Case Studies on Dam Safety

25 March 2008

Presented by

Dr Gamini Adikari
Principal Engineer Dams
SMEC Australia

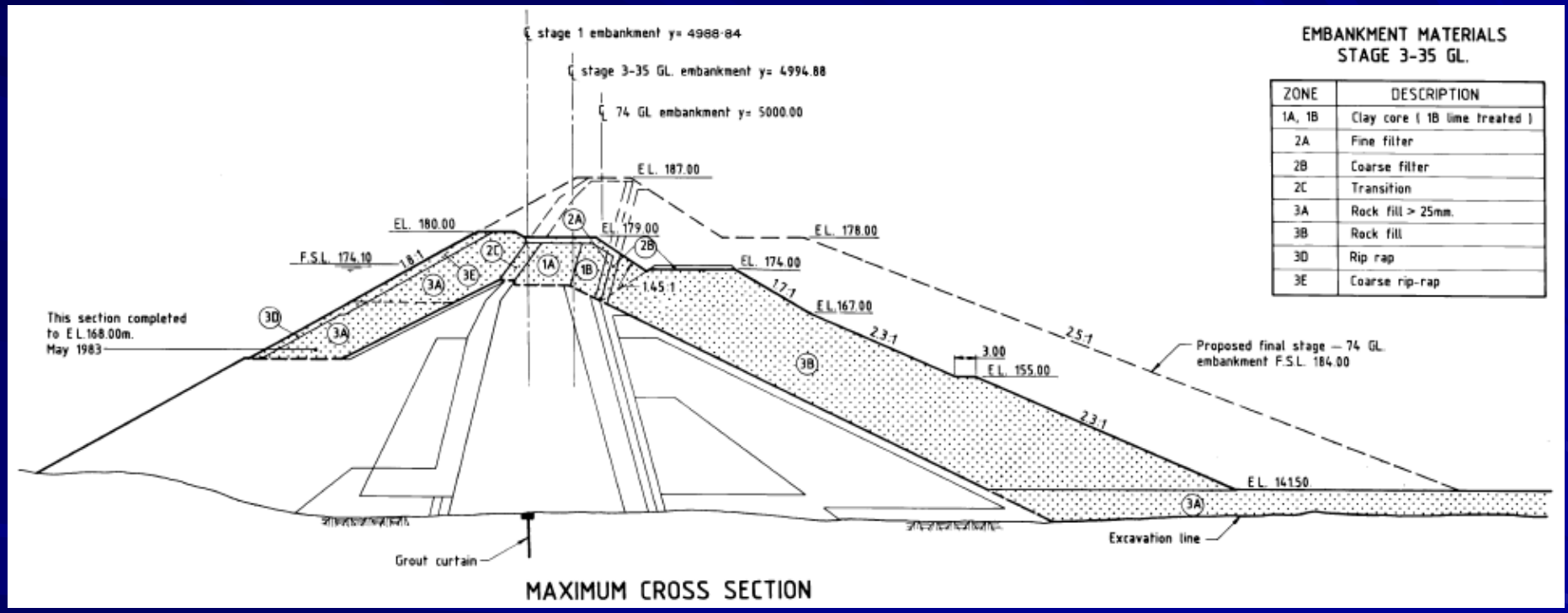
Case Studies on Dam Safety Monitoring

- Movement in the upstream rockfill zone at Merrimu Dam
- Settlement and longitudinal cracking at the crest of Eppalock Dam
- Transverse and longitudinal cracking at the crest and downstream face and rip rap settlement at Pine Lake Dam
- Movement in the outlet tower access bridge at Rosslynne Reservoir
- Rise in downstream toe seepage at Merrimu Dam

Merrimu Dam Upstream Rockfill Movement

- Compacted Stage 3 rockfill placed over dumped upstream Stage 1 rockfill
- Substantial crest settlement of up to 250mm over the 10 year drought cycle from 1997 to 2007
- Longitudinal cracking observed in 2004, coinciding with core/upstream filter interface
- Differential settlement on the upstream side of crack

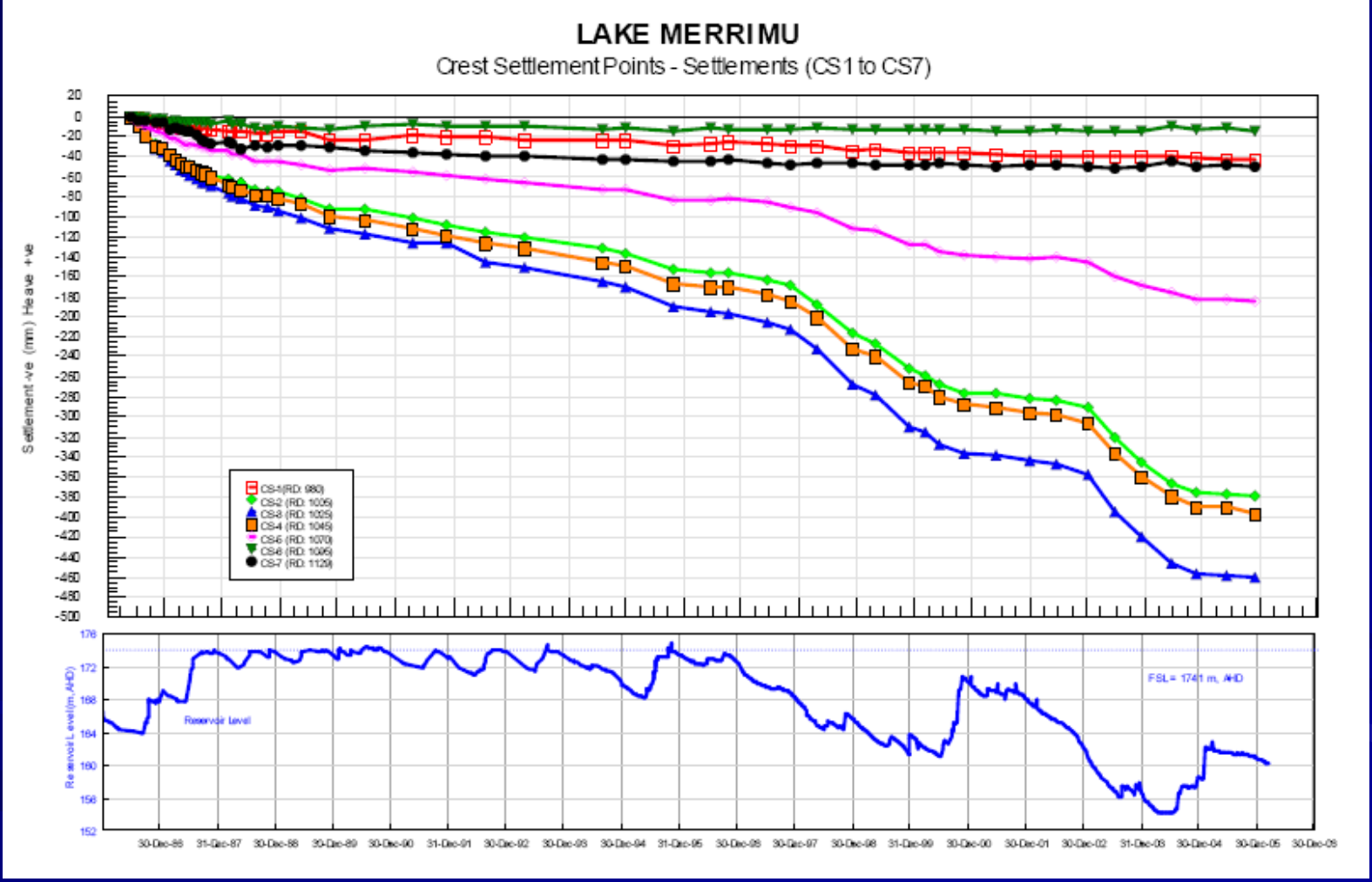
Merrimu Dam Cross Section



EMBANKMENT MATERIALS
STAGE 3-35 GL.

ZONE	DESCRIPTION
1A, 1B	Clay core (1B lime treated)
2A	Fine filter
2B	Coarse filter
2C	Transition
3A	Rock fill > 25mm.
3B	Rock fill
3D	Rip rap
3E	Coarse rip-rap

Merrimu Dam Upstream Rockfill Zone



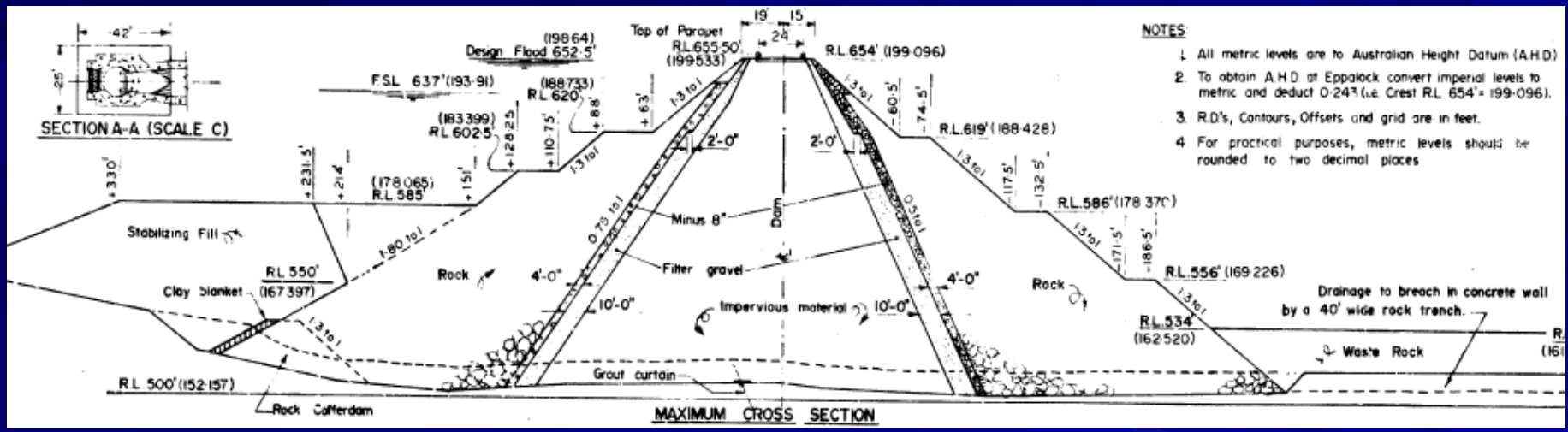
Possible Cause of Movement

- Increase in effective weight in the upper portion of upstream rockfill zone due to drawdown of water during drought compressing the dumped rockfill in the lower portion
- Upper portion of rockfill settling as a block along the core/filter interface causing cracking and differential movement at the crest of the dam

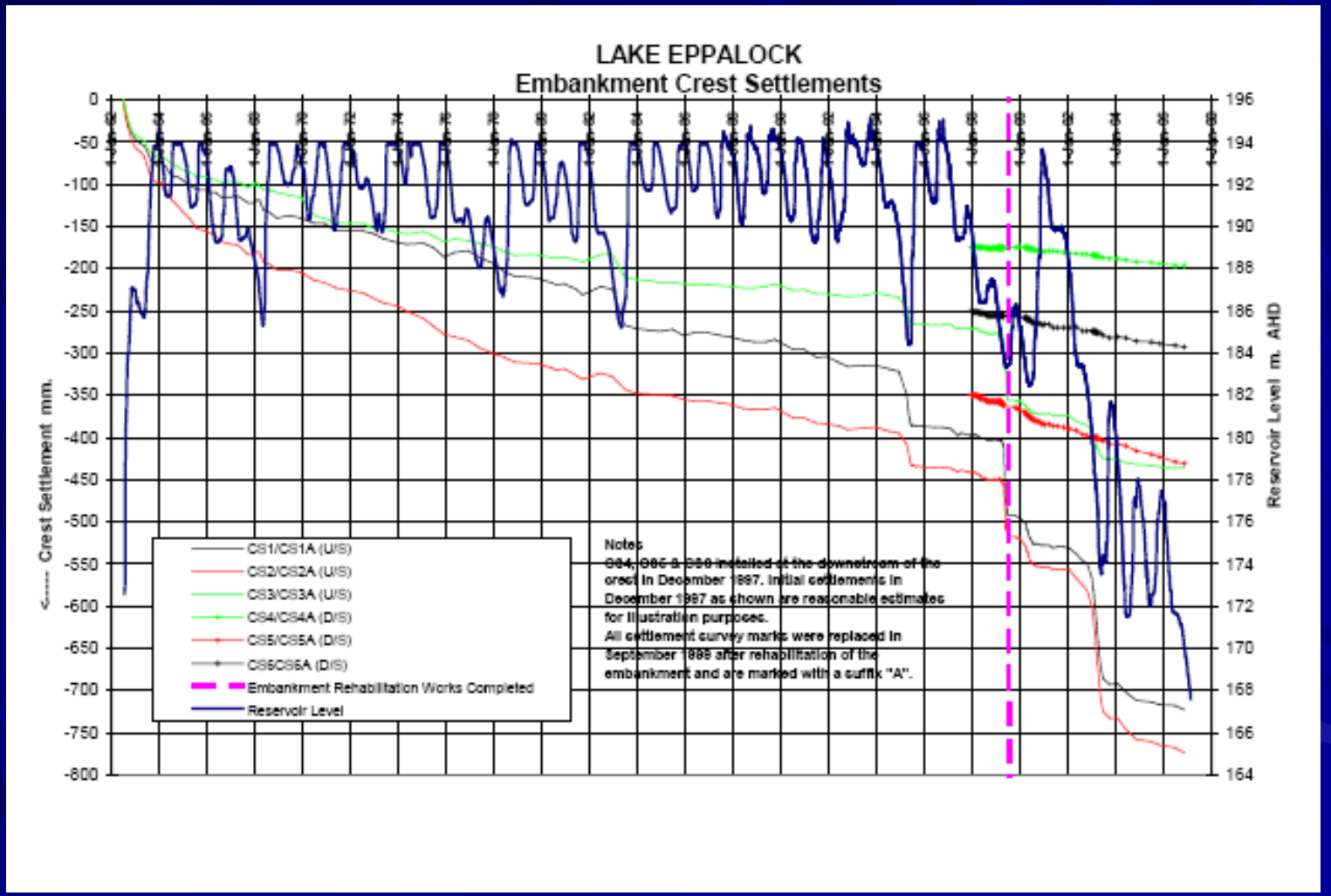
Eppalock Dam Settlement and Crest Cracking

- 47m high central core dam with dumped rockfill zones
- Largest historical drawdown occurred during the 1997-2006 drought cycle
- Reservoir volume down to 1% with no water load acting on the dam
- Crest settlements of up to 400mm were recorded during this cycle
- Substantial longitudinal cracks opened at crest

Eppalock Dam Cross Section



Eppalock Dam



Possible Cause of Crest Settlement and Cracking

- Long term consolidation, creep and outward deformation of the dumped rockfill shells exerting downward drag on the clay core, inducing tensile cracks at the crest
- Water ingress to cracks causing instability, softening of core and slope movement
- Increased effective stress during drawdown causing further settlement of rockfill, accelerating settlement and cracking of the core
- Drawdown continued even after 1999 remedial works causing further crest settlement and cracking

Pine Lake Dam Embankment Cracking and Rip Rap Settlement

- 15m high, 3.7km long earthfill dam with a central clay core; constructed in 1923
- Reservoir has been empty since late 2003 and the dam embankment has not had water against it since 2000
- Widespread longitudinal and transverse cracking has occurred at the crest and downstream face of the dam
- Settlement depressions are evident on the rip rap protected upstream face


23/03/2006


TJK 758
23/03/2006

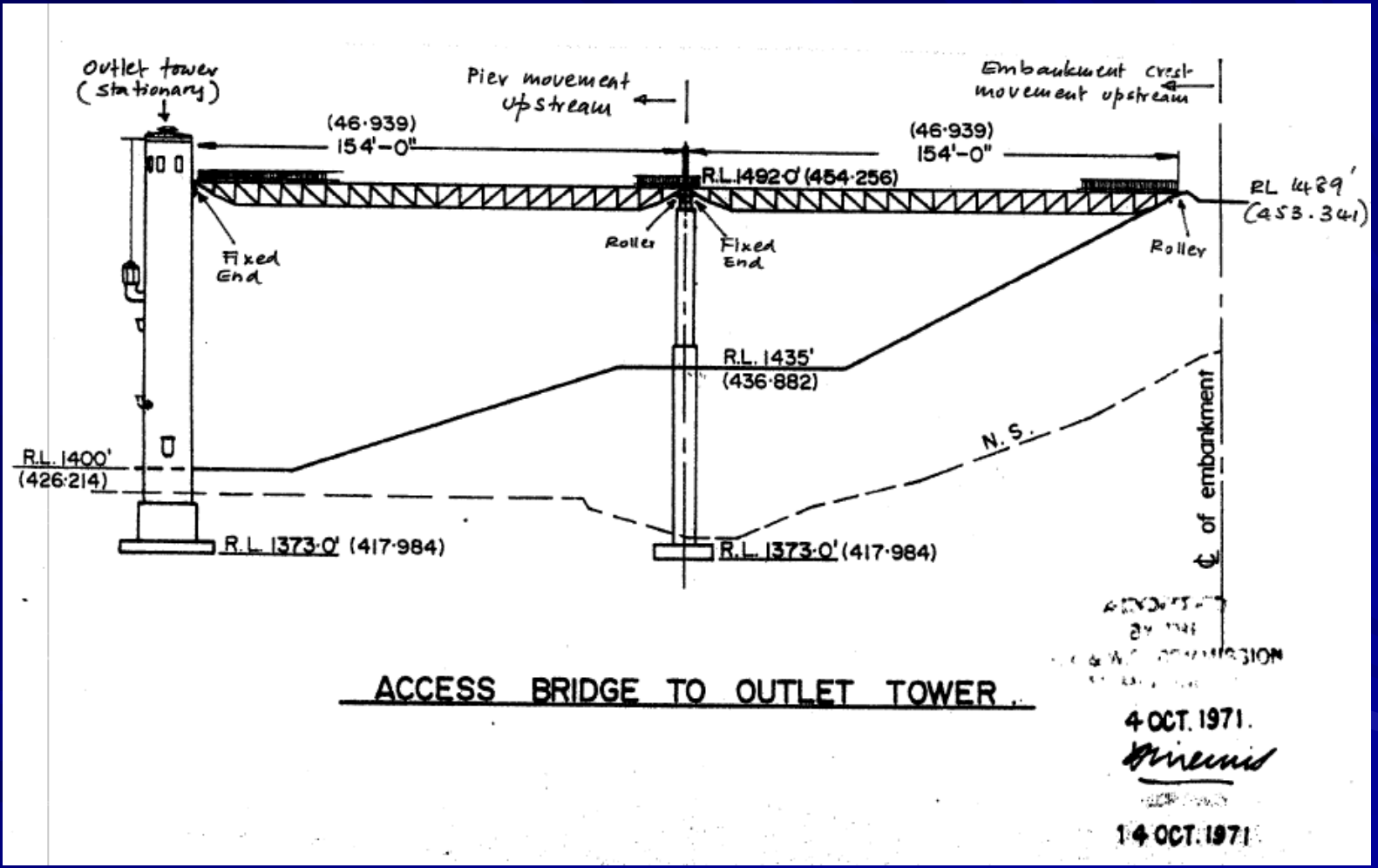
Possible Cause of Cracking and Settlement

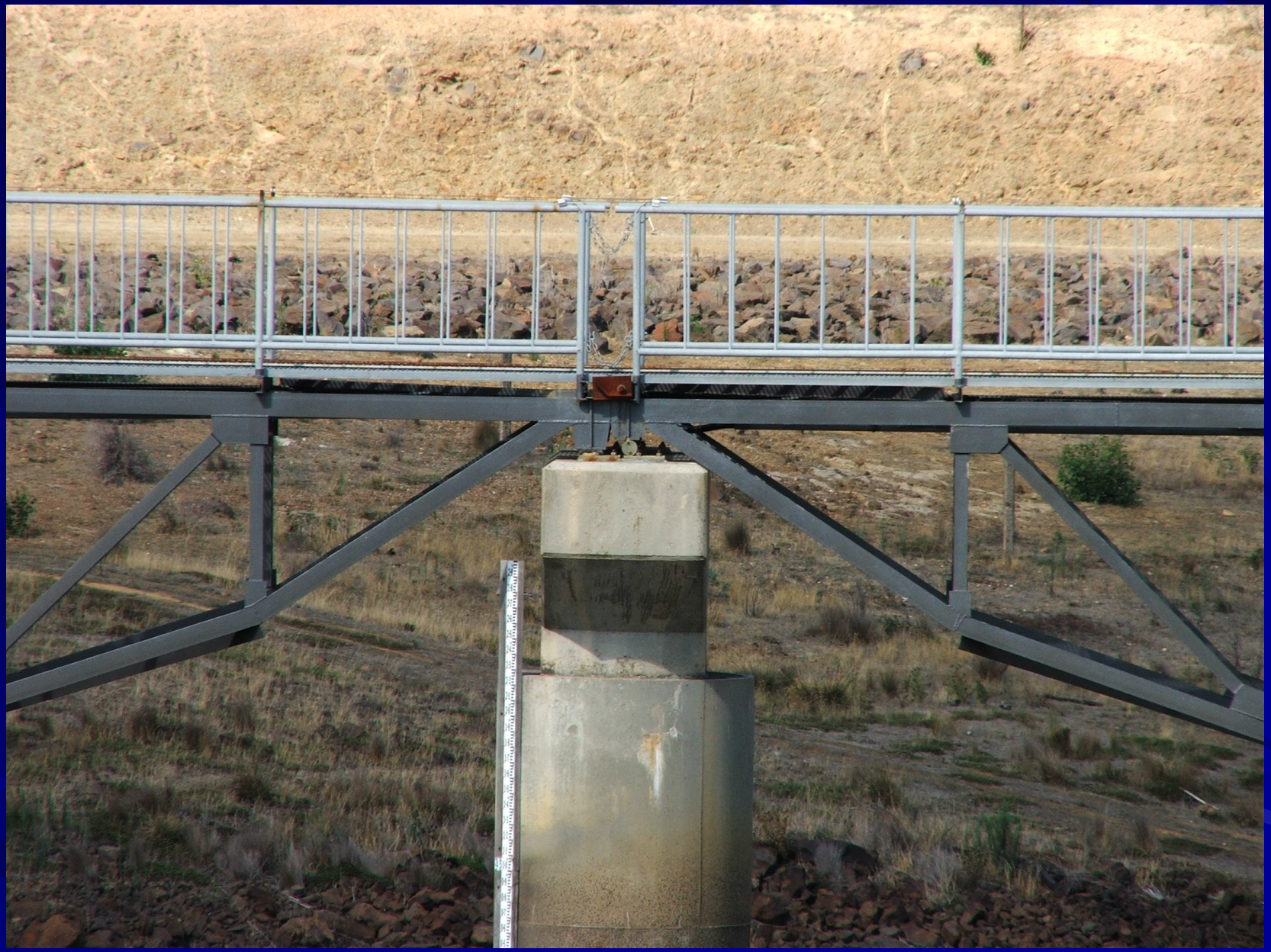
- Combined effects of low phreatic surface within the dam and shrinkage of the unprotected outer earthfill zone are believed to be the cause of cracking
- Increased effective weight combined with loss of strength of earthfill material may be a factor affecting settlement of the rip rap layer on the upstream face

Rosslynne Reservoir Outlet Tower Access Bridge

- Movement of the rockfill embankment and the central pier in the upstream direction due to reservoir drawdown has caused the gap at the access bridge rails to close
- Further movement will result in buckling of the rails
- Bridge supports are close to their design travel limits
- Bridge members are now close to the pier

Rosslynne Reservoir

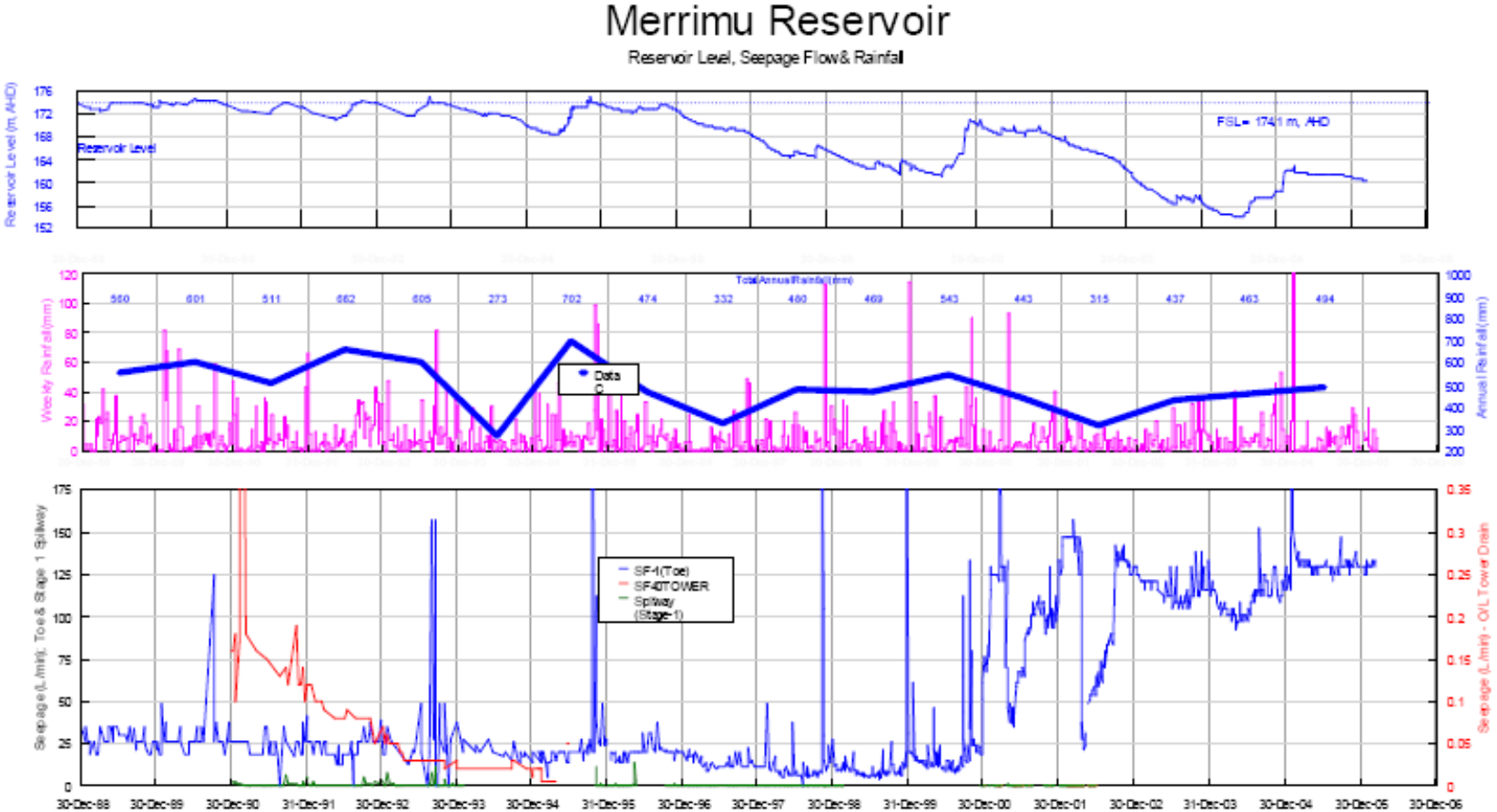




Merrimu Dam Seepage

- 40m high earth and rockfill dam constructed in 1969 and raised in 1986
- Dam core constructed of dispersive clay, downstream portion lime treated
- 10 year drawdown cycle with a 13m drawdown over 1997-2000 and a 16m drawdown over 2001-2004
- Significant movement occurred in the upstream rockfill zone
- Seepage increased five-fold during the drawdown cycle (from 25 lit/min to 130 lit/min)

Merrimu Dam Seepage



Possible Causes of Seepage

- Transverse cracking in the embankment core
- Spring activity in the dam foundations
- Drying of clay infill in foundation joints
- Load transfer and redistribution; Hydraulic fracturing
- Leakage in the outlet conduit
- Leakage in the pipework at the downstream toe

Cause of Seepage

- SRW have now identified the cause of seepage
- A test on the pipe from the valve pit to pump station was run by turning off supply during a zero demand period
- Toe seepage levels dropped below those originally recorded, to about 10lit/min
- Leakage in the pipework at the downstream toe was the cause of increased seepage
- Location of the leak has been pin pointed
- Repairs are programmed

Case Studies on Dam Safety Upgrades & Fixes

Common Drivers

- Our understanding of the behaviour of dams improve over time
- Design standards evolve
- Inadequate flood capacity
- Internal erosion & piping protection
- Seismic retrofitting

Dam Safety Upgrades and Fixes

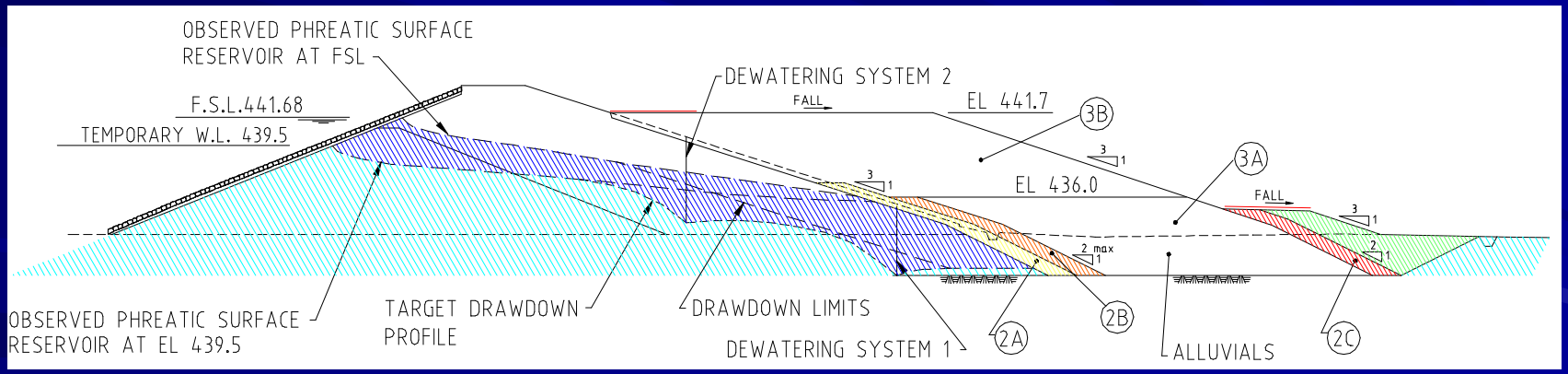
- Wartook Dam
- Kerferd Dam
- Yan Yean Dam
- Hume Dam

Case Study 1 - Wartook Dam

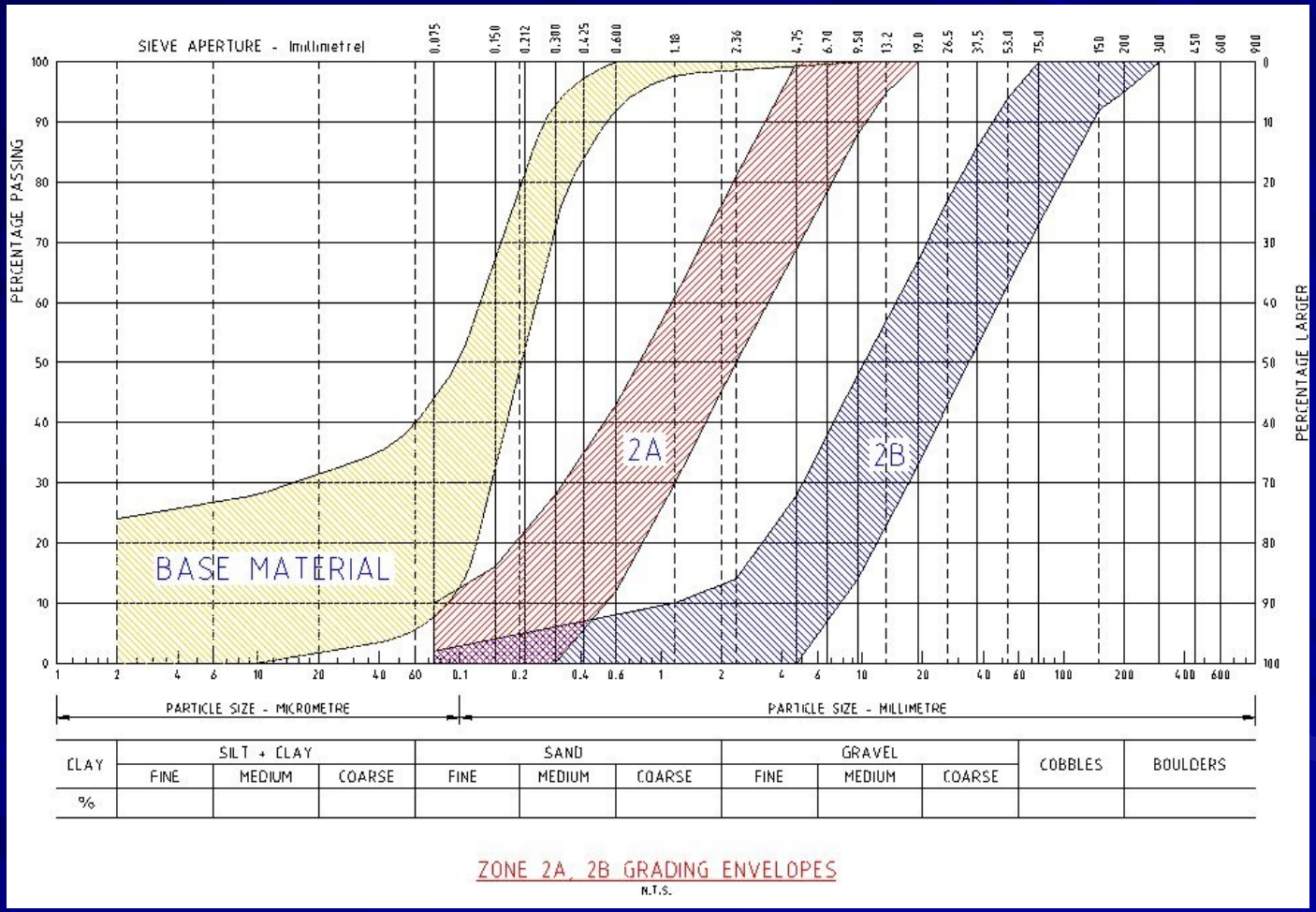
- 120 year old embankment predominantly constructed of fine silty sand
- Seismic stability and liquefaction issues
- Work behind a live storage supplying a major regional city posed challenges
- New outlet works required for ensuring further 100 years of service life

Wartook Dam Upgrade

- **stabilising rockfill, Zones 3A & 3B**
- **filters to prevent piping due to seepage & liquefaction**
- **total cost $ 5M compared to full rehabilitation option with upstream and downstream stabilising shells at $15M and new dam downstream at $25M**



Wartook Dam - Filter Grading Limits



Wartook Dam – Quarry Operations

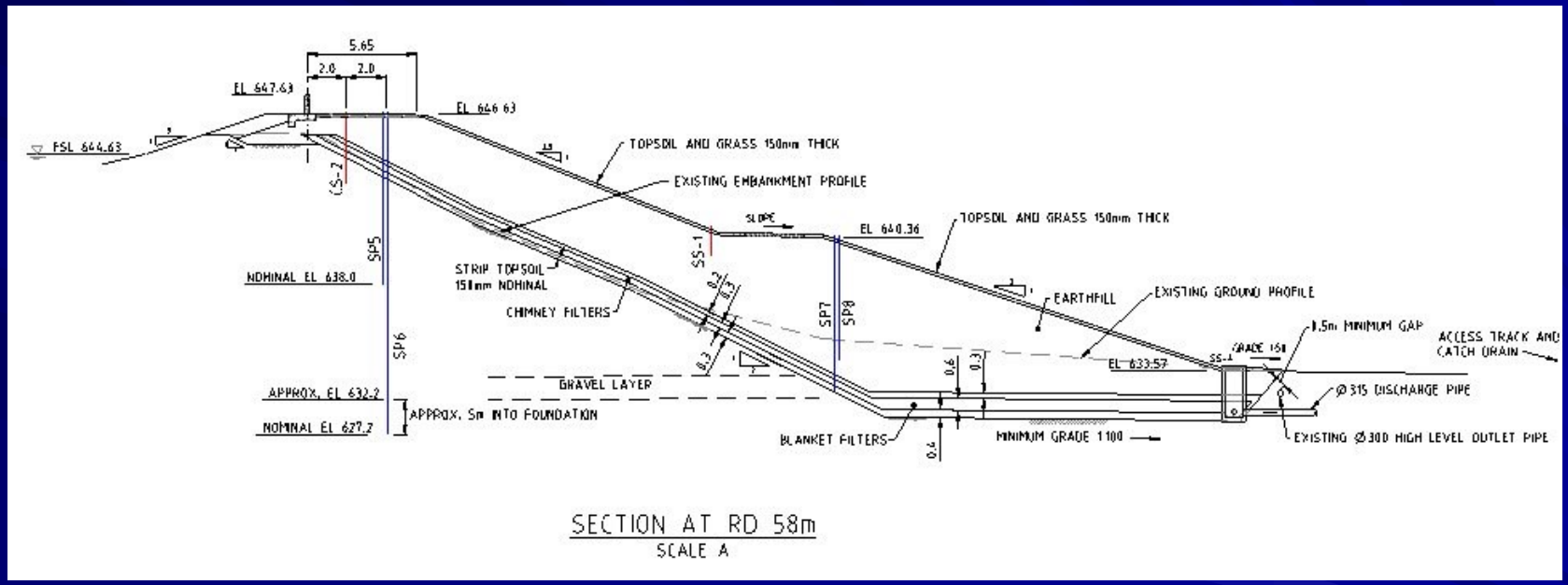
Wartook Dam – Rockfill Placement

Wartook Dam – Filter Placement

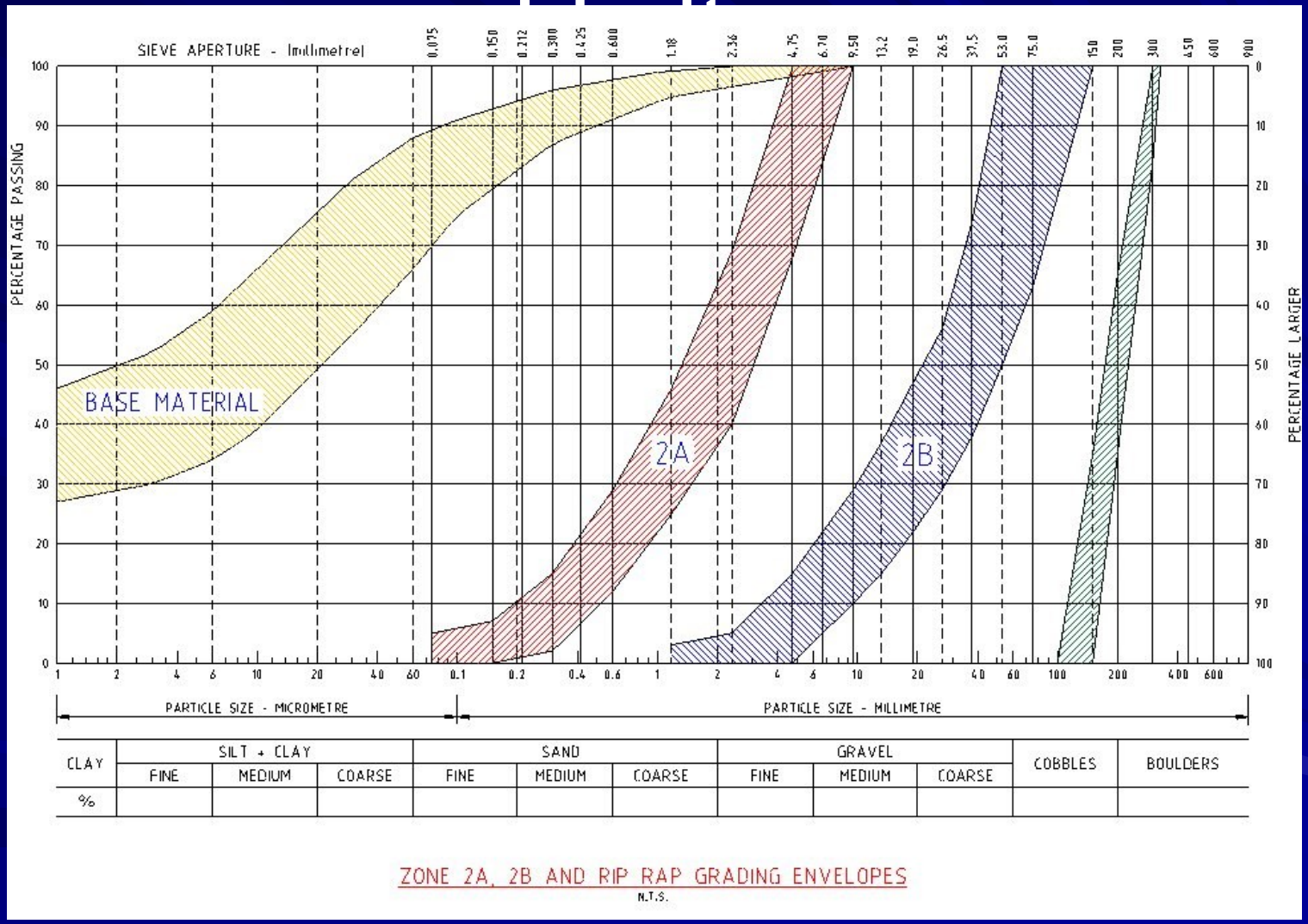
Wartook Dam – Filter Placement

Case Study 2 - Kerferd Dam

Kerferd Dam - Typical Cross Section



Kerferd Dam - Filter Grading



Kerferd Dam

Kerferd Dam

Kerferd Dam

Kerferd Dam

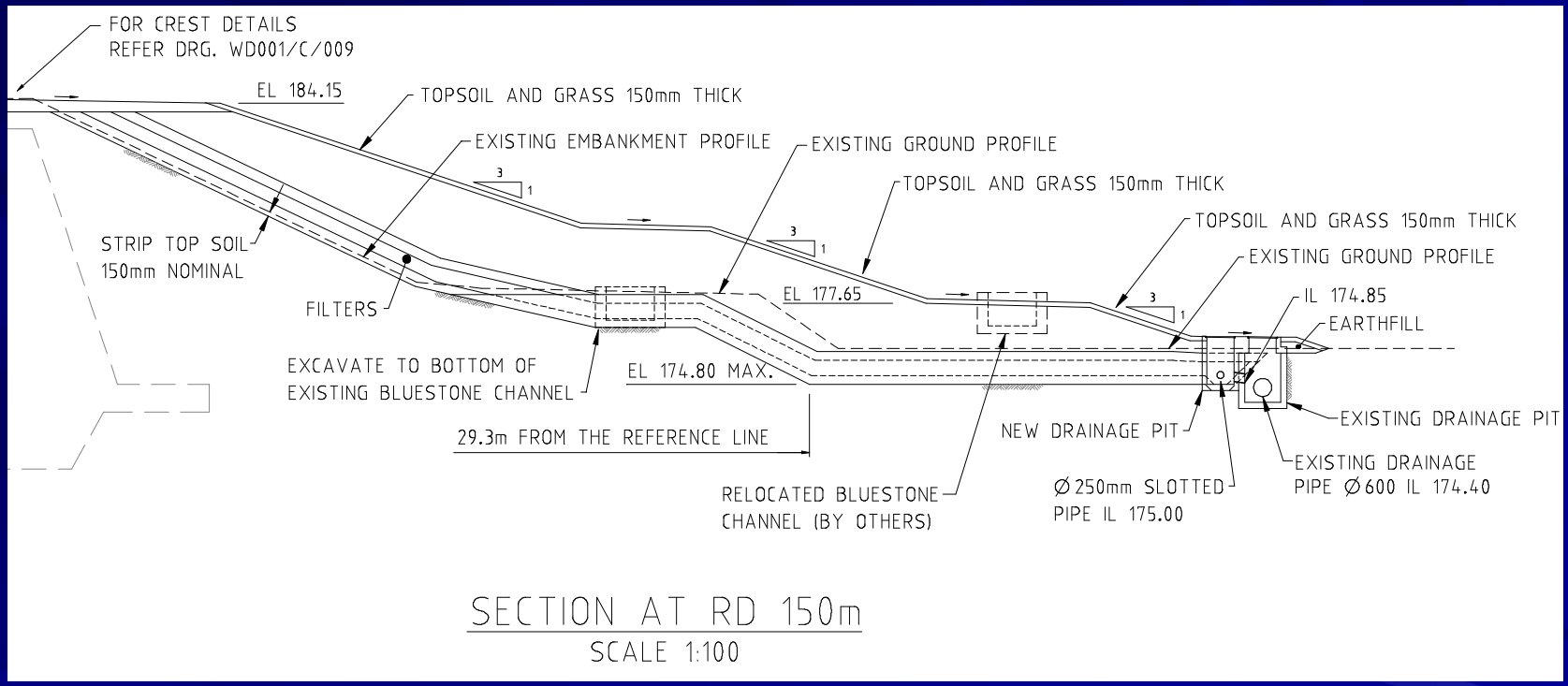
Kerferd Dam

Kerferd Dam

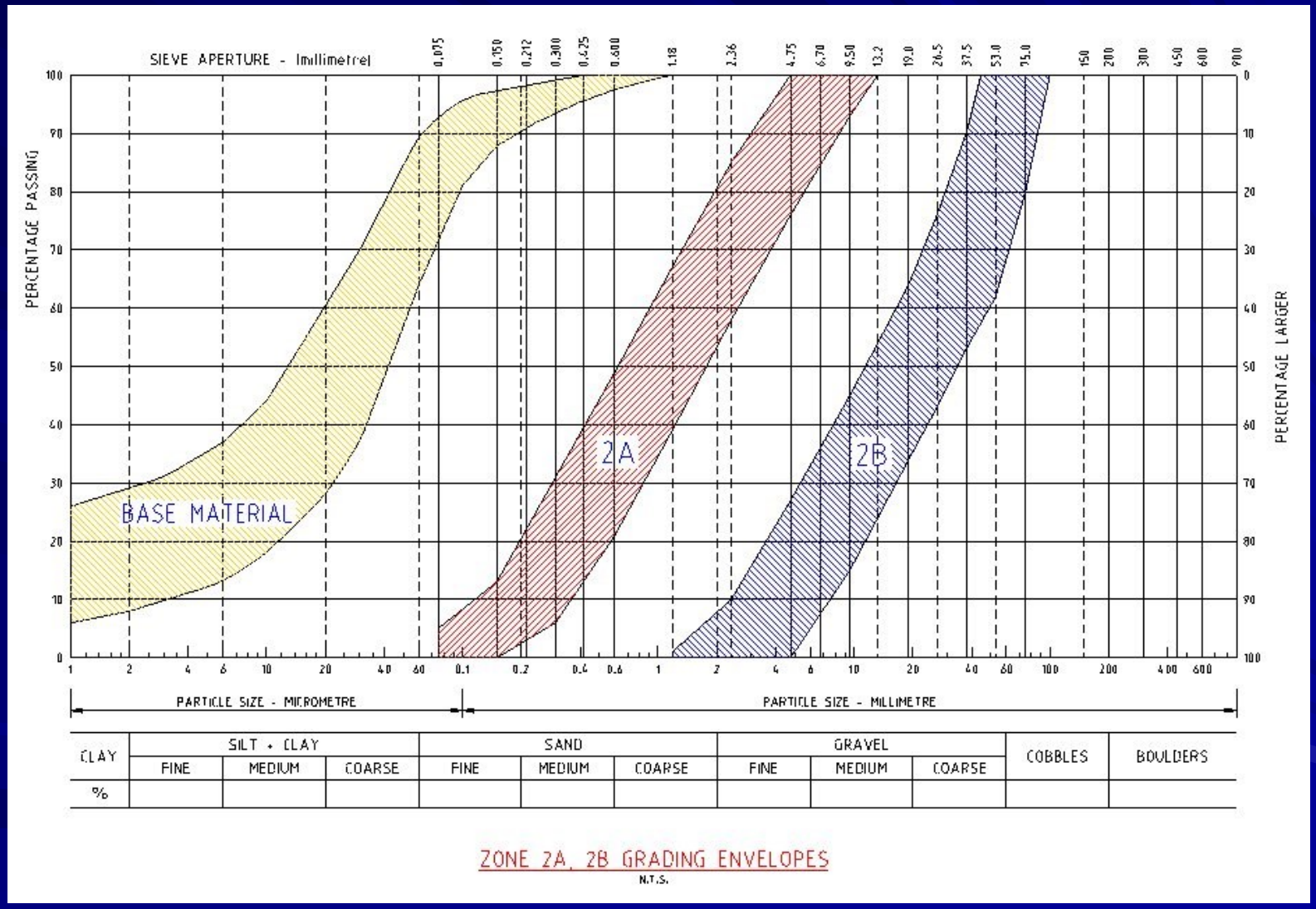
Kerferd Dam

Case Study 3 - Yan Yean Dam

Yan Yean Dam - Typical Cross Section



Yan Yean Dam - Filter Grading



Yan Yean Dam

Yan Yean Dam

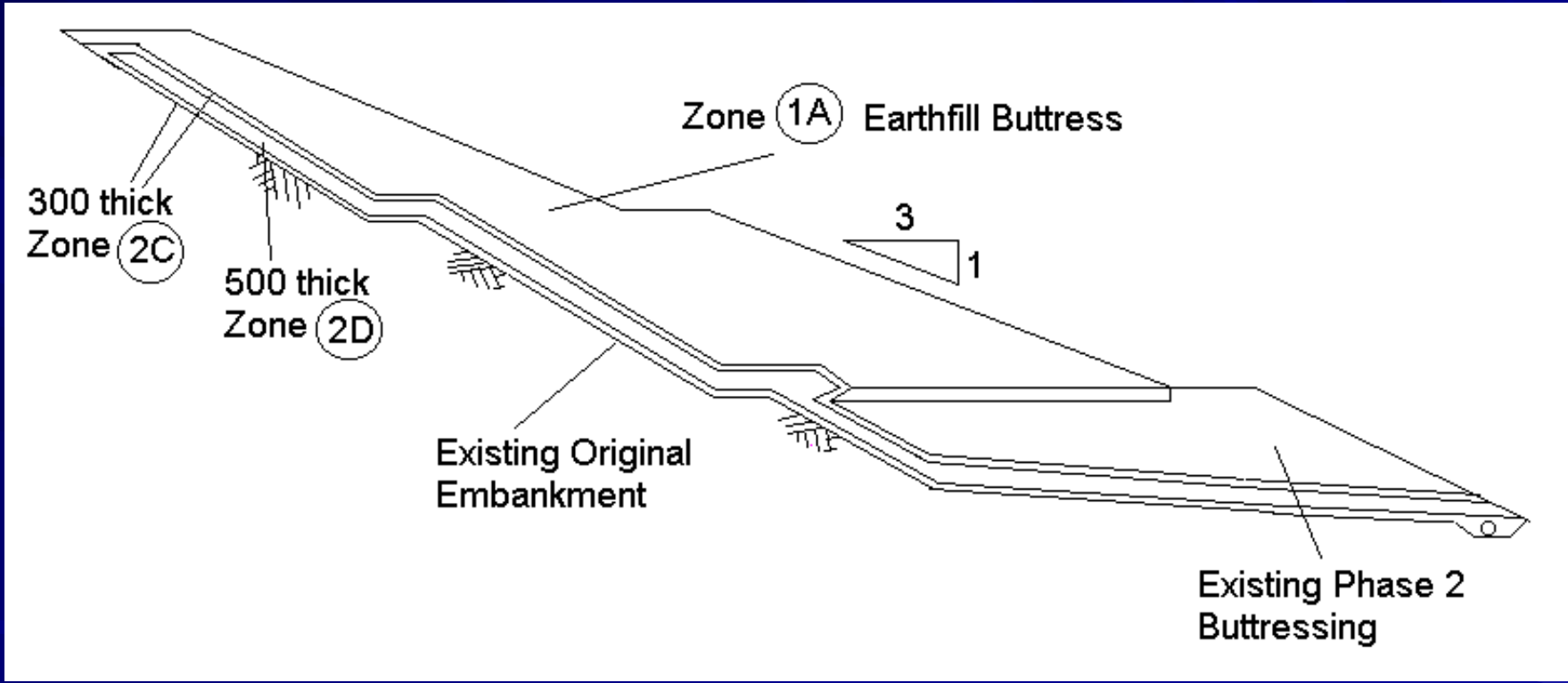
Yan Yean Dam

Yan Yean Dam

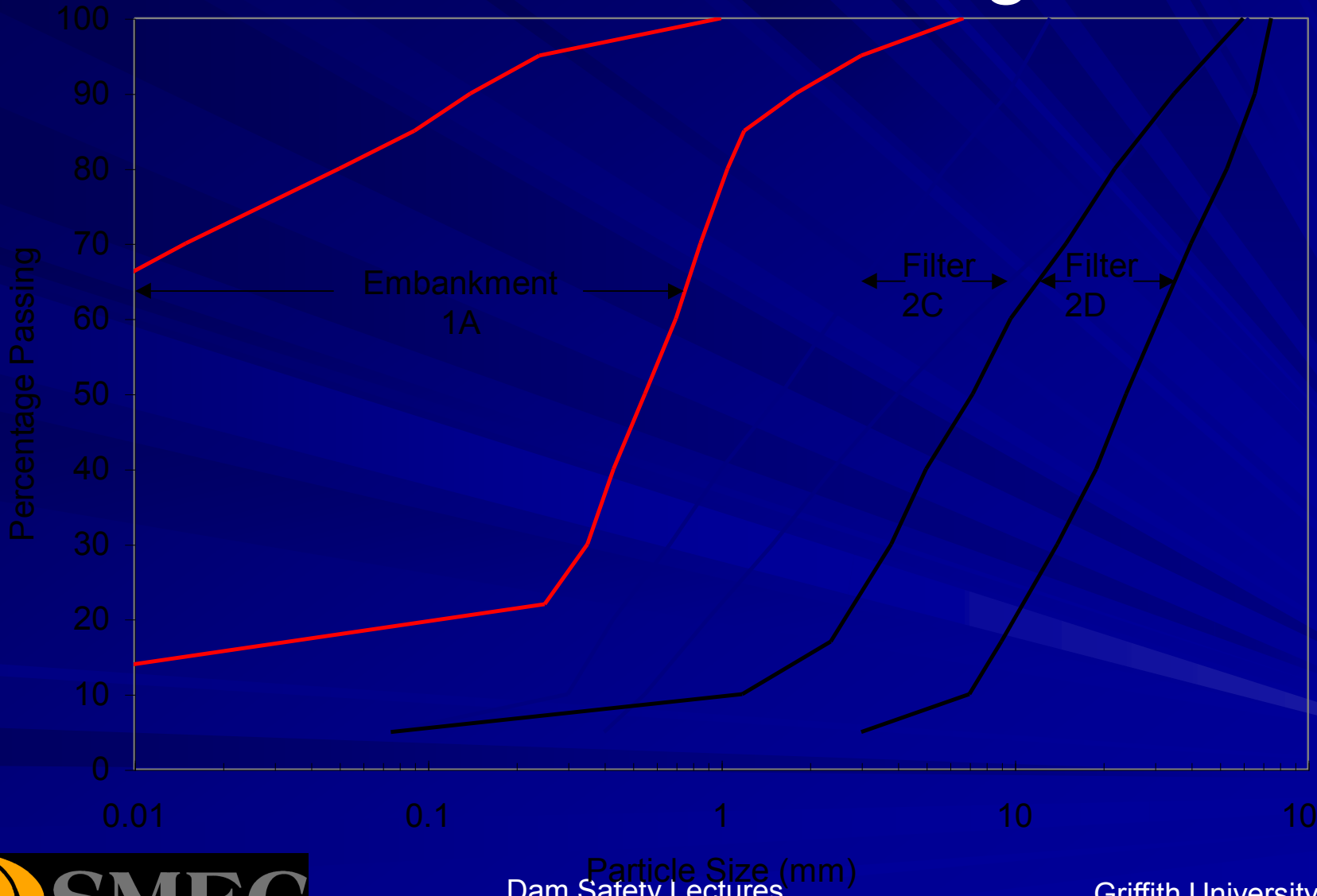
Yan Yean Dam

Case History 4 - Hume Dam

Hume Dam - Typical Cross Section



Hume Dam - Filter Grading Limits



Hume Dam

Hume Dam

Hume Dam

Hume Dam

Hume Dam

Hume Dam

Hume Dam