Technical Webinar

Improving the Sustainability of Sprayed Seals

19 December 2024

Austroads

Today's moderators

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Austroads acknowledges the Australian Aboriginal and Torres Strait Islander peoples as the first inhabitants of the nation and the traditional custodians of the lands where we live, learn and work. We pay our respects to Elders past, present and emerging for they hold the memories, traditions, culture and hopes of Aboriginal and Torres Strait Islander peoples of Australia.

Austroads acknowledges and respects the Treaty of Waitangi and Maori as the original people of New Zealand.

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About Austroads

The collective of Australasian transport and traffic agencies

- Transport for New South Wales
- Department of Transport and Planning (Transport Victoria)
- Department of Transport and Main Roads Queensland
- Main Roads Western Australia
- Department for Infrastructure and Transport South Australia
- Department of State Growth Tasmania
- Department of Infrastructure, Planning and Logistics Northern Territory
- Transport Canberra and City Services Directorate Australian Capital Territory
- Department of Infrastructure, Transport, Regional Development, Communications and the Arts
- Australian Local Government Association
- NZ Transport Agency Waka Kotahi

Transport Infrastructure Program

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Aim: Improve the management and performance of transport infrastructure for road users and the community.

Program Manager

Ross Guppy

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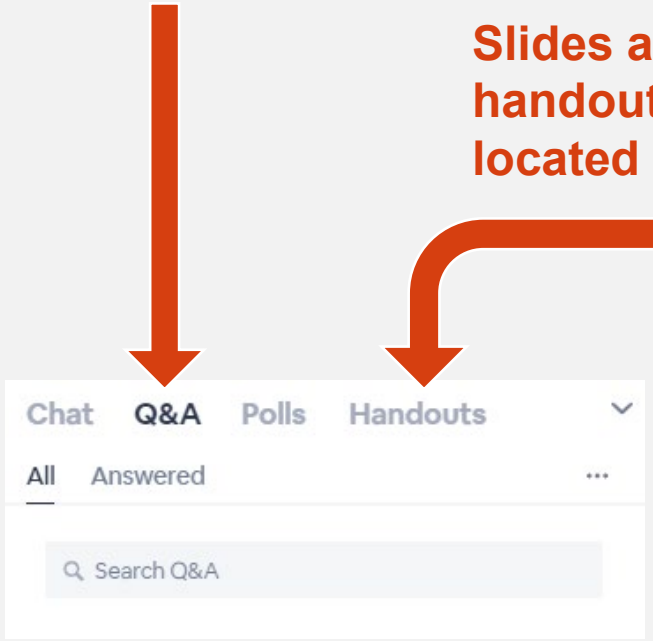
Housekeeping

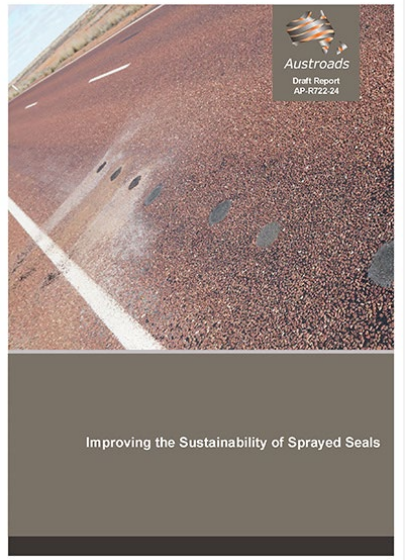
Type questions here
and let us know the slide number your question relates to



Presentation = 40 mins

Question time = 15 mins

Slides and handouts are located here



Today's presenters and agenda

Topic
Alternatives to existing materials and practices
Sprayed seal lifespans
Life cycle analysis
Q+A

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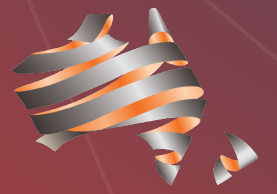
Introduction to the team

Steve Patrick



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Introduction to the team

Project team

Austroads Project Manager
Robert Busuttil (DTP)

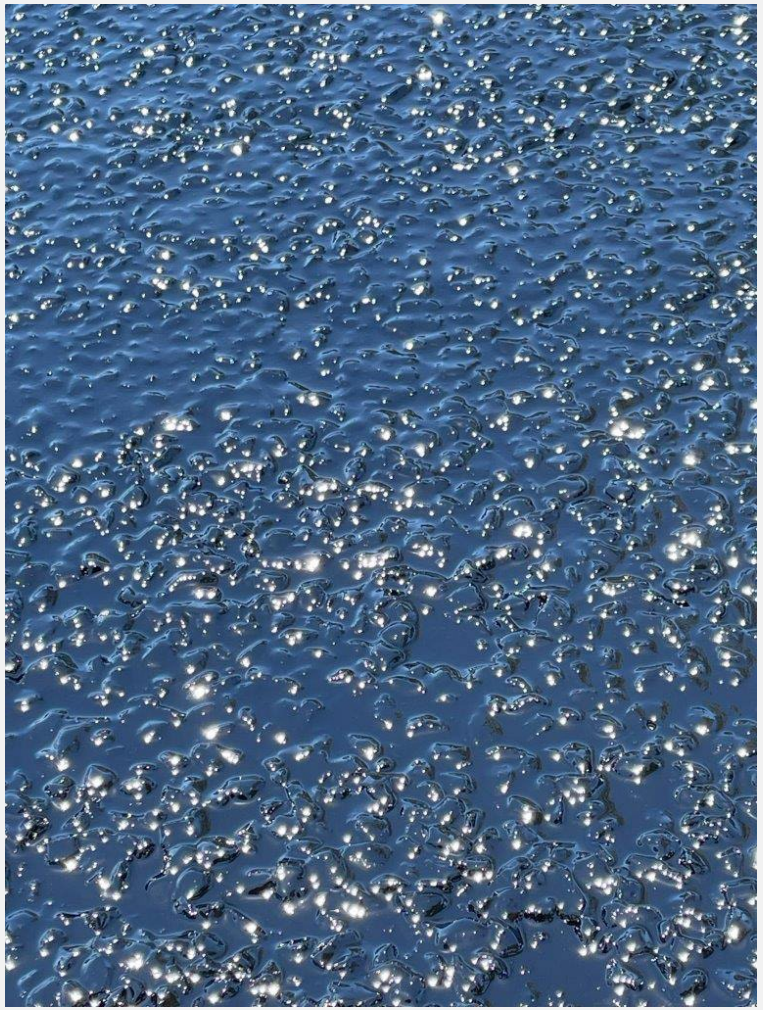
Project Team
Steve Patrick
John Esnouf
Jaspreet Pooni
(NTRO)

Working group

Background

Sprayed seal fundamentals

- A thin, flexible pavement surfacing solution.
- Predominant surfacing in Australia and New Zealand.
- Essential for low-cost road construction.
- Uses non-renewable, virgin materials extensively.
- Bitumen binder often modified with polymers to improve performance.
- Binders often heated to 180–190°C, cutback with kerosene.
- Binder hardens over time, causing cracking; periodic maintenance needed to prevent deterioration.



Purpose and objective

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- Gather knowledge and increase understanding of sprayed seal technologies and practices.
- Reduce the environmental impact of sprayed seal technologies.
- Provide transport agencies with guidance to improve sprayed seal sustainability.
- Identify benefits and risks related to sprayed seal performance.
- Overview of potential effects of climate change on seal performance.

Scope

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The contents of the research included:

- an overview of sprayed seals in terms of sustainability, including the materials used, the desired qualities of seals and their materials and different placement techniques
- a summary of current agency sprayed sealing requirements
- an evaluation of alternative sprayed seal materials and practice
- review of alternative biomass materials for sprayed seal usage
- a study of the impact of climate change on sprayed seal performance
- a review of the lifespan of sprayed seals
- a life cycle analysis (LCA) to quantify the environmental impact of sprayed seals

Alternatives to existing materials and practice

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Cutter oils

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Cutter oils are petroleum solvents (kerosene/ aviation jet fuel) used in small proportions to reduce binder viscosity.

Uses:

- Achieve uniform binder distribution.
- Assist aggregate adhesion in cool conditions.
- Provide slower curing bitumen for light traffic applications.
- Ensure prime penetrates the base in priming applications.
- Assist adhesion to the pavement for initial seals.
- Reduce binder viscosity to facilitate aggregate wetting.
- Studies show increased cutter proportion lowers the coating temperature of binder films.
- Essential for achieving aggregate wetting and adhesion in sprayed sealing operations.

Cutter oils

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Performance

- Cutter oils are sacrificial and intended to dissipate.
- Long-term presence in binder is undesirable.
- Evaporation occurs mostly in early months; can remain longer in cooler climates.
- Insufficient evaporation can cause issues like flushing in hot weather

Environmental Impact

- Sourced from non-renewable crude oil.
- Energy-intensive refining processes release significant greenhouse gas emissions.

Cutter oil reduction strategies

- Cutter usage has been reducing – reflected in proposed reduced cutter rates from AfPA.
- Sealing in warm weather.
- NZTA Waka Kotahi have mandated the use of bitumen emulsions for new chipsealing contracts.
- Changes to practice:
  - Focus on high cutter usage scenarios – use lower dosage cutbacks/emulsions for initial sealing.
  - Modernised equipment – synchronised sprayers/spreaders.

Emulsions

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- Bitumen emulsions offer a way to conserve non-renewable resources and reduce cutter oil use.
- Emulsions contain bitumen, an emulsifying additive, and water, keeping bitumen particles suspended during application.
- Sprayed at ambient temperatures or up to 90°C, much lower than the 180°C for cutback bitumen.
- Typical crumb rubber modified bitumen cannot be emulsified unless rubber size is reduced or solubilised.

Emulsions

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Reduced carbon footprint?

- Research outcomes differ
  - Uncertainty from estimates involved in the studies
- Compared to cutbacks - Estimates from 50% reduction to equivalency
  - Emission reduction from reduced cutter evaporation and heating for the hot cutback
  - Balanced by the extra energy required to make emulsion and transport the water component.

Warm mix asphalt additives

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- Reduce production and placement temperatures of asphalt mixes.
- Allows mixing and compaction at 20–30°C below hot mix asphalt (HMA) temperatures.
  - Blended with binder before mixing.
  - Added directly to the asphalt mixer with the binder.
- Enables longer haul distances and improves workability.
- Suitable for incorporation into sprayed seal binders to reduce viscosity and temperature, potentially replacing cutters.
- Reducing operational temperatures and cutter usage can enhance sustainability in sprayed sealing.

Warm mix asphalt additives

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Sprayed sealing case studies

- Several overseas trials identified
- Primarily focused on expanding working windows into more marginal weather conditions
  - Reductions of approx. 30 ºC spraying temperature reported
- Little information on reduction of application temperatures
- Various seals constructed
  - Satisfactory outcomes – lower risk at marginal pavement temperatures
  - Lower emissions/smoke/odours

Synchronised sprayers and aggregate spreader

Modernised technology

- Synchronised bitumen sprayers and forward-moving aggregate spreaders are increasingly used in Victoria.
  - Shift away from reversing vehicles in sprayed sealing operations to improve safety.
- Exclusion of Cutters:
  - Cutters excluded when using proprietary low-viscosity hot-applied crumb rubber binders.
  - Achieved due to superior wetting of aggregate from immediate placement on hot sprayed binder.

Synchronised sprayers and aggregate spreader

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Performance outcomes

- Major advantage: Immediate spreading of aggregate onto sprayed bitumen at 160–170°C vs. 40–60°C with conventional equipment.
- Often sprayed without cutter, achieving sustainability gains and allowing early brooming.
    - Cutter used in cold weather to prevent adhesion loss.
- Advanced technology reduces aggregate use by at least 20%.
    - Direct loading of aggregate avoids stack site wastage and reduces spread rates

Crumb rubber

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- Using tyre-derived crumb rubber in bituminous binders is widespread.
  - Europe, USA, and Canada use crumb rubber in HMA.
  - Australia, South Africa, and parts of the USA (California and Arizona) use it in sprayed seals.
- Benefits:
  - Use of recycled material to extend bitumen.
  - Increased crack resistance and improved adhesion for better chip retention.
- Barriers to expanded usage:
  - Cannot be emulsified.
  - Stable crumb rubber supply is critical.

Aggregate precoat materials

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Precoats are used on aggregate for sprayed sealing to:

- Improve Adhesion: Precoats help the aggregate stick better to the binder, ensuring a more durable seal.
- Reduce Dust: They help to bind dust particles on the aggregate, which can otherwise interfere with adhesion.
- Enhance Performance: Precoated aggregates are less likely to strip away from the binder, especially under traffic stress.

Aggregate precoat materials

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Diesel based products most common – alternatives?

- Biodiesel as Precoat:
  - More sustainable alternative to flux oil (diesel) based precoat - GHG emission benefits compared to petroleum diesel.
  - Approximate cost implications:
    - USA:
      - 99–100% biodiesel concentration costs 18% more
      - 20% biodiesel has cost parity
    - Australia: higher cost offset by excise advantage – relative parity
- Avoiding precoat – depends on clean aggregate supply, may require washing.
- Minimising Precoat Usage – determine rates and improve control measures

Bio-binders

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- Binders from biomass or sustainable resources as bitumen substitutes.
  - Replacement for Bitumen: 100% replacement.
  - Bitumen Extenders: 25–75% replacement.
  - Bitumen Fluxes: 7–15% replacement.
  - Bitumen Modifiers: Less than 10% replacement.

- Properties of bio-binders:
  - Depends greatly on production process and selected biomass.
- Sources and Methods:
  - Various production methods and biomass sources have been investigated.

Bio-binders

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Overview of findings

- Potential to improve low temperature performance / Increased resistance to cracking.
- Lower viscosity and decreased binder stiffness – may be mitigated with polymer additives
  - Viscosity of bio-oils decreases with content increase but increases after ageing (RTFO treatment).
- Accelerated ageing compared to crude-oil-derived binders.
- Lignin acts as a natural antioxidant.
- Segregation depends on temperature and bio-oil concentration – increased risk above 20 wt.% and 160°C

Sprayed seal lifespans

Lifespans of sprayed seals

- Long lifespans for sprayed seals delay or avoid material and energy use for replacements.
- **Lifespan Variability**:
  - Depends on seal type, traffic, climate, and location.
  - In Australia: Typically 5-15 years, but can be up to 20-30 years.
  - New Zealand study: Average lifespan 9 years, with significant variability.
- **Influencing Factors**:
  - Seal type, traffic volumes, and maintenance triggers.
  - Early failures – Aggregate loss and low friction.
  - Long-lasting seals – Cracking, loss of texture, and low friction.
  - Oxidation – a significant factor in binder hardening.

Life Cycle Assessment

Life cycle analysis

- A Life Cycle Assessment (LCA) was conducted to:
  - Evaluate environmental impacts of typical sprayed sealing practices.
  - Assessed potential impacts of alternative processes on GHG emissions.
- Goal of the LCA Study:
  - Determine environmental viability of:
    - Sprayed seal methods avoiding the use of cutter.
    - Bituminous emulsion technologies.
  - Compare these alternatives with conventional cutback bitumen practices.

LCA scenarios

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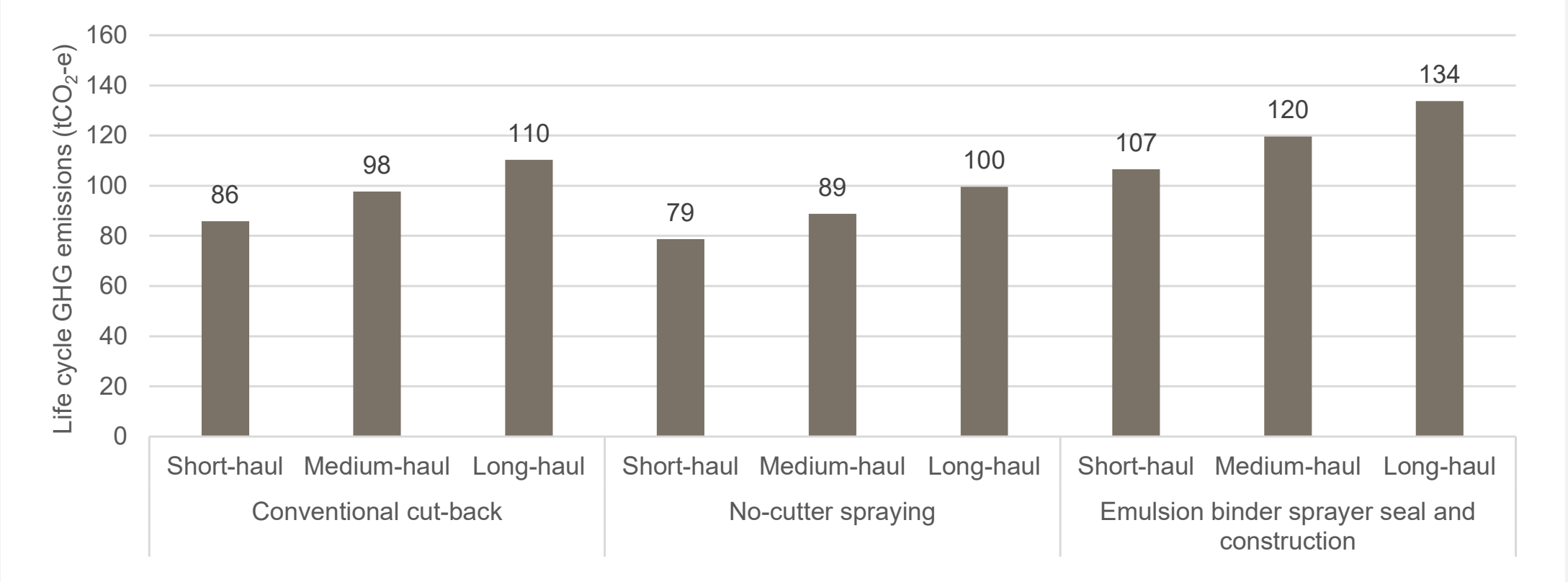
- Three Sprayed Seal types for comparison:
  - Conventional cutback.
  - No-cutter and reduced aggregate use.
  - Emulsion binder sprayed seal.
- Binder Selection:
  - Reflects emerging trends from road agencies.
    - S9R: Contains 9% crumb rubber, supporting recycled material use.
    - Polymer Modified Bitumen Emulsion: Contains latex, similar performance to S9R.
- Design Process:
  - Conducted following Austroads AGPT04K processes.
  - No-cutter and reduced aggregate use approach includes a 20% reduction in aggregate usage, achievable with advanced equipment.

LCA scenarios

- These scenarios are designed to demonstrate the relative impact of transportation of materials over increasing distances.

Haulage scenario	Aggregate haulage distance	Binder haulage distance
Short-haul	50 km	50 km
Medium-haul	100 km	250 km
Long-haul	150 km	500 km

LCA results


Life cycle GHG emissions (tCO2-e)
160
140
120
100
80
60
40
20
0
86
98
110
79
89
100
107
120
134
Short-haul
Medium-haul
Long-haul
Short-haul
Medium-haul
Long-haul
Short-haul
Medium-haul
Long-haul
Conventional cut-back
No-cutter spraying
Emulsion binder sprayer seal and construction

Summary of findings

How to improve sustainability?

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- Reduce use of cutter oils:
  - Improving practices to lower rates
  - Utilising modernised equipment
- Reduced aggregate usage
- Precoat Materials:
  - Consider biodiesel as a replacement.
  - Minimise precoat usage for sustainability.
- Bitumen Emulsion:
  - Alternative to hot applied cutback bitumen.
  - May provide sustainability benefits, but not in all situations.

How to improve sustainability?

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- Expanding use of crumb rubber:
  - Well-established additive, increasing crack resistance and adhesion.
  - Sustainability gain from recycled material and reduced bitumen use.
  - Limited emulsification capabilities.
- Bio-Binders:
  - Derived from biomass, partially replace bitumen.
  - Limitations: low viscosity, accelerated ageing.
  - Developments needed for large-scale adoption.

Life cycle analysis

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- No-Cutter and Reduced Aggregate Use Approach:
  - Lowest life cycle GHG emissions (7–11% less than conventional cutback).
  - Lower quantity of materials, especially reduced aggregate usage.
- Bitumen Emulsion scenario:
  - Stored and transported at lower temperatures (less heating required).
  - Increased transportation task results in higher life cycle GHG emissions than conventional cutback.
  - Emulsion binder sprayed seal approach produces more emissions than other approaches, even with short haul transport.

Questions?

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Upcoming Austroads webinars

Topic	Date
Driving Safety for Two: Study on the Correct Seatbelt Use During Pregnancy	27 March 2025
Unlocking the Potential of Telematics Analytics Platform for Local Government	1 April 2025

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