in particular to dump trucks)

b) the front head board or highest extremity of all trackless equipment to provide visibility in undulating terrain.

It is noted this guideline does not provide specific detail about the type and location of lights and reflectors on heavy vehicles.

Additional observations regarding the mine's risk management process

The following observations were made during the investigation:

- There was no distinction drawn in risk assessments and control measures concerning the interaction of heavy and light vehicles between night and day time operations.
- No risk assessments regarding the suitability of the visibility devices on light vehicles and haul trucks were conducted between 1 January 2013 and 30 November 2013.
- No formal analysis had been undertaken to determine the need to separate light and heavy vehicles on the mine haul or access roads.
- The mobile equipment risk assessment conducted in July 2012, had only four team members involved and only two of them were operators. The risk assessment review team did not represent all of the stakeholders that could be affected by the outcomes.
- Design specifications for the intersection were unable to be located.
- There were no risk assessments specific to the intersection identified.
- The reverse camera not working on the truck was not classified as a safety critical defect under the mine's defect management system. As such the truck could continue to be used.
- There was no procedure regarding the transportation of operators to crib huts for crib breaks.

Safety climate

A safety climate survey was completed by 305 Ravensworth mine workers (100% of the workforce) in November 2012. The survey report noted that overall the worksite safety climate was fair and moderately strong. The report noted that the frequency of near-misses and minor safety events were fairly prevalent across the site and respondents indicated they were not always compliant with safety procedures. Priorities identified in the report were as follows:

- The extent to which workers are encouraged to contribute to and get involved in safety initiatives onsite.
- Perceptions of supervisor production pressure.
- Between-team safety communication quality.
- Willingness to report errors and mistakes to the organisation.

- Work-safety tension, in particular, the perception that tasks and duties performed as part of standard work practice can interfere with staying safe.
- Fatigue management, in particular, more effective strategies to improve the sleep quality of workers during nightshifts and intervene in the relationship between sleep quality and incidents.

With regard to fatigue management recommendations, the report identified that the mine may consider revising their roster to reduce night work.

Post-incident changes at the mine

Pre-operational inspections

Ravensworth mine introduced an external contractor to ensure pre-operational safety inspections were being completed on a 24-hour basis.

Draft guideline for intersections

Glencore developed a draft guideline for intersections and site standards were reviewed against this guideline. A draft intersection approval assessment checklist was developed for future intersection construction.

Intersection control

In accordance with a statutory improvement notice issued by the inspector of coal mines dated 1 December 2013, all ‘GIVE WAY’ signs were changed to ‘STOP’ signs.

An intersection signage review was completed on 7 May 2013. The review considered the incident intersection and as a result the signage remained a ‘STOP’ sign due to there being less than 30 metres of flat ground prior to the intersection and because water pools on the ramp. Some other mine intersections reverted to “GIVE WAY” signs.

Intersection review

An intersection review was conducted which covered the intersection. It noted “most corner bunds lowered” and “consider a process to ensure that water does not capture at the base of…[8th] ramp…”

The truck recessed light

The right hand side low beam light of the truck was relocated forward at the request of the site check inspector. The work order for this noted that it was done to allow for unrestricted vision.

Light vehicle competence

Trainees now receive a 12-hour shift of instruction on driving a light vehicle in the hours of darkness. Trainees are now required to complete a series of skidpan exercises, including descending a wet ramp and controlled braking in wet conditions.

Dump truck visibility trial

There was a trial of green clearance lights, luminescent paint, and reflective tape on certain haul trucks to attempt to improve truck visibility (see Figure 31, below).

Figure 31. Dump truck visibility trial.