



Some Perth Bridges on Soft Soils

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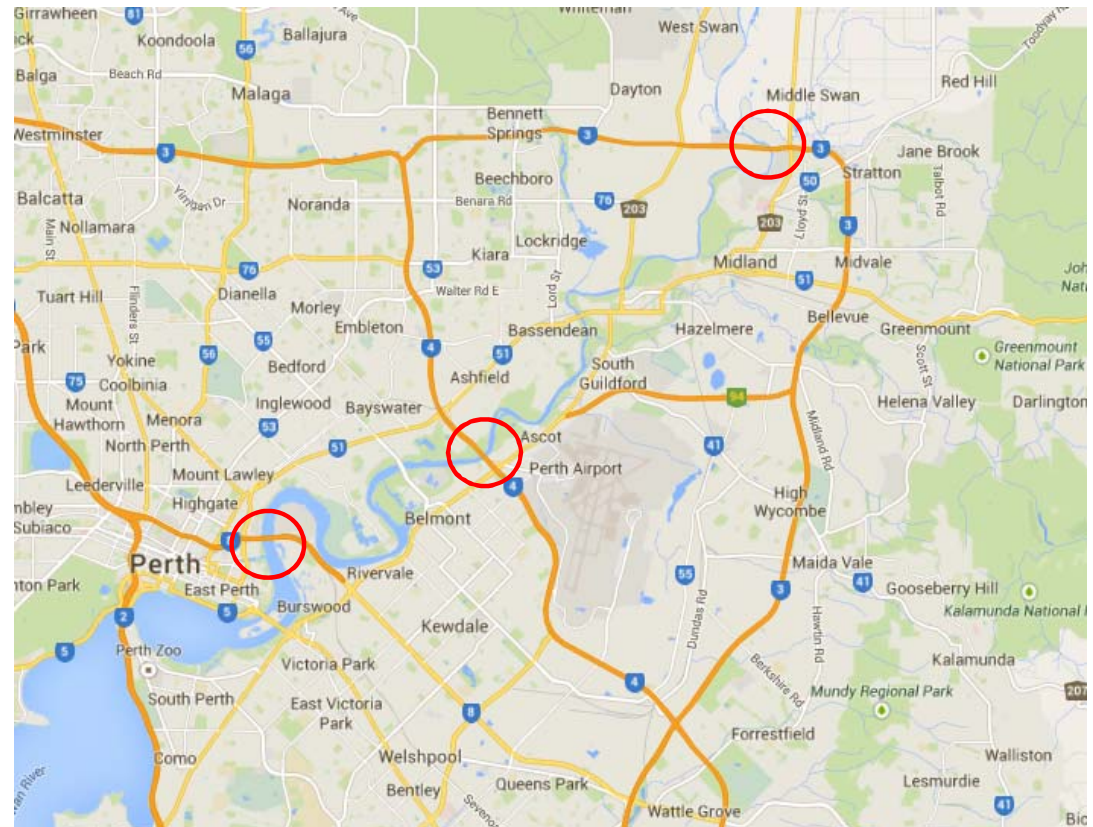
Australian Geomechanics Society
Soft Soils Seminar 14 November 2014





Overview

- Most bridges across the Swan or Canning Rivers have encountered soft soils. Some of these are described in the previous presentation.
- Some further experiences with selected Perth bridges on soft soils:
 - Goongoongup Rail Bridge
 - Redcliffe Bridge
 - Whiteman Bridge
- Summary of solutions adopted



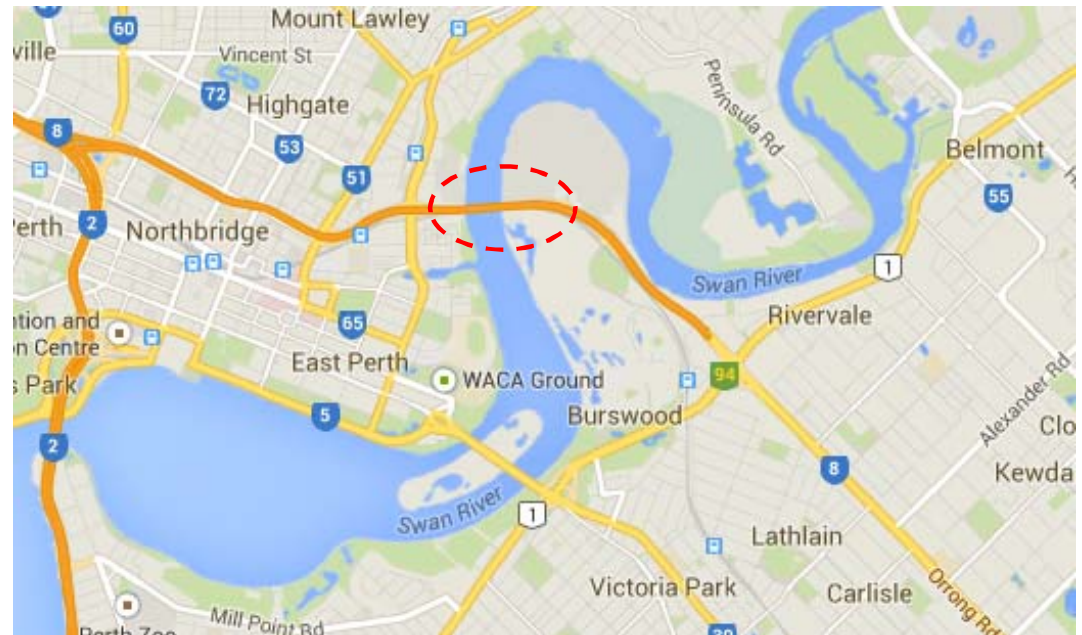


Goongoongup Rail Bridge



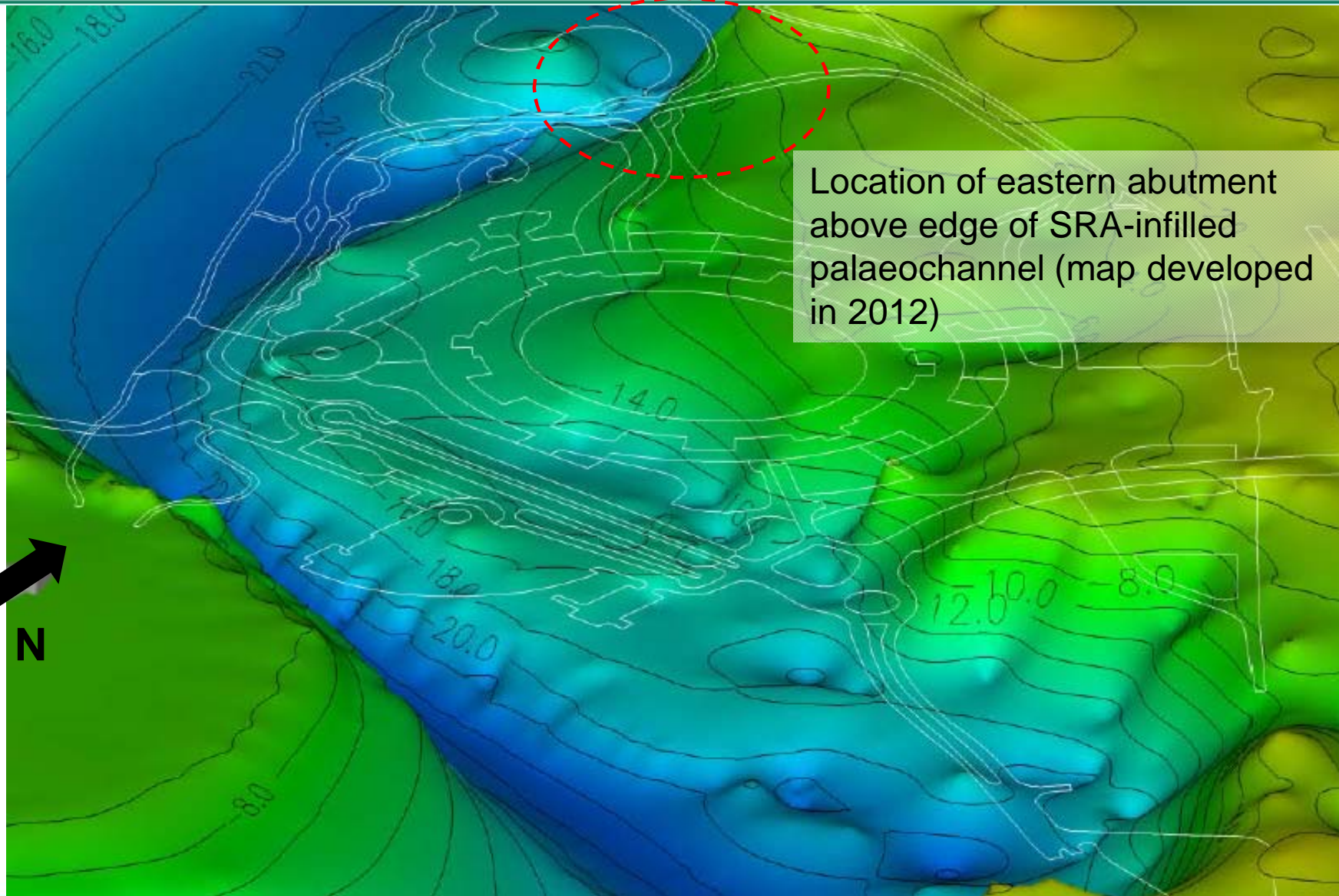
Goongoongup Rail Bridge design commenced in 1992, bridge opened in 1995.

Windan Bridge (opened 2000) carrying Graham Farmer Freeway is located immediately upstream (to the left in the photograph).





Position of East Abutment

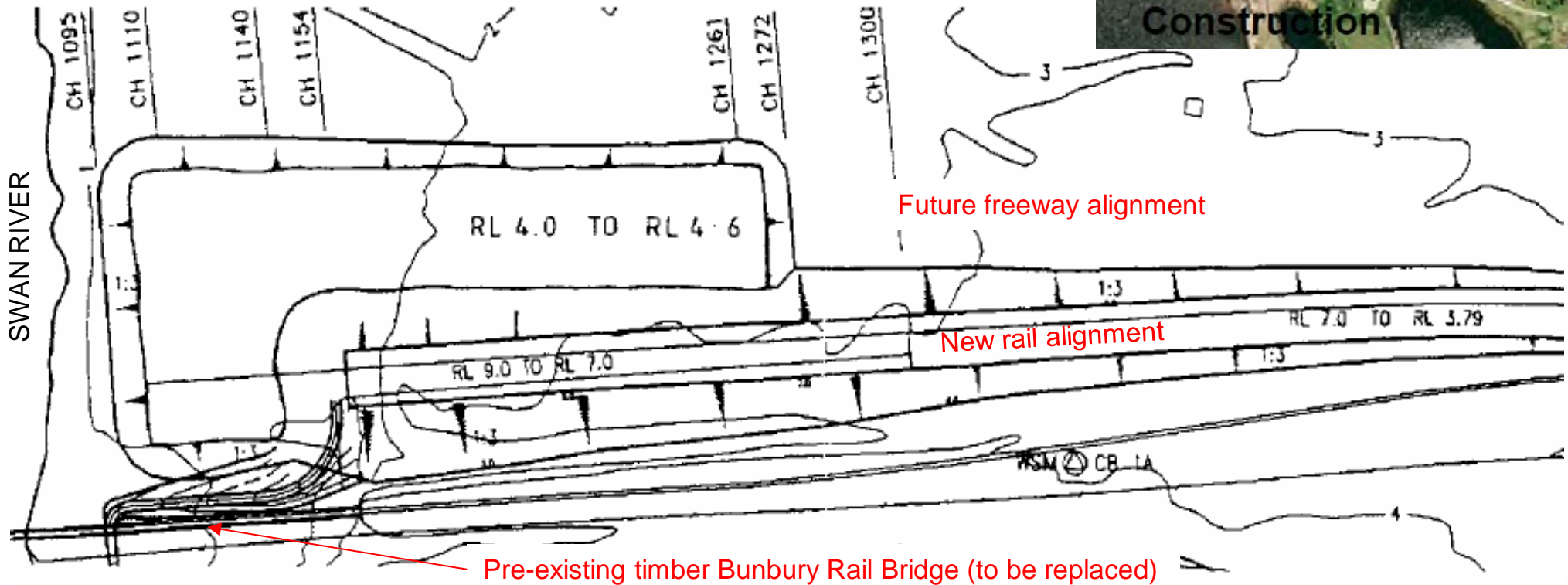


Location of eastern abutment above edge of SRA-infilled palaeochannel (map developed in 2012)



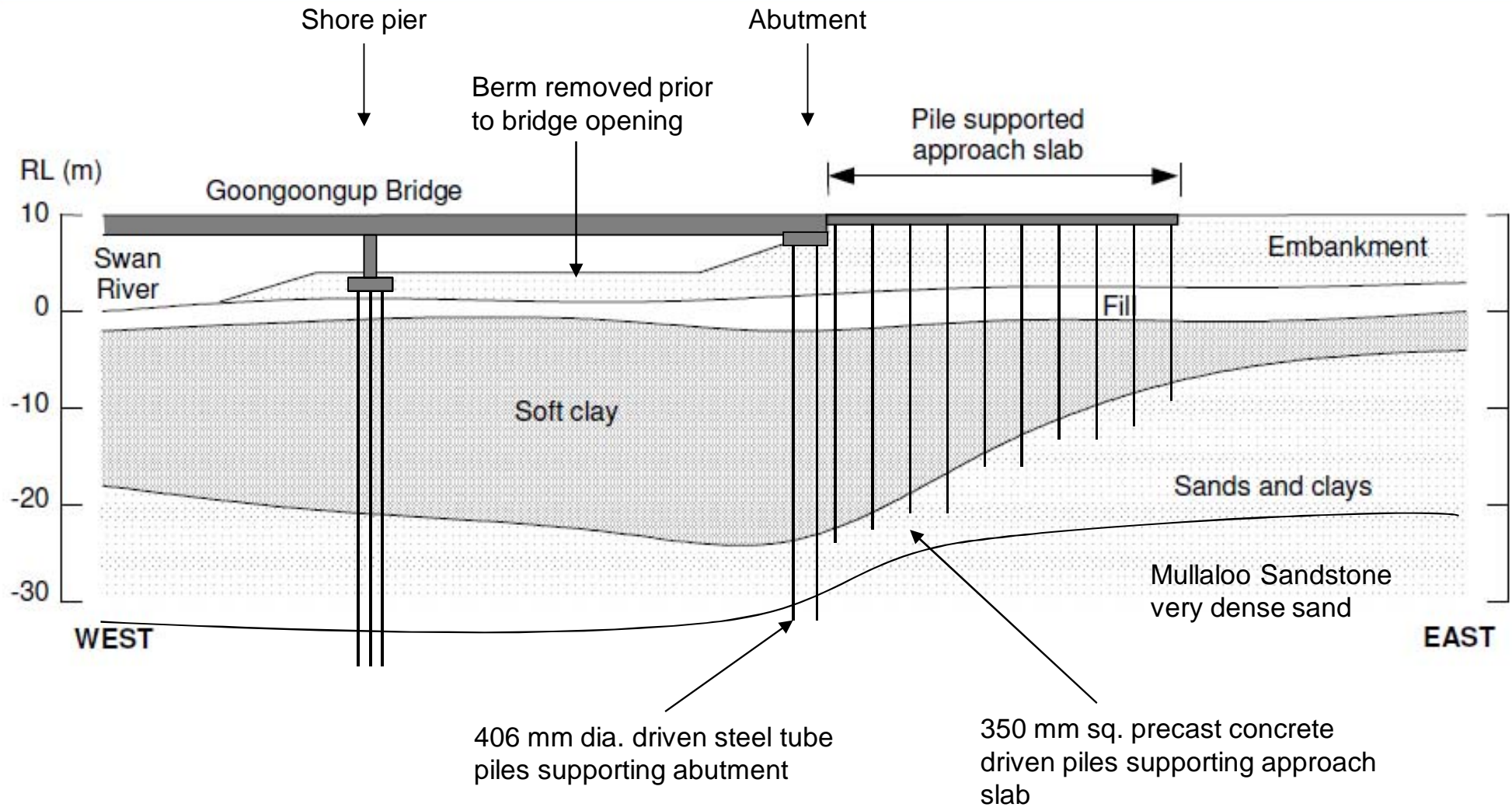
Earthworks

- Oct 1993 – Wick drains installed to ~20 m depth (depth limit of equipment used) at 1.8 m spacing on a triangular pattern.
- Dec 1993 – Rail embankment raised to RL 6. Stabilising berms to about RL 4 extended out over the future road bridge embankment and to the river foreshore.
- June 1994 – Rail embankment raised to RL 10.
- Aug 1994 – Driving abutment piles after about 1.5 to 2 m settlement.





Foundations



Diagrammatic representation



Post Construction Movement

Parameter	Horizontal Movement of Abutment		Vertical Settlement of Embankment
	South (Downriver)	West (Toward River)	
Movement 1995 to 1997 (measured)	13 mm	71 mm	
Movement 1995 to 2008 (measured)	88 mm	151 mm	~ 500 mm
Movement 1995 to 2095 (projected)	163 – 178 mm	226 – 281 mm	
Approx. rate of movement in 2008 (ref. to 1 Nov. 1993)	125 mm per log cycle of time	85 mm per log cycle of time	400 mm per log cycle of time

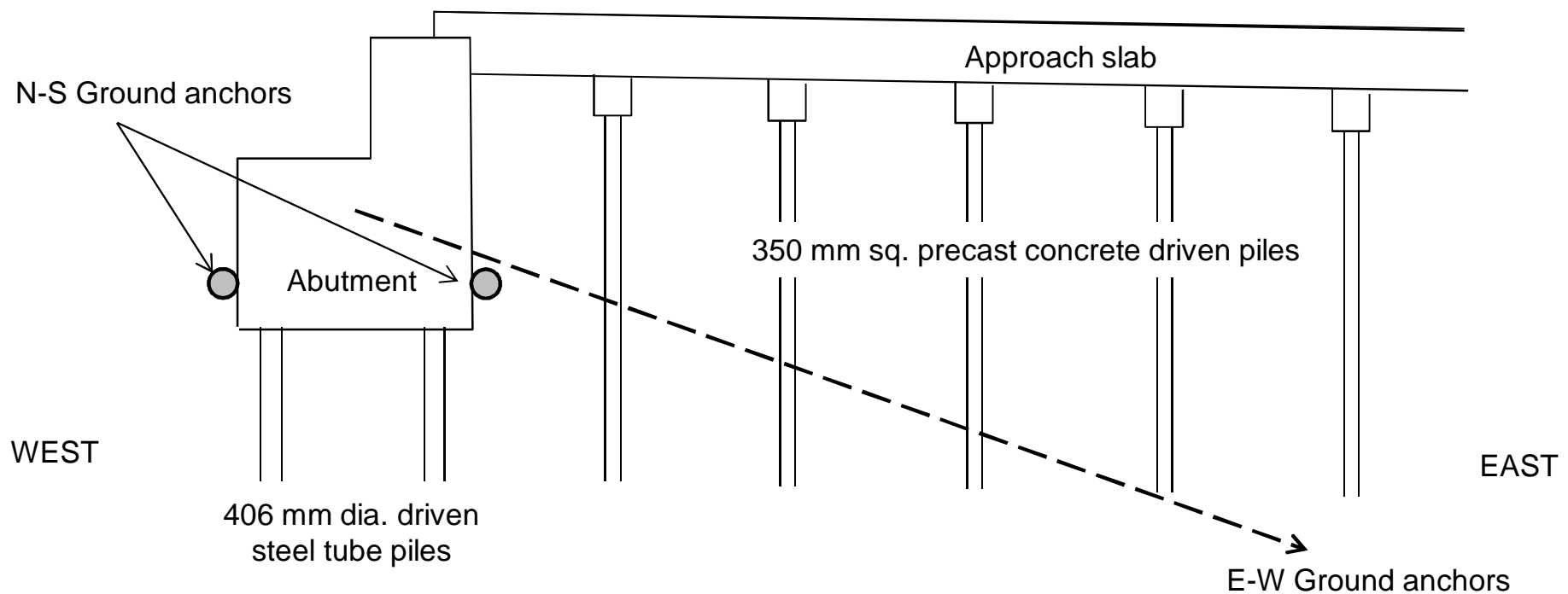
Ratio of projected horizontal abutment displacement to soil settlement is approximately 0.4.

Early design estimates of post-construction horizontal abutment displacement: about 45 – 250 mm. At the time, the upper end of this range was interpreted to be conservative.



Completed Remedial Works to East Abutment

- Replacement of main bridge bearings.
- Replacement of expansion joint and increase of clearance between abutment and superstructure.
- Ballast keeper plates loss of clearance rectified.
- Twelve ground anchors (48 m to 73 m long) installed to provide restraint to abutment – restraining movement in westerly and southerly directions.
- Remediation to cracking in precast piles.



SCHEMATIC OF ANCHORING

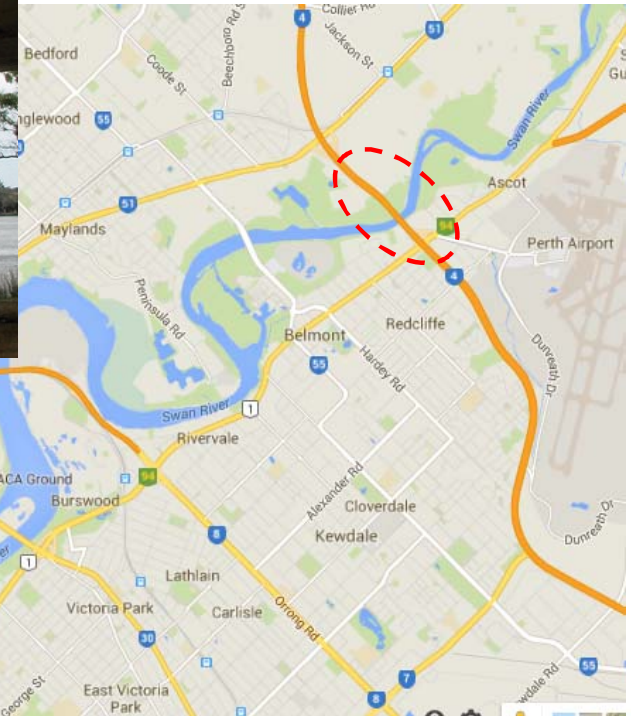


Complexities

- Subsurface stratigraphy at abutment location.
- Soft soil creep behaviour.
- Existing Bunbury Rail Bridge remaining in service during construction.
- Construction activities & timing:
 - removal of toe berm
 - fill placement for adjacent Windan Bridge
- Roles and responsibilities in design:
 - separate D&C package for pile design
 - communication between various parties throughout.
- Long-term survey monitoring:
 - affected by movement of benchmarks in unstable ground
 - several different groups collected data.
- Analytical tools were less-advanced and less-accessible than today.



Redcliffe Bridge – Tonkin Highway

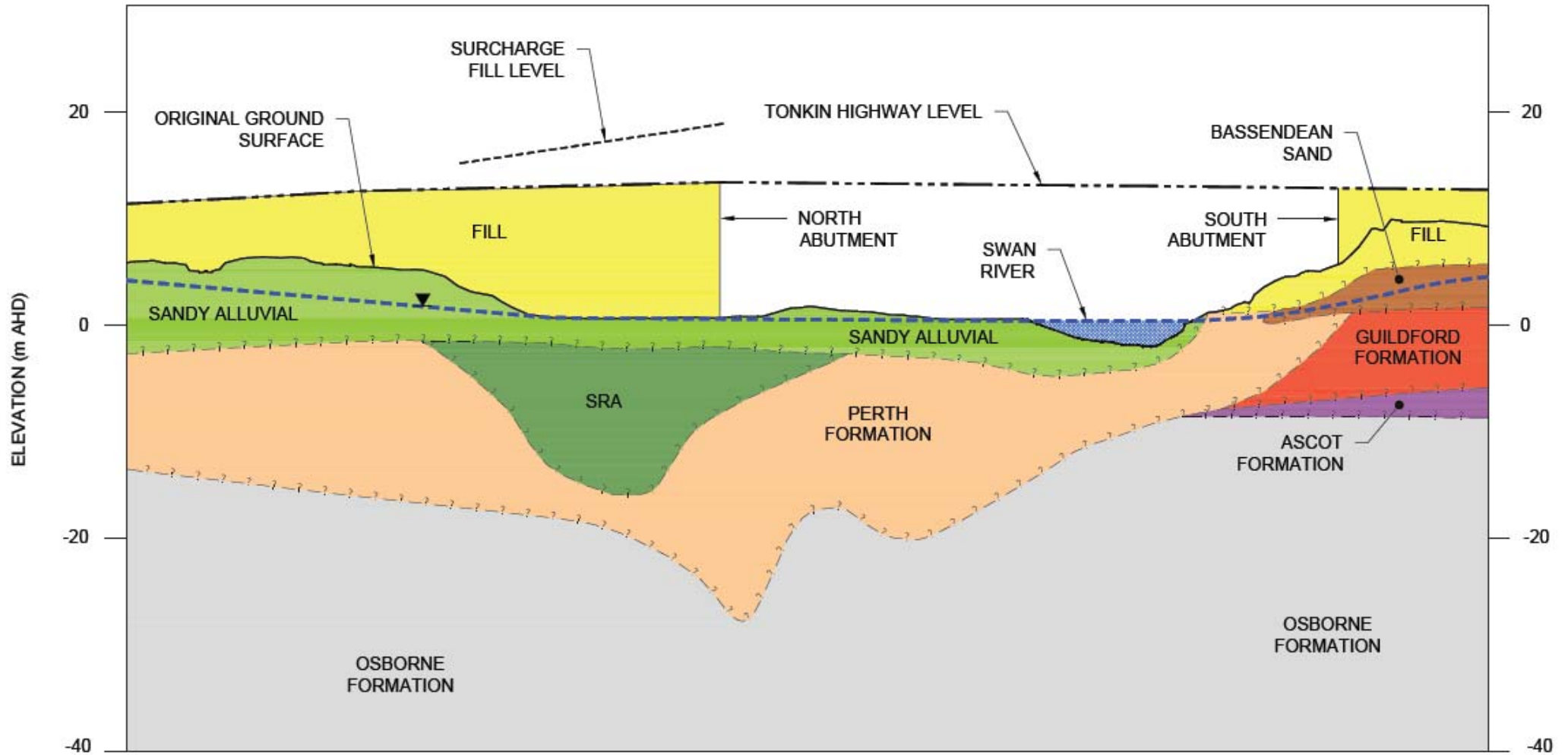


Redcliffe Bridge opened in 1988.

The northern approach embankment crosses the river flood plain.



Redcliffe Bridge



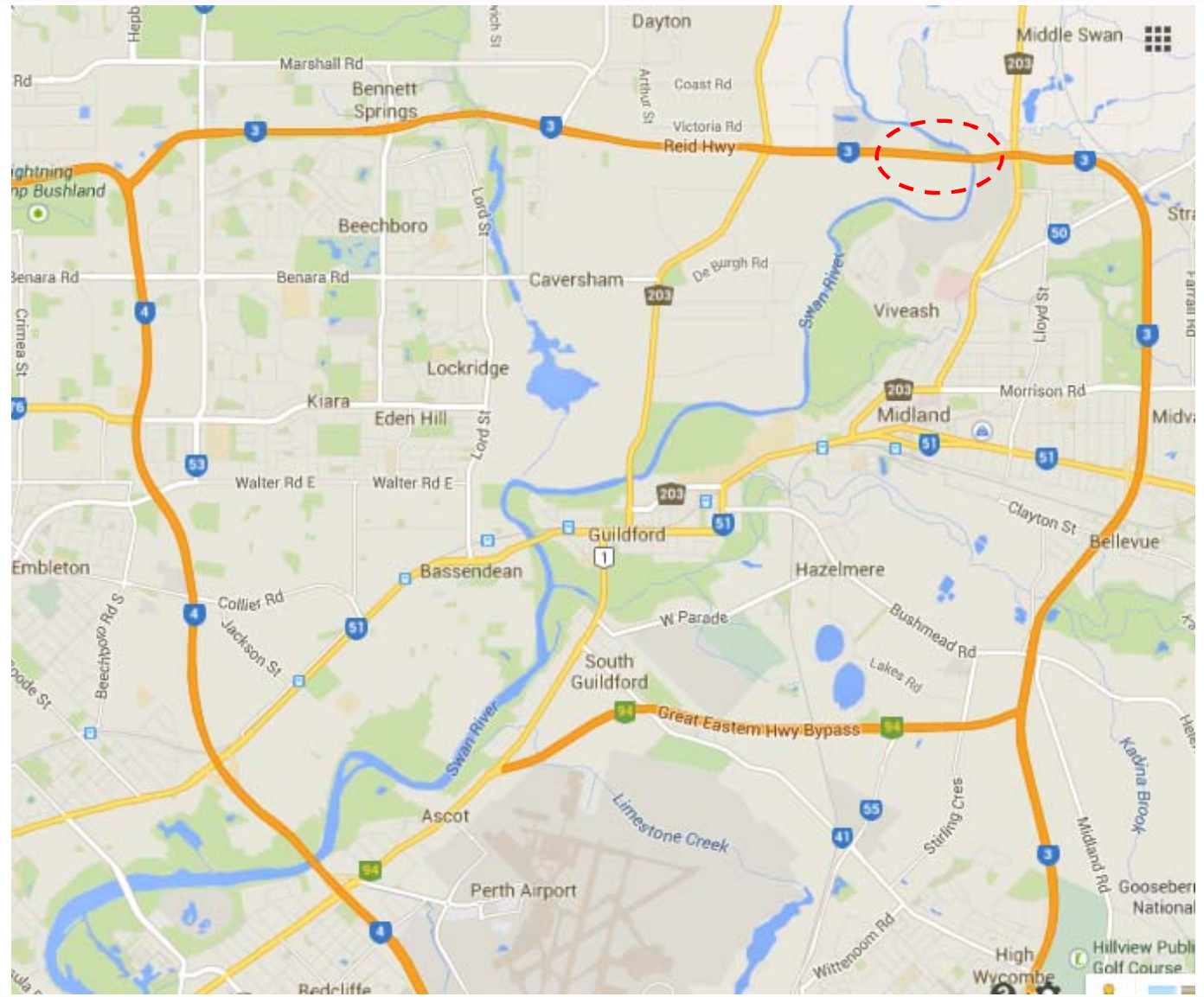


Redcliffe Bridge

- Trial embankment was constructed to failure.
- Main embankment constructed in stages with wide stabilising berms.
- Embankment surcharge placed to RL 18 m AHD for finished road level of RL 13 m AHD
- Back-analysis of response of first two lifts:
 - c_v in the range 1 to 100 m²/yr
 - $c_v = 37$ m²/yr average
- Final design based on the back-analysis results with $c_v = 20$ m²/yr
- Influence of drainage paths important.
- Design surcharge period = 2.5 yrs

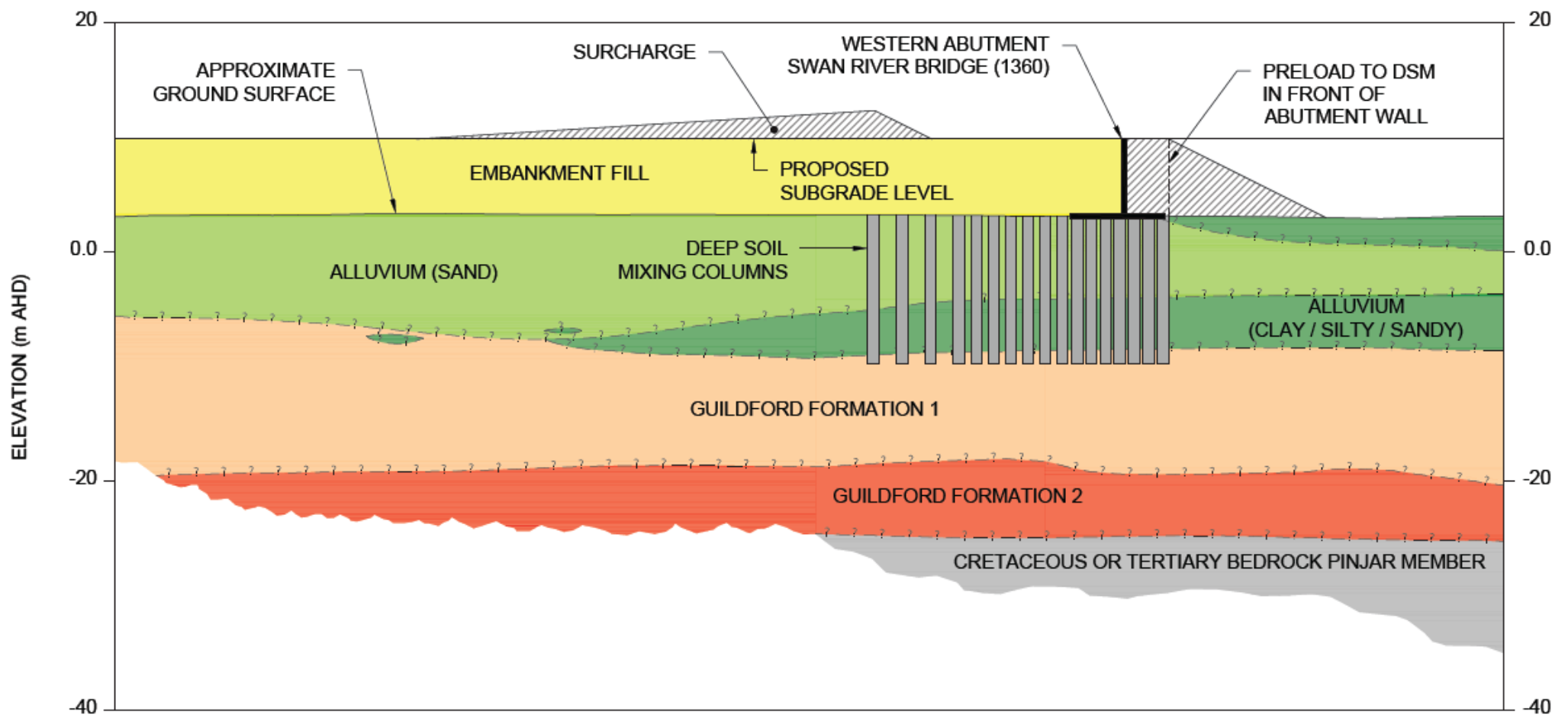


Whiteman Bridge





Whiteman Bridge



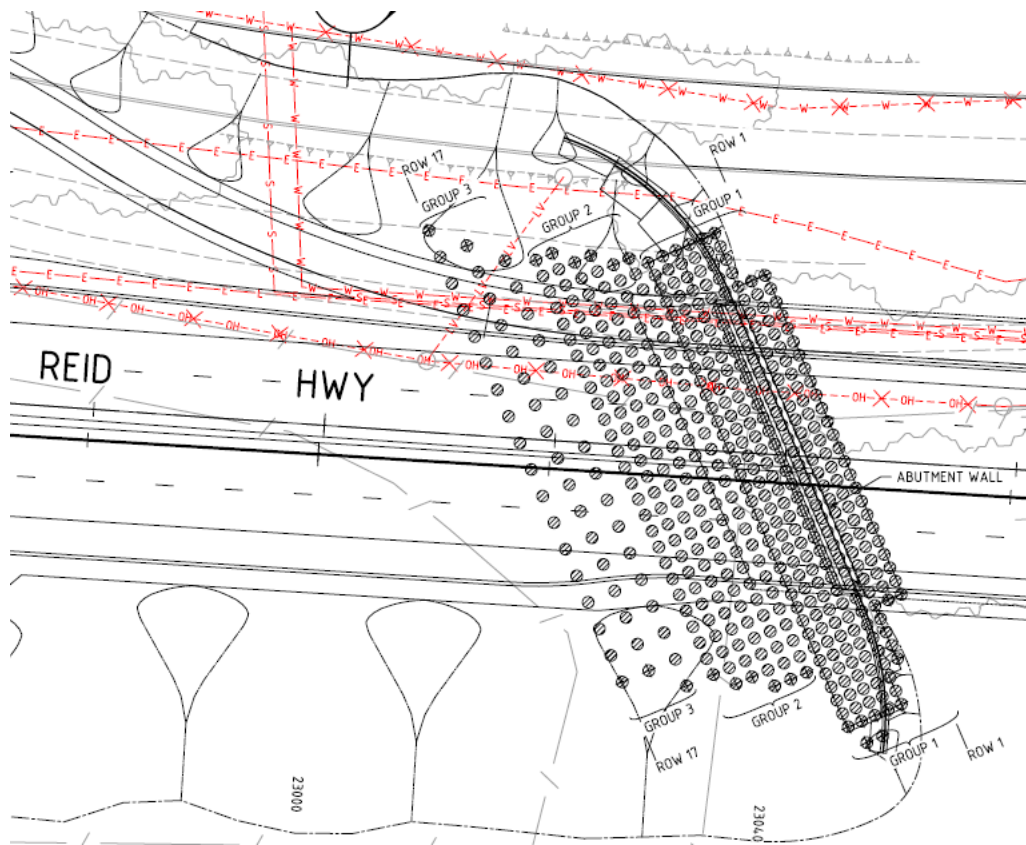


Whiteman Bridge





Whiteman Bridge



Settlements during preloading:

- ~50 mm under approach embankment
- ~10 mm at abutment location

Post-construction settlements
~10 to 15 mm

Deep soil mixing ground improvement allowed relatively rapid construction



Summary of Solutions

- Surcharge in advance of construction without wick drains (Redcliffe Br)
- Vertical drains to accelerate settlement – Narrows, City Northern Bypass, GRB and Windan Bridges
- Stone columns – PCEC loop bridge, Crown original entry road
- Deep soil mix columns – Whiteman Bridge
- Protective casings around piles – Narrows Bridge
- Caisson foundations – Narrows Interchange Bridges
- Piled approach slabs – Second Narrows Bridge, Goongoongup Bridge, Windan Bridge
- Displacement of soft soil – Narrows interchange



Acknowledgements

- Main Roads WA
- Public Transport Authority
- MacMahon Contractors
- BG&E Pty Ltd

- Doug McInnes, Andrea Xanthis, David Gu