Life-cycle costing of rain and flood events in Queensland

Case studies and network-wide implications

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Background

• **Purpose**
  – 2010-13 weather events in Queensland reveal that the network is more exposed to damage than desirable or originally thought
  – Government has challenged Transport and Main Roads to review and amend its pavement management practice to decrease this exposure to road asset damage in a cost-effective manner

• **Asking the question**
  – “What are the economic benefits of improving the ability of the road network to better withstand the effects of flooding events, and how might it be done?”
Project milestones

- Background on the rain/flood events and TNRP
- Developed analysis methodology and case study selection criteria
- Identified 7 case studies including background data

- Two site visits to case study links
  - Observations and feedback included:
    - Table drains blocked/inadequate
    - Identified the need to do drainage maintenance well
    - Low cost treatments in past have not performed well
    - Still many sections “waiting to fail next time”
    - Maintenance/rehab/reseal funding is tight and can’t cover everything
Case studies

- 7 case studies analysed with model developed by ARRB

<table>
<thead>
<tr>
<th>Base case: What actually happened</th>
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<tbody>
<tr>
<td>• Models network prior to events and TNRP response</td>
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<tr>
<td>• Real data on closures, reconstruction costs, road condition</td>
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<td>• Reconstruction based on damage incurred</td>
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<table>
<thead>
<tr>
<th>Option 1: ‘Full resilience’</th>
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<tbody>
<tr>
<td>• Extensive rehab work required to make the link fully resilient</td>
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<tr>
<td>• Network nearly immune from all flood effects</td>
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<th>Option 2: ‘Stitch in time’</th>
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<tr>
<td>• Shortened reseal and rehabilitation intervals</td>
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<td>• Reduced network vulnerability leads to reduced repair bill and lower ongoing maintenance</td>
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<td>• More cost-effective rehabilitation options</td>
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**Total transport costs**

Cost

- Excess transport costs
- Budget shortfall
- Minimum transport cost
- Sum of costs
- Agency’s total maintenance cost
- Road user cost

Level of service / maintenance standard

- Actual budget
- Optimum budget

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AN INITIATIVE BY:
Modelling and assumptions

Source data

- TMR sourced input data for model, including ARMIS
- each case study link is broken into 1km sections

Calculate vulnerability

- model determines vulnerability using data on:
  - soil type (reactive vs non-reactive)
  - seal width (lower seal width = higher vulnerability)
  - seal age (older seals more vulnerable)
  - pavement age (older pavements have higher vulnerability)

Calculate condition

- Model determines condition using data on:
  - Rutting 80th percentile value
  - Roughness (IRI)
Results

• 30 year life cycle cost analysis (2006–35)
  - Option 1 generally not advantageous
    – very high agency costs, not recovered
    – viable on higher order roads and with low discount rate
  - Option 2 appears to lead to savings
    – agency costs are same or lower with targeted spending
    – reduced impact of rain/flood events leads to significant life cycle cost savings
Can a change in agency costs lead to significant long-term savings in accident and road user costs?

<table>
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<tr>
<th>Change compared to base case for:</th>
<th>Option 1</th>
<th>Option 2</th>
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<tbody>
<tr>
<td>Increase in agency costs</td>
<td>$1,728 million</td>
<td>$105.9 million</td>
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<tr>
<td>Reduction in accident costs</td>
<td>$88.4 million</td>
<td>$40.3 million</td>
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<tr>
<td>Reduction in vehicle operating costs</td>
<td>$253.8 million</td>
<td>$162.1 million</td>
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<tr>
<td>Savings from reduced travel time</td>
<td>$211.5 million</td>
<td>$95.4 million</td>
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<tr>
<td>Freight delay savings</td>
<td>$38.9 million</td>
<td>$17.6 million</td>
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<tr>
<td>Savings from fewer trip cancellations and alternate mode trips</td>
<td>$989.5 million</td>
<td>$412.0 million</td>
</tr>
<tr>
<td><strong>Overall change to net present value</strong></td>
<td>$146.5 million</td>
<td>$621.5 million</td>
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</table>
Observations and outcomes

• Generally beneficial to spread works over greater time
  – Cheaper construction per/km (more competition)
  – Freight vehicles only encounter one/two disruptions along route
• Greater seal age was an indicator of likelihood to require TNRP works
• Strong case for sealing Peninsula Development Road
• Excluding PDR, Option 2 generates larger returns on higher volume roads
• Most western Queensland areas have not had a serious ‘test’ since 2013
Modelling performance of aged seals

- Evidence of aged seals (past target age) showing rapid deterioration and susceptibility to flood damage
- Model modified to include accelerated deterioration rate for seals over target age
  - Compared base case to option cases with typical seal age, typical minus 3 years and plus 3 years
- Shortening or extending seal lives found mixed results on the overall net present values
- Option 1 best suited with maintaining target age, Option 2 at maintained or extended seal age
Future climate and weather

- Climate change impact on Queensland:
  - more Category 3-5 cyclones
  - cyclones impacting further south
  - stable or decreased rainfall with equal or fewer heavy rain events
    - However, extreme rainfall events likely to be more intense
  - sea level rise of 1m+ by 2100
- Road pavements built for 20-30 years are especially vulnerable
- The model can incorporate various future scenarios

Projected increase in extreme rainfall events in northern, eastern and central Australia

Source: CSIRO (2015) - Climate Change in Australia: Projections for Australia's NRM Regions
Varying event recurrence intervals

- Uncertainty in future climate variables
- Analysis of shortened recurrence interval presents 'worst case' climate scenario
- Both Option 1 and Option 2 indicate high sensitivity to shortened interval
- Much higher cost savings if more regular extreme events
- Should this be considered when designing pavements for 30+ years?
Discussion and recommendations

• Many lessons learnt from 2010–13 period
• Events of this magnitude and breadth are likely in the future
• Investment strategies will have an increasing need to consider the likelihood of major weather events to build greater resilience into the network
• Modelling has shown us that…

Major routes
• benefit from high investment to create fully resilient pavements
• considerable value in maintaining passability

Rural highway network
• need assessment for vulnerability
• critical routes benefit from increased resilience
• targeted investment

Development roads and remote links
• too expensive to impart full resilience for low traffic volumes
• important to maintain basic connectivity
Next steps

• Data and modelling through agencies such as the Bureau of Meteorology could allow predictive modelling of relative flood/cyclone risk each year
  – Could this be used to develop a funding apparatus for rural networks?

• Vulnerable pavements could be identified by combining river/creek mapping with pavement structural data
  – Will this allow more efficient prioritisation of pavement maintenance and rehab?

• Are funding models appropriate? NDRRA-style joint funding has benefits but requires strong ongoing commitment from Commonwealth
  – In times of austerity, will Commonwealth funding always be accessible?
Thank you

Any feedback, thoughts, suggestions...
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