Position Paper 2.21: P4

Managing Road Assets in Times of Multiple Extreme Flooding Events

Project 2.21:

New project management models for productivity improvement in infrastructure

Sustainable Built Environment National Research Centre

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Synopsis

Position Paper 4 provides the background for NSW Roads & Maritime Services and Queensland Transport & Main Roads escalating maintenance costs related to the effects of flooding from multiple extreme weather events. This escalation puts into question traditional asset management rational choice methodology. The international benchmark of predictive maintenance to conserve road assets becomes impossible to operationalise under the continuing bombardment of extreme weather on the same assets year after year.

The Position Paper outlines the ravages of flooding (2009-2013) from Declared Natural Disasters (DND) events in both New South Wales and Queensland. From the statistics available it is easy to understand the extent of the problem.

Location-based thinking (LBT) is offered as a solution to the reactive maintenance cost escalation problem. LBT is a fundamental proximity framework that shifts the focus onto service provision as an asset management solution.

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MANAGING ROAD ASSETS IN TIMES OF MULTIPLE EXTREME FLOODING EVENTS

Traditional Portfolio Asset Management programs can no longer cope with multiple extreme flooding events. The Commonwealth and state governments' National Disaster Repair and Relief Arrangement has supported state transport authorities to return road networks "to normal" after flood damage. However, the continuing problem of multiple flooding of the same roads, calls for another solution. The service enablement perspective is fundamental for applying location-based proximity integration methodologies to road network management under conditions of disaster recovery.

Introduction

This project was borne from the idea that, to make a radical improvement to the productivity of construction work, it is first necessary to deconstruct the way we do things. This project aims to deepen our understanding of the way we organise construction work arising after environmental disasters.

The concepts are neither radical nor new. In fact, the ideas come from direct observation of construction management and project administration. And yet, they seem radical and perhaps even confronting. Any change can seem a challenge to what we know.

While Project 2.21 explores the way location is already used in the management of infrastructure projects, this position paper presents the case for a service oriented response to capital works arising from natural disasters. In this context, an alternative approach to location-based thinking allows for location to be defined not only in terms of physical location breakdowns, but also according service corridors where the principle of proximity applies to service lines. Thus continuity of service (and minimising disruption) become key components of asset management.

The importance of location for predictive and reactive maintenance

Location is the organising principle of economic activity as well as social-ecological interaction. Location-based thinking is implicit in all decisions for public road asset management (Kenley, 2014). Location-based thinking is also key to both predictive and reactive maintenance informed by services enablement decision-making processes for public roads asset management.

Whether or not roads have just been built, just been flooded or are undergoing some maintenance work, their geographic location provides an epicentre for government administration and user "reality".

Public Roads as Assets

The 2013 UK *Highway Infrastructure Asset Management Guidance* provides an explanation for the purpose, the processes and the monitoring of a road authority asset management system. The most effective means of managing assets is a well ordered, standardised plan of maintenance.

In their 2014 journal article, Taggart et al. provide an easy-to-read, step-by-step overview of this guide from the perspective of rational choice

theory. Their paper describes public road asset management complexity: levels of policy decision-making responsibility, operationalisation processes and whole-life monitoring/audit expectations.

The authors' statements, in which a well-managed and well-funded predictive maintenance regime is the outcome of an asset management plan, are based on standardised ratings for prioritizing works. Prioritised planning that aims to identify short, medium and long-term activities, has its foundation in a "steady state" premise with utilitarian measuring of road "wear and tear". Human use, such as vehicular traffic, can be measured, and changing safety or construction standards can also be factored into maintenance requirements.

Managing the Australian Road Networks Assets

Historically, road travel has played a dominant role in the lives of Australians. In a country that has a large landmass and a small population, roads are always critical for national productivity, local economic growth and individual social well-being (BCA, 2014).

Thus, responsibility for construction and maintenance of public roads is a major function of all levels of government (Allen, 2009). The Transport Infrastructure COAG is the major cooperative roads policy development mechanism. It creates policy and operational ways and means for all Australian public road

networks to ensure positive economic and social outcomes.

Until recently the benchmark to obtain positive outcomes was asset management based on a standardised plan of predictive maintenance (Burningham and Stankevich, 2005).

However, predictive maintenance is often replaced with reactive maintenance. For example, between September 2010 and March 2011 Australia experienced a doubling of the annual rainfall. The heavy rains resulted in widespread and extensive flooding inundating the roads of major cities, towns and regional areas (ABS, 2012) forcing road authorities to focus on reactive maintenance procedures (Schraven et al., 2011).

We have to accept that statistical analysis of data on road use (Taggart et al., 2014) is only part of the story. What is increasingly important is the 'wear and tear' impact of extreme weather events. For road authorities responsible for a significant proportion of the national road network, the issue of managing road maintenance and repair during and after heavy flooding is of growing concern (MRWA, 2012; QLDMR, 2012; NSW RMS, 2012).

Natural Disaster Relief and Recovery Arrangements (NDRRA)

The Transport COAG was instrumental in the development of the National Disaster Relief and Recovery Arrangements (NDRRA) (Biggs, 2012). The aim of NDRRA is to reduce the financial burden for states, communities and individuals by providing financial assistance for specified items during emergencies or recovery.

A Declared Natural Disaster (DND) is specified by the Federal Minister responsible at the time of event. Two types of natural disasters effect Australia. Bush fires are usually related to hot, dry weather. Storms (excessive rainfall, cyclones and tornadoes) are related to wet weather.

The NDRRA archive lists DND (Australian Government 2014) as shown in Table 1, events between January 2006 and January 2014 for the three states with the largest road networks.

The DND descriptors provide evidence of the number of extreme wet weather events characterised by storms and flooding. The expected high percentages for both Queensland (80.0%) and Western Australia (74.3%) during this period are not replicated in NSW in Table 2. This is because NSW was afflicted by an usually large number of dry weather DNDs. The 34 Bush Fire DNDs (many burning concurrently) outnumbered the flooding events that occurred between August 2013 and January 2014.

Table 2 compares the number of DNDs associated with extreme flooding during 2010-2012 with the number of local government areas (LGA) affected. Although the number of events is small, the extent of the flooding is indicated by

State	Previous	Current	Flooding as % of total number
New South Wales	20	42	40.3
Queensland	20	19	80.0
Western Australia	22	13	74.3
Total	**62**	**74**	**61.2**

Table 1. Comparison of the number of Declared Natural Disasters and the percentage with flooding (2006–2014)

State	2010	LGA2010	2011	LGA2011	2012	LGA2012
New South Wales	4	87	5	70	2	18
Queensland	1	5	4	85	3	32
Western Australia	1	12	8	38	3	16

Table 2. Comparison of the number of extreme flooding events and number of local government areas (LGA) involved (2010–2012)

the large number of LGAs. In this case, a definition of an extreme weather event can be measured by the size of the geographical area flooded.

NSW Roads and Maritime Services (NSW RMS)

The New South Wales Department of Transport was restructured and re-named in November 2011 (NSW RMS, 2012). The Road Transport Authority (RTA) became the Roads and Maritime Services (NSW RMS). However, the change of internal structure does not appear to have changed the road management systems for the years under consideration (2009–2013) and in this position paper NSW RMS will be used. Table 3 provides some details of the extent of the NSW road networks and the jurisdictional demarcation (changes in actual numbers during the period being studied is minor).

Local Government roads within cities and towns far outnumber those in rural regional areas (Allen, 2009). It is interesting to note that types of road surface are as important as the location of the asset. Of course, significant maintenance relates to resurfacing.

The Assets to be managed are listed in Tables 3 and 4, and include both a ferry (because the waterway to be crossed is considered a highway) and the iconic Sydney Harbour Bridge.

According to the annual reports, Asset Management for the New South Wales road network is developed within the context of projections for population growth, economic prosperity and environmental sustainability. The aims, goals and outcomes are related to the State Plan and reports of the Auditor-General (NSW RMS, 2010–2013).

The performance of the department is monitored for a wide variety of outcomes. The major categories are road usability, transport capacity and public safety. Major and/or minor maintenance works focus on road surface condition, slope, stability and culvert functionality. The planning for these activities is linked to continually improving regulation, rising technical standards and effective management of ICT systems (NSW RMS, 2010–2013).

State Roads	Local Government Roads (regional)	Local Government Roads (local)
42,000 lane-km arterial pavement	13,600 km sealed roads	20,000 km urban sealed roads
750 lane-km unsealed road	4,800 km unsealed roads	40,000 km non-urban sealed roads
200 million m of surface		82,000 km non-urban unsealed roads

Table 3. Indicative road infrastructure NSW RMS managed assets

State Structures	Local Government Structures (regional)	Local Government, Structures (local)
4,800 bridges	1,500 non-timber bridges	5,000 bridges non-timber
37 tunnels	323 timber bridges	2,600 timber bridges
3,300 signals		

Table 4. Indicative non-road infrastructure NSW RMS managed assets

The consistent expectation is for the Department to provide a cost effective or "value for money" infrastructure, based on available funding (Rouse and Chiu, 2009). A variety of sources of funding is identified: individual road users as part of their vehicle license fee, company road user fees and federal infrastructure support.

These basic Asset Management activities and funding sources are impacted by severe weather events that cause flooding of any part of the road network within the State.

NSW RMS 2009–2013 Declared Natural Disasters: road repairs for storms and flooding

Annual Reports do not provide a breakdown of maintenance for Declared Natural Disasters into units smaller than "road" as shown in table 5. The NSW RMS annual reports provide a picture of natural disaster flooding increasing between 2010 and 2012, which is inferred from the ever increasing repair bill provided in Table 5. A significant amount of funding is provided by the Commonwealth government to be administered by state governments for local government road repair and recovery to pre-disaster condition (NSW RMS, 2010–2013).

Table 6 provides an indication of the continuing number of extreme weather events. According the annual reports, during 2009-10 some NSW communities experienced up to five separate extreme weather events. Extreme weather events place excessive unexpected demands on 'normal' social, political and economic decision-making (Bosher, 2014; Biggs, 2012) It can be inferred that there was growth in funding for reactive rather than predictive maintenance in order to rapidly regain normal services.

Table 5 also illustrates the importance of road asset management responsibility throughout the entire road network. The extent of the damage to different types of roads (Table 6) within the variety of administrative jurisdictions (Table 5) means that the location and especially the proximity of damage and repair efforts becomes an important element for prioritising maintenance.

Government level	2010–2011	2011–2012	2012–2013
Local Government Roads	120.0	158.4	167.0
State Roads	71.2	32.4	39.4
Regional Roads	22.6	27.2	36.2
Crown Roads	0.8	1.5	0.7
Total	**214.6**	**219.5**	**243.3**

Table 5. NSW Designated National Disaster road expenditure: AU$m during financial year

	2009-2010	2010-2011	2011-2012	2012-2013
Number of severe weather events Declared Natural Disasters (NDRRA)	6	8	7	5
Number of Local Government Areas effected (NDRRA)	87	95	94	104
Repair of ROAD storm & flood damage (NSW RTA/RMS)	$80.5m	$214.6m	$219.5m	$243.3m

Table 6. Comparison of DND for NSW severe weather, local government areas involved and road repair expenditure

Although the uncertainty of severe weather event road damage cannot always be included in a state Roads Asset Management Plan, adapting the Plan becomes necessary. This is especially important because the percentage of the total road maintenance budget allocation to deal with continuing disruptive effects of flooding events has been increasing since 2010 as shown in Table 7. These worrying figures indicate that by 2013 over half the available budget was allocated to natural disaster recovery driving the need for methods to minimise expenditure.

Reconstructing Queensland

The main component of physical assets for QTMR is the value of the land under the road infrastructure network (QTMR, 2013). The asset has increased in value, as noted in Table 8.

The ideal of having a long-term plan to manage fixed assets is important. However, what happens when your asset, such as the road network in Queensland, keeps being washed away or damaged due to continuing extreme weather events that includes extensive flooding?

Queensland 2010-2013 declared natural disasters

Table 9 lists the 11 extreme flooding events in Queensland between December 2010 and March 2013. Queensland has 77 Local Government Areas (LGA)s. The extreme weather events affected all 85 LGAs in 2010–11. The number of LGAs experiencing transportation and economic disruption has decreased since then: 89% (65) in 2011–12 and only 76% (56) in 2013. However, the widespread disturbances required a state-wide organisational oversight.

	2009-2010	2010-2011	2011-2012	2012-2013
Total ROAD maintenance budget (RTA/RMS)	$412.5m	$849.7m	$856.6m	$933.2m
Repair of ROAD storm & flood damage (RTA/RMS)	$80.5m	$214.6m	$219.5m	$243.3m
Estimate of outstanding ROAD recovery damages (RTA/RMS)	----	$200.0m	$240.0m	$280.0m
Percentage of total ROAD maintenance for disasters	19.50%	25.30%	25.60%	26.10%
Percentage of total ROAD maintenance budget for current year (disaster recovery plus outstanding disaster recovery)	-----	**48.00%**	**53.40%**	**56.10%**

Table 7. NSW DND road recovery expenditure and planned recovery, plus percentage of total road maintenance budget (2009-2013)

Financial year	QTMR $value	Infrastructure network $value	Infrastructure network % of value
2011-2012	$46.91 billion.	$40.92 billion	87.20%
2012-2013	$54.45 billion.	$45.00 billion	82.60%
2013-2014	$60.74 billion	$56.22 billion	92.60%

Table 8. QTMR asset value 2011-2014

The Queensland Reconstruction Authority (QRA) was established to manage and administer the NDRRA program in Queensland in 2010–11. However, with the constant number of extreme weather events, the role of the QRA has been expanded to include continued work required from 2007.

An integrated State recovery and reconstruction plan *Queensland 2013 Flood Recovery Plan* is the umbrella Plan for the Queensland Reconstruction Authority. The initial time frame for the Authority continues to be extended due to continuing problems caused by repeated flooding. Current end-date is June 2015.

Extreme Weather Events
NDRRA/SDRA Activations 2013-2014
Far North Queensland Flooding, 27 - 31 January 2014
Tropical Cyclone Gillian, 10 - 11 March 2014
Central Coast and Southern Queensland Trough, 26 - 30 March 2014
Tropical Cyclone Ita and associated rainfall and flooding, 11 - 14 April 2014
Central and Western Queensland Flooding and Rainfall, 18 - 28 February 2014
North East Queensland Monsoonal Rainfall and Flooding, 7- 9 Feb 2014
Tropical Cyclone Fletcher and Associated Rainfall and Flooding, commencing 2 February
Tropical Cyclone Dylan, 31 January 2014
NDRRA/SDRA Activations 2012-2013
Longreach Floods, 18 February 2013
Central and Southern Queensland Low, 25 Feb - 5 March 2013
Tropical Cyclone Oswald and Associated Rainfall and Flooding, 21-29 January 2013
Barcoo Severe Storm, 15 January 2013

Table 9. Queensland extreme weather events 2012—2014
On-line: http://www.disaster.qld.gov.au/Financial%20Support/Activations.html

The role of the QRA is to work with local communities affected by disasters to co-ordinate service delivery ensuring "unique characteristics" are factored into the rebuilding process. The State has budgeted more than $6.5 billion for major restoration and repair to State controlled roads under the NDRRA framework since 2010.

Department of Transport and Main Roads allocate NDRRA funds for reconstruction and longer term delivery of repair works. Queensland provides more than 25% of total funds (the Commonwealth funds up to 75%) under the joint NDRRA scheme.

The *Transport Network Reconstruction Program* is a program developed by the Department to manage the volume of works required to implement the Program. Repairing the road network also includes repair or replacement of: bridges & culverts, earthworks & batters; removal of silt & debris.

QTMR capital expenditure is "mainly spent on construction of transport network assets." The standard reporting format for 2009 to 2013 provided details for both road maintenance and capital expenditure (new road construction) as shown in Table 10 (The revised budget is now $6.519b).

However, the continuing extreme weather events have come to dominate the QTMR annual report. The operating environment outlined in the annual reports from 2011 is based on Transport and Main Roads Corporate Plan 2011–2015. In 2011–12 the first listed factor impacting on delivery of the strategic plan is: re-prioritisation of resources to reconstruct parts of the transport and road network damaged in severe weather events in 2010–11. This is an indicator of the impact of reactive maintenance adapting to the planned asset maintenance program.

Category	Investment
Total investment in transport infrastructure program (2013–14), including:	$4,532,494
Natural Disaster Relief and Recovery Arrangements (NDRRA) works	$1,820,899
Maintenance and operation state transport network	$629,880

Table 10. Annual Report expands on this change, by reporting maintenance funding in a new format; Statistics for Queensland at 30 June 2014.

Clearly, the on-going, never stopping reality of limitation on transportation of goods, motor vehicle use for work and pleasure, access to the road network by cyclists, has meant a redefinition of maintenance works.

An increasingly important factor in the QTMR operating environment was indicated in the 2013–14 Annual Report; "Future disasters—managing disrupted transport infrastructure and services due to unforeseen or significant events".

Queensland Betterment Of Flood Recovery Road Works

The continuing number of Declared Natural Disaster (DND) funded by NDRRA each year, has placed extreme pressure on traditional road management methods. The early limitation for NDRRA funds to be used to "repair" rather than "improve" the road network did not take into account problems of multiple flooding events in the same location.

Queensland, as in other states, has found that "returning to normal" often means repairs that are then washed away in the next extreme flooding event. Table 11 indicates how the reporting of government funding for roads implements a type of services enabled asset management funding

Year	Length of Flooded State Controlled Roads	% of total State controlled roads (33 328 km)
2011	20,610km	61.90%
2012	10,890km	32.70%
2013	7,655km	23.10%

Table 11. Queensland State-controlled roads affected by flooding 2011–2013

arrangement. Currently 45% of the Capital Works Funding is directed at NDRRA projects, and 47% at Road Construction.

In parallel to the NDRRA funding is a Pilot program focused on Local Government assets only and administered by the Department of Local Government, Community Recovery and Resilience (DLGCRR). An additional $80M Federal/State Betterment Fund was instituted after 2013 events. with the purpose to construct more resilient assets, such as stronger roads, bridges & culverts to provide better drainage for potential long term cost savings. NDRRA project assessment also includes betterment options (Bosher, 2014).

The Role of Location-Based Thinking

“Location” as a management system is poorly documented in relationship to network asset management literature.. Although location is understood to be a significant factor for planning and organising works, there are no publications highlighting location as a significant analytical factor. Indeed there is a lack of published research suggesting models for more efficient management of network assets based on location.

Physical and service proximity

This research has identified two meanings for location in relation to works management (both planned and reactive) and each is a factor in efficient works planning:

- Physical proximity such as regions
- Service proximity such as a road line

These are both illustrated for the case of the Newell Highway Corridor (Figure 1), showing the dual effect of proposed works.

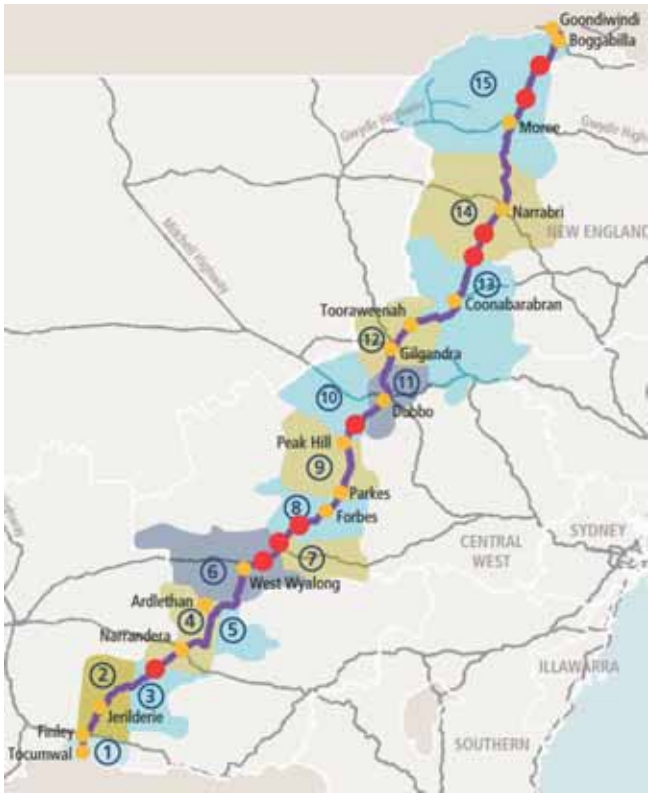

Figure 1: Newell Highway Corridor showing
—Physical Location as regions
—Service Location as the road corridor
—Works (red) in both regions and on the corridor

Moreover, physical and service proximity factors are exaggerated in the context of a widely distributed portfolio. In the two jurisdictions considered in this research, NSW and Queensland, each has a very large portfolio, with a diagonal distance of approximately 1,300 and 2,000 Km respectively. This means many regions to be managed as well as very long “service”

runs on major highways. A long service run means that two works planned at the same time in different regions (hundreds of kilometres apart) should be considered in close proximity. Location-wise a road user will experience disruption to their journey from both works on the same journey. This type of disruption incurs societal costs due to the impact on road users which, given the service provision function of the asset portfolio, represents a reduction in service delivery.

Services enabled transport infrastructure Asset Management

The traditional transport infrastructure Asset Management approach is the preservation of the condition of the asset, where strategy is based on management of the life-cycle of the asset. Indeed, there is a conflict between the desired outcomes for those responsible for asset condition (governance approach) and those responsible for service delivery for which the asset is provided (service orientation) (Brackertz & Kenley, 2002).

Increasingly, road authorities appear to be taking a service oriented approach in managing their road network assets. QTMR, for example, have a services enabled prioritisation model of planned works that takes into consideration both physical proximity and service proximity. In this way both cost efficiency and service efficiency can be targeted.

However, the extent to which physical proximity and service proximity factors are used in Portfolio Management varies greatly. This may be because it is poorly documented. Thus, the lack of location-based research highlights a need for a well-defined methodology to assist managers identify and justify their approach.

Budgeting for compounding extreme weather events

SBEnrc Project 2.21 is concerned with the relationship between organisation of project data and the production efficiency of work. In the context of planning and managing a program of capital works which is impacted by extreme weather events, the aim is to reduce both the cost of planned works and reactive maintenance.

In this situation, reactive maintenance should be considered a disruption to planned works. And as has been the experience in Australia lately, the planned reactive maintenance works may themselves be disrupted by further extreme weather events leading to more reactive works.

The coincidence of planned works with reactive works, the situation where planned works are at the same location (both physical and service) as reactive works, needs careful consideration. Due to the different source of funding of reactive works from the source of funding for planned works, non-prioritised planned works that are adjacent to urgent reactive works may be ignored (or recovery budget rules may only fund reinstatement). This will result in increased cost and increased service disruption when planned works are eventually undertaken. Indeed, it may

be the case that planned works may negate the need for reactive works—an upgrade to prevent flood damage being a good example.

Recommendations

Three important recommendations arise for Portfolio Asset Management of distributed road networks:

1. When planning capital works, both physical and service location groupings should be used to drive production and service efficiency.
2. When planning reactive works, both physical and service location proximity should be used when reassessing the priority of planned works—including previously non-prioritised works.
3. Reactive budget prioritisation and allocation should allow for reinstatement contributions to be redirected into previously non-prioritised planned works that will prevent repeat damage.

Figure 3. 100 year flood simulation after preventative works
Source: NSW RMS

Figure 2. 100 year flood simulation without preventative works
Source: NSW RMS

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