



# 16<sup>TH</sup> AUSTRALASIAN TUNNELLING CONFERENCE 2017

30 OCT - 1 NOV 2017  
THE STAR SYDNEY

**CHALLENGING UNDERGROUND  
SPACE: BIGGER, BETTER, MORE**

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**Dan O'Connor, Team Leader Tunnels, GHD**



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UNDERGROUND SPACE:  
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# Nightcap WTP Outlet Tunnel Rehabilitate or Replace?

DD O'Connor<sup>1</sup>, SR Macklin<sup>2</sup>



# Overview

- Background on Nightcap WPT
- History and setting of the Nightcap WPT Outlet Tunnel
- The Problem
- Success criteria
- Constraints on the project
- Solution development
- Solution outcomes

# Background

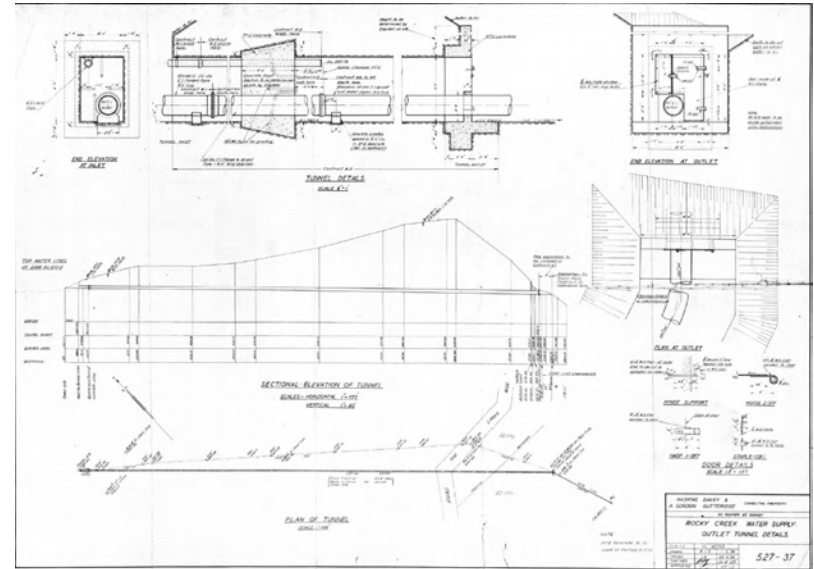
- Owner – Rous County Council
- Rous County Council is the regional water supply authority of Northern Rivers region of NSW.
- Nightcap Water Treatment Plant provides approximately 90% of the water.
- Bulk water passes through a DN 750 cement lined mild steel pipe, located within the unlined Outlet Tunnel.





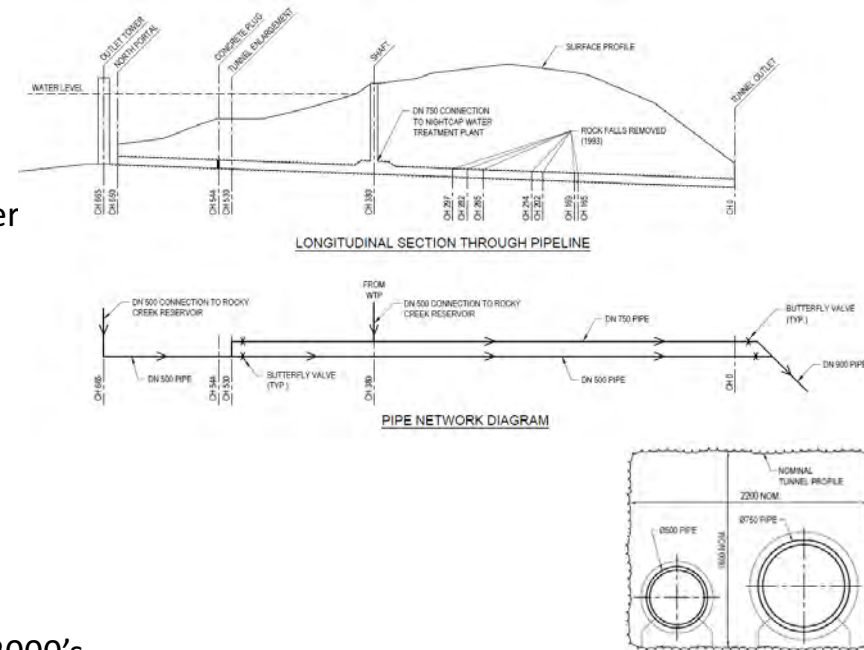
# Construction

- Designed by GHD in late 1930s.
- Original concept consisted of:
  - ~25 m high dam
  - Water intake tower
  - Cast Iron DN 500 (mm) water transfer pipe
  - 1200 mm wide x 1800 mm high unlined tunnel
  - Mass concrete tunnel plug
  - Tunnel ventilation intake
- Anecdotally this reflects the scheme that was constructed and first impounded in 1953



# Upgrades

- Upgrades were carried out in 1984:
  - Widening of the tunnel to 2200 mm wide
  - Installation of mild steel DN 750 water transfer pipe
  - Removal of rock fall debris
  - Installation of sections of rock support
  - Installation of intake shaft for future Water Treatment Plant
- Construction of Water Treatment Plant in 1992/3
- Construction of New Water Intake Facilities early 2000's



# The Problem

- 2013 safety concerns raised regarding leaks around the mass concrete tunnel plug.
- Inspection of the tunnel considered that risks to the tunnel, water transfer pipes and plug were high.

GHD engaged in 2014

- A DN 150 ventilation pipe of unknown material/condition that penetrates the plug.



# Success Criteria

- What is a successful outcome?
- Critical Review = Listening + Reflect

Two separable success criteria:

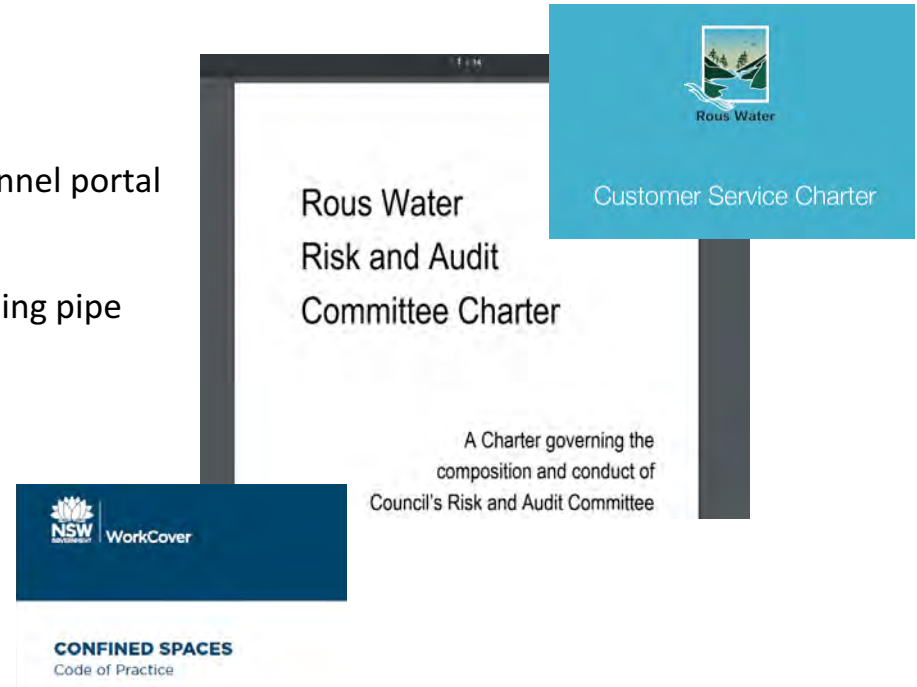
1. Isolation of the tunnel from the reservoir; and
2. Improving the risk rating of the DN 750 pipe to the year 2060 and beyond.






# Constraints

1. Access – Limited access to the pipeline and tunnel portal
2. Operation - Critical nature of flows in the existing pipe
3. Work Health and Safety
  - Underground, and
  - Confined space.




  
Rous Water

Customer Service Charter

Rous Water  
Risk and Audit  
Committee Charter

A Charter governing the  
composition and conduct of  
Council's Risk and Audit Committee

  
NSW WorkCover

**CONFINED SPACES**  
Code of Practice

# Access

1. The trackway was in poor condition
2. Necessary to upgrade the access track for significant works at the southern portal.
3. Crossed private land with a risk that access could be restricted.



# Operation

1. Any outage of greater than 24 hrs would be catastrophic to Rous
2. DN 750 pipe and the tunnel had to remain in almost continual operation
3. Surface bypass pumping expensive and would result in a pipe that would pass under/over the only entrance to the water treatment plant.





# Work Health and Safety

Work Health and Safety Act (2011) requires:

*“persons who have a duty to ensure health and safety to ‘manage risks’ by eliminating health and safety risks so far as is reasonably practicable, and if it is not reasonably practicable to do so, to minimise those risks so far as is reasonably practicable”*

1. Confined space
2. Unlined rock tunnel that had suffered significant rock falls in the recent past.

## Builders negligent in Sydney tunnel death: coroner

Updated 24 Aug 2007, 2:42pm

The New South Wales coroner has found that the builders of the Cross City Tunnel should have done more to protect a worker who was killed in a rock fall.

Ronald Shores died on July 29, 2004, when a section of roof collapsed on him while he was working on a ventilation tunnel as part of the tunnel project.

At the time, Mr Shores was drilling a hole from under unsupported roofing.

The Deputy state coroner, Carl Milovanovich, has found that the death was preventable.



PHOTO: Ronald Shores died during the construction of the Cross City Tunnel. (File photo) (ABC TV)

MAP: Sydney 2000



# Confined Space

## Model Confined Space – Code of Practice (2014)

- Relies on the “self assessment of risk”
- Owner, Rous, and their officers have a duty of care to ensure works use the appropriate measure to eliminate or minimise risks. In particular:

*“should eliminate the risk of engulfment”*

Concerns included:

1. Uncertainties with regard to the bulkhead
2. Restricted means of escape due to the pipes in the invert.



# Unsupported ground

## Unsupported ground in existing tunnels:

- There are no regulations, Australian Standards or Codes of Practice
- Guidance is given by some recent authors:
  1. Gilchrist and Lee, 2014
  2. Rosin, 2005 or
  3. Rosin and Brown , 2005

The combination of risks indicated that rehabilitation works within the tunnel would present an unreasonable level of risk to personnel and the water supply



# Solution Development

- Conventional methods
  - Barraging down and rock bolting
  - Grouting tunnel
- Early isolation
- Permanent bypass pumping
- Constructability Review
- 16 different solutions
- MCA with a 30/40/30 Split between Cost, Construction Risk and Residual Risk
- Confirmed by ECI process and competitive tender

Assessment Multi Criteria		Weighting (%)	Code
<b>COST</b>			
Comparative cost:		100%	\$
<b>Risk during construction</b>			
Risk of damage to operating DN 750 pipe		40%	Des
Risk of damage to redundant DN 600 pipe prior to isolation		20%	Des
Construction Safety - Geological/geotechnical risk and uncertainties slips, pits and falls, etc.		20%	Des
Risk to construction cost and program - Access limitations		20%	Des
Impact on RW reputation (ie Does this option involve a greater risk of negative publicity for Ecos Water)		5%	Q
Statutory approval requirements / delivery risk - Engineering & Environmental Approvals and Planning		5%	Q
<b>Residual Risk and Ability to Close Water</b>			
Corrosion of pipes etc. - Risk and consequence of damage to existing assets due to pipe failure down stream of bulk head		20%	Q
Falling rock - Risk and consequence of damage to existing assets due to geological/geotechnical risk and uncertainties		20%	Q
Ease of increasing water transfer volumes		20%	Q
Blow, trips falls within the tunnel - Risk and consequence of injury to maintenance staff due to loose objects		10%	Des
Transport and access - Risk and consequence of injury to maintenance staff due to road closures		10%	Des
Falling rock - Risk and consequence of injury to maintenance staff due to geological/geotechnical risk and uncertainties		10%	Des
Blow, trips falls within the tunnel - Risk and consequence of injury to maintenance staff due to loose objects		10%	Des
Transport and access - Risk and consequence of injury to maintenance staff due to road closures		20%	Des
Falling rock - Risk and consequence of injury to maintenance staff due to geological/geotechnical risk and uncertainties		0%	Q
<b>TOTAL</b>			

# Solution Outcomes

- First:  
Permanent duplication of the water transfer system (pipe jacking).
- Second:  
New tunnel plug from an adit  
(Conventional)

Pipe jack is complete; New tunnel plug due to begin shortly.





## Concluding Remarks

- There is a wide range of technologies that can be used in the rehabilitation and replacement of tunnels.
- Assessment of risk constraints is vital for successful outcomes
- It is vitally important to *critically review the objectives of the work at the outset to make sure we are “solving the right problem”*



This work was conducted in collaboration with Michael McKenzie Rous County Council Mark Stalhut of the NSW Public Advisory.