DRIVEN BY VALUE

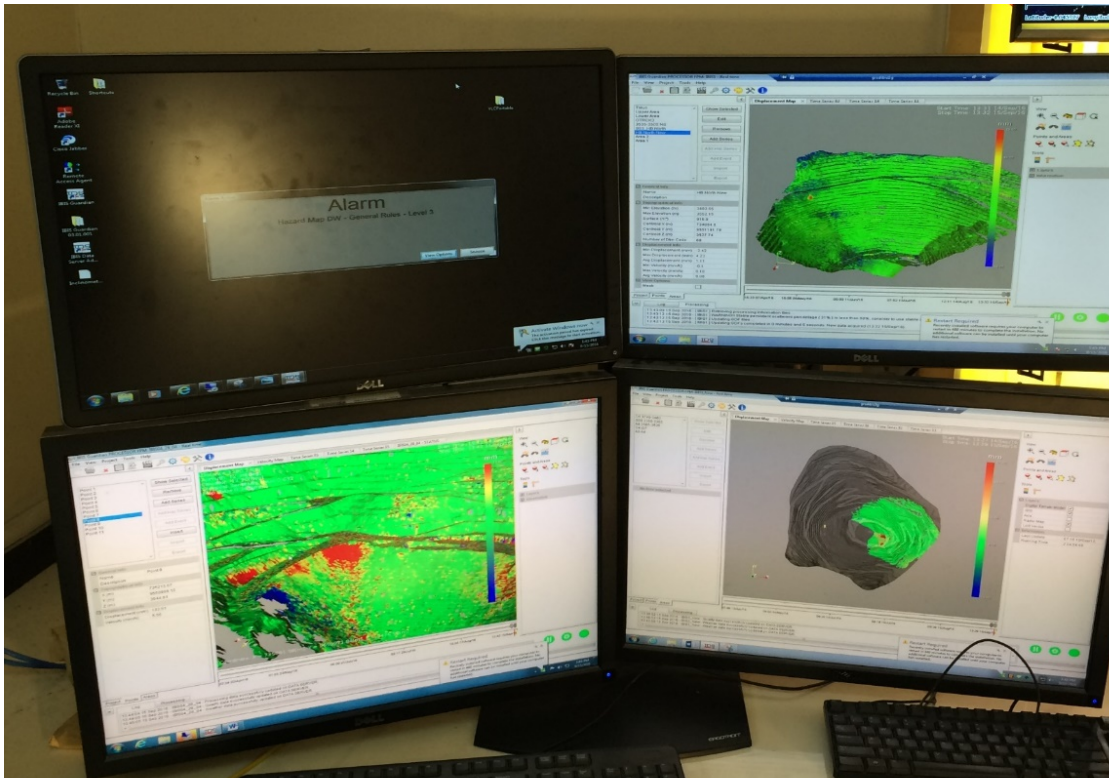
FREEPORT-McMoRan

Optimizing Slope Angles with controlled blasting, slope monitoring, and good communication

Keith Taylor

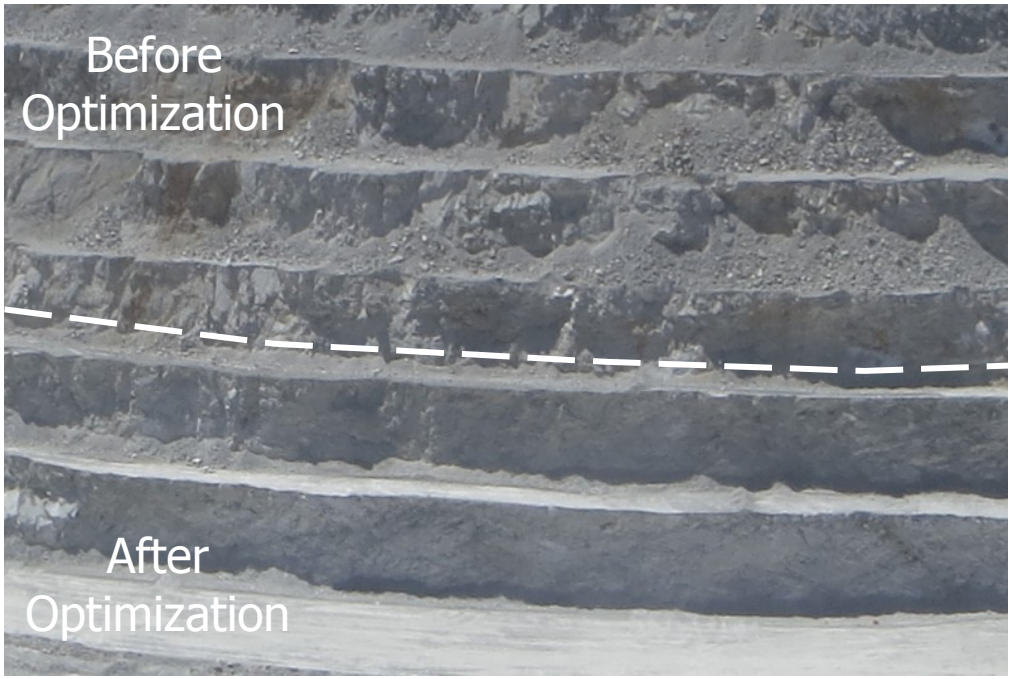
May 8, 2017

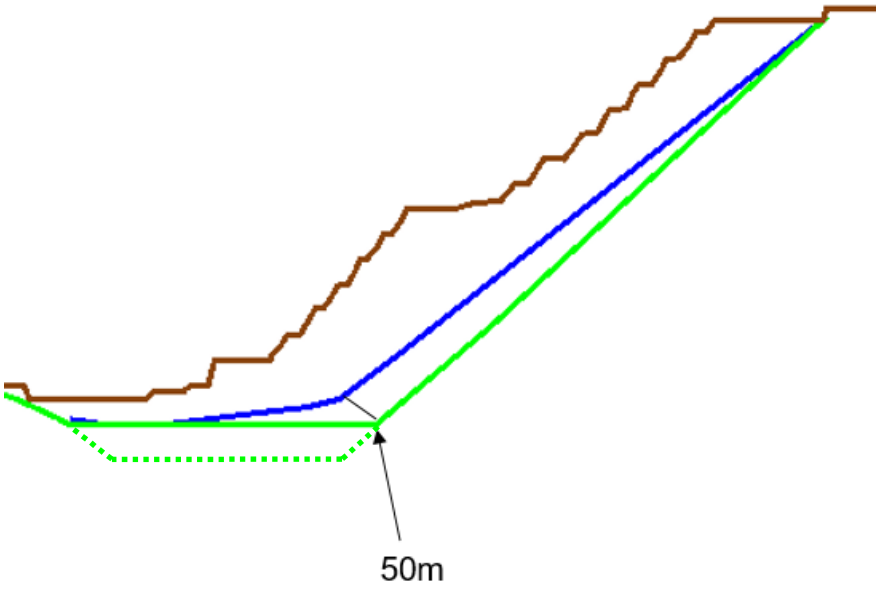
Geotech



Slope Optimization Value

- **More careful construction means safer highwalls**
- **Steeper walls mean less stripping, more ore, or some combination of both**

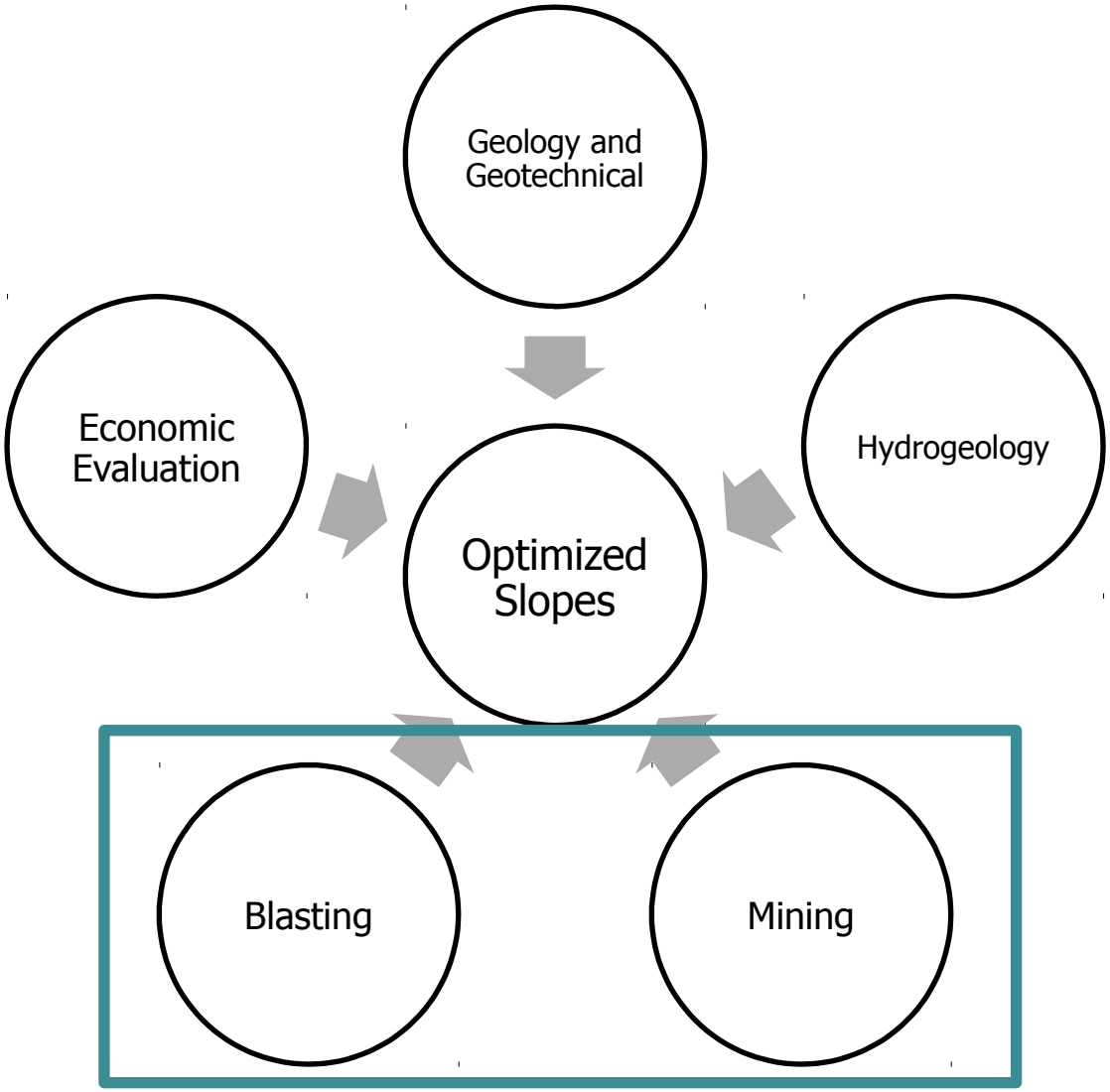




Slope Optimization: Why now?

- Not new in the industry, or at Freeport
  - 1960's to the present
  - Recent published examples at Cripple Creek and Boddington
- What's different?
  - Top down support
  - Implementing all the wall control blasting techniques we have known about for years
  - Much better feedback with LiDAR scanners
  - Process, not project

Slope Optimization Process



Wall Control Blasting

Design and Planning

- Blast Master Plan
- Detailed designs for each blast
- Frequency control timing
- Shot direction determined by geology

Preparation

- Production overbreak control
- Blast relief
- Bench Preparation

Monitoring

- Video monitoring
- Near and far field seismograph monitoring

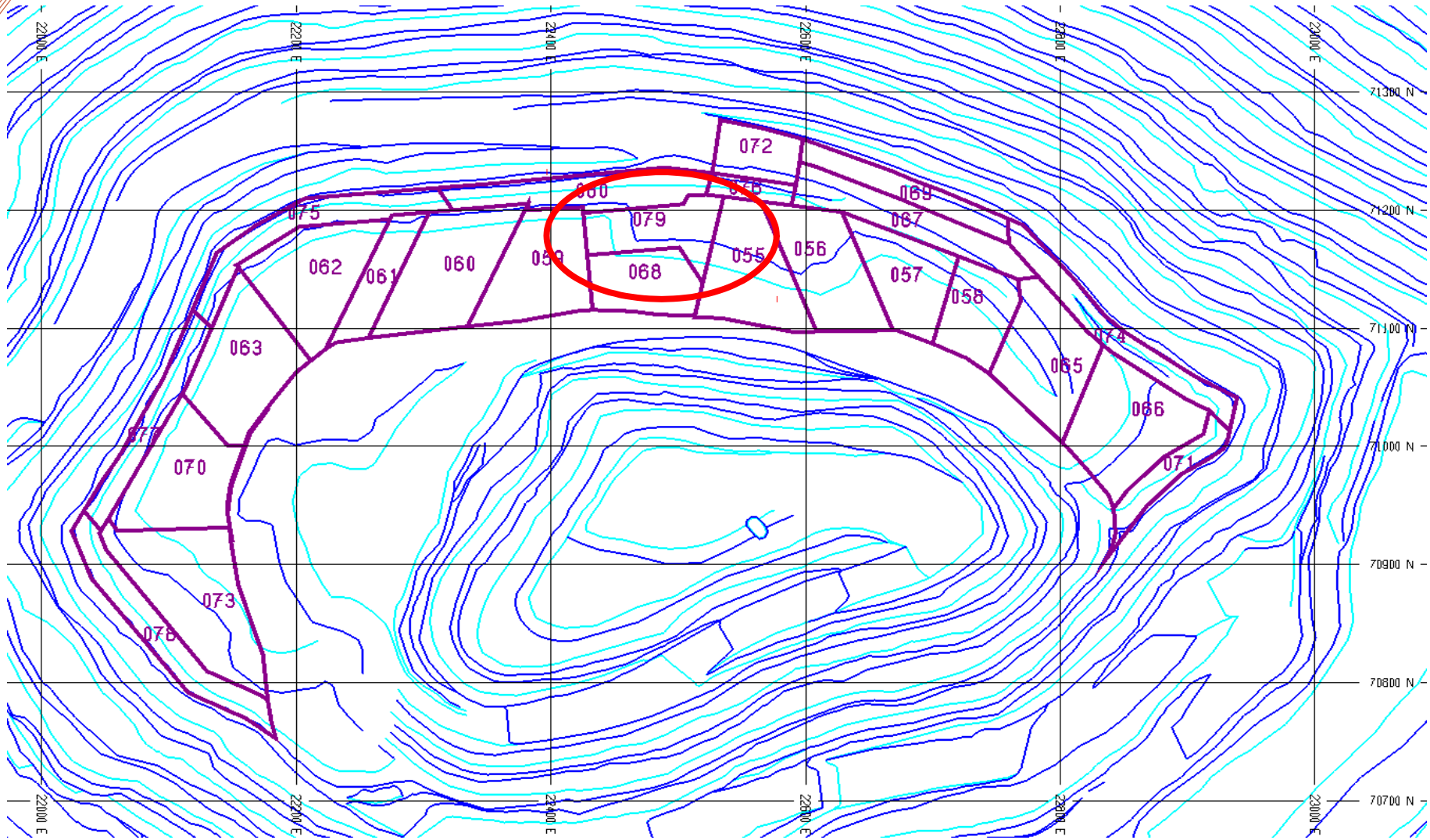
QA/QC

- PPV vs prediction
- Frequency vs simulation
- Drilling and loading accuracy

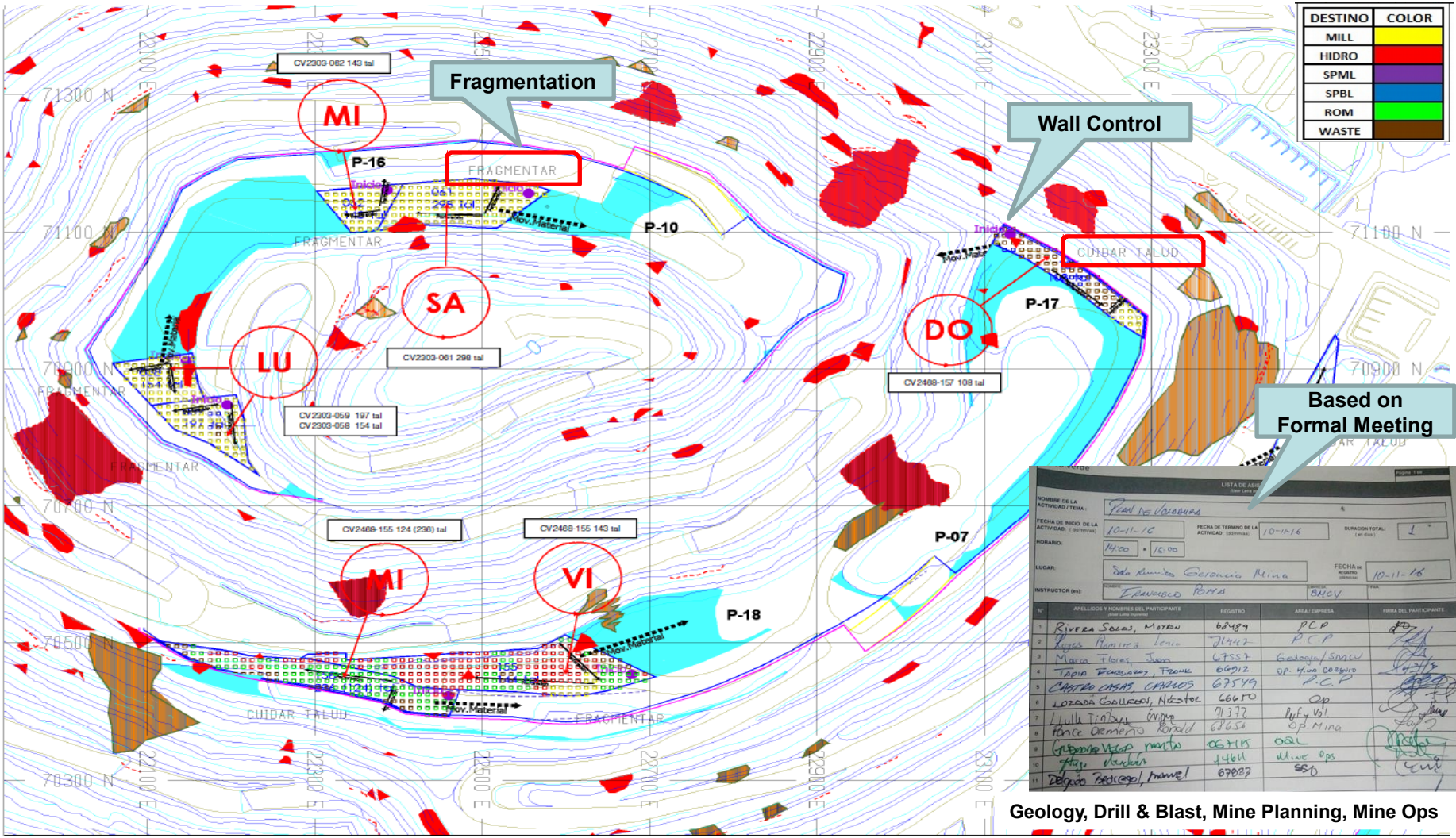
Reconciliation

- Excavated face inspected
- Cross section versus designs
- CBW, BFA, ISA analysis

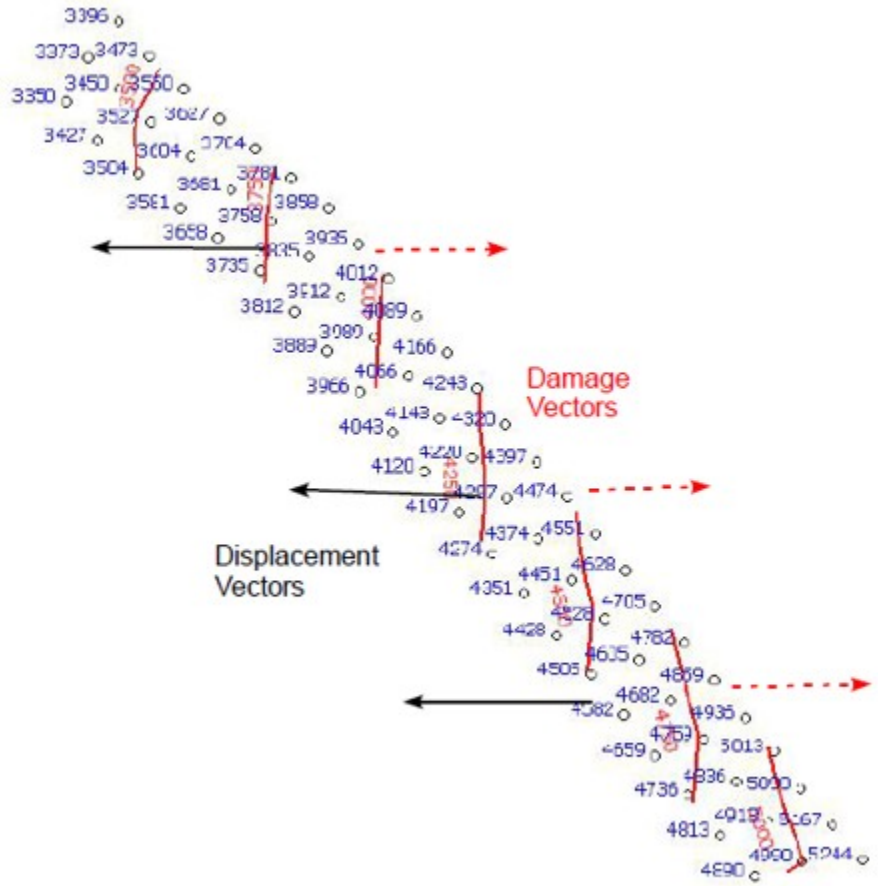
Blast Master Plan

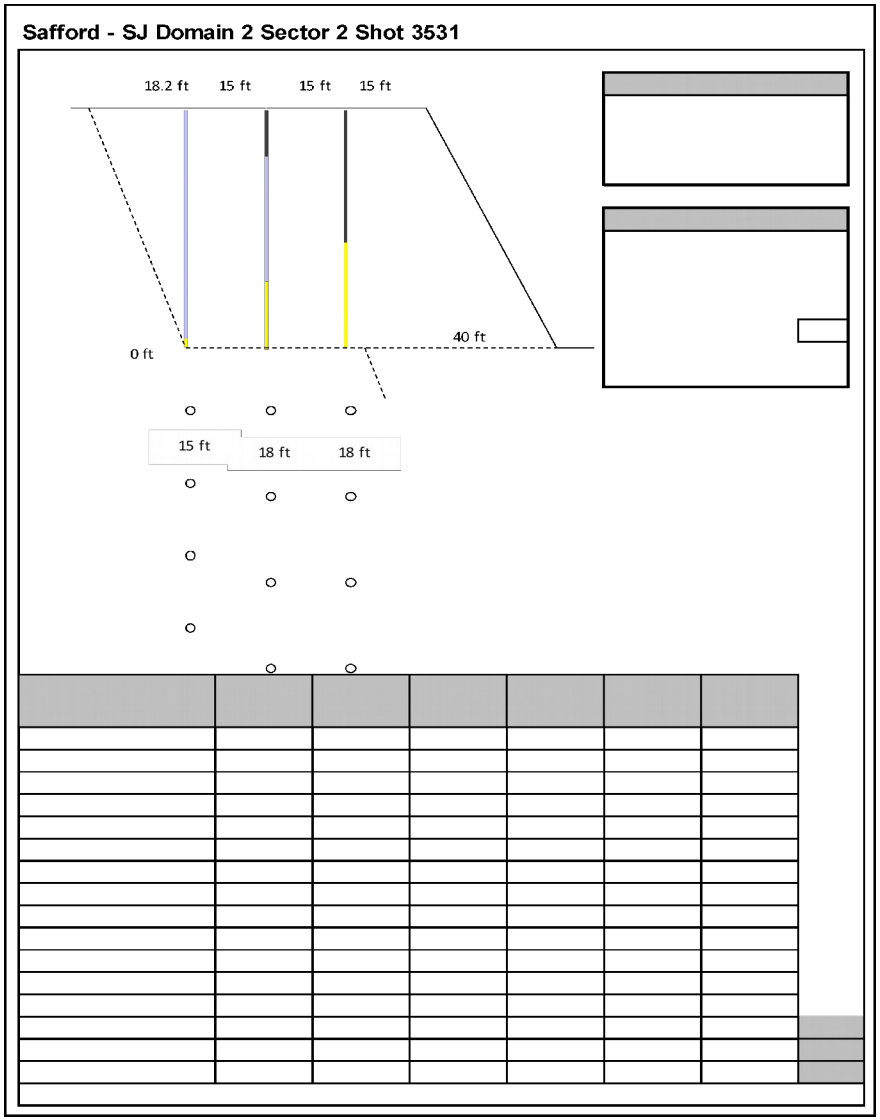


Blast Master Plan

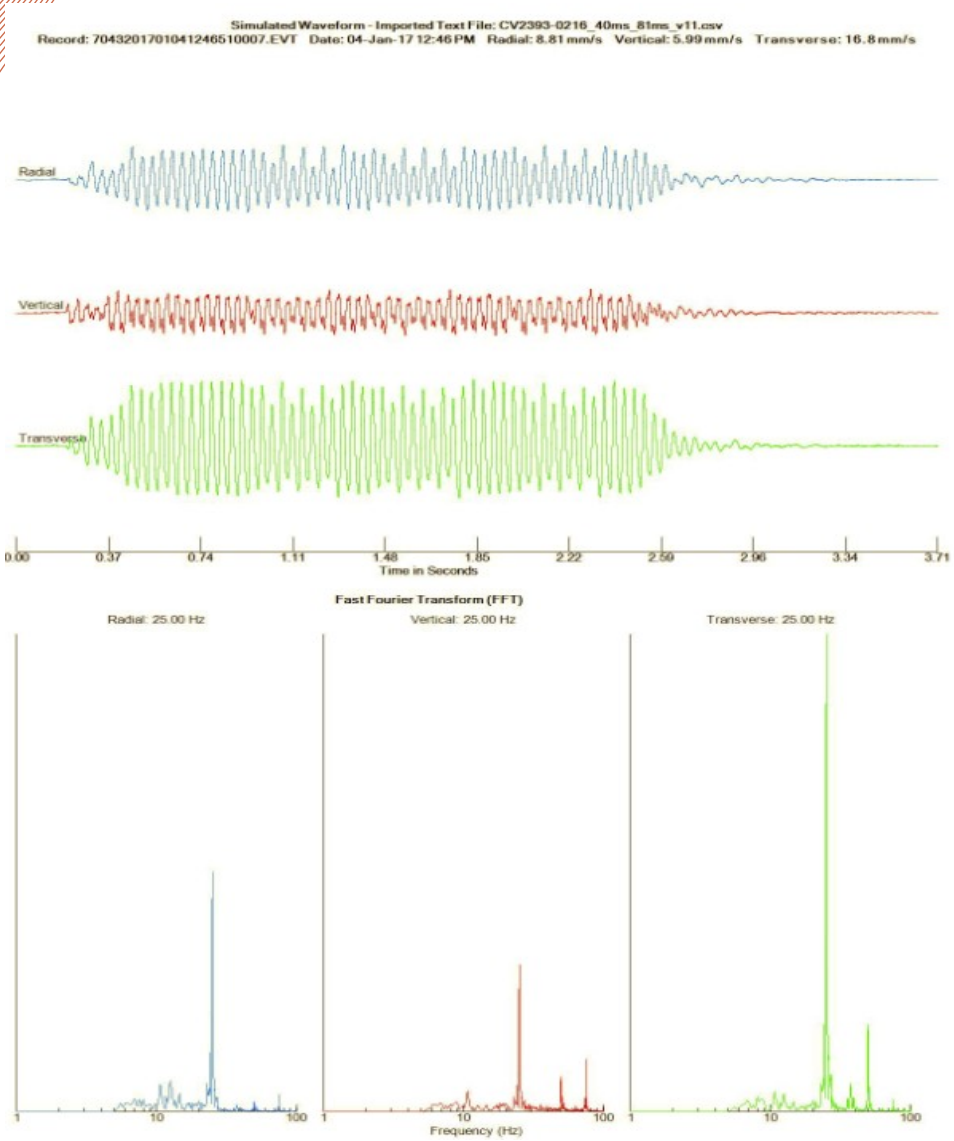


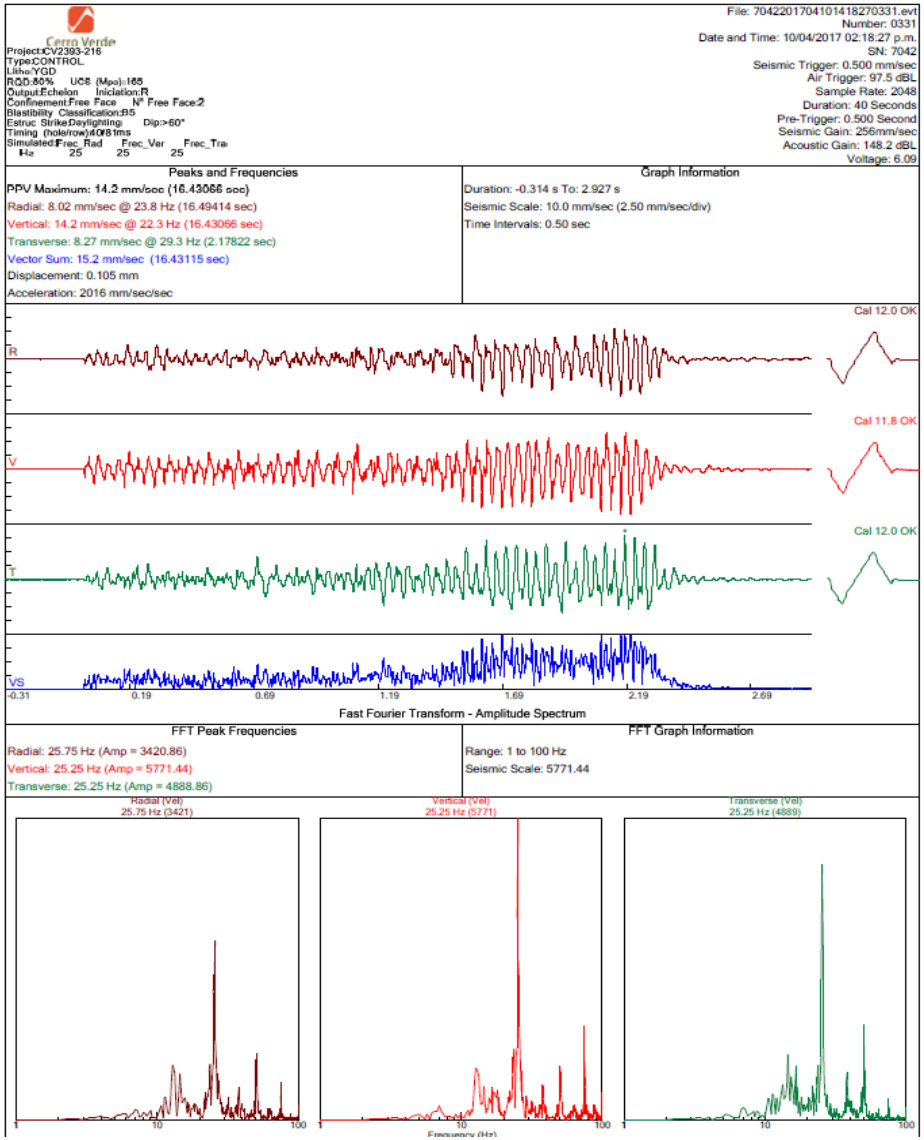
Consistent Blast Design



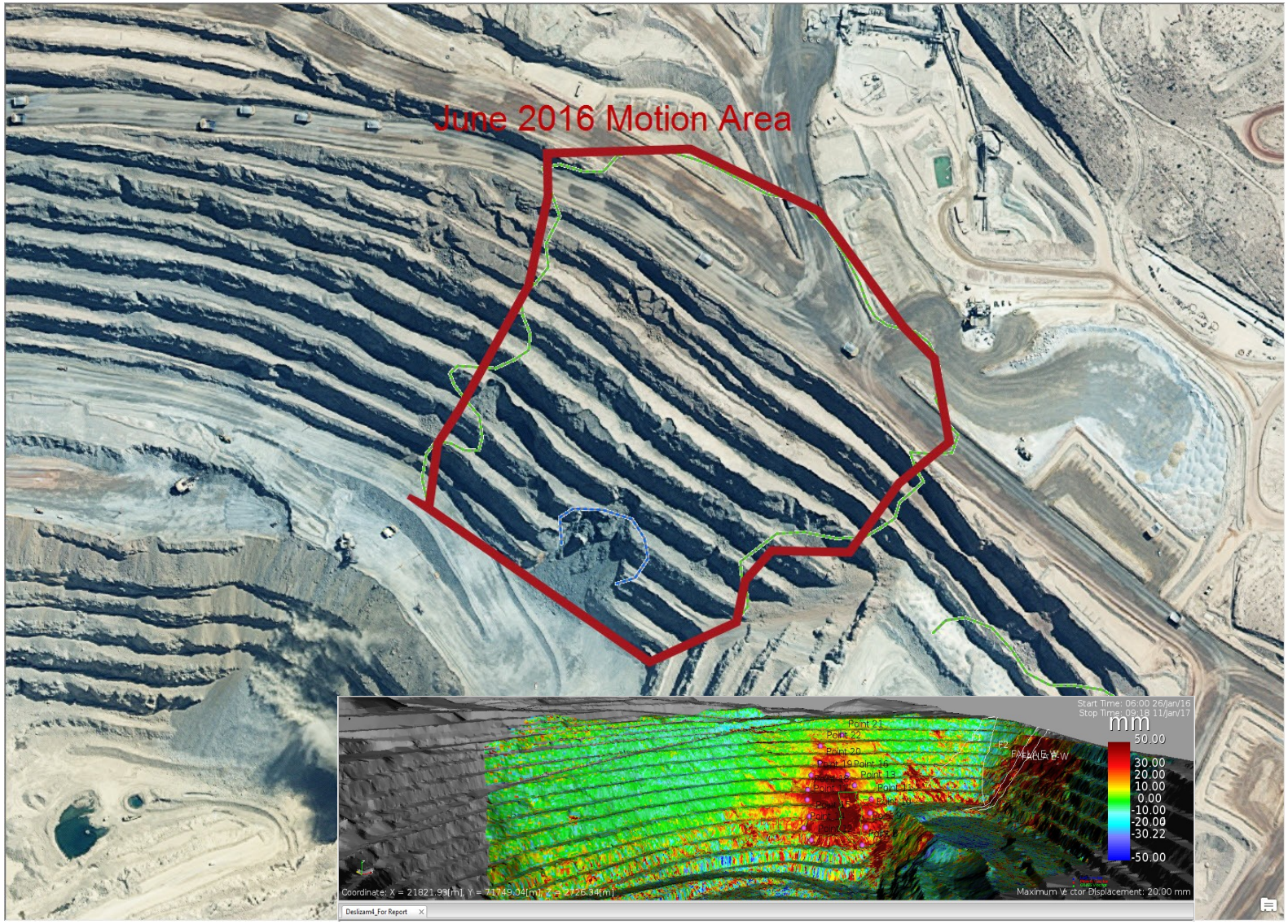


Frequency Control Timining

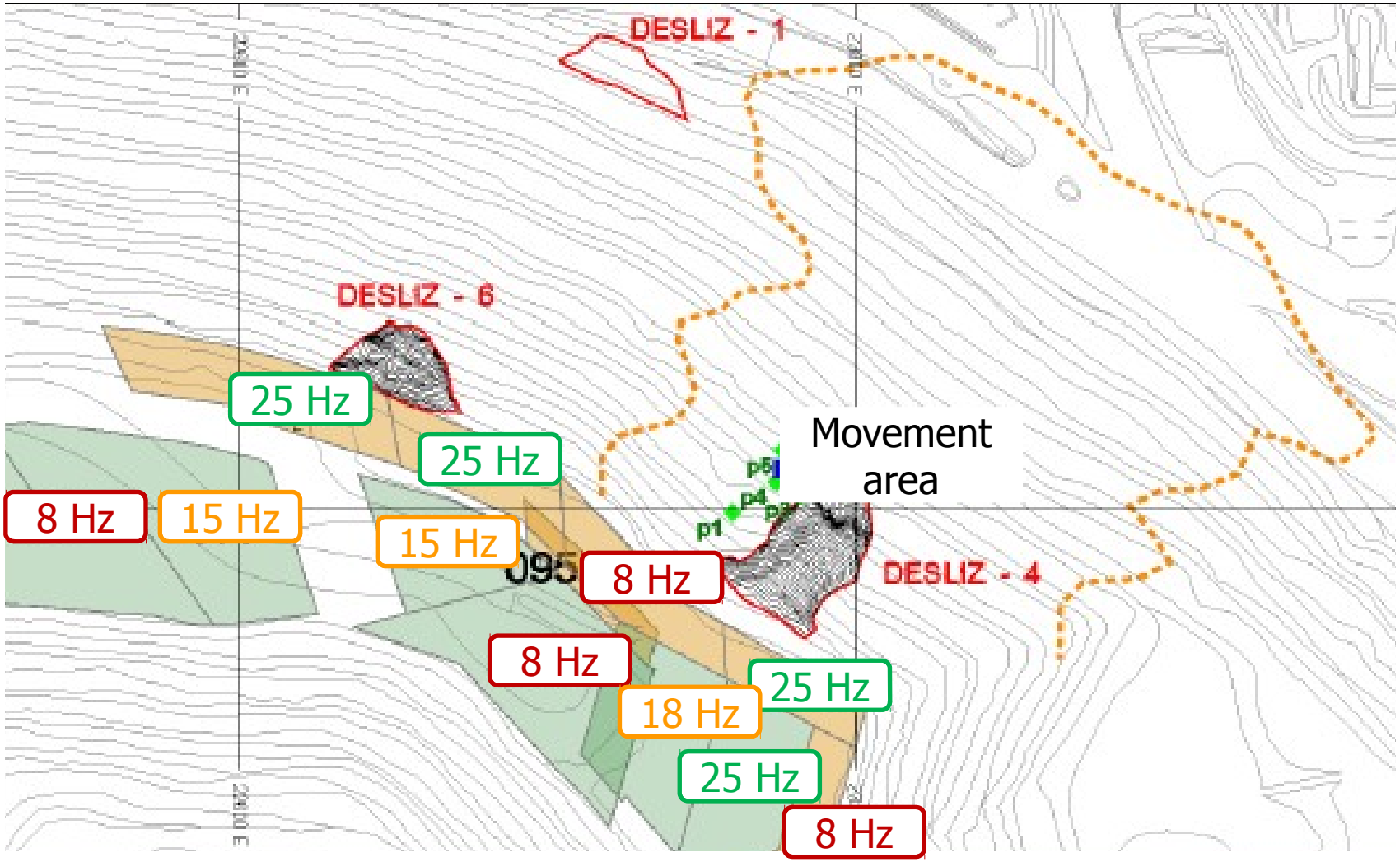




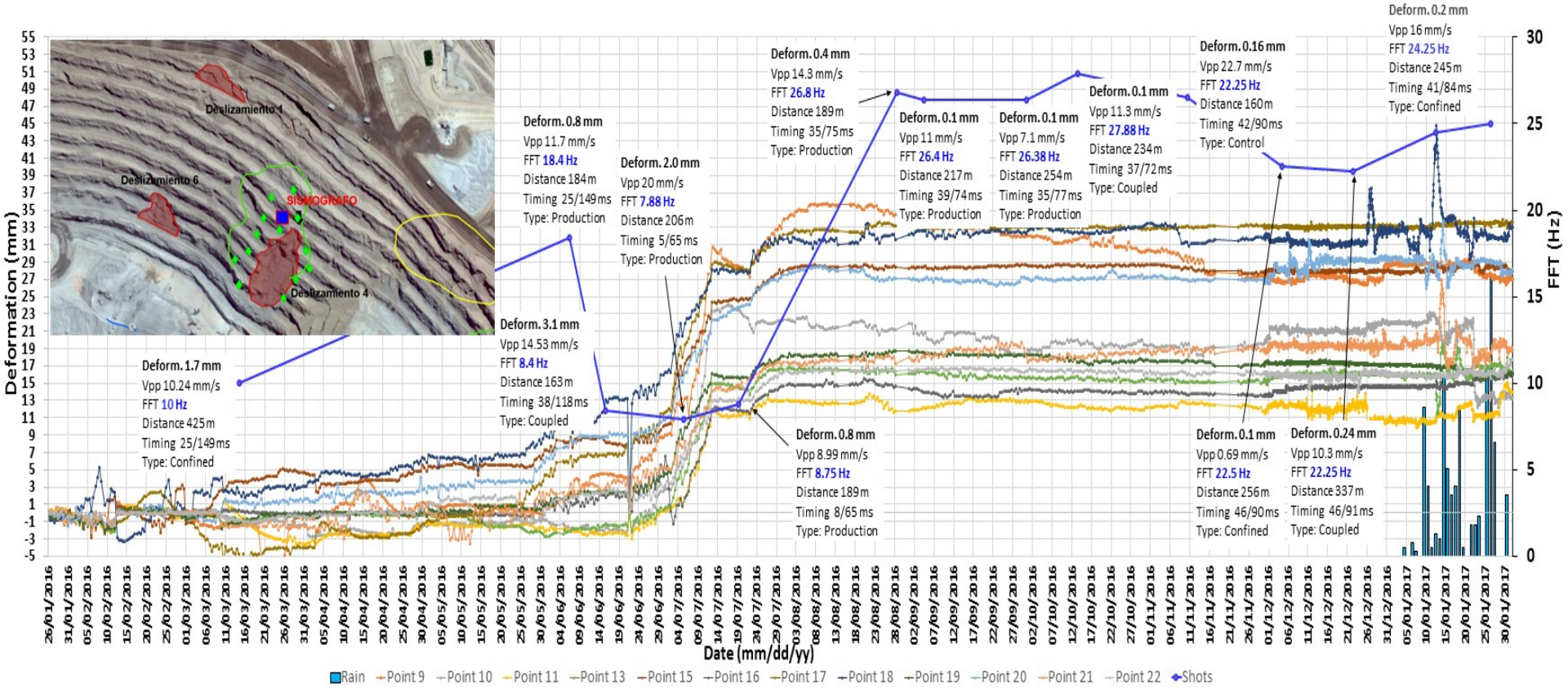
Frequency Control Timing



Frequency Control Timing



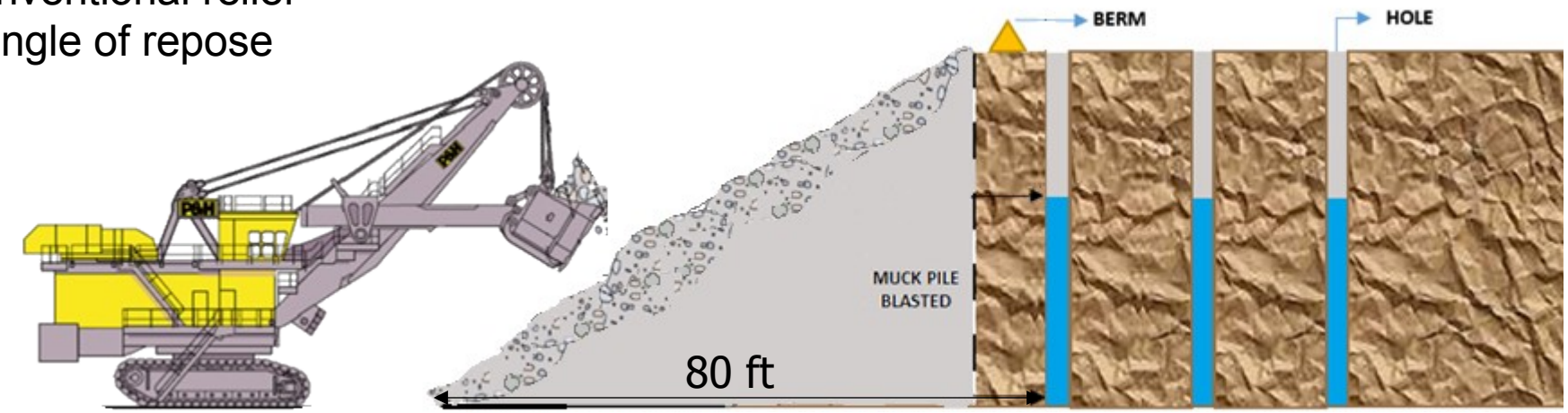
Frequency Control Timing



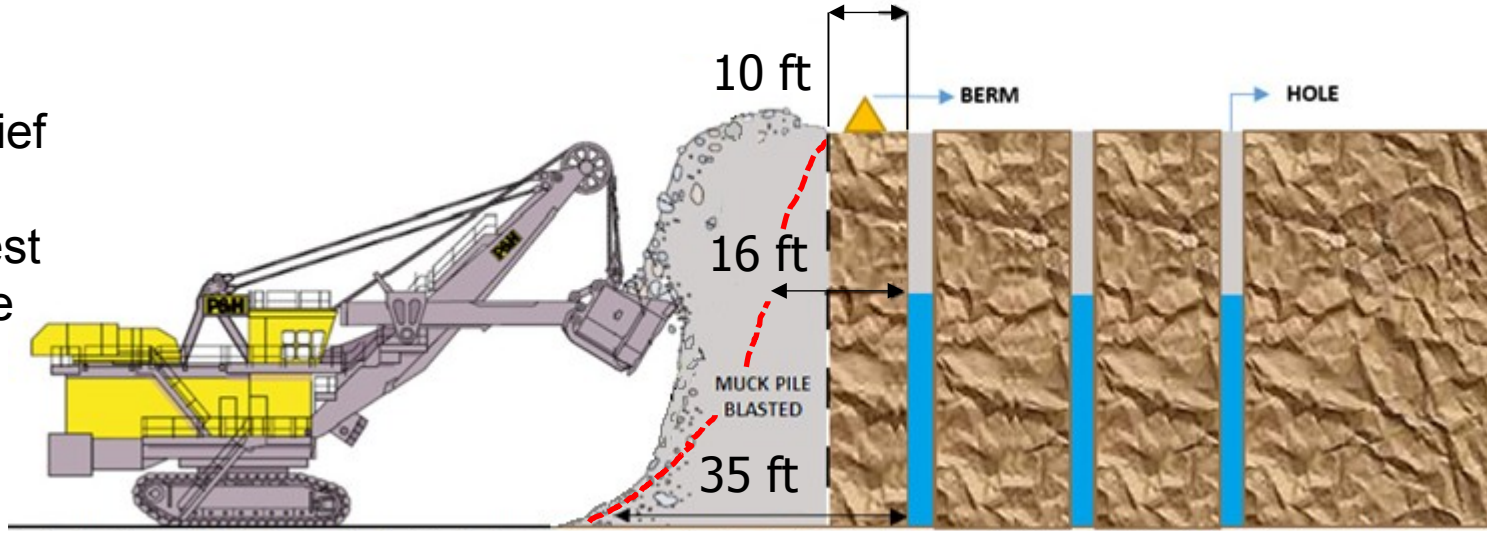
Frequency Control Timing

Blast Relief

Conventional relief
~ angle of repose

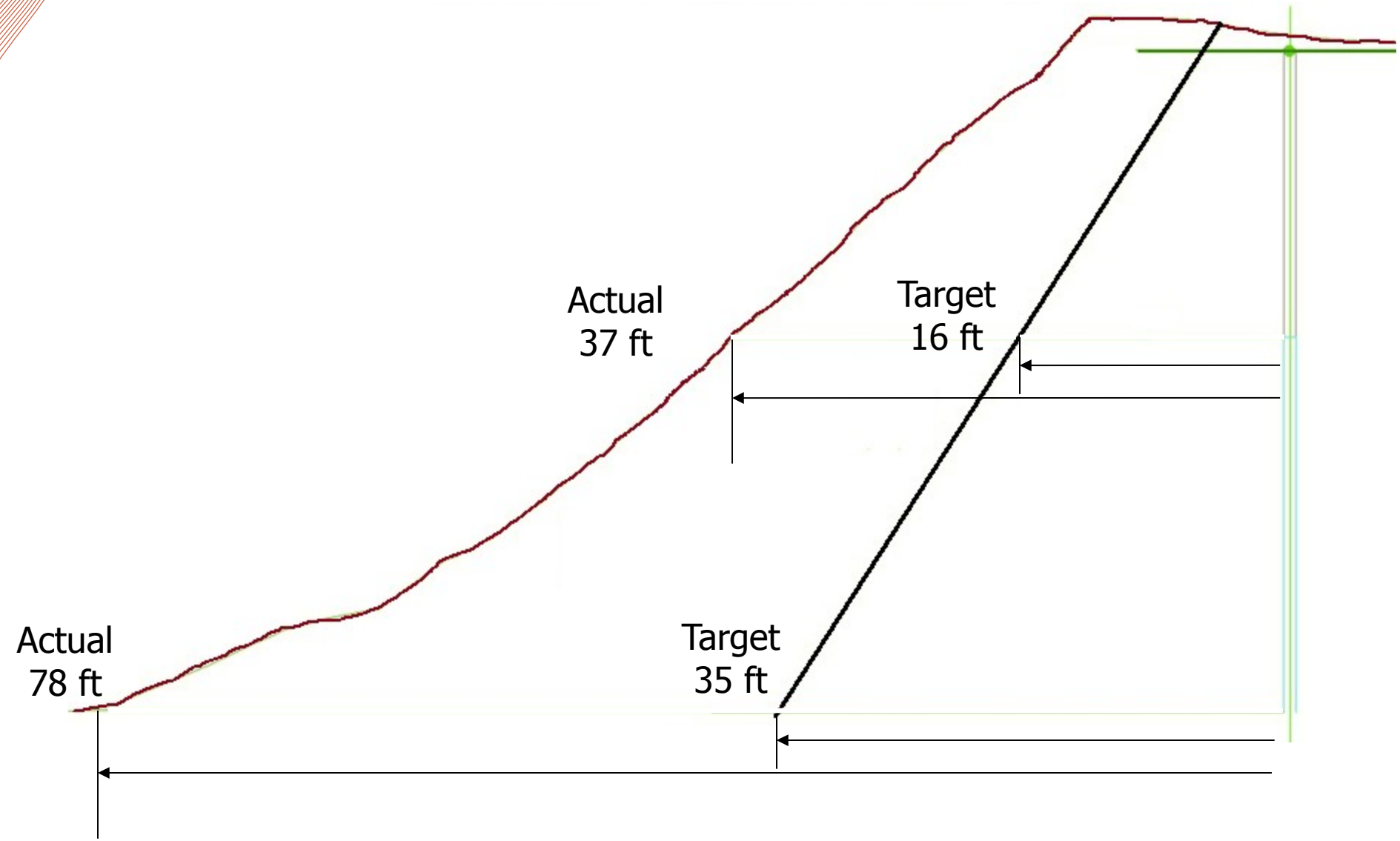


Wall control relief
60° to 65°
10 - 15 ft at crest
35 – 40 ft at toe



Conventional Blast Relief

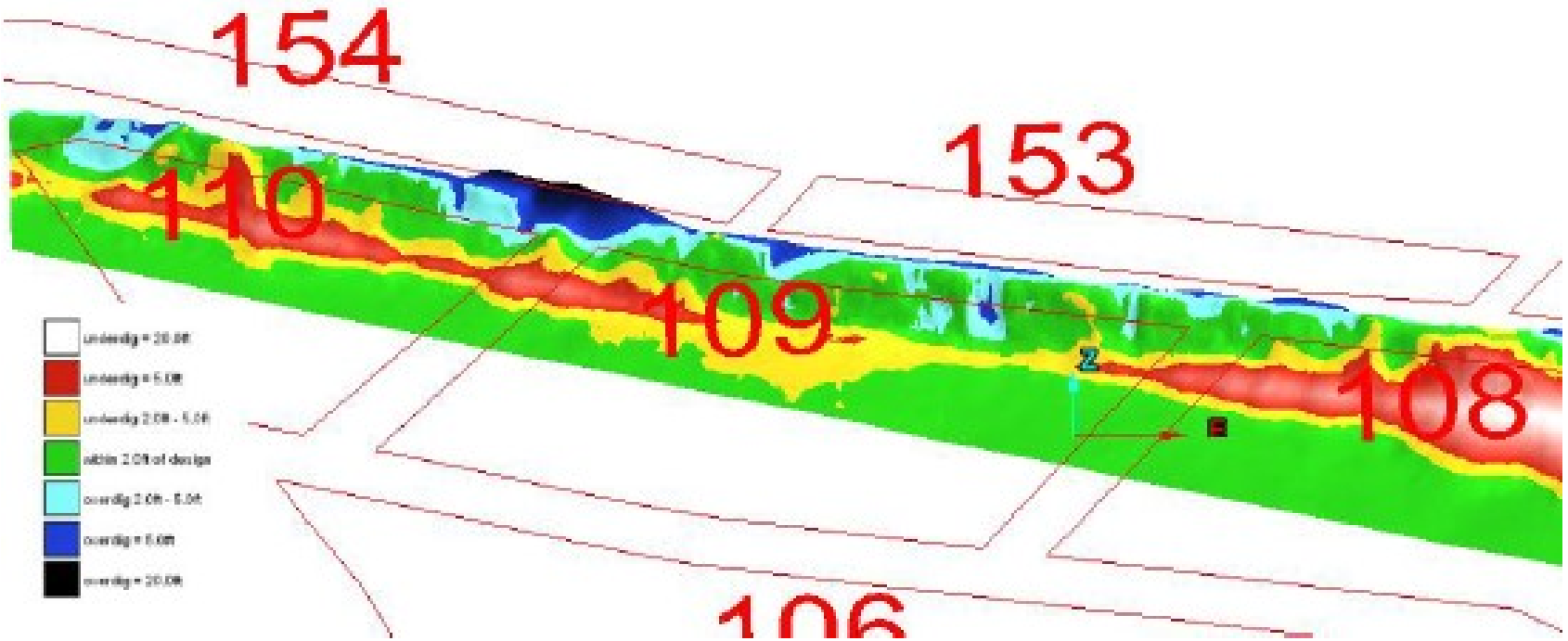
Conventional Blast Relief



Wall control blast relief

Wall Control Blast Relief

LiDAR scan of free face compared to design free face



Underdig > 5 ft

+ / - 2 ft

Overdig > 5 ft

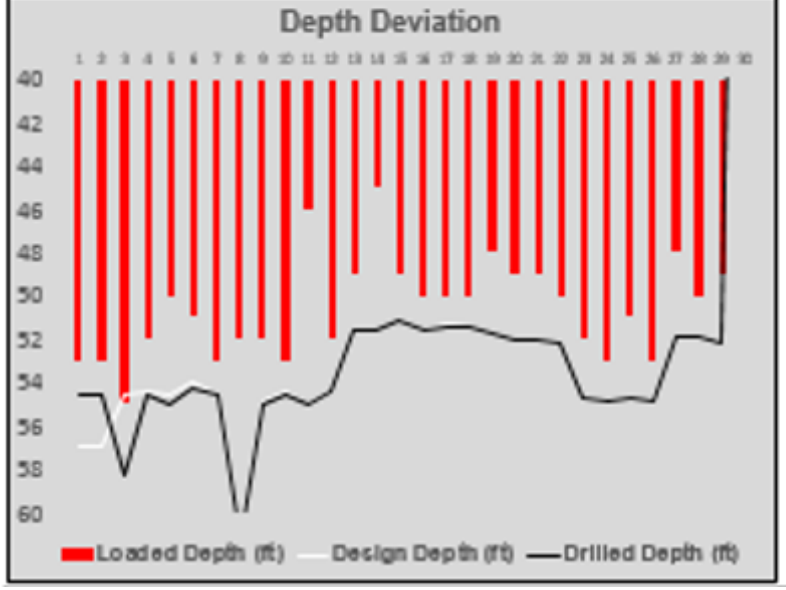
Video Monitoring

Drilling and Loading Accuracy

Number of Blastholes: 29 **Overall Accuracy Score (100, all targets are achieved): 42**

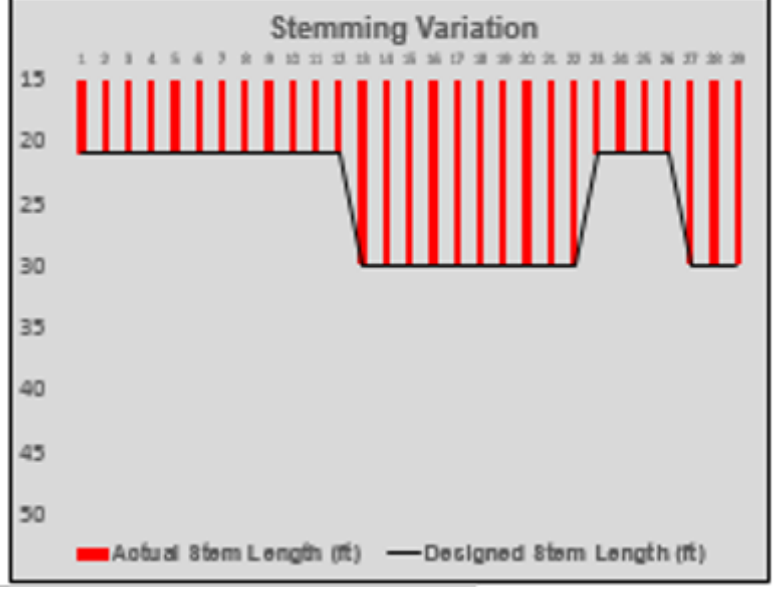
Blastholes Within 1ft of Designed Depth:	3%
Blastholes Within 2ft of Designed Depth:	28%
Percent Too Short:	97%
Percent Too Deep:	0%

Score: 3

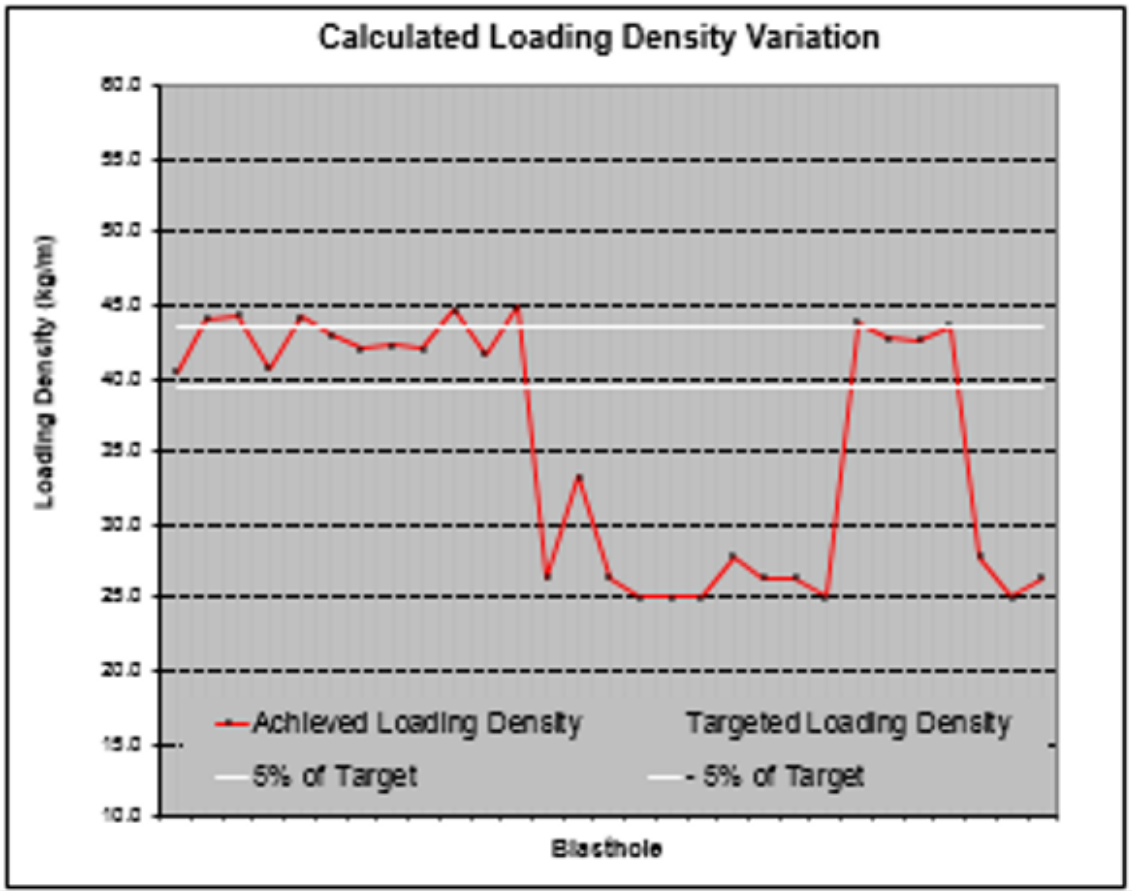


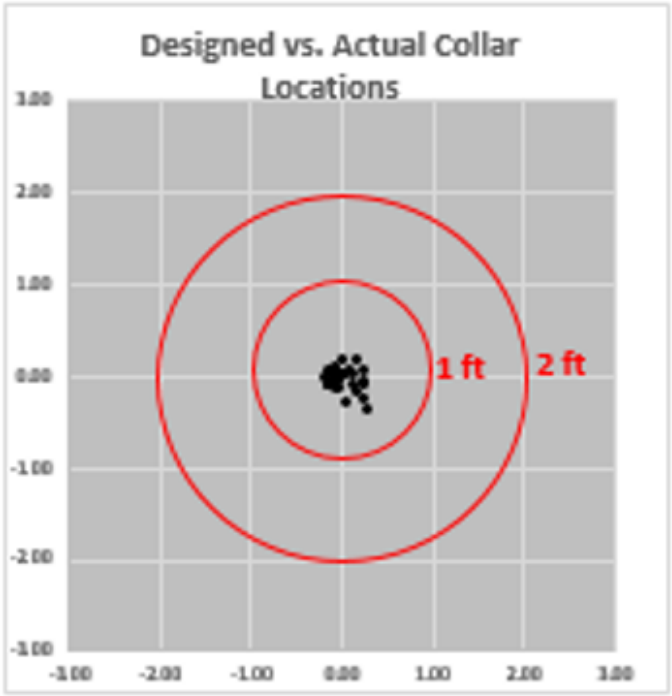
Stem Length Within 1ft of Design:	32%
Stem Length Within 2ft of Design:	0%
Percent Too Short:	68%
Percent Too Long:	0%

Score: 32



Drilling and Loading Accuracy

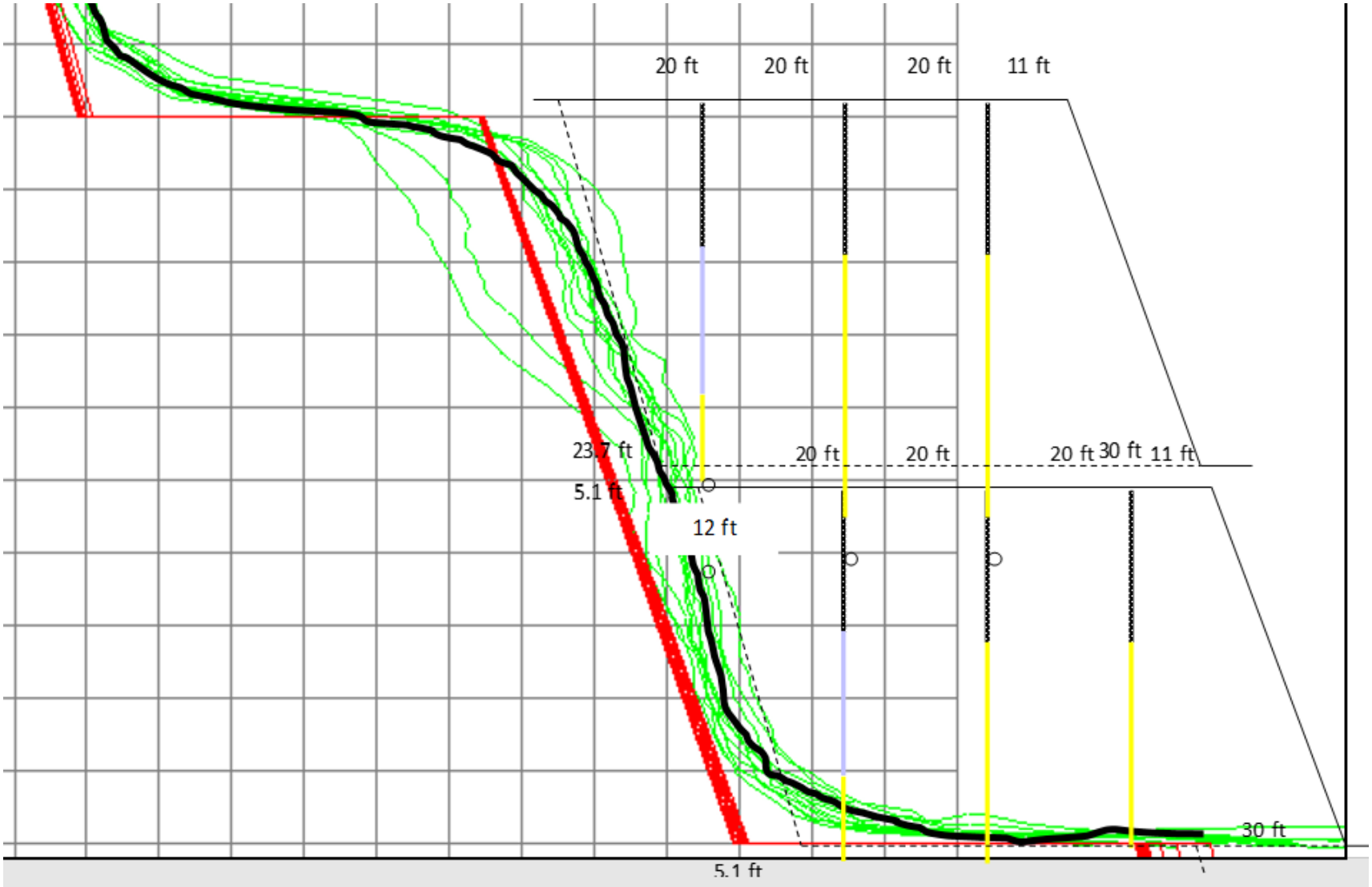




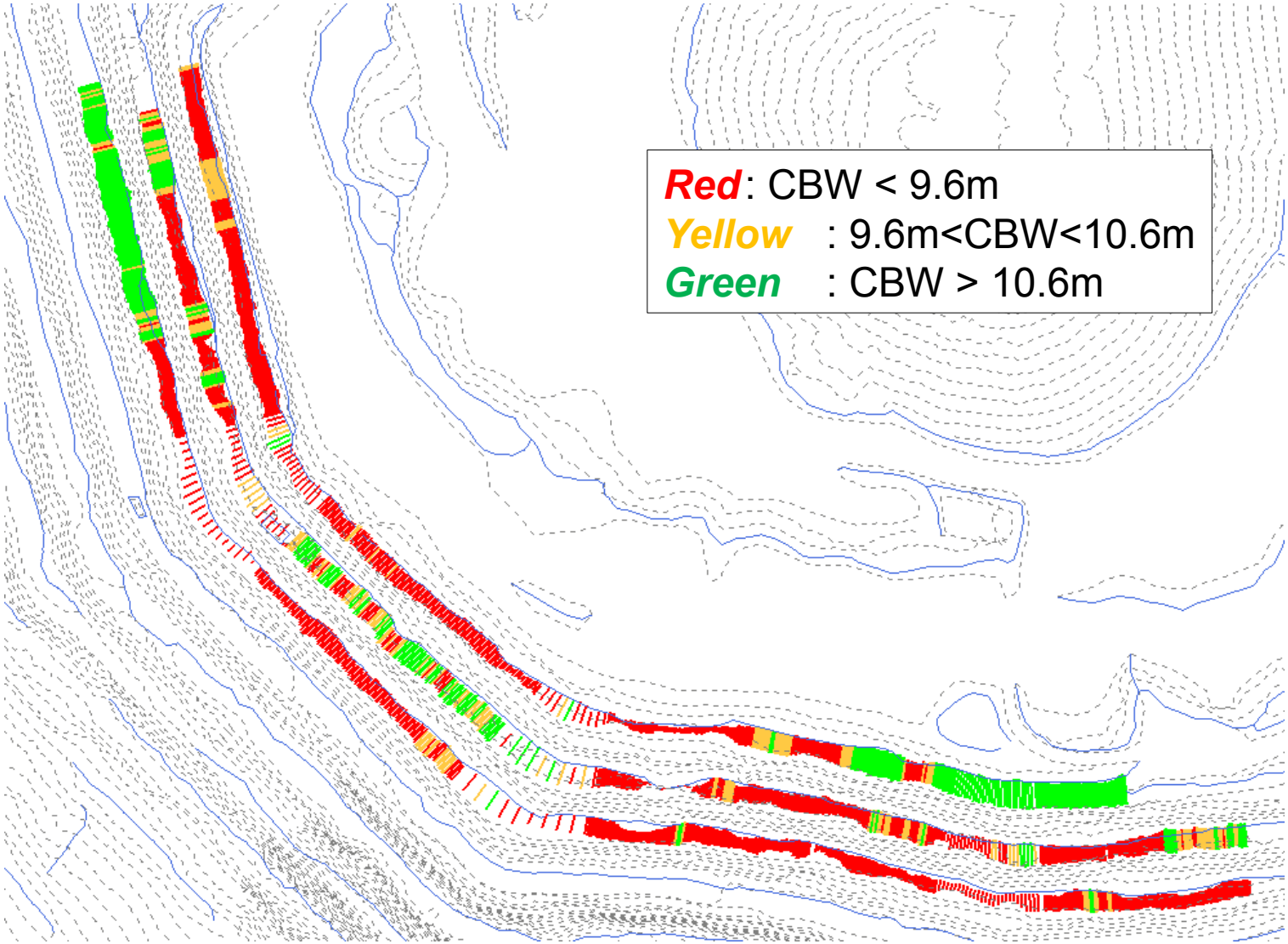
Deviation Percentage	
< - 1 ft	100%
> 1 < - 2 ft	0%
> 2 ft	0%

Score: 100

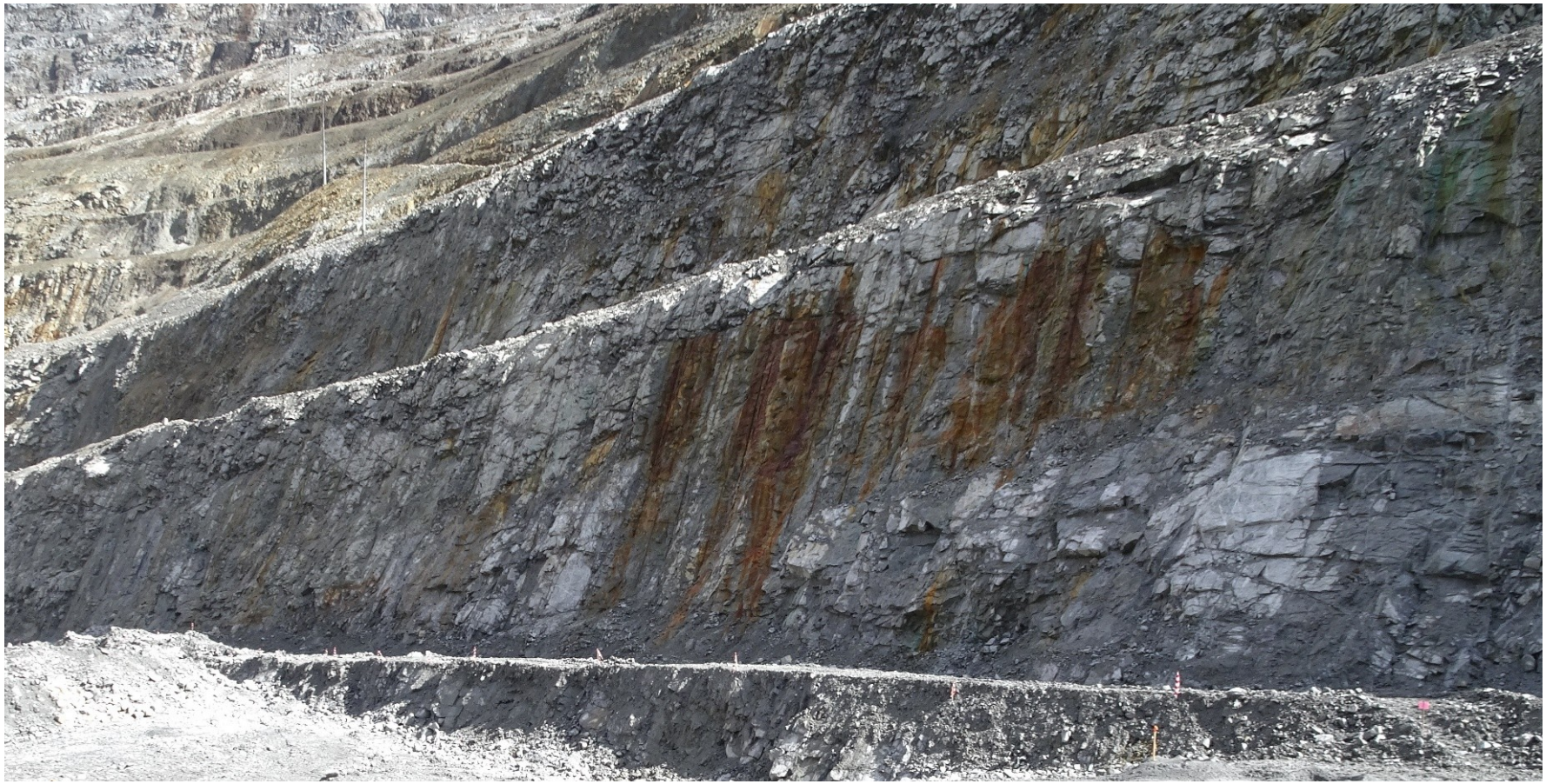
Reconciliation



Reconciliation



Pre-splits



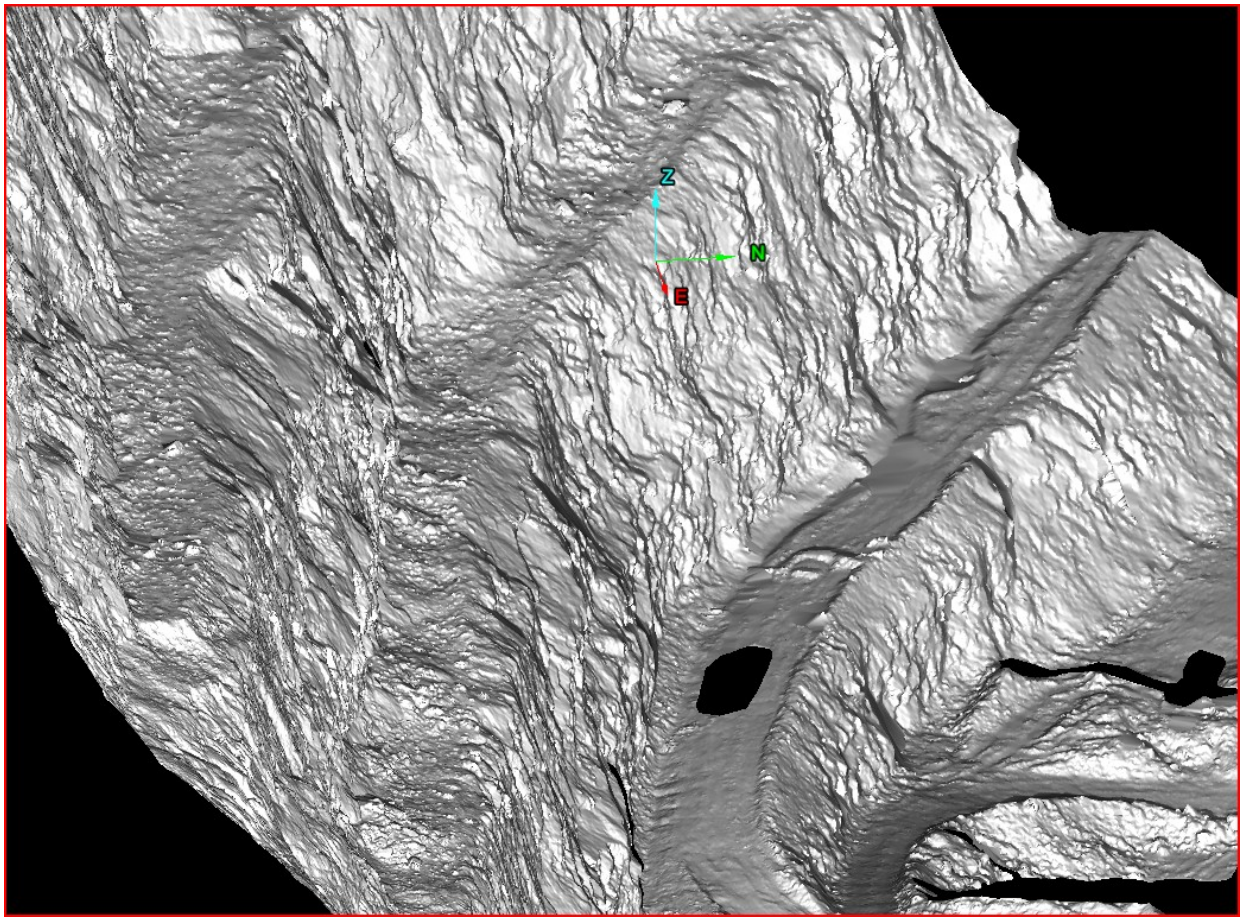
In use at several sites, where economically justified.
They can achieve steeper, cleaner benches when used properly.

Presplits

Trim blasting, and even production blasts, can damage beyond pre-splits if wall control blasting process is not implemented

LiDAR Scanner

- Detailed point cloud
- Inaccessible areas, unsafe areas
- More consistent and reliable data
- Surface comparison tools
- Accurate and repeatable measurements of catch bench width and bench face angle



Wall Control Mining

- GM – to - shovel runner understanding of what we are trying to achieve
- Listening to operator feedback
- Using the right tool for the job
- Building a safe bench

Right tool for the job

Right tool for the job

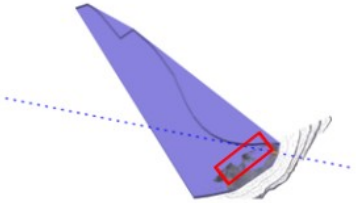
Right tool for the job

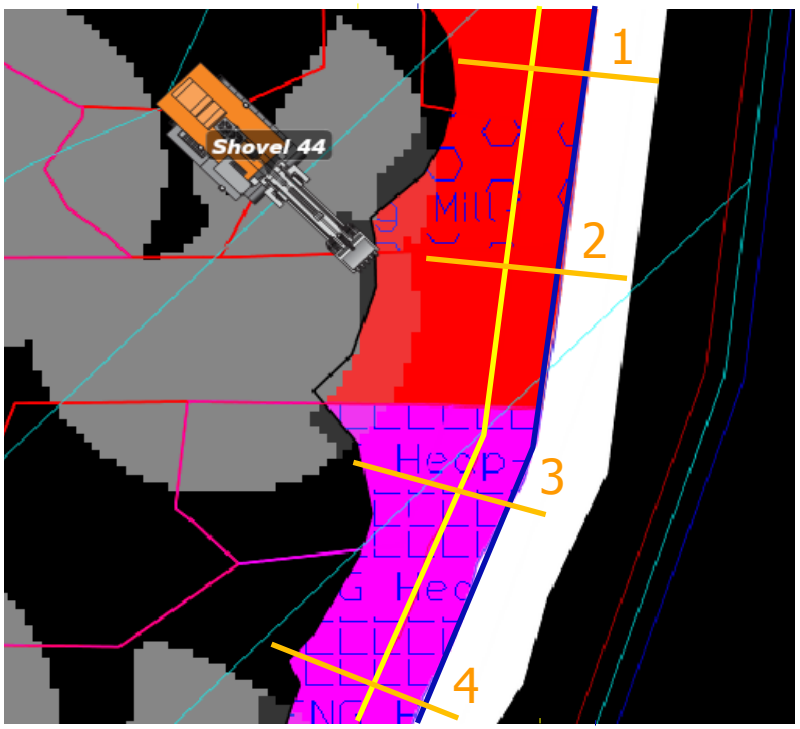
Right tool for the job

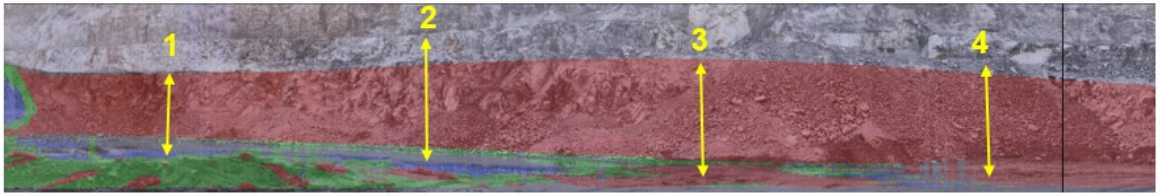
Right tool for the job

underdig > 3.0ft
within 3.0ft of design
overdig > 3.0ft

Scan Date 04-27-2017







E: 2,359.7ft
N: -6,051.5ft

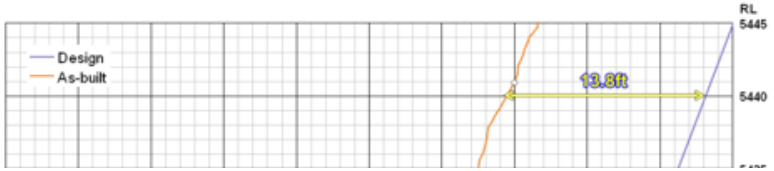
E: 2,258.5ft
N: -6,203.3ft

E: 2,119.3ft
N: -6,257.7ft

E: 2,026.4ft
N: -6,310.3ft

Right tool for the job

Section 1



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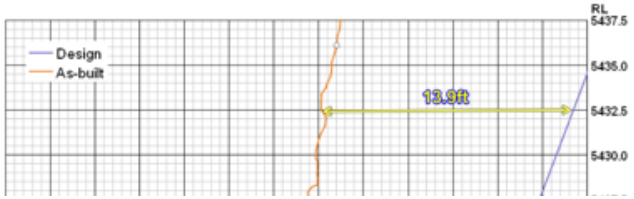
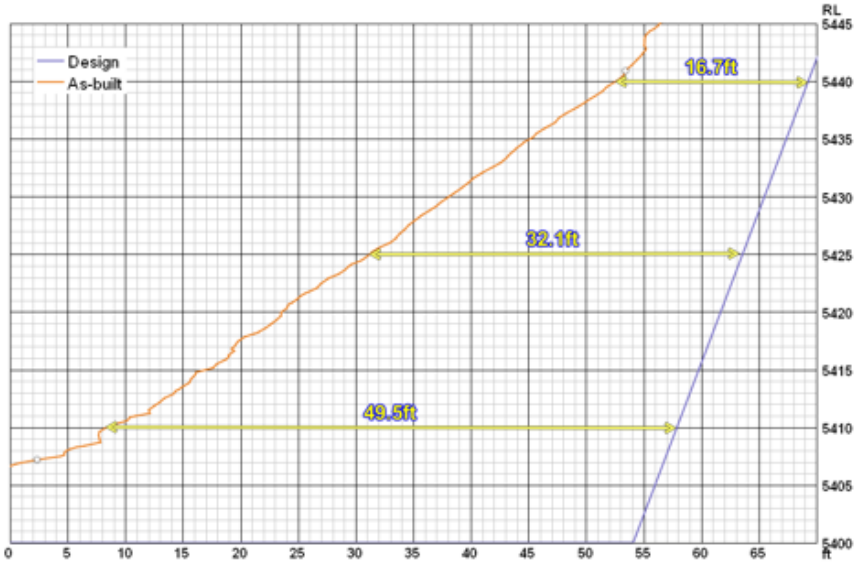
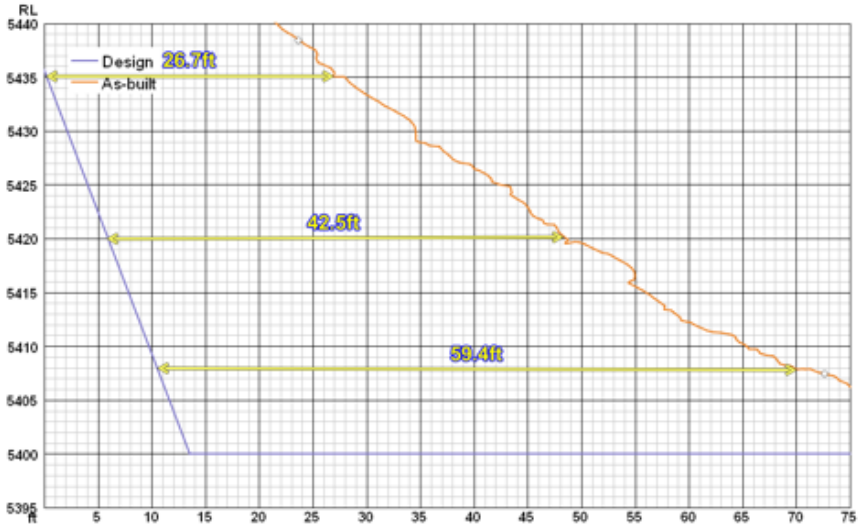


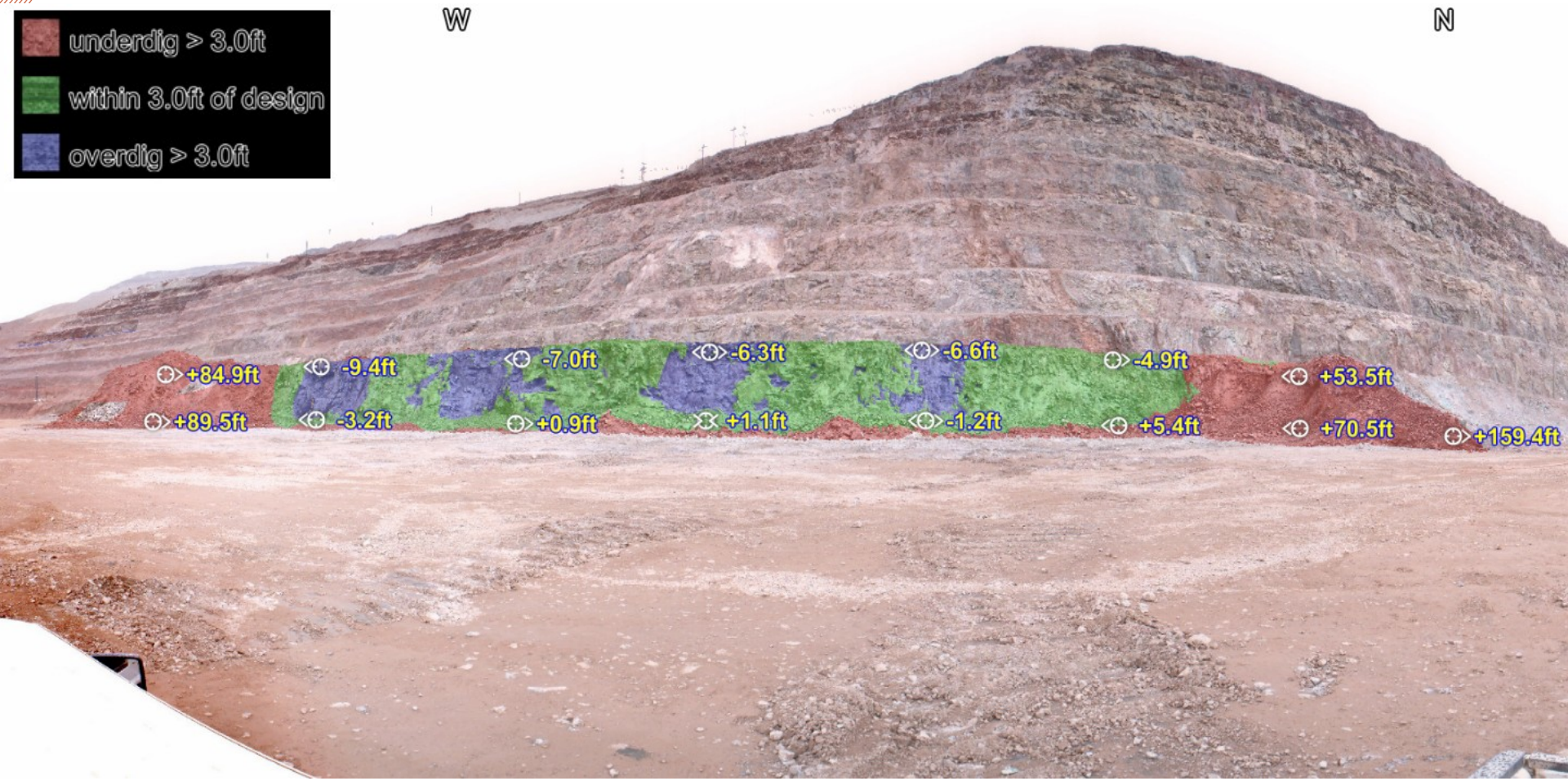
Section 3



Section 4



Right tool for the job



Conclusion

- **Slope optimization may add value from steepening; it will leave better, safer benches**
- **A clear understanding of geological, geotechnical, and economic opportunities and limitations is essential**
- **Blasting, mining, and hydrogeological improvements can return significant value**
- **Everyone needs to be on the same page, working toward the same goal**
- **Technology, especially LiDAR scanning, is key to understanding the results**
- **Continuous reconciliation, feedback, and improvement is the path to success**

Questions?