



# Underground Mine Development and Operations Plan

## Addendum for M-Zone Mining

November 2013

## Summary

As part of its ongoing optimization of mining plans, Minto has recently identified an opportunity to extract a portion of the Phase IV underground reserve, accessible from the bottom of the Area 2 pit, earlier in the mining sequence. Now known as the M-zone, this was previously one of the stopes within the Area 2 portion of the Phase IV underground, where it was scheduled to be one of the last mined.

In order to bring forward high-grade ore and avoid the risk of mining in close proximity to the tailings / water deposit slated for Area 2, a portal could be collared at the bottom of the pit, along the west wall, directly into the ore. After a short development campaign along the footwall of the ore zone, 250,000 tonnes of ore at 1.81% grade could be extracted using an uphole retreat mining method.

This development would require no new land disturbance, as both the portal and the ventilation raise will be located along the pit highwall. The reserve would not represent an increase in mining rate, as equipment from the currently-active Phase IV underground would be used.

This mining opportunity is time-critical, as the Area 2 pit is scheduled to be filled with tailings and water in October 2014.

## Ore Zone

The final ore lens to be mined as part of the Area 2 pit, known as the M-zone, dips at approximately  $12^\circ$  at a dip-direction of  $330^\circ$ , i.e., the lens dips N-NW into the northwest corner of the pit.

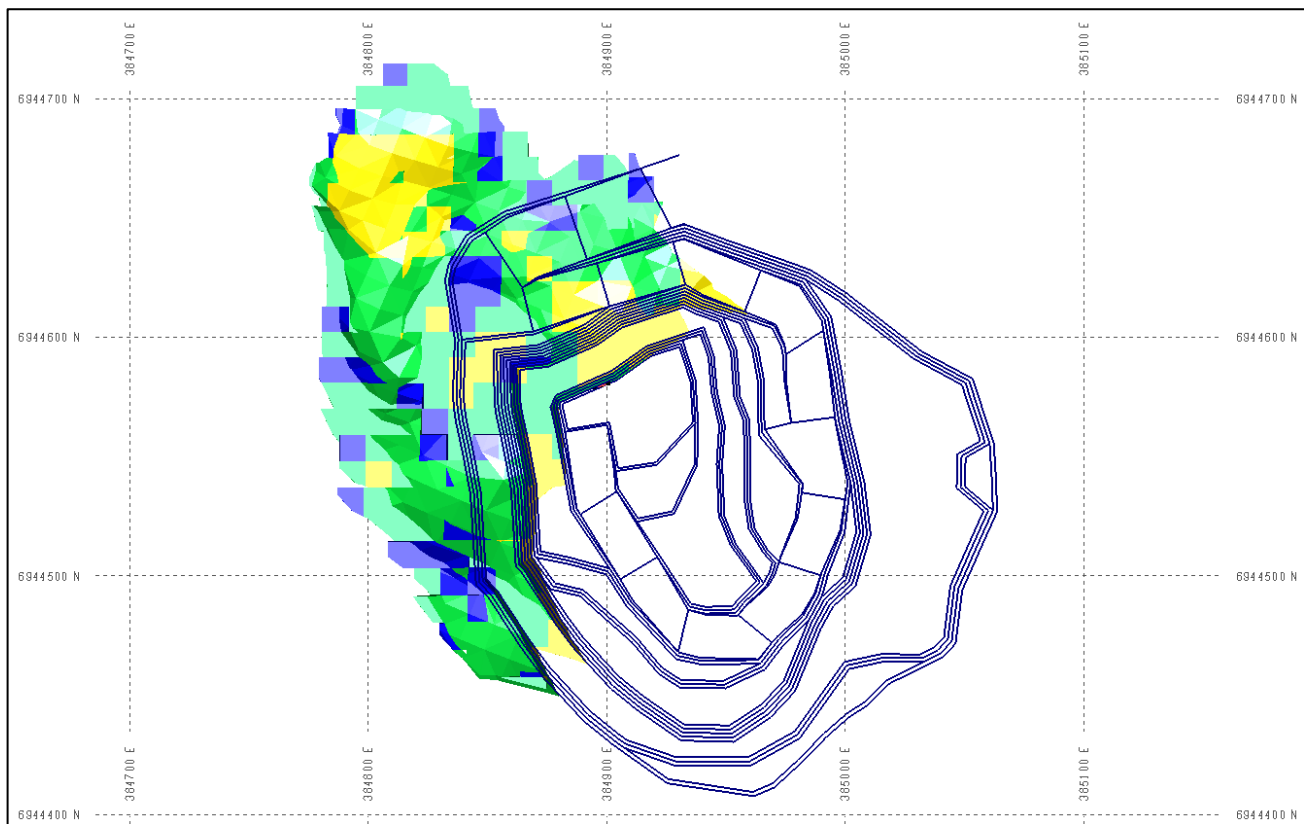


Figure 1: plan view of M-zone ore lens in relation to pit design below 725m elevation, showing ore beyond pit walls.

The lens continues to have economic ore grades and widths for another 175m into the wall; however, a further pushback of the Area 2 pit is uneconomic due to the high strip ratio. Underground mining of this lens is therefore an attractive option.

Figures 1 and 2 shows the ore lens in relation to the pit. Figure 3 shows the blocks to be mined within the M-zone.

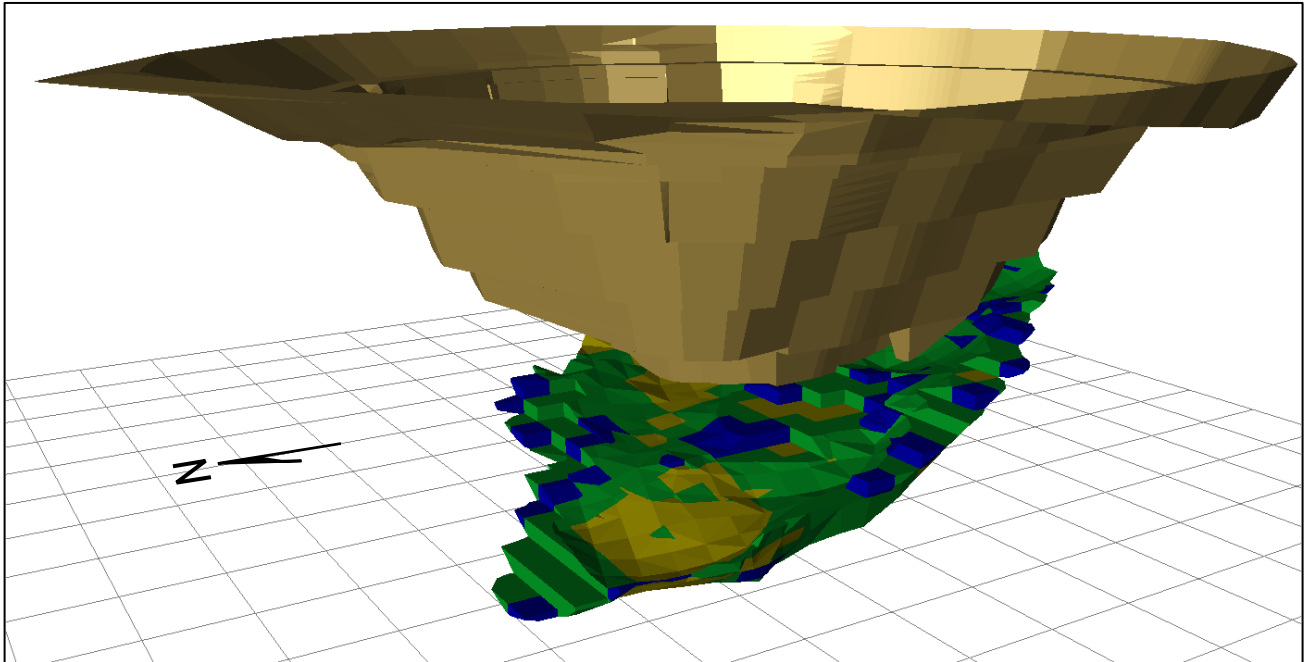


Figure 2: Perspective view of M-zone ore in relation to pit design.

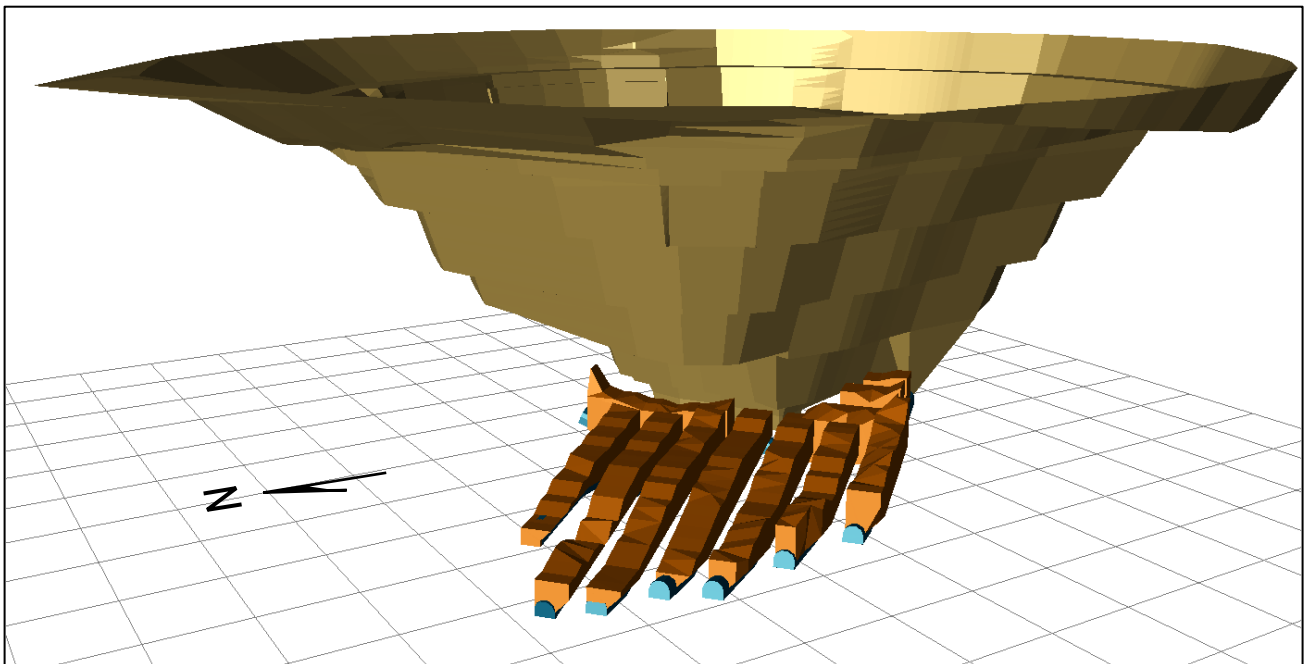


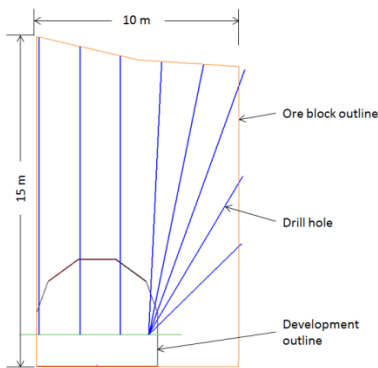
Figure 3: Perspective view of M-zone Underground mining blocks in relation to pit design.

## Mining Method

The ore lens will be mined by first establishing a decline from the bottom of the pit, then driving a series of crosscuts along the footwall of the ore zone at 15.0m spacing. The crosscuts are 6.0m wide. Figure 6 provides an overview of all M-zone development in relation to the pit.

Starting at the ends of these footwall crosscuts and progressing back along each, rings of up-holes will be drilled to the hangingwall contact using an ITH rig. These will be loaded with emulsion and blasted. The ore will be mucked via remotely operated LHD, thus eliminating any exposure of personnel to the open void left by the mining process. The void will not be backfilled. Blocks are 10.0m wide, with 5.0m rib pillars left between them.

A typical ring design is shown below in Figure 4. Figure 7 shows a plan view of all M-zone mining blocks, and Figure 8 presents a typical cross-section through, and perpendicular to, six blocks.



**Figure 4: Typical ring design**

The vertical dimensions of the blocks vary with the distance between the footwall and hangingwall. Maximum block height is 24m. Appendix A presents cross-sections through all ten mining blocks.

A ventilation raise and manway will be created near the east end of the M-zone development; this is shown in Figure 9. The raise will measure 16.9m in length, 3x3m in cross-section, and be inclined at 46.7° from horizontal. The raise will breakthrough at the toe of a 24m face on the pit highwall.

Sections of the Area 2 pit highwall above the portal and raise breakthrough will be rock-bolted and screened.

## Scheduling and Equipment

The expected life of the proposed mining is eight months. The M-zone is time-sensitive due to the location of the portal at the bottom of the Area 2 pit, which will be required for tailings deposition by October 2014. Mining will commence upon completion of the open-pit, currently scheduled for early January; however, ground support of the pit highwall, infrastructure installation, and preparations for portal collaring will be made in late 2013.

The short haul distances (maximum 260m from the portal to the end of F block) make truck haulage unnecessary: all mucking will be done with 8-yard or 10-yard LHD units. A combination Minto / contractor fleet will be used for development, as well as production mucking and ground support. A contractor will be used for longhole drilling.

The mining rate will ramp up to 1,600 tonnes / day by April. Mining will be complete in early September.

## Geotechnical Parameters

An exploratory crosscut of the ore zone at the 740m level in the Minto South Underground has demonstrated that spans of 6.0m can be safely mined. The ground support standards developed thus far are shown below, and will be modified, if required, based on the findings of a geotechnical analysis currently being completed by Itasca Consulting Ltd.

Type	Span (m)	Primary Support	Comment
1 Development	5.0	<ul style="list-style-type: none"> <li>8' rebar in back and shoulders</li> <li>6' rebar in walls to 1.5m above floor</li> <li>3' Split-sets (to secure mesh)</li> <li>1.4m intra-ring x1.2m inter-ring spacing</li> <li>Galvanized weld wire mesh to 1.5m above floor</li> </ul>	Life-of-mine infrastructure
2 Production	<6.0	<ul style="list-style-type: none"> <li>6' rebar in back and walls to 1.5m above floor</li> <li>3' Split-sets (to secure mesh)</li> <li>1.4m intra-ring x1.2m inter-ring spacing</li> <li>Black weld wire mesh to 0.9m above floor</li> </ul>	Non-permanent development i.e. stope and level access
3 Development	5.0	<ul style="list-style-type: none"> <li>8' rebar in back and shoulders</li> <li>6' rebar in walls to 1.5m above floor</li> <li>3' Split-sets (to secure mesh)</li> <li>12' Swellex in back and shoulders</li> <li>1.4m intra-ring x1.2m inter-ring spacing</li> <li>Galvanized weld wire mesh to 0.9m above floor</li> </ul>	Life-of-mine infrastructure. Used when poor ground is expected or observed. Adds 12' Swellex to Type 1 standard.

**Table 1: Current primary support standards in the Minto South Underground**

Type	Span (m)	Secondary Support (in addition to primary support)	Comment
1, 2, 3 Production / Development	<12.0	6m Super Swellex 1.8 x 1.8m spacing	Intersections: life-of-mine and non-permanent infrastructure
	<9.0	3m Super Swellex 1.8 x 1.8m spacing	

**Table 2: Current secondary support standards for the Minto South Underground**

Stress analysis of the rib pillars between blocks and the crown pillars separating block hangingwalls from the pit above is currently in progress; the block extents will be adjusted to ensure that pit wall stability is not impacted.

## Power

The M-zone underground will be supplied with power by a connection to Minto's power grid, which currently extends to the edge of the Area 2 pit.

Approximately 550m of 5kV Teck 2/0 cable will be run down the pit wall. From 811 to 788 m elevation, the cable will be placed along the overburden cut at the east corner of the pit, which is sloped at 30°. The cable will then drop down to the portal elevation (691m) via four drops of 18 to 24m along the bench faces of the pit highwall. The cable will cross the haul ramp at the 739m elevation through a length of buried 16" heavy-wall HDPE pipe. The routing for the cable, as well as for the other infrastructure around the portal, is shown in Figure 5.

A 4160 to 600V transformer rated at 750kVA will be installed at the south end of the pit, 95m from the portal.

## Ventilation

The M-Zone ventilation system design, designed by Stantec Inc., is a positive or “push” system designed to deliver 80,000 cfm supplied by two 48 inch / 26° / 1800rpm / 150 hp fans, each pushing 40,000 cfm into a 48 inch metal rigid duct line.

Rigid 48 inch metal tees with dampers to control the direction and quantity of airflow will be installed at the entrance to each crosscut. From each tee outlet, crews will extend 48 inch flexible vent tubing into the crosscuts.

The distribution of air along the portal access ramp and mining horizon will be controlled via the two main fans near the portal entrance and a regulator door located at the ventilation raise / manway. Both fans will be equipped with variable frequency drives to provide flexibility in the air delivery rate. No underground fans are required to control distribution.

The fresh air fans will require mine air heating systems during the winter months. The heating system capacity is designed for a 50°C (-43°C to +7°C) temperature rise. Each duct run and fan will have a direct propane-fired heating system comprised of a 1.2 MW (4.0 MMBTUH) heater, common control room, valve trains, electrics, and a 150 HP variable frequency drive for the fan motor.

The target temperature for the fresh air supply is 3.0°C. At this temperature, 367,000L of propane will be required to heat the M-zone in 2014. This assumes the full 80,000 cfm is supplied continuously; during initial decline development in January, the airflow will be reduced to match the size and composition of the equipment fleet operating in the mine.

	Jan	Feb	Mar	Apr	Total
Average Temp (°C)	-27.4	-21.1	-11.2	0.5	
Propane Req'd (L)	161,000	119,000	75,000	13,000	367,000

## Water Management

The portal is placed at the 691m elevation, while the bottom of the pit is at the 676m elevation. After dumping in a laydown pad, this leaves 30,000 m<sup>3</sup> of water storage capacity below the portal, providing a buffer against spring runoff, high precipitation events, and pump downtime. Inflows into the pit can be estimated from past experience: between freshet and early September 2013, the Area 2 pit was not pumped and accumulated 68,000 m<sup>3</sup> of water.

As part of the dewatering setup installed during open-pit mining, a 4” steel pipeline, insulated and heat-traced, will run to the bottom of the pit. This pipeline will be re-purposed to convey M-zone waste water to surface. The M-zone fresh water supply will be from an insulated tank adjacent to the portal, which will be filled either from the accumulated water in the Area 2 pit or from a water truck.

As the pit fills in spring 2014, an additional 8” non-insulated pipeline will be installed to convey water from the bottom of the pit to the 10x10m sump at the 715m elevation, and from there to the Main pit via Minto’s water conveyance network.

## Conclusion

The designs presented in this report will be further refined based on the conclusions of Itasca’s geotechnical analysis. Stantec and Bestech Engineering have been retained to complete detailed designs for ventilation/heating and electrical distribution, respectively.

Scheduling will be critical to the successful and complete recovery of ore in the M-zone, as the need to use Area 2 for tailings and water storage limits the time available for mining.

Figure 5

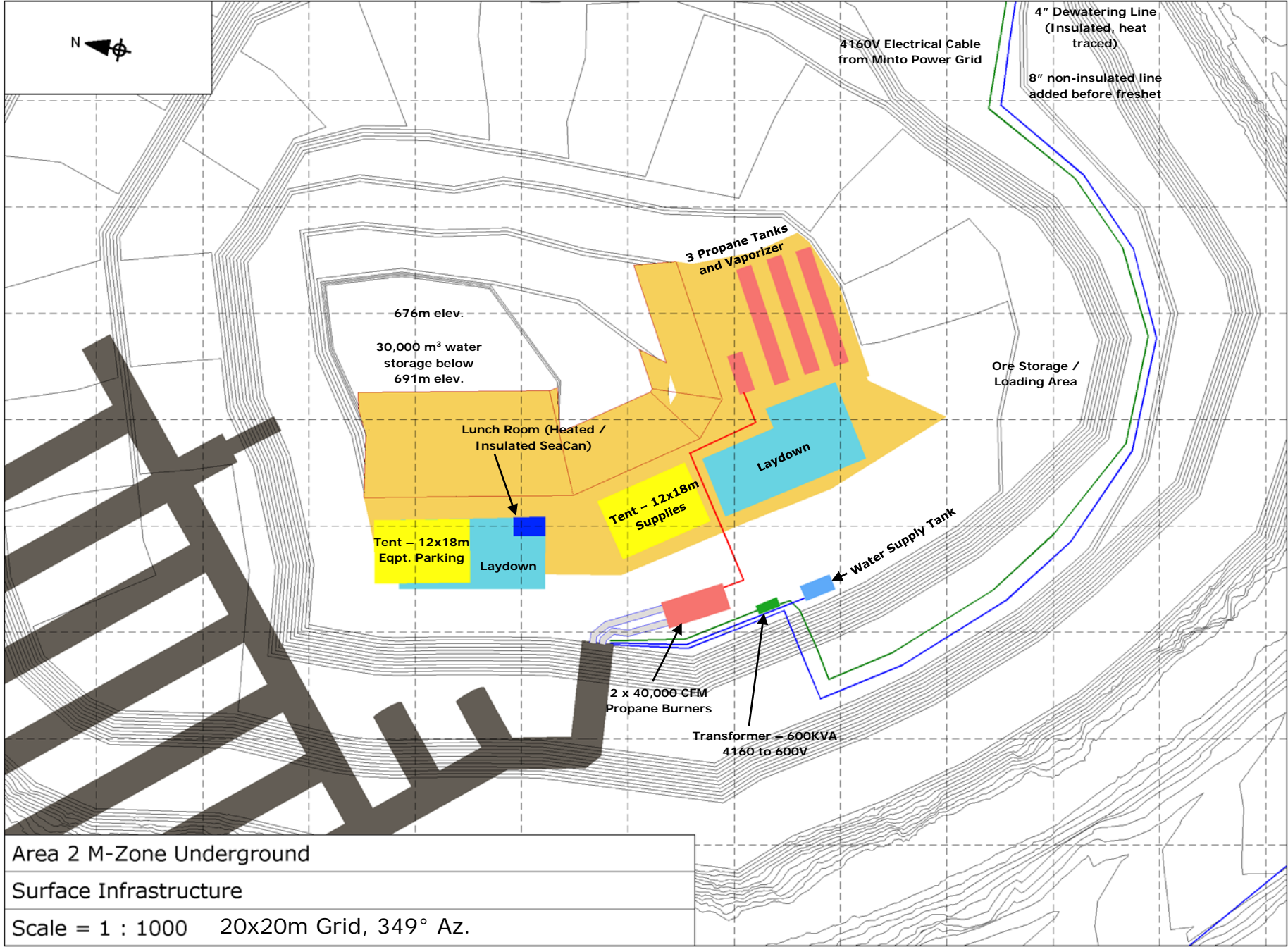


Figure 6

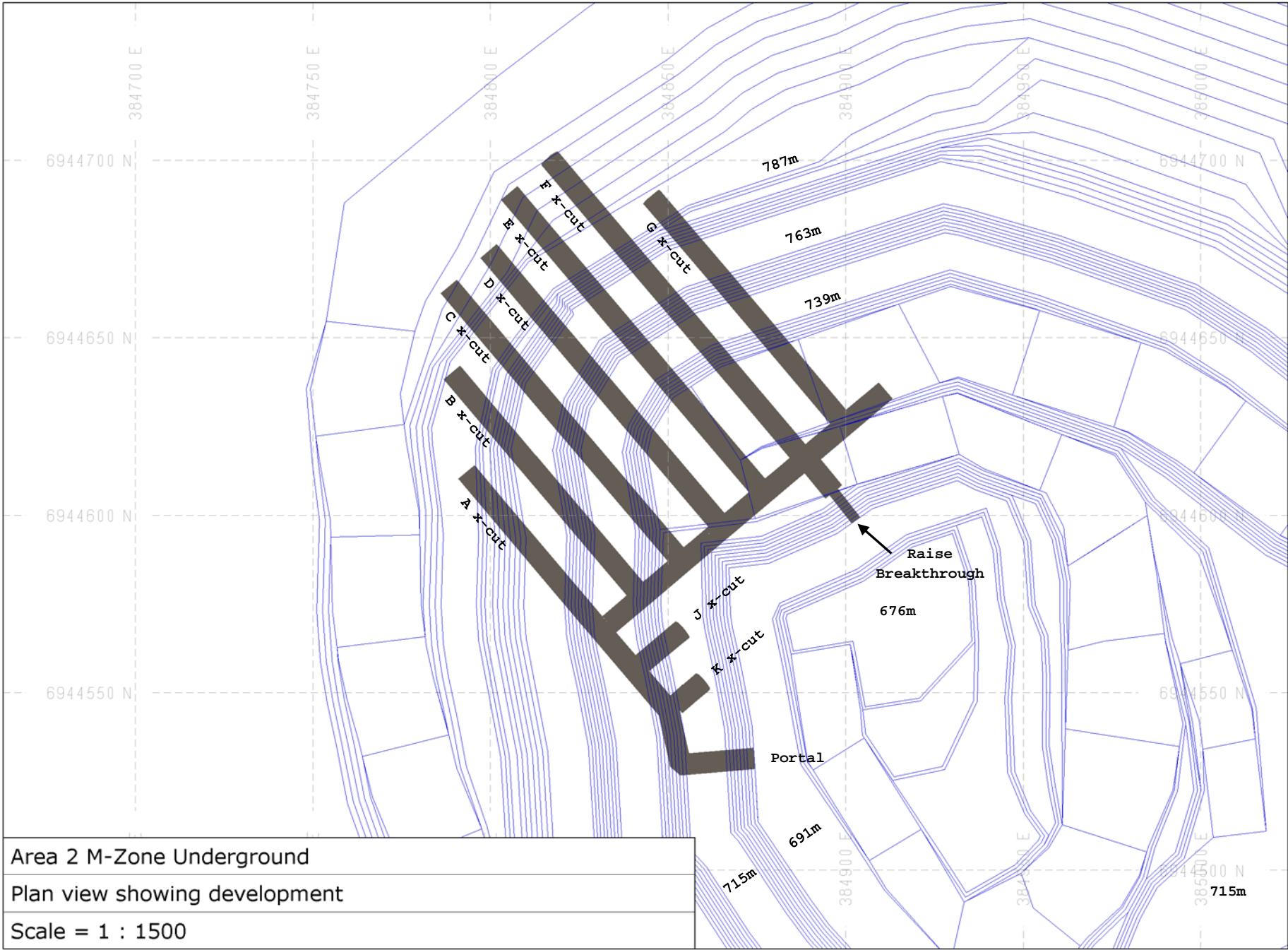


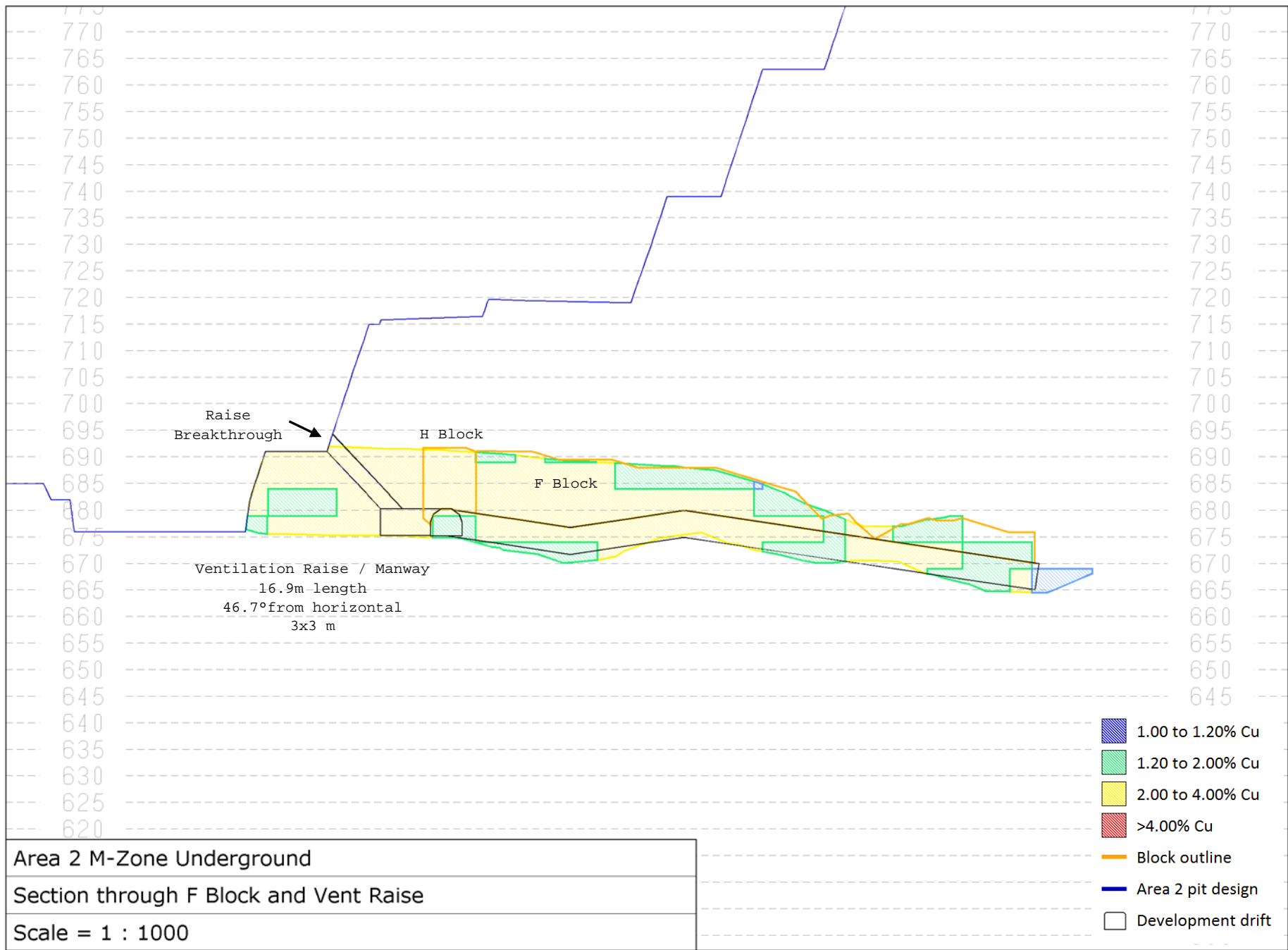
Figure 7



Figure 8



Figure 9



## **Appendix A – Long Sections through Area 2 M-Zone Underground Blocks**



