Stopping water truck related uncontrolled movements on mine haul roads

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Abstract

"Ground speed" water truck spray systems were introduced to curb the high number of uncontrolled movements occurring on mine haul roads. Serious concerns have been raised over the recent increase in such incidents suggesting that current spray system controls and practices are deficient.

Best practice for mine haul road watering should dictate that water trucks use a defined input value to achieve a quantitative water output and be used in conjunction with road profiling technology that can advise a safe level of water to apply to a haul road to maintain an adequate level of friction. As we move towards wirelessly connected water trucks, geo-fence automation will lead to hard engineering controls.

1. Background

Uncontrolled movements on mine haul roads still account for a high percentage of the total number of HPI's. Since 2010, the Mines Inspectorate has released a number of Mine Safety Bulletins with recommendations aimed at reducing the number of water truck related uncontrolled movements. 5 years on, water truck related uncontrolled movements are still a common occurrence on mine haul roads.

Putting an end to water truck related uncontrolled movements can be greatly advanced by implementing an objective measurement process and using a tool that can reliably apply the results of the measurement process. Simply put, we need a process that can identify how much water to apply to a haul road, and we need a tool that can reliably apply that amount of water to a haul road.

2. How much water to apply to a haul road?

The process of watering a mine haul road is the conundrum of managing risk on the road network; it reduces one hazard but increases another. The first question that must be answered when watering a haul road is how much water should be applied

to the haul road? To determine the answer we must understand the outcome we are trying to achieve. The outcome is haul road that has been coated with water to suppress dust but still has an adequate level of friction, that will ensure haul road users maintain traction on the unsealed haul road. Understanding this requirement is the first key step in stopping water truck related uncontrolled movements.

3. Road Friction

For a safe haul road, the available friction supply must exceed normal vehicle operation friction demands.

Using specialised measurement devices it is possible to objectively measure the available friction on a watered mine haul road. A portable accelerometer device is fitted to the interior of a mine light vehicle equipped with ABS brakes and will display test results in real time.

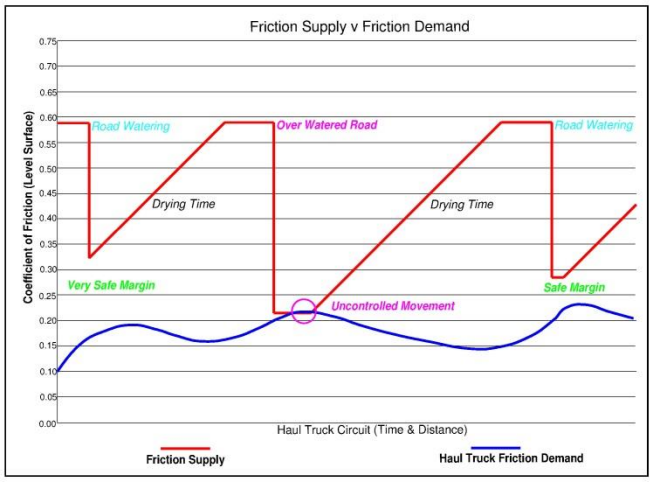
Measuring road friction is an unobtrusive process with no interference to mining activities or operational road safety. An audit process on an individual section of haul road typically takes 5 minutes using a light vehicle and a calibrated water truck.

The focus is on the higher risk classified roads with poor material or road geometry.

4. Friction Supply vs Friction Demand

A sufficient coefficient of friction is required to maintain traction under acceleration, braking and cornering. Friction supply is the available friction in the haul road and will change based on haul road material. Friction demand is determined by the size of equipment used on site and road geometry.

The friction requirements of a haul road user can be put simply as supply vs demand. The friction supply must exceed the friction demand for safe operation; the factor between the two is the safety margin. Road material is the major element that determines friction supply; clay materials generally have poor friction whilst coarse sheeting will have a high level of friction.



5. Safe Water Application Rate

A Safe Water Application rate is the link between haul road friction measurement and mine haul road watering processes.

The application rate is expressed as millimetres per meter squared (mm/m^2). As an example, 0.3 mm/m^2 application of water is equivalent to equally dispersing 300ml of water over a 1 m^2 area of ground.

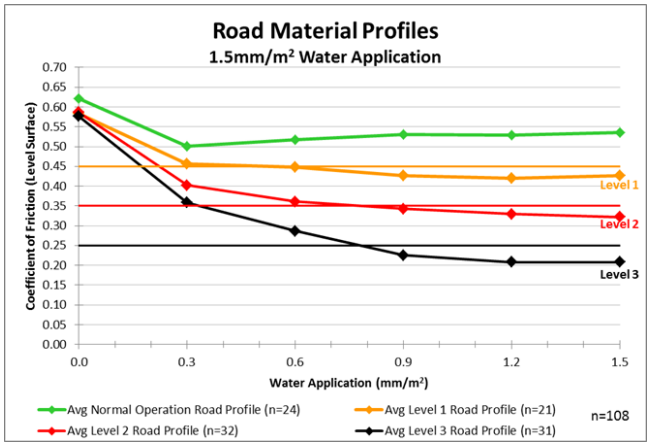
A water application rate is a standard form of measurement and is used in conjunction with the friction measurement device to determine the available coefficient of friction.

The next generation, true smart water trucks will use a water application rate as a definable input for configuring water application.

6. Benchmarking & Road Profiling

The road friction audit process will determine the category a haul road, based on the Haul Road Friction Protocol. The friction audit is a simple application of water followed by a friction test.

A total of 1.5 mm/m^2 water application is applied to a single section of haul road. A friction test is completed at regular 0.3 mm/m^2 intervals until a total of 1.5 mm/m^2 water is applied to the haul road. Measuring the friction at regular 0.3 mm/m^2 intervals will determine how the haul road reacts to water and the result of the coefficient of friction.



7. Global Haul Road Friction Protocol

The Global Haul Road Friction Protocol is a simplified method of classifying haul roads. Haul roads are classified into four categories based on the available coefficient of friction that has been determined after a road friction audit.

- A watered Green haul road will maintain an adequate level of friction for all vehicles.

- A watered Orange haul road can be potentially hazardous for haul trucks.

- A watered Red haul road can provide hazardous conditions for haul trucks and potentially hazardous conditions for light vehicles. The safety margin between friction supply and friction demand is reduced if over watered.

- A watered Black haul road can provide extremely hazardous conditions for all vehicles. The safety margin between friction supply and friction demand is greatly reduced if over watered.

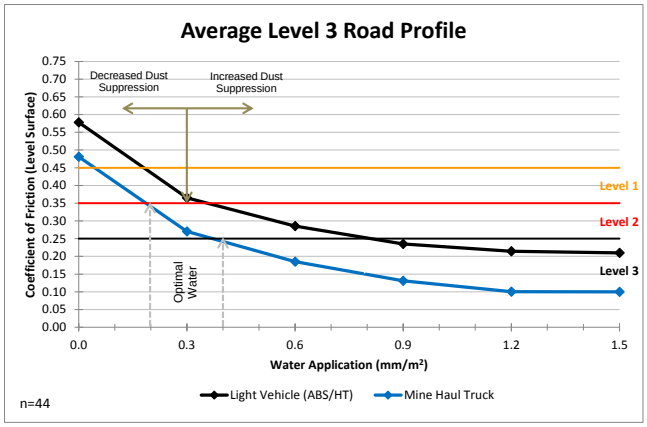
Normal	0.45	Level 1	0.35	Level 2	0.25	Level 3
Level Surface Friction above 0.45		Level Surface Friction between 0.45 – 0.35		Level Surface Friction between 0.35 – 0.25		Level Surface Friction below 0.25
Safe Operations for All Vehicles		Caution for Haul Trucks		Potentially Hazardous for Haul Trucks & Caution for Light Vehicles		Hazardous for Haul Trucks & Potentially Hazardous for Light Vehicles
		OCE/Supervisor to Determine Operational Restrictions		OCE/Supervisor to Determine Operational Restrictions		OCE/Supervisor to Determine Operational Restrictions

The Tulloch/Stocker Friction Model©.

8. Road Profile Example

Analysing the average level 3, black category haul road. The black line represents the measured coefficient of friction by a light vehicle. The blue line represents the correlated link between a light vehicle and a mine haul truck. Due to the increase in size and weight of a mine haul truck, the supply of friction is reduced based on the correlated link to present the truck coefficient of friction.

A coefficient of friction under 0.25 will provide an extremely hazardous condition for all haul road users. To ensure an adequate level of friction is maintained, the optimal water application rate is 0.3 mm/m^2. This application rate will satisfy both dust suppression requirements as well as friction demand requirements.



9. Correct Tool For The Job

Determining the optimal and safe water application rate is only step one in the process of stopping water truck related uncontrolled movements.

A major factor contributing to water truck related uncontrolled movements is the tool for the job is normally incapable of applying the optimal and safe amount of water in critical areas of the mine. Critical areas like ramps, tight radius corners and intersections.

To stop uncontrolled movements It is necessary that you can reliably and consistently apply a set water application rate onto the haul road.

The solution is not simply a “ground speed” water truck spray control system. A ground speed spray control system simply moderates the flow of water based on ground speed without taking into consideration other vital variables.

A true smart water truck spray control system must be compatible with the results of haul road friction testing and accept a defined input.

10. Measurable Water Truck Spray System

Typical spray control systems including ground speed spray control system use undefined terms like “high” or ”low” water output or a percentage of water pump flow. Therefore the amount of water being applied to the ground is unknown.

A true smart spray control system is measurable and uses a defined input value to achieve a quantitative output of water. The measurable spray system will be able to input the safe water application rate as defined by a road friction test result.

A true smart spray control system will apply the same amount of water to a haul road regardless of the changing variables like ground speed, engine RPM, truck setup or operator.

11. Water Truck Development Timeline

Pre 1994, water truck spray control systems were rudimentary. There was no speed control of the water pump and the water was delivered at a flow rate equivalent to the maximum output of large spray heads, some water trucks were fitted with up to five spray heads delivering 15 tons of water per minute.

With no water pump speed control, spot or pulse spray operation is a common method used to control the amount of water being applied to the road. The result is still a very hazardous condition to all haul road users as the watered spots can contain a very high volume of water. This type of spray control system is still regularly used today.

Post 1994, ADE was approached by a major OEM to design and build a speed control system for large off-highway water trucks. The system offered four different fixed flow rates that would allow four different water pump speeds. Control of water flow at lower speeds is now better managed however the water output was still considerably high and operators again turned to Spot spray operations.

The Queensland Mines Inspectorate investigates mine haul road accidents cause by incorrect watering of mine haul roads. Post 2010, begins the era of ground speed spray control systems. The four speed control valve concept is coupled with electronic controlled sequencing with ground speed inputs to provide a speed banded spray control system.

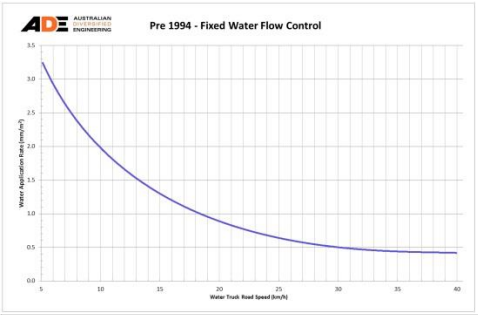
This four speed system and like most other ground speed spray control systems available on the market are a speed banded spray control system. The system reacts to ground speed however cannot adjust for engine RPM and therefore only satisfactory operates within ideal speed ranges. Overwatering can still occur in critical areas such as ramps or tight radius curves.

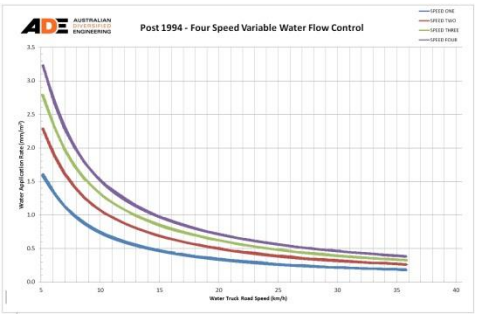
Now, begins the era of the true smart spray, measurable water truck spray control system that can apply a set water application rate in mm/m^2.

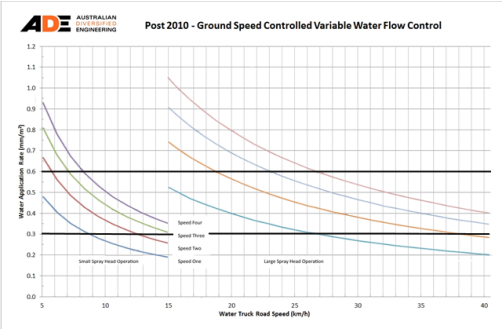
The true smart spray control system will maintain a water application rate regardless of ground speed, gear or engine RPM, up to the maximum limit of the water pump output.

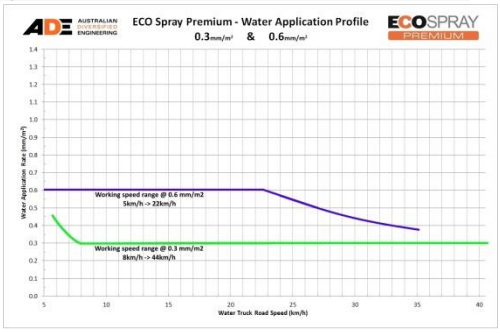
Using a water application rate means everyone is speaking the same language and regardless of the mine site, water truck or operator, if the water truck is fitted with a measurable spray system, every water truck can simply apply the same amount of water to the haul road.

Water truck operators now have a tool that will allow them to apply the correct amount of water to the haul road.









12. Technology

A true smart spray system will be computer controlled adding the benefits of data logging, remote connectivity and automation.

With data logging it will be possible to determine what a water truck was doing at any given time or location, what spray heads were open, what the water application rate was. In the event of an incident, investigators will have a new level of information available to them.

In the age of big data and live tracking, remote management of the water truck assets will prove a vital tool in managing and improving water truck operations giving the ability to correlate water truck data with weather, dust monitors and maintenance statistics.

The development of an automated water truck all of a sudden seems conceivable.

13. Geo-fence Automation

The journey to water truck automation will be via geo-fence automation that will manage water truck operations based on the water trucks geographic location within the mine.

Geo-fence automation will add a new level of control to help manage the risk of over watering.

Geo-fence operation will require two key attributes, a settings profile and a geo-fence barrier.

14. Geo-fence Profile

In the simplest form, a geo-fence profile will manage the water application rate and spray mode.

Mine operators can choose to restrict the water application rate and choose what spray mode is used for a particular location, ramp or corner on a mine. The mine operator may even choose to restrict watering operations around critical locations.

A typical Geo-fence profile will have the following settings:

- Water application rate
    - Min rate
    - Max rate
- Active time
    - Day hours
    - Night Hours
- Spray mode operation

15. Geo-fence barrier

Exploring how a mine site may choose to set up the geo-fence barriers.

At a minimum, geo-fence barriers should have priority ratings and optional time restrictions. Meaning, geo-fences can be placed on top of each other and based on the priority or time of day, will determine what profile settings are used.

This will allow mine operators to configure a default geo-fence over the whole mine site with pre-configured safe settings.

Mine operators can then choose to geo-fence blackspot or critical areas with more stringent profile settings.

16. Conclusion

By measuring the risk we can manage the risk.

Haul road profile and friction testing can be completed in house. Friction measurement devices are available for purchase by mine operators and personnel can be trained in their operation.

True smart spray control systems or measurable spray systems are available on the market and are critical to managing overwatering of haul roads.

Geo-fence technology will lead to automated water trucks.

17. Other Benefits

Overwatering also causes damage to haul roads and water trucks.

Applying to much water to a haul road can result in soft spots, pot holes and road deformation resulting in increased rolling resistance and increased road maintenance.

When ramps are overwatered it generally results in wheel spin and additional load through the driveline.

The major advantage to stopping overwatering is that a water truck will now spend more time spraying and less time travelling to the refill point, resulting in more kilometres of road sprayed per tank of water.

By managing the application of water, mine sites will be able to reduce the quantity of water used, potentially savings billions of litres of water each year.

18. References

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