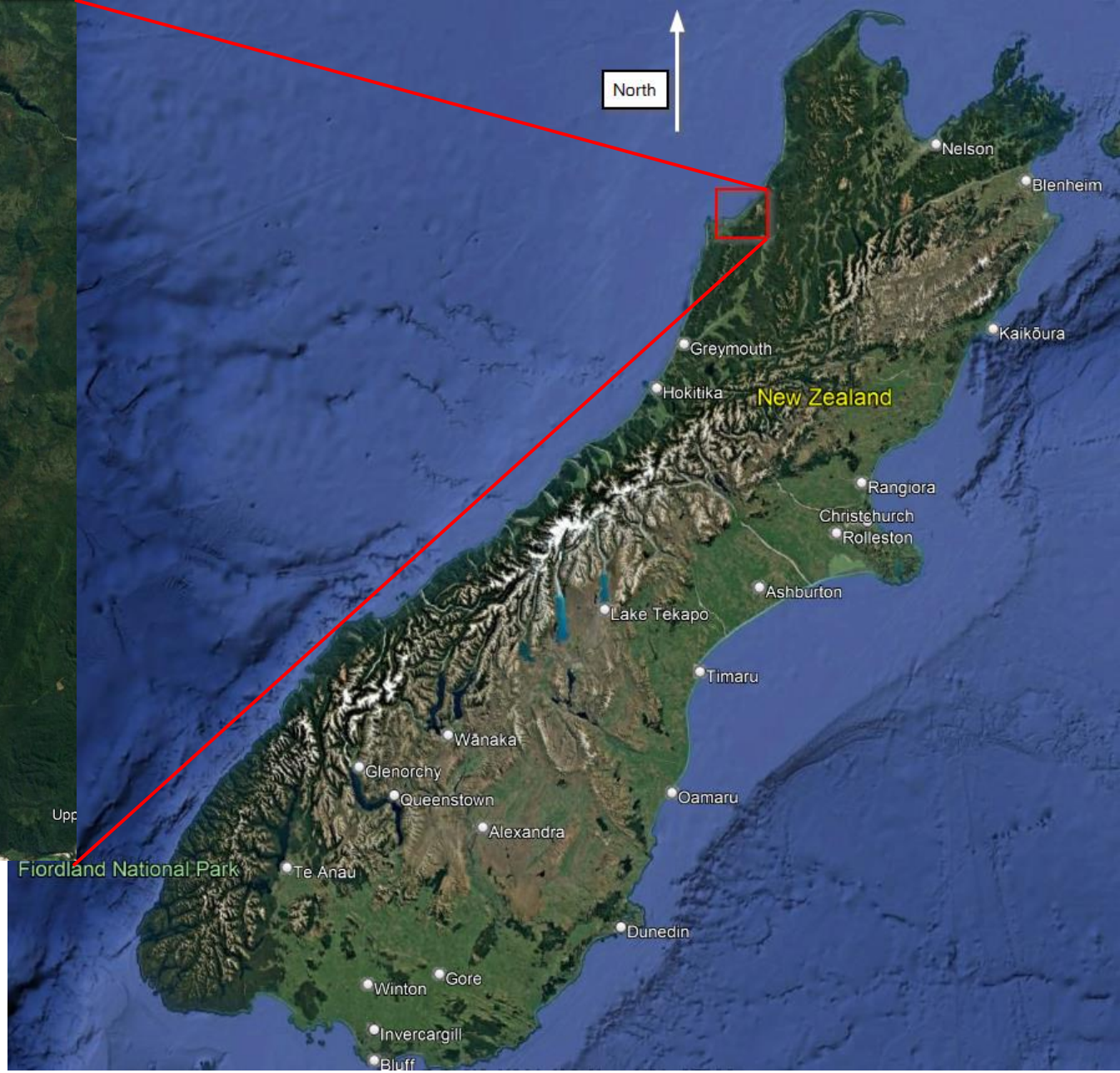
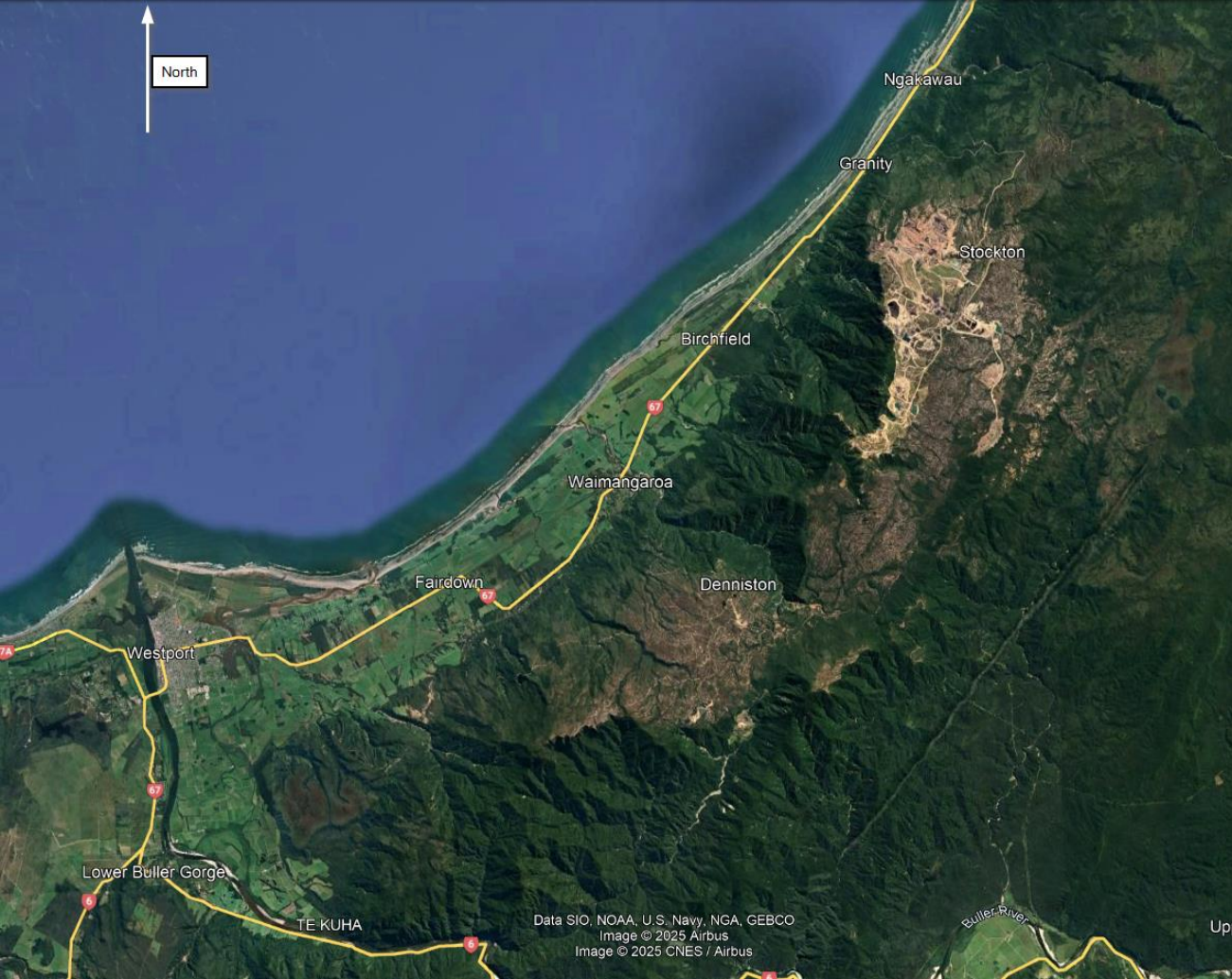


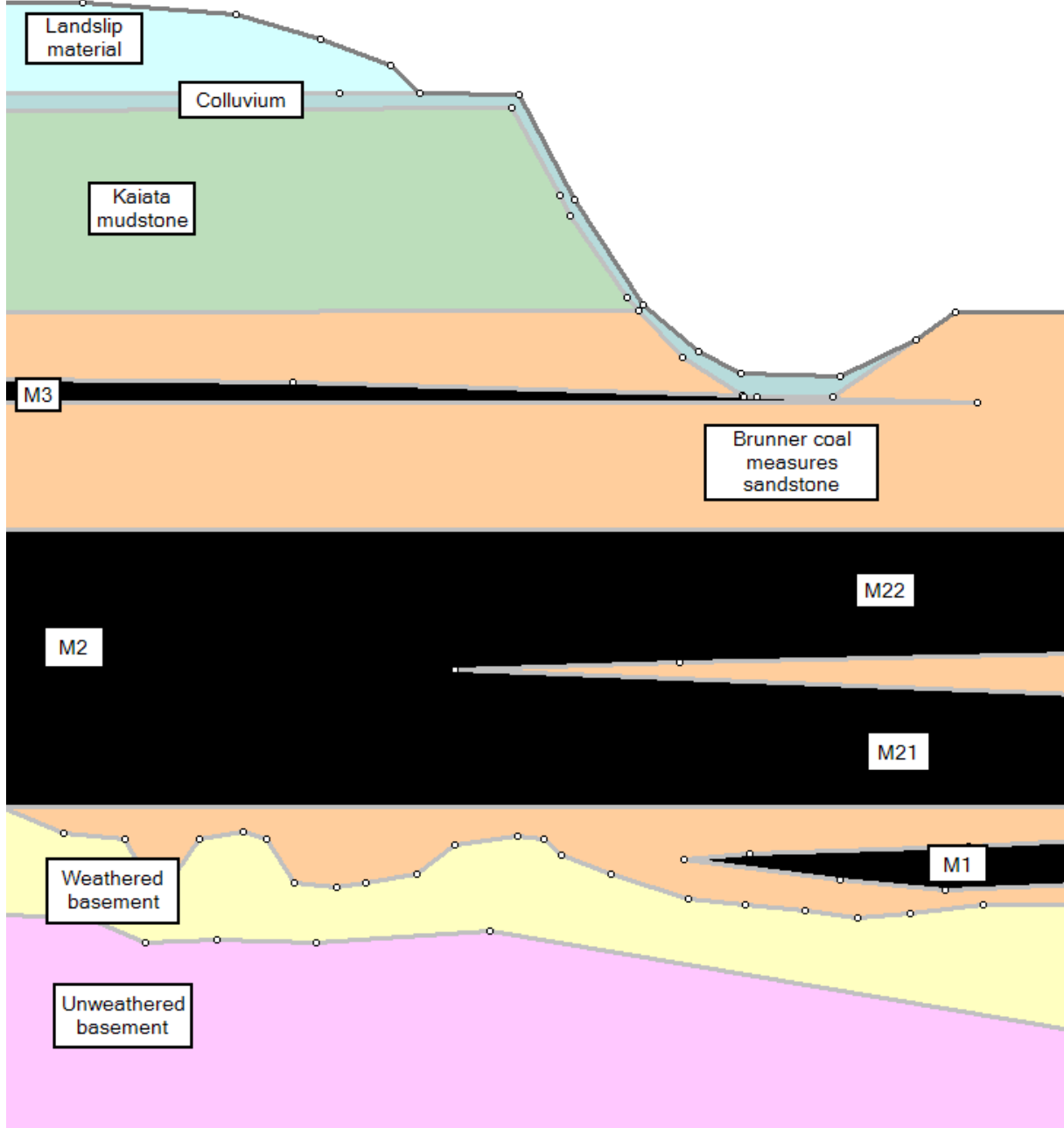


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Stress strain regime changes around the Mt William fault and its implications for highwall stability

Benjamin Godfrey Hyde MSc



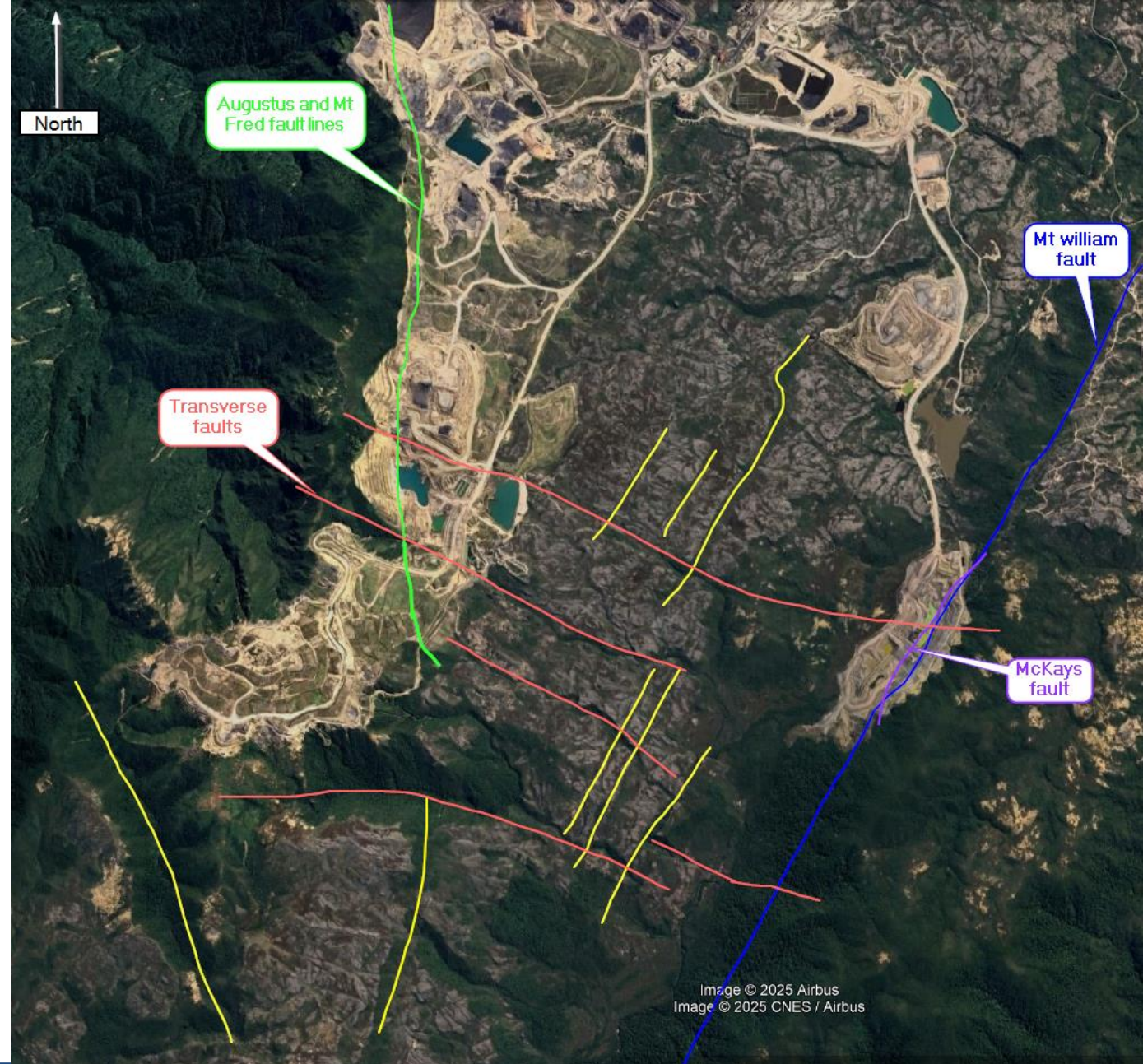


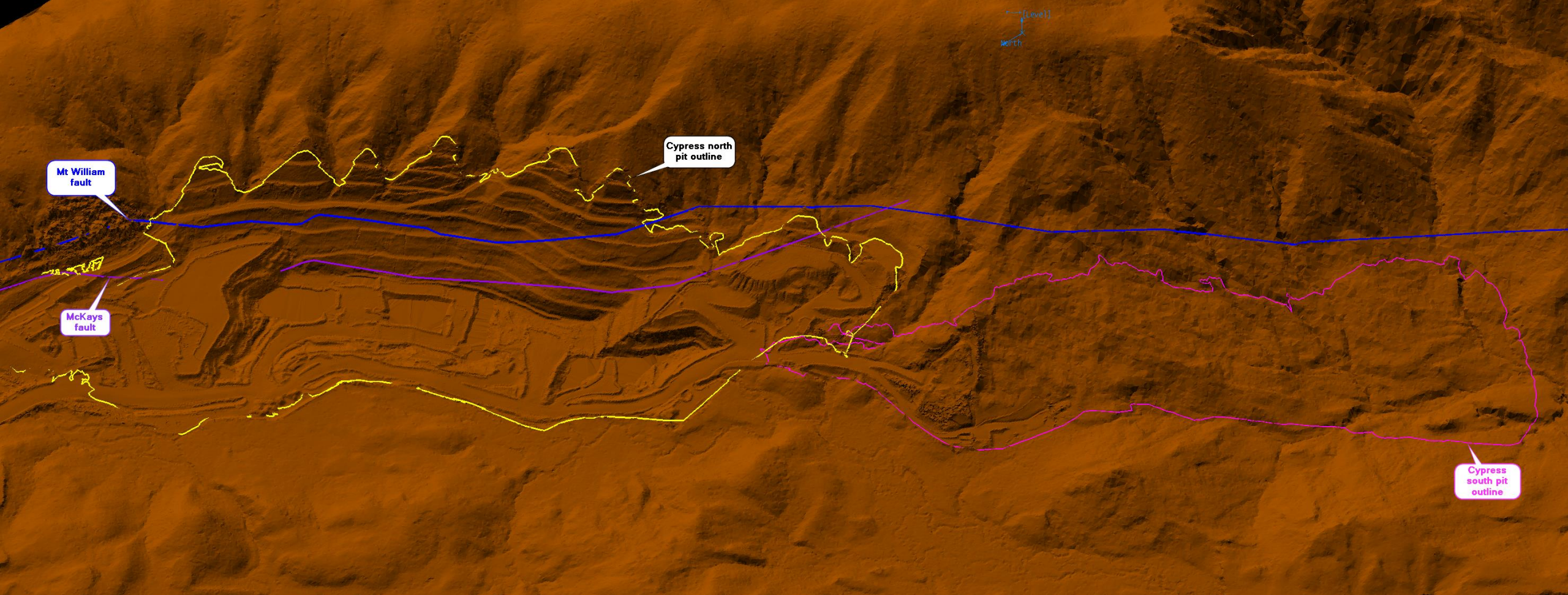
Structural system

Reactivated normal faults have uplifted the plateau. The faults moved from an extensional system of NNE-SSW trending faults 90-40Ma to a compressional phase starting around 15Ma

This history has allowed for old and new shearing to form along with the faults. Shearing in basement likely formed due to differential movement between the faults and shears in the Brunner and Kaiata formations are due to the steeply dipping normal faults not being well suited to accommodate the current compressional movement.

This has lead to stress in and around the major reactivated faults to be expressed in unusual ways. Due to the partial WNW-ESE component of the compression faulting in this orientation has taken advantage of the existing shearing in basement.



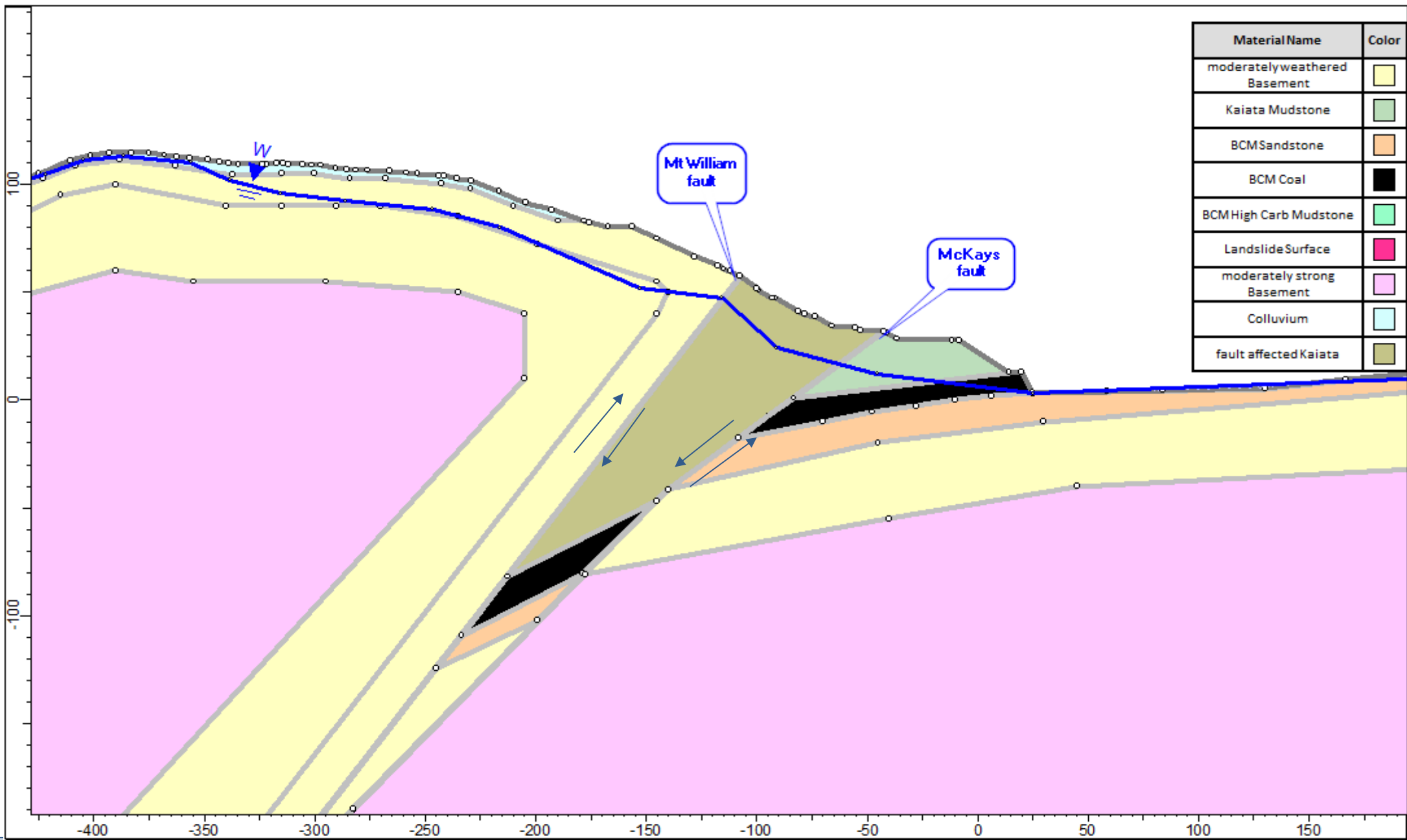


- Cypress north pit shown in Yellow
- Cypress south pit shown in Pink
- Mt William Fault in blue
- McKays fault in purple

Cypress pit overview

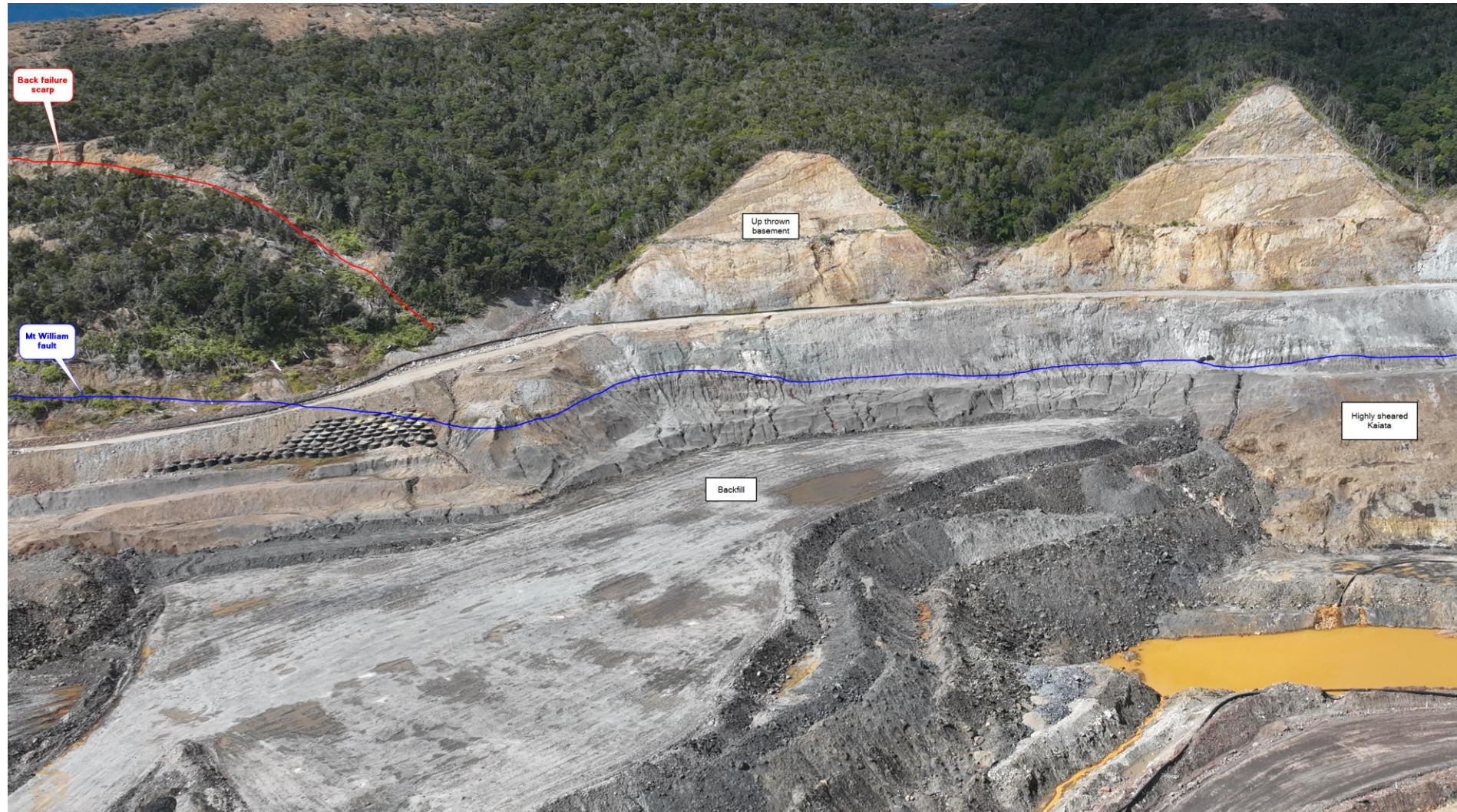
East

West

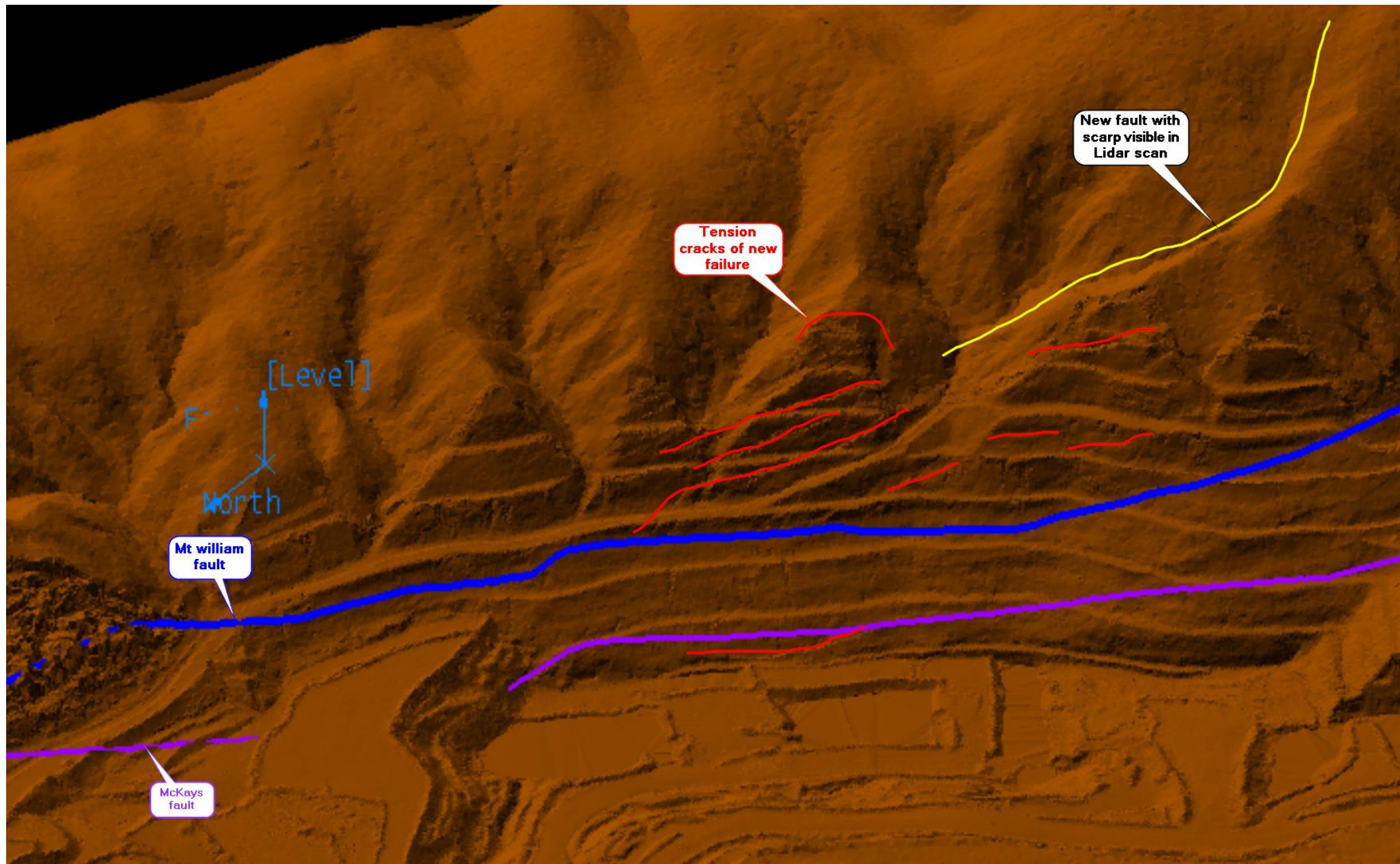


Section view looking south

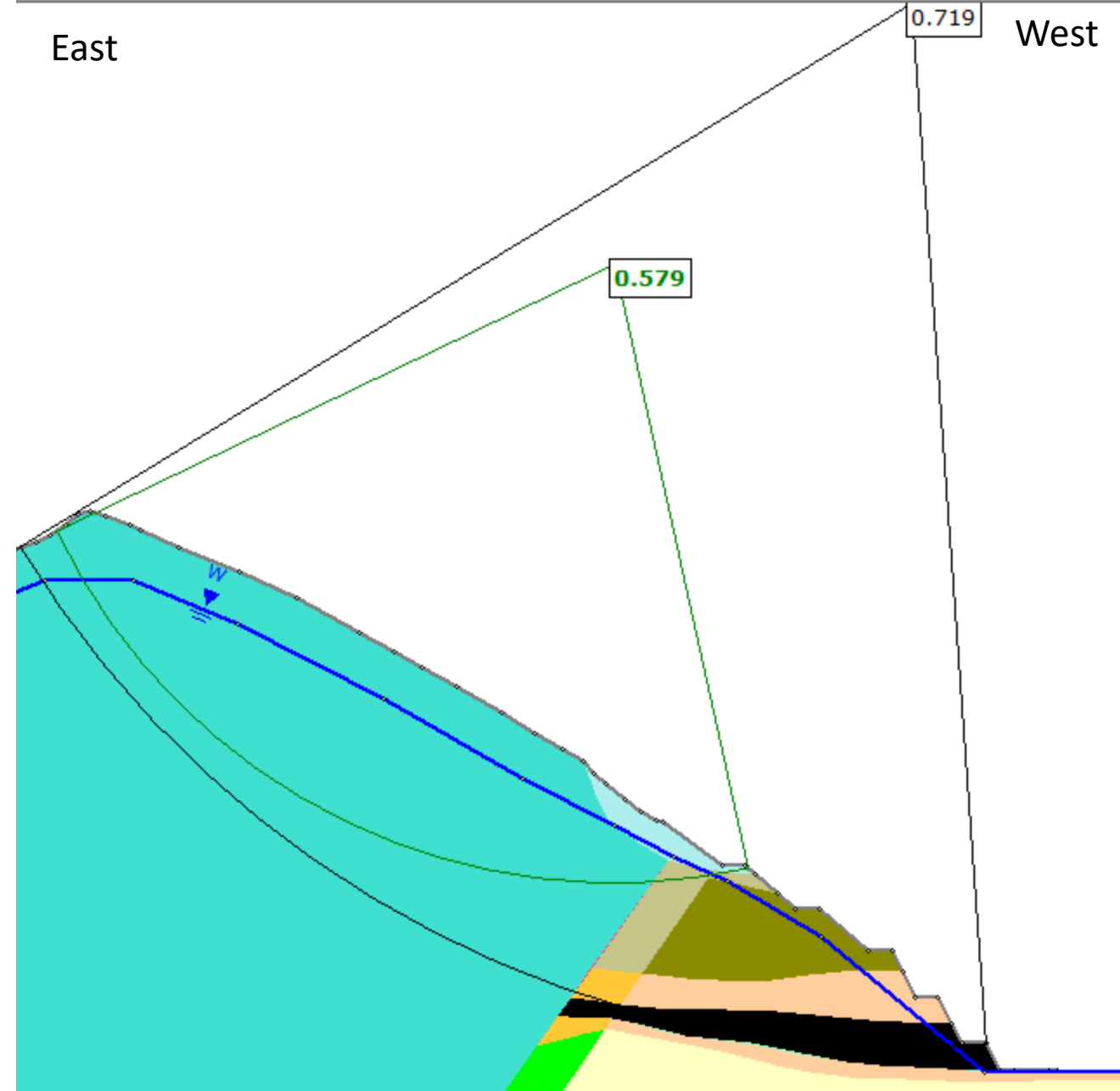
- In the north pit the highwall cuts through the upthrust basement at the top of the slope through the Mt William fault into the highly sheared Kaiata mudstone and down into the coal measures at the toe of the slope.
- Economic constraints resulted in a significant portion of the wall being cut through the fault affected Kaiata rather than stepping back and removing it.
- This then resulted in a failure of the slope due to this fault affected ground with limited drilling not providing a full picture of the ground prior to excavation.



- After the initial problem due to shearing in the Kaiata was designed out of the highwall an additional previously unknown fault caused an additional failure.
- This new failure is the result of additional rock mass damage to the basement behind the Mt William fault in a limited area.

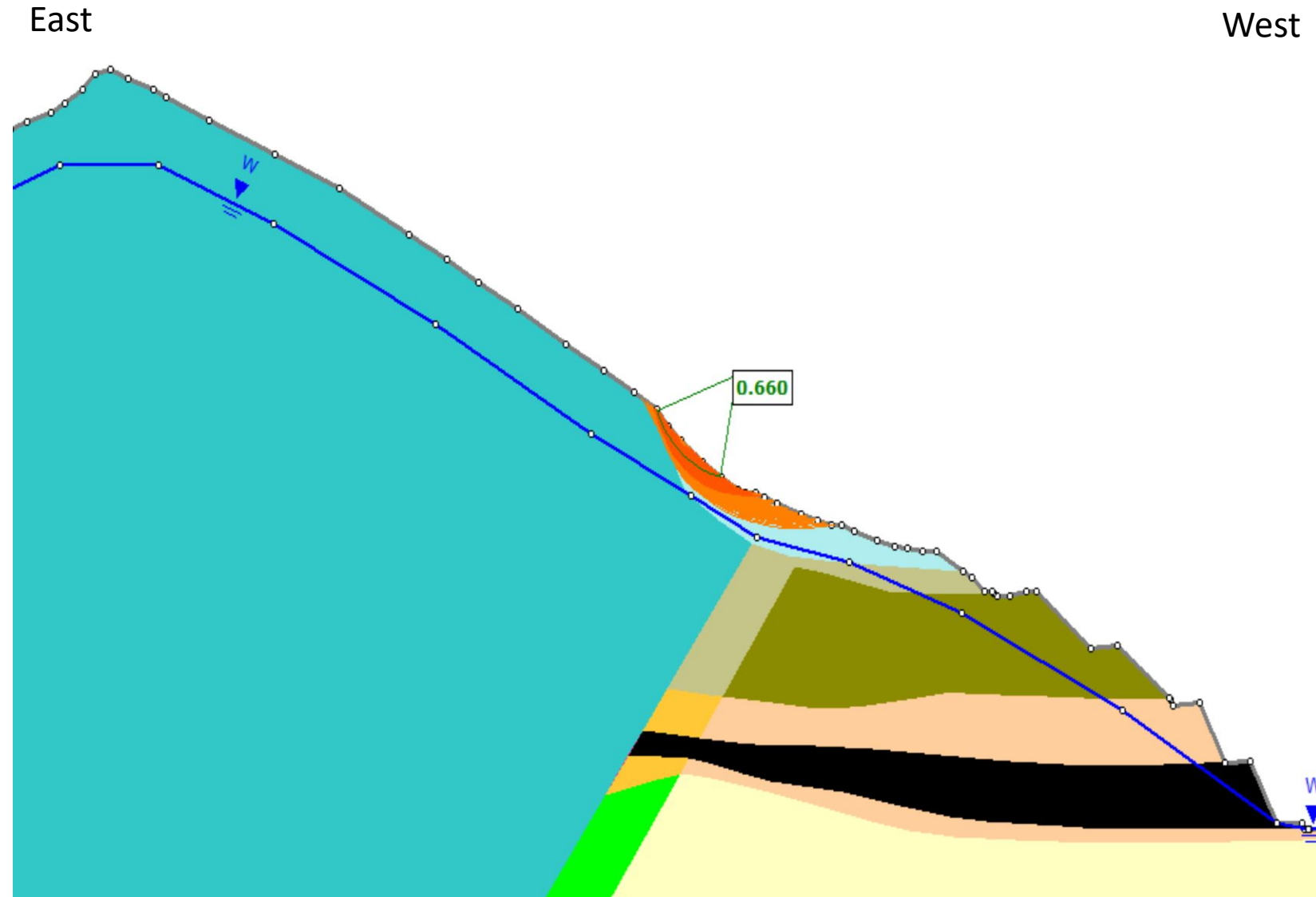


- In the south pit the rock mass damage is to the east of the Mt William fault across a much wider area.
- In the original design this would have caused highly sheared basement to be outcrop through the upper slope and be behind the majority of the slope with little weight/material at the toe of the slope.
- This would have resulted in FoS well below 1 in high water conditions indicating failure.
- This required stepping the pit to the west to avoid disturbing the damaged rock mass thus leaving intact material towards the toe preventing potential highwall stability issues.

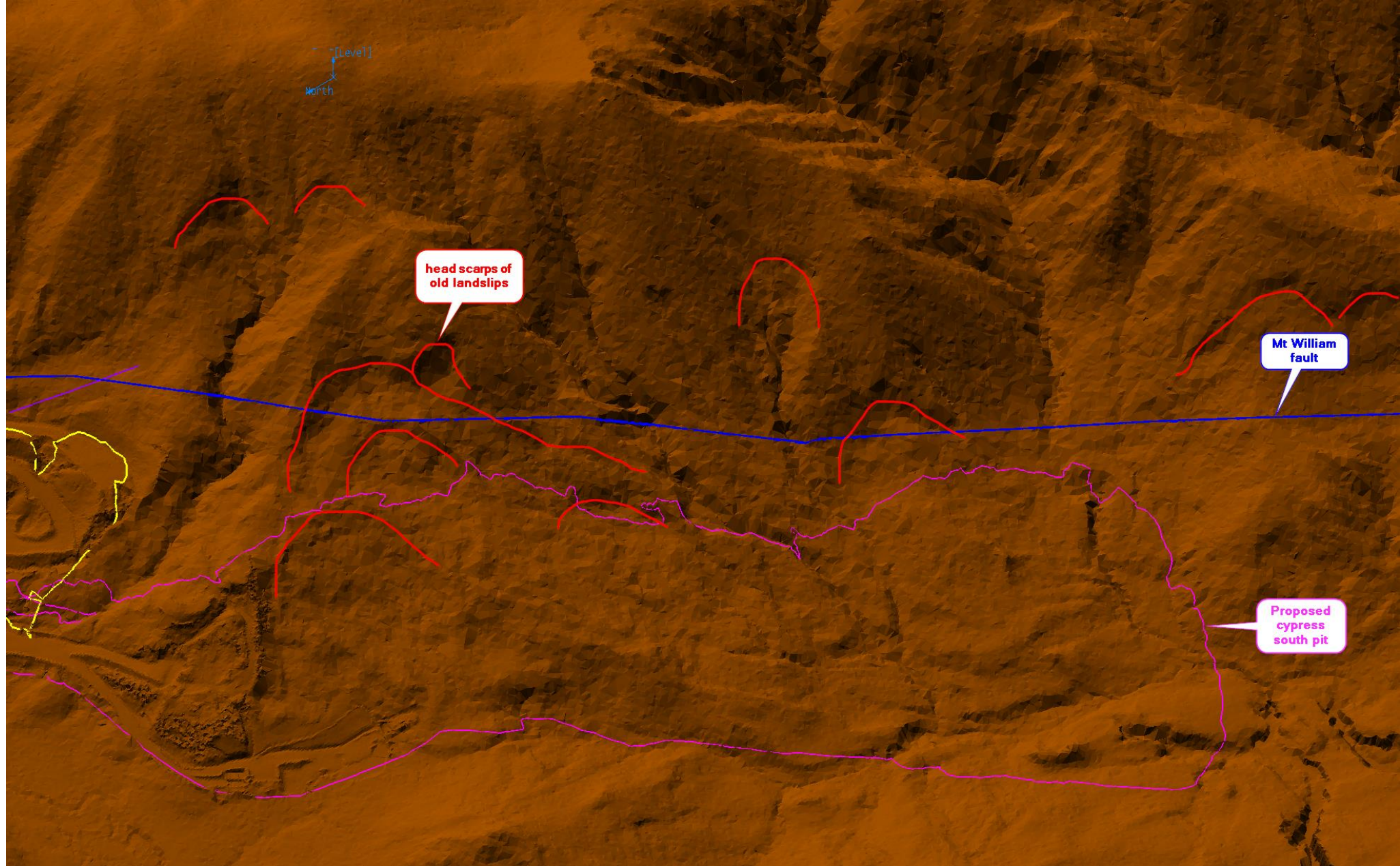


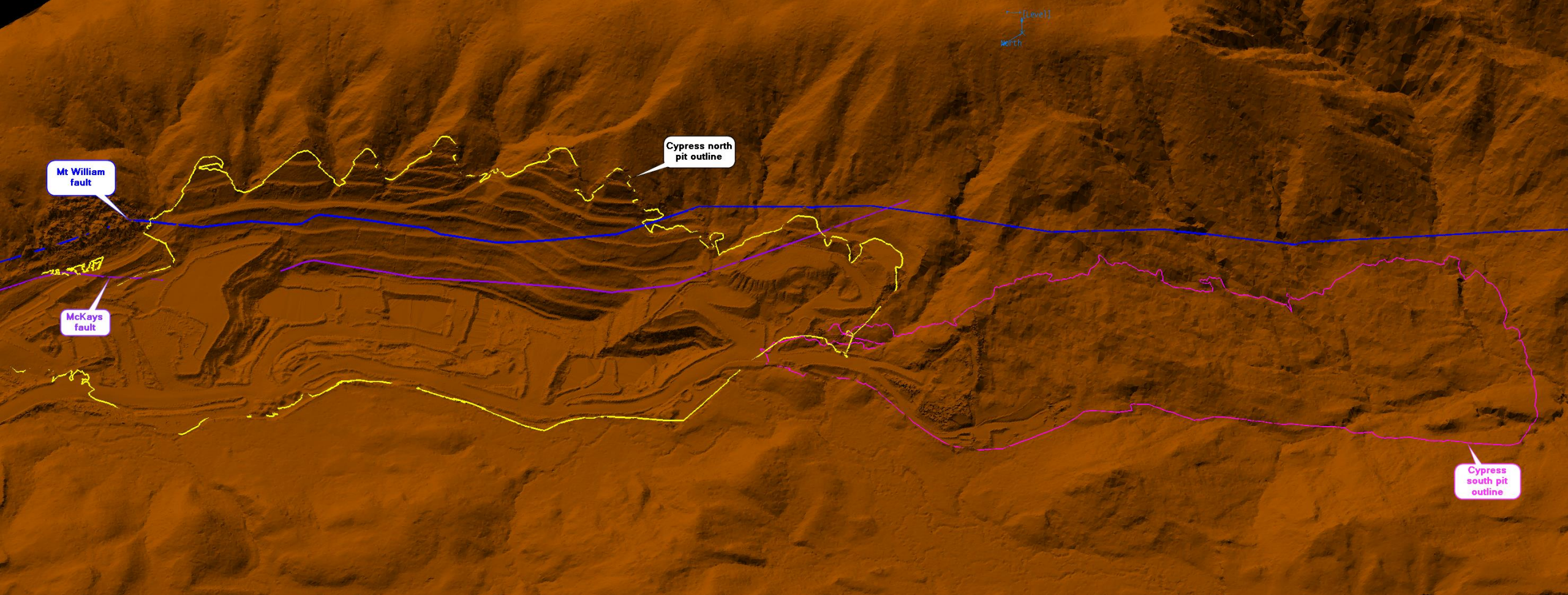
Implications for the originally proposed south pit

- The revised proposal for Cypress south now leaves considerable coal behind to prevent highwall instability.
- Small potential issues still remain due to existing landslips which will be cut into.
- These landslips are the result of the highly sheared and weakened basement historically failing.



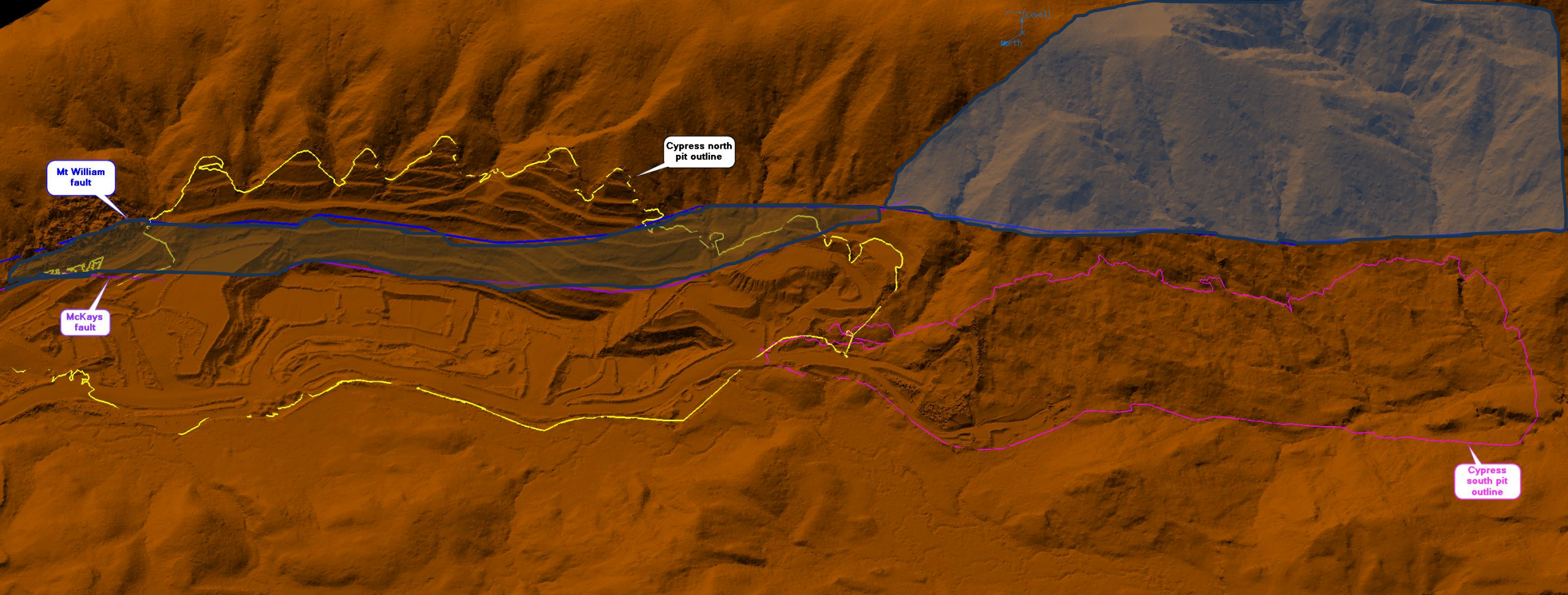
- The historic landslips are far more numerous and pronounced in the south than in the north.
- These slips are likely caused by the highly weakened basement towards the top of the ridgeline allowing larger failures to propagate.



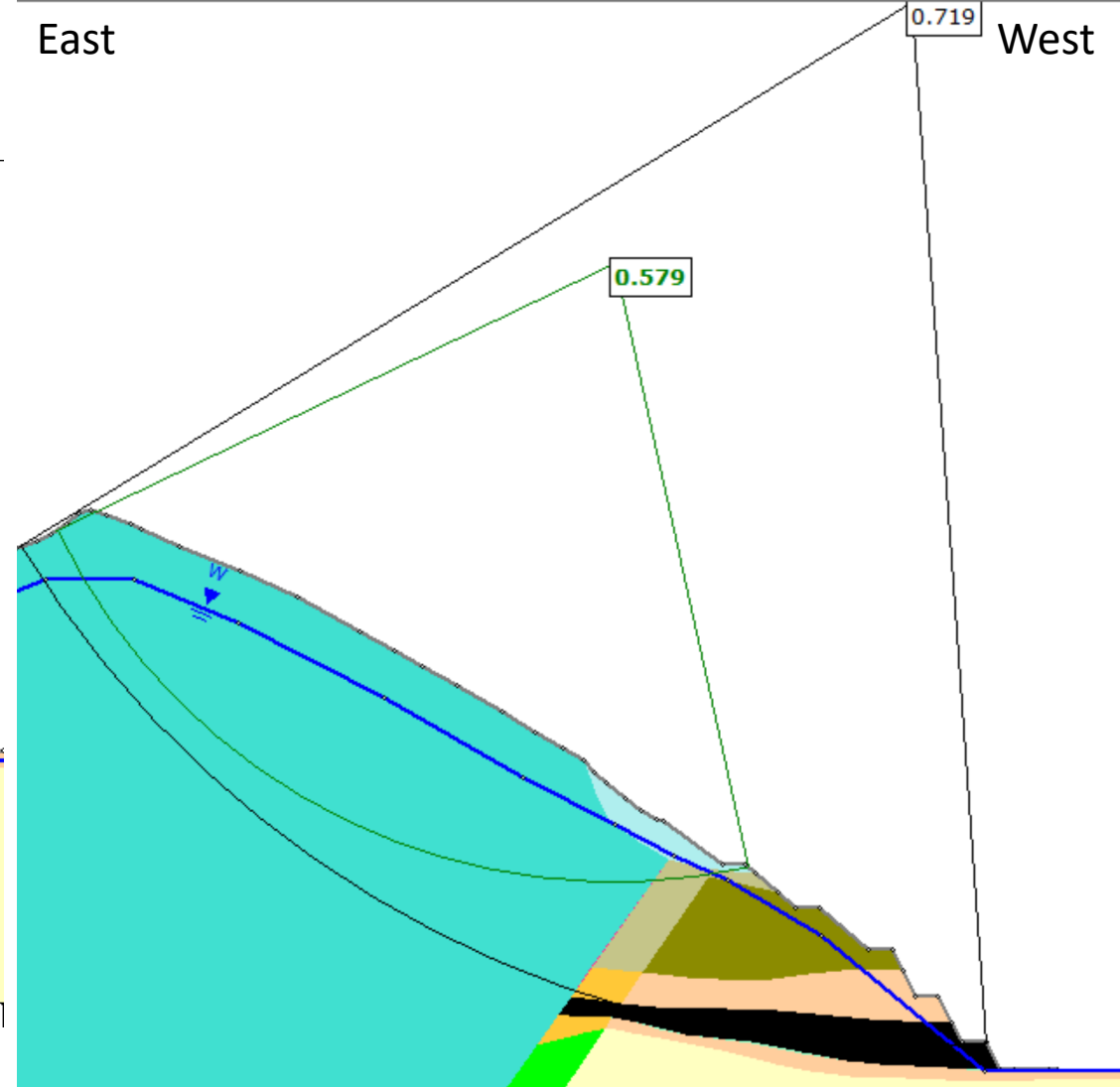
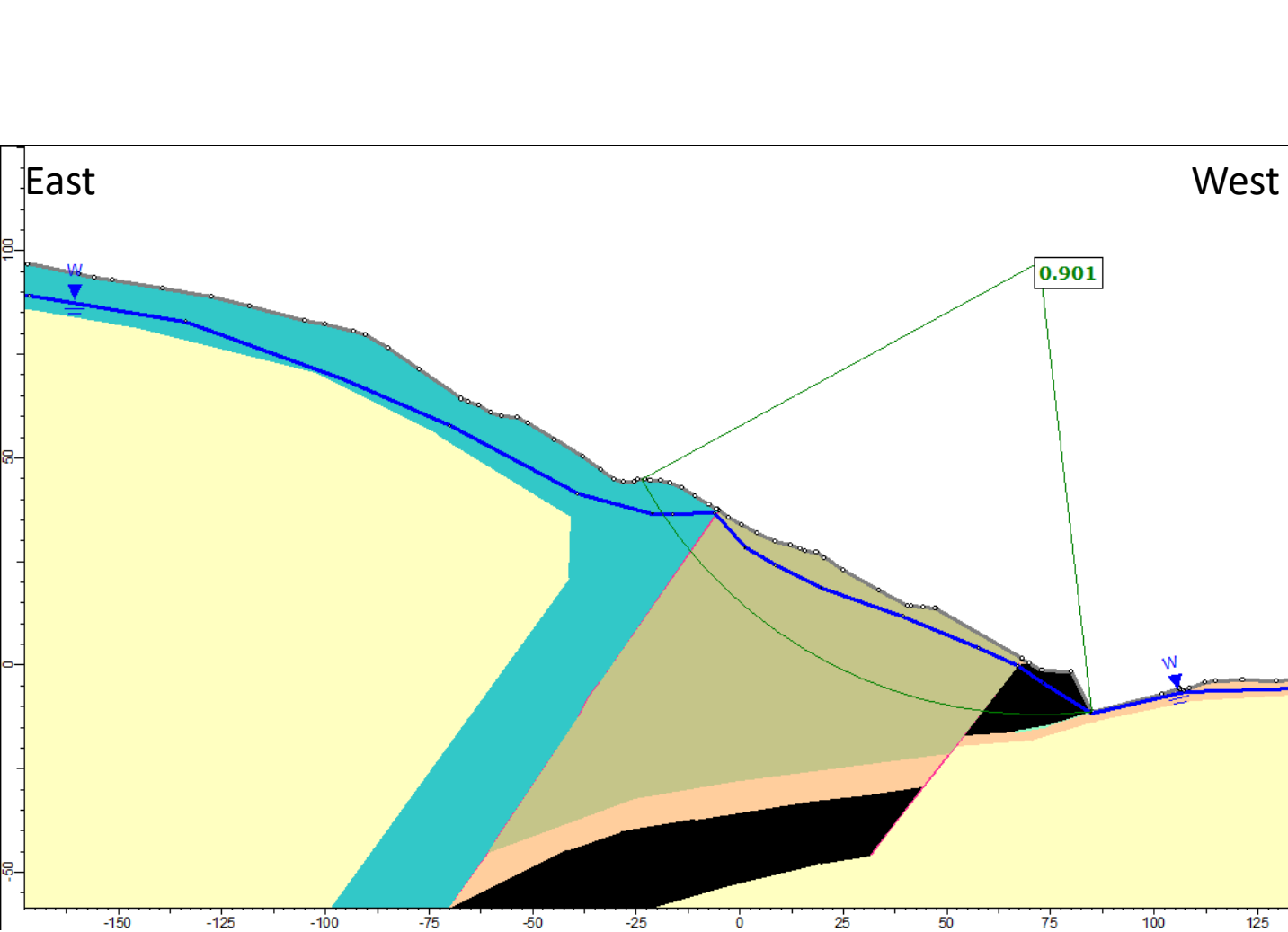


- As the Mt William fault kinks up to the east the McKays fault rejoins it.
- This change in the faults corresponds to a change where the principal damage to the rock mass around the Mt William fault occurs.
- In the north pit the shearing and mechanical fracturing has principally been to the west of the Mt William fault (bound by the McKays fault).
- In the southern pit the drilling has shown the damage has been pushed to the east of the Mt William fault into the upthrust basement.

Damaged rock mass around the Mt William fault



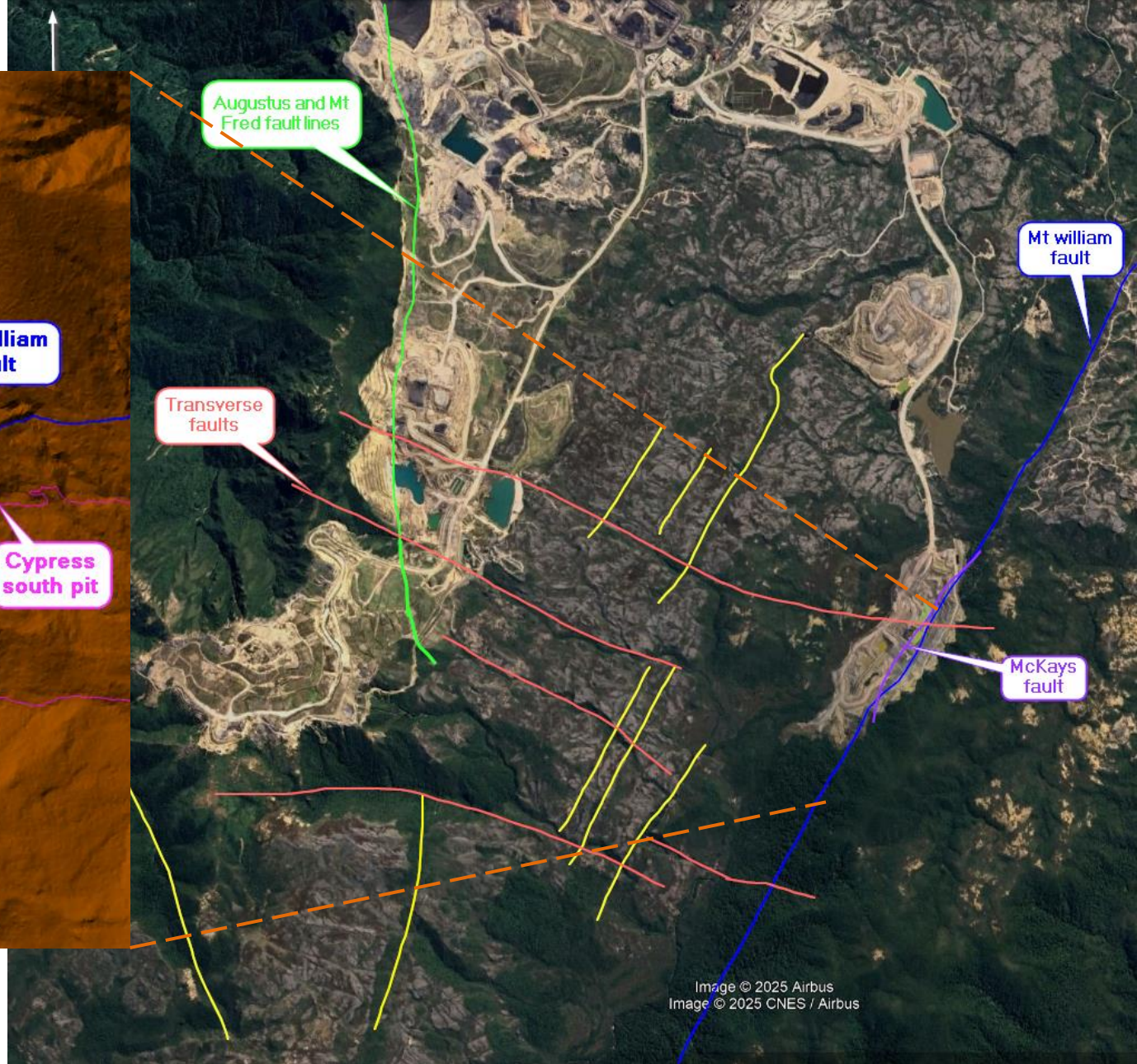
- This difference in rock mass damage has been caused by the change in the stress regime around the Mt William fault.
- This is likely due to the compressional stress not being able to be easily accommodated on the reactivated normal fault systems.
- This has caused stress to propagate out from the fault with minor changes along the fault potentially acting as pivot points.



- Cypress North initial failure with shallow failure modelled

- Cypress South original proposal with Deep seated potential failure

Summary of the affects on North and South pits highwalls



Broad driving forces



Current pit

- F.C. Ghisetti, R. H. Sibson 2006. Accommodation of compressional inversion in North-western South Island (New Zealand): Old faults versus new? *Journal of structural geology* 28 (2006) 1994-2010.
- R. H. Sibson, F.C. Ghisetti 2010. Characterising the Seismic Potential of compressional Inversion Structures, NW South Island. EQC Project 08/547