YukonZinc CORP
Wolverine Mine

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MEMO

To: Mineral Resources – Energy, Mines and Resources

From: Paul Christman, Woo Shin

CC: Floyd Varley, Robin McCall, Andrea Kenward

Date: August 15, 2013

Re: 2013 Wolverine Mine annual underground inspection

Introduction

The authors are employees of Yukon Zinc Corporation at the Wolverine Mine site.

Paul Christman is Technical Services Superintendent with over four years of mining experience and is currently waiting for license designation in Alberta and Yukon expected in August 2013. Paul Christman regularly inspects the underground workings on nearly a weekly basis.

Woo Shin is Senior Geotechnical Engineer with over 11 years of mining and tunneling experience and is a registered Professional Engineer in Alberta (#159176) and Yukon (in progress). Woo Shin is the author of the Wolverine Mine Ground Control Management Plan (GCMP) and inspects the underground workings on nearly a daily basis as part of normal ground control duties.

The annual underground inspection report is divided into two sections:

1. General explanation of underground workings and mining method
2. General condition of underground workings

The general explanation section focuses on key areas of safety and production and areas of significant change over previous years' inspection reports. The specific Yukon Occupational Health and Safety Regulations pertaining to the areas are highlighted in parentheses for reference throughout the section.

The general condition section summarizes the current activities, ground conditions and ground support instructions for the active underground workings:

General explanation of underground workings and mining method

Wolverine is an underground poly metallic base metal mine. The primary mining method used is overhand drift and fill with retreat slashing. Both paste and waste back fill are used. Paste is produced from mill tailings and waste is produced from underground ramp and stope development. Full design production of 1,750 tonnes per day was achieved in the first quarter of 2013.

Ramp
The mine is accessed by a single ramp driven at -15% (15.61) from a surface portal at the 1,355m elevation to the current bottom of the mine at 1,150m elevation. The ramp is supported with steel culvert and sets at the portal and with rock bolts and shotcrete elsewhere underground. The ground support for all ramp development is outlined in the Wolverine Ground Control Management Plan (GCMP) and strictly followed. The current revision of the GCMP is attached in appendix (15.48). The support is regularly inspected by the geotechnical engineers and underground supervisors. Rehab work on the steel sets at the portal was completed in May and June 2013. The current mine as built, showing all the waste and paste back filled drifts and currently open and active drifts, is attached in appendix.

Ventilation
The mine is ventilated by a main surface fan that pushes fresh air down a single raise from surface to 1,280m elevation where it splits into two separate raises for the Wolverine and Lynx sides of the ore body. Auxiliary ventilation fans pull fresh air from these raises into the active levels. All air exhausts out of the mine by the ramp. Ventilation upgrades, including the purchase of new auxiliary fans, was completed in 2012 and 2013. Raise development for ventilation will continue as the ramp is extended to new levels. Ventilation air flow volumes are adequate at all active levels and there is capacity available from the main surface fan to ventilate additional future levels. Weekly ventilation surveys are performed by safety or technical services personnel and posted in the workplace for all workers to review (15.61).

Dewatering
The mine is dewatered by a series of sumps underground. Currently, the sumps pump mine water to a surface sump where the water is recycled for mill processing and underground drilling. Pump and pumping infrastructure, including development of new sumps and purchase of new pumps, was completed in 2012 and 2013. The system is capable of handling the natural inrush of ground water and additional inrush during spring runoff (15.46-15.47).

Diesel equipment
The underground diesel equipment fleet is in good working order (15.58-15.60). Weekly tailpipe testing is performed on each piece of equipment by maintenance personnel. New equipment was purchased in 2012 and 2013 to replace older equipment rented from the mining contractor. Preventative maintenance programs are in place to keep equipment in good working order. The required ventilation air flow volumes for each piece of equipment are posted in the workplace.

Electrical equipment
The underground is serviced by both high and low voltage distribution systems. New underground electrical sub stations were purchased in 2012 to replace older equipment rented from the mining contractor (15.38).

Blasting
The underground blasting is carried out twice per day at the end of each shift by designated blasters holding valid or provisional Yukon blasting permits (14.03). A new blasting procedure was successfully implemented in 2012 to minimize over break and to prevent misfires and sulphide dust explosions. No sulphide dust explosions have occurred since control measures were implemented and the number of misfires has gone down significantly. Gas testing is performed after blasting by workers in full SCBA to clear all headings of hazardous blast gases.

Refuge stations
The mine has one refuge station at the 1240m elevation. The refuge is in good condition and in compliance with regulations (15.15). The proper operation of the refuge station during an emergency is frequently reviewed with all workers. A second refuge station at the 1,160m elevation is currently under construction.

Escape ways
The fresh air raise on the Lynx side of the ore body is equipped with ladders and landings and serves as an escape way to surface (15.26). The Lynx fresh air raise is located near the ramp and is accessible from all Lynx levels and the ramp. The fresh air raise on the Wolverine side of the ore body serves as fresh air bases during an emergency. The fresh air raise is equipped with Femco phones that can be used to communicate with surface during an emergency. Escape way upgrades, including new steel ladders and landings, were completed in 2012 and 2013 in the Lynx fresh air raise.

Fire protection and emergency preparedness
The underground diesel equipment fleet is equipped with fire suppression equipment and fire extinguishers. Fire extinguishers are located throughout the mine and clearly marked with signage. All fire extinguishers are checked monthly (15.14).

The stench gas release system was tested multiple times in mock underground fire drills (15.14, 15.28). Both the ventilation and compressed air systems are equipped with stench gas release systems.

Communications
The primary communication system underground is leaky feeder radio. The leaky feeder system was expanded in 2012 and 2013. Mobile radios were installed in underground equipment and base station radios were installed in designated areas. The secondary communication system is Femco phone. Log books are maintained for ground support instructions, gas test readings and abnormal conditions affecting the safety of workers (15.15).

Explosives storage
The underground has one powder magazine (YT-543) and one detonator magazine (YT-544) underground on the 1230 level. The new licensed magazines were completed in 2013 and are permitted to store up to one week supply of explosives. The old underground magazines were decommissioned. Three other licensed magazines are located on surface for additional inventory (14.24 -14.32).

Mine rescue
The site has trained mine rescue personnel on all crews and a dedicated mine rescue station on surface. Mine rescue practices are completed regularly (15.36 -15.37).

Mine plans
The technical services department maintains all mine plans and drawings on a central server (15.04). Driving layouts for all developments are provided to the mining contractor and posted in the underground mine office. The driving layouts include historic workings and diamond drill holes (15.47).

Ground control
The ground conditions of the active mining areas are inspected daily by dedicated technical services personnel. Ground support instructions are prescribed for all active mining areas on a round by round basis (15.48). The Wolverine GCMP published May 18, 2011 and revised August 5, 2012. The most recent version of the GCMP is dated August 5, 2012 and will be updated by the end of August 2013 (15.06).

General condition of underground workings

Underground mine inspection has been conducted daily base by geotechnical engineers and geologists, reported as a daily inspection report. This section of general condition of underground mine based on daily inspection reports and physical inspections by Woo Shin accompanied with Procon superintendents, Wayne Coles and John Boyd, from July 4th to 10th 2013.

The entrance ramp start from surface portal (1355m elevation) down to the first production level (approximately 1209m elevation) and is driven at minus 15% in mostly hanging wall rocks. The average size of main ramp is 5m wide by 6m high. The beginning of ramp within 50m from the mine portal is fully supported using shotcrete, rock bolts and steel sets. No major damage was found this section except a few signs of deterioration in the support envelope. Recently, couple of damaged steel sets in a portal area which caused by traffics were replaced and shotcreted.

The main ramp currently driven to 1150 level and the leg to 1140 level is in progress. In general the ramp is well supported following the Wolverine GCMP. Wire mesh screens which installed to the wall of intersection areas at 1230, 1180, and 1160 levels were ripped out by scoop during truck loading muck piles and required rehab. Services and power cables in the ramp are generally well hung and need to keep this condition by scheduled maintenance.

The following is a summary of the ground conditions in stopes that are currently active as observed during inspection:

1310 Lynx Sill
This heading has been built 2 shotcrete arch fill fences beside ore pillar. The ore pillar will be taken after paste pour. Ground condition at the beginning of the drift is fractured FW and expected around 10m wide opening after take slash between fences. Extra supports for the back in wide intersection area were required.

1300 Lynx Lift 1 268 P
Half of the face from the back is graphitic HW. Pre-shotcrete was sprayed and 12ft super swellex rock bolts were installed in the HW back. This heading is on hold to control ore grade due to high content of carbon from HW material.

1300 Lynx Lift 1 260 P
This heading is marked up by surveyor and ready to take a slash under engineering control. Additional supports for the back of intersection area are may needed depends on ground condition after slash.

1290 Lynx 331 Sill
This drift is passing through transitional fractures area. Series of tinny ore bands in highly sheared FW material and dilution is around 60%. Pre-shotcrete and 12ft super swellex bolts are required for the back to keep opening size and reduce dilution.

1270 Wolverine Lift 5
Main drift completed to the end of ore body. Shotcrete was sprayed to the face. Waste fill and shoulder slashes are needed following issued engineering plan.

1260 Lynx Lift 3
342 drift was completed. Last round of this heading was shotcreted but need to follow abandoned heading procedure including barricade off. 334 drift is on hold for grade control and need to complete rock bolt installation.

1240 Lynx Lift 2
319 drift was stopped and sprayed shotcrete and barricade off. Ground condition of 331 drift is typical FW contact heading. Back and right side wall is ore and left side wall up to 2m from the sill is RHCL FW

material. Dilution is around 40% and 4% of them is ARMS. 8ft regular swellex bolts are required all around of heading.

1230 Wolverine Lift 3

Around 2m thick ore band between HW and FW contact with 50% of dilution. HW at left top corner was over broken and 6m high opening. Pre-shotcrete and 12ft super swellex rock bolts were required for all around heading. 4m by 4m blasting pattern is recommended for the next round to reduced opening size and dilution. Cracks were found at right side wall around 30m from current face where side pass 1250 sill drive wide with 1.5m thick pillar. Cracks were marked up and if additional cracks are developed the area need to rehab with shotcrete arch and extra 12ft super swellex rock bolts.

1210 Wolverine Lift 2

Around 65% of the current face is ore below RHCL HW (35% of dilution). Opening dimension is 5.1m high at centre and 5.3m wide. 8ft regular swellex and 12ft super swellex spot bolting for HW exposure are required. This heading needs to turn hard right to avoid over-breaking HW back.

1190 Wolverine Lift 1

Left side wall height of current heading is 5.7m due to HW over-breaking in left top. Both side walls and 65% of face is ore. Pre-shotcrete and 12ft super swellex bolts were required for the back and left shoulder. Both side wall is OK with 8ft regular bolts.

1180 Lynx Lift 1

Main drift development in lift 1 level was done and need to take retreat slashes and bench cuts as issued plan. Retreat slashes will be taken from HW side and minimum 2m thick safety pillar must be considered every two 5m slashes.

1160 Lynx Sill

Main drift in sill level and retreat slashes for both FW and HW sides were completed by the next fill fence location. This drift need to build a fill fence and paste fill.

1150 Wolverine Sill

This heading is in transition area between saddle zone and Wolverine ore body. Two tinny ore bands are located between ARST HW and RHCL/RHSR FW materials with 60% of dilution. Pre-shotcrete was required for HW exposure in left top corner and 12ft super swellex bolts were needed to all around of current heading.

1150 Wolverine Sill Exploration

This heading is in HW ground. Current heading height is 6m. Pre-shotcrete and 12ft super swellex bolts are required. 4m by 4m blasting blasting pattern with 2m advance also recommendable to reduce opening size.

Regards,

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Appendix

1. *Current Ground Control Management Plan*
2. *Current Mine As Built*

YukonZinc CORP
Wolverine Mine

GROUND CONTROL MANAGEMENT PLAN

August 5, 2012

Report No. 002-2012

Yukon Zinc CORP
Wolverine Mine

GROUND CONTROL MANAGEMENT PLAN

August 5, 2012

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1. INTRODUCTION

It is the policy of Yukon Zinc Wolverine Mine to reduce the risk to work force, machinery and underground workings associated with ground control to an acceptable level.

The Wolverine Underground Ground Control Management Plan (GCMP) has been developed in accordance with the requirements of the following health and safety regulations;

- Yukon Occupational Health and Safety Act and Regulation
- Quartz Mining Act
- Yukon Zinc Corp Health and Safety Policy (2009)

The GCMP revolves around;

- Risk assessment
- Clear definition of authority and responsibility as they relate to ground support
- Manager's Ground Support rules defining appropriate ground support types
- Trigger Action Response Plan (TARP) providing indicators and response to change in ground condition
- Design review and feedback

2. SCOPE

The scope of this plan is specific to the Wolverine Underground Mine and is based on the understanding of ground control principals and the geological, geotechnical and mining conditions that apply at the time of the current revision.

This GCMP;

- Applied to all underground mine personnel, contractors and visitors who have stated duties under the GCMP.
- Takes effect from the date of issue and is not retrospective.
- Forms the basis for training content and specifies requirements for training and competency under the GCMP.
- Outlines the responsibilities and roles of individuals under the GCMP.
- Specifies the Managers Support Rules, 14 different Support Types, requirements for development and production at Wolverine Underground Mine.
- Details the Trigger Action Response Plan (TARP) for both the development and extraction processes.
- Does not address controlled or uncontrolled movement of ground resulting in subsidence or uncontrolled movement of ground.

3. OBJECTIVES

The objectives of the Wolverine Underground GCMP are to;

- Reduce the risk of uncontrolled ground failure.
- Contribute to the development and maintenance of a safe working environment.
- Contribute to efficient extraction of ore reserves.

The objectives are achieved through;

- Identification of hazardous areas and assess associated risks.
- Design and implementation of appropriate ground control systems.
- Communicating known hazards to the workforce in advance of both development and production.
- Design and implementation of systems to detect and control change (Trigger Action Response Plan).
- Design and implementation of procedures associated with ground control including a Standard Operating Procedure for installation of ground support.
- Providing clear and unambiguous definitions of roles and responsibilities for individuals working under the Plan.
- Internal and external auditing to assess the effectiveness and degree of compliance with the GCMP and assist in identifying improvement requirements.

4. DEFINITIONS

HAZARD	That which has the potential to cause harm or damage.
RISK	The risk of injury or illness to a person or damage to equipment arising out of a hazard.
EVENT	Occurrence of an incident.
GCMP	Wolverine Underground Mine Ground Control Management Plan.
TARP	Trigger Action Response Plan defines; (1) ground support based on observed conditions during development; and (2) actions based on ground conditions in stopes.
INTERNAL AUDIT	An audit conducted by mine personnel.
EXTERNAL AUDIT	An audit in which the lead auditor, at least, has no constant operational ties to the mine.
CONTINUOUS IMPROVEMENT	The process of enhancing a process, system or item, to achieve improvements in overall safety, performance, reliability, serviceability, efficiency, cost, or other parameter in line with Yukon Zinc Wolverine Corp Wolverine Mine management philosophies.
MANAGEMENT OF CHANGE	The process used to assess and assimilate all internally and externally driven changes in a routine but methodical fashion.
MI	A Mining Instruction is a formal document that has been approved (signed off) by senior technical staff and management. It should clearly outline the design of development, survey controls, minimum ground support and relevant geological, geotechnical and other points of note and clearly states the limit of development.
SI	A Site Instruction is a means of recording, documenting and authorizing a minor deviation from the MI for operational reasons. It should take into account ground conditions and the size of existing development. An SI must be signed off by the Shift Geology Technician.

GROUND SUPPORT NOTE

A written instruction specifying additional ground support to that required by the Managers Support Rules. This should include a sketch and detail of the ground support elements to be installed.

RISK ASSESSMENT A risk assessment involves the systematic identification of risks to safety, values (financial) and reputation of the Yukon Zinc Corp Wolverine Mine. Appropriate measures to control potential risks should be a key outcome. An RA can take the form of a Job Hazard Analysis (JHA) meeting, or a formal Risk Assessment and include appropriately experienced staff depending on the circumstances and the magnitude of the consequences.

PRIMARY SUPPORT The installation and application of shotcrete, wire mesh and rock bolts.

SECONDARY SUPPORT

The installation and application of further shotcrete, mesh, rock bolts, or cable bolts. Secondary support may be installed due to deteriorating ground conditions or in anticipation of future operations.

UNSUPPORTED GROUND

Area beyond the last row of roof bolts, shotcrete less than an hour old or open stopes. No personnel are to venture under unsupported ground.

GROUND SUPPORT An element installed around an underground excavation to control stability.

INTERSECTION The area where two (or more) headings meet or cross one another.

FACTOR OF SAFETY The support capacity divided by support load.

MANAGER'S SUPPORT RULES

Drawings that specify and define the location and type of support to be installed in a heading.

5. RISK ASSESSMENT PROCESS

The main focus of the Yukon Zinc Wolverine Underground Ground Control Management Plan (YZC Wolverine GCMP) is to facilitate early recognition and timely control of ground control hazards by the underground workforce. It is recognized that not all hazards are predictable and accurately defined in advance of mining by such methods as exploration, geological evaluation and therefore the GCMP must remain responsive to ground conditions and mining variations to reduce the risks to an acceptable level.

5.1 Hazard Identification

The key hazard associated with underground development in regard to ground control is rock fall due to;

- Geological structure
- Over-excavation
- Groundwater
- Ground movement
- Stress change
- Drill and blast techniques

5.1.1 Geological Structure

Geological structures include normal faults, strike slip faults and folds. These can have an adverse impact on conditions primary through weakening the rock mass conditions and creating unstable wedges in the back and walls.

A review of major structures at Wolverine mine indicate presence of numerous faults and shear zones with different dips and dip directions. Some of these structures contain significant gouge and graphitic shear zones. Further, some have moved, folded and/or intersected other structures.

The FW units contain multiple planes of weakness with millimeter scale clay coatings. The contact with the ore can be described as a series of fault planes filled with clay and/or fault gouge with thicknesses ranging from 0.5 m to 2.5 m. The contact between the ore and HW is comprised of graphitic rich fault gouge containing sericitic clays (ARGG)and loosely consolidated graphitic argillites (ARGR) with foliation planes. The ore zone is massive and poly-metallic (SSMS, SPMS, PYMS). It is severely fractured with slickensided surface forming multiple planes of orientation in some locations and these fractures become more predominant approaching the HW.

5.1.2 Over-excavation

Increasing the span or heights over the specified dimensions can have an adverse impact because;

- The capacity of the ground to support itself may be exceeded
- By increasing the size of the potential wedge over the capacity of the ground support elements.

5.1.3 Groundwater

Ground water in the general back or walls can have an adverse impact on ground control. Water can weaken the immediate ground or reduce the integrity of ground support, particularly cement based support element such as shotcrete and grout. It can have a lubricating effect on slip and joints.

Water can be from;

- Natural source along with discontinuity
- Exploration drill holes

5.1.4 Ground Movement

Ground movement is a result of post mining relaxation or change in local conditions. Ground movement is monitored at Wolverine Underground with various instruments, from relatively simple disto-meter and Ground Movement Monitor (GMM) to multi-point extensometers. Change in rate of movement may mean that the primary or secondary support design may need to be supplemented or access to that area restricted.

5.1.5 Stress Change

Changes in ground stress can lead to loading ground support and possible failure. At Wolverine this is not likely to occur around all underground openings including main ramp, stope access and stope drift areas but may become apparent in development at depth. Indicators of stress may include flattering or buckling or rock bolt plates, straining of cable plates, bird caging of secondary support tendons, spalling of shotcrete and unusual popping sound caused by rock burst.

Unusual roof noise: audible cracking, squeaking or "banging" observed in the backs or walls generally indicate that the ground is "working". This is a sign of ground instability which can lead to loss of control and ground failure. To date this has not been reported at Wolverine Underground. Because this noises associate with major faults, immediate notice by miners and special remedial action were required for this case.

5.1.6 Drill and Blast Techniques

Drill and blast is the one major variable that can be controlled. Ground control can be enhanced by ensuring that drilling is to design and the appropriate explosives and numbers are used when firing development headings. Drill and blasting techniques should limit collateral damage to host rock surrounding the excavation.

5.2 Likelihood and Consequence of Occurrence of the Risk

The likelihood of occurrence can be based on both past experience and judgement; it must be clearly stated which.

In some circumstances the likelihood of a potential failure may be quantified from past failure recorded in the YZC Ground Control Risk Assessment report (Appendix-A). The report should be used to record all back and/or wall failures that occurred in any supported ground. A failure that requires an Incident Report shall be recorded in the YZC Wolverine Incident Investigation Report.

5.3 Risk Assessment

The risk associated with ground related and other identified hazards are estimated by considering the Consequence, Exposure and Probability of the hazard. To facilitate the risk assessment process the Team-based Risk Assessment - Consequence, Exposure and Probability Risk Evaluation Table and the Wolverine Safety Risk Ranking Matrix (Appendix - A) shall be used.

The risk assessment may be done as part of the Mining Instruction (MI) process. The GCMP is but just one of a number of management plans and risk mitigation measures to be addressed in an MI.

During the daily and weekly meetings risk shall be reviewed and if required highlighted so that appropriate action can be taken.

6. ROLES AND RESPONSIBILITY

The UG Mine Manager has the overall responsibility for implementation, review and revision of the GCMP and is the only official who may authorize the GCMP, its review and revisions.

The Wolverine UG Mine technical team, in conjunction with operation staff, will determine the appropriate levels of development support, monitoring and hazard response for all headings and stopes.

6.1 Ground Management Responsibilities

Relevant personnel (employees, staff, contractors and visitors) entering YZC Wolverine Underground Mine should be made aware of and take note of their responsibilities under the YZC Wolverine Underground GCMP, relevant regulations and implied duty of care.

The YZC Wolverine Underground GCMP defines the specific responsibilities of key personnel in terms of the Wolverine underground mining process.

6.1.1 UG Mine Manager

- Ensure the requirements of the GCMP are compiled with
- Shall approve and sign all Managers Support Rules
- Shall oversee and drive the GCMP and ensure the GCMP and TARP are audited annually
- Appoint and ensure that the necessary resources are provided to manage the GCMP
- Ensure budgets are sufficient to provide for adequate geological/geotechnical understanding of the mining environment
- Provide guidance and input as required

6.1.2 Procon Project Superintendent

- Ensure the requirements of the GCMP are compiled with
- Ensure sufficient materials are on site to implement the Manager Support Rules
- Ensure clear communication of the GCMP to all Procon personnel
- Shall communicate operational deficiencies and improvements in the GCMP to relevant Yukon Zinc personnel
- Ensure channels of communication are open for the operators to make suggestions regarding the GCMP
- Provide guidance and input ground support as required

6.1.3 Senior Mine Engineer

- Ensure that GCMP is taken into account in mine design
- Arrange the annual internal and external auditing of the Wolverine Underground GCMP
- Provide guidance and input to ground control as required

6.1.4 Geologist

- Shall gather data and information, in so far as it relate to geological and geotechnical parameters and record that information in face mapping and line mapping/GSI sheets and database
- Report areas of concern to the Geotechnical Engineer, Supervisor or other relevant staff
- Provide advice on any geological issues as they relate to ground support
- Shall ensure that the geological model is updated and ensure that the geology and structure indicated on the plans is correct

6.1.5 Geotechnical Engineer

- Responsible for ground support in the mine
- Provide geotechnical input into the ground control management process at Wolverine Mine
- Undertake regular inspections of their work areas, specifically back and wall support, making reports of any non-conformance or deterioration
- Periodically review and manage change of the Wolverine Underground GCMP
- Facilitate the design of the various Support Types, in terms of Manager Support Rules
- Ensure that required testing of support performance is carried out
- Manage the installation, reading and interpretation of monitoring equipment and ensure findings are communicated to management in a timely manner
- Ensure ongoing monitoring occurs of the ground control and geotechnical/geological environmental
- Determine and communicate trigger levels and TARP

6.1.6 Supervisor

- Ensure that those people under their charge who have responsibilities under the GCMP understand and perform those duties
- Contribute to the design and implementation of the various Support Types
- Communicate minutes and outcomes of all meetings to all mining crews
- Undertake inspections of the backs and walls or the mine and ground support

- Ensure crews are reporting all unusual visual observations, ground noise or ground (control) related events on their plods or end of shift reports
- Ensure that the appropriate changes in support hardware are made in accordance with the MI's, TARP's, letters to Procon and other instructions
- Quality control: ensure Shift Supervisors and Operators are aware of and conduct necessary QC checks on installed ground support

6.1.7 Shift Supervisor

- Ensure compliance with TARP and Manager Support Rules
- Undertake inspections of the backs and walls of the mine and ground support
- Report in writing, on their shift report and verbally to the Supervisor any deterioration in ground conditions and/or support behavior prior to or at the end of their shift
- Quality Control: Operators are aware of and conduct necessary QC checks on installed ground support

6.1.8 Operators

- Develop headings and install support in accordance with the Manager Support rules
- Verbally report any changes or anomalies in ground conditions or support behavior to the Shift Supervisors
- Install monitoring tools as instructed
- Quality Control: ensure the necessary QC checks on installed ground support are conducted in a timely manner

6.1.9 Geotechnical Consultant

- Provide advice on any geotechnical issues raised by the Wolverine UG Manager, Geotechnical Engineer or other technical team

6.2 Other Key Personnel

6.2.1 Mine Surveyor

- Shall report to the Mine Manager, Supervisor and Geotechnical Engineer any development or intersection that exceeds design dimensions
- Survey the locations of all types of monitoring instruments and boreholes drilled through the mine and record

6.2.2 Procon Safety and Training Officer

- Assist with the development of training modules that address the GCMP in conjunction with the Geotechnical Engineer
- Develop and maintain a comprehensive training and assessment plan and maintain records of any training and assessment conducted in compliance with the GCMP

6.3 Temporary Delegation of Responsibilities

The Yukon Zinc Wolverine mine system of mining on a 24 hours per day, 7 day week basis (with personnel requiring rostered time off), requires particular attention when considering available personnel. Where staffs are absent or unavailable, it is the responsibility of individuals to provide clear and unambiguous delegation of their authority to appropriate proxy. Such delegation should be made in writing (including e-mail) and will include details of;

- Contact details for the proxy
- Duration of delegation
- Any potential limitations of duty with respect to the proxy
- Resource authorization of the proxy
- Any specific instructions to the proxy

7. GROUND SUPPORT DESIGN

The ground support design process is integral to the overall mine design and needs to be considered at every stage.

The Mine Design process incorporates the assessment of geotechnical considerations at a "global scale".

7.1 Mine Design Process

The design of openings, ground support, or pillars should be undertaken in a systematic manner take into general account;

Geological Factors

- Distribution of regional structure
- Distribution of rock types
- Groundwater conditions

Geotechnical Factors

- Back, floor and wall geology and parameters
- Known or predicted geological structure and rock defects
- Rock strength parameters (uniaxial compressive strength, cohesion and friction angle)
- In-situ stress
- Expected change in stress
- Groundwater
- Ground response from monitoring

Mining Factors

- Excavation dimensions
- Mining method and sequencing
- Required use of excavation
- Ground support equipment and constraints
- Required life of area or excavation

7.2 Ground Control Management Process

No extraction or development shall take place unless the area has been assessed and an appropriate support system designed, documented and authorized by the Wolverine UG Mine Manager.

Ground control management shall be specifically discussed in the monthly planning meetings and as events required. In particular, the ground control management shall be discussed;

- Monthly, as minimum (covering all relevant geotechnical & operational issues)
- Prior to commencement of production in a new stope or on returning to an old area
- Prior to development of new headings
- Prior to development of significant underground infrastructure sites
- Additionally as required to assess changes in geotechnical conditions (as identified by the TARP), stope layout or change in operational needs of development

The Ground Control Management Process and detailed Underground Mining and Mine Planning Processes are shown in Figure 1 and 2.

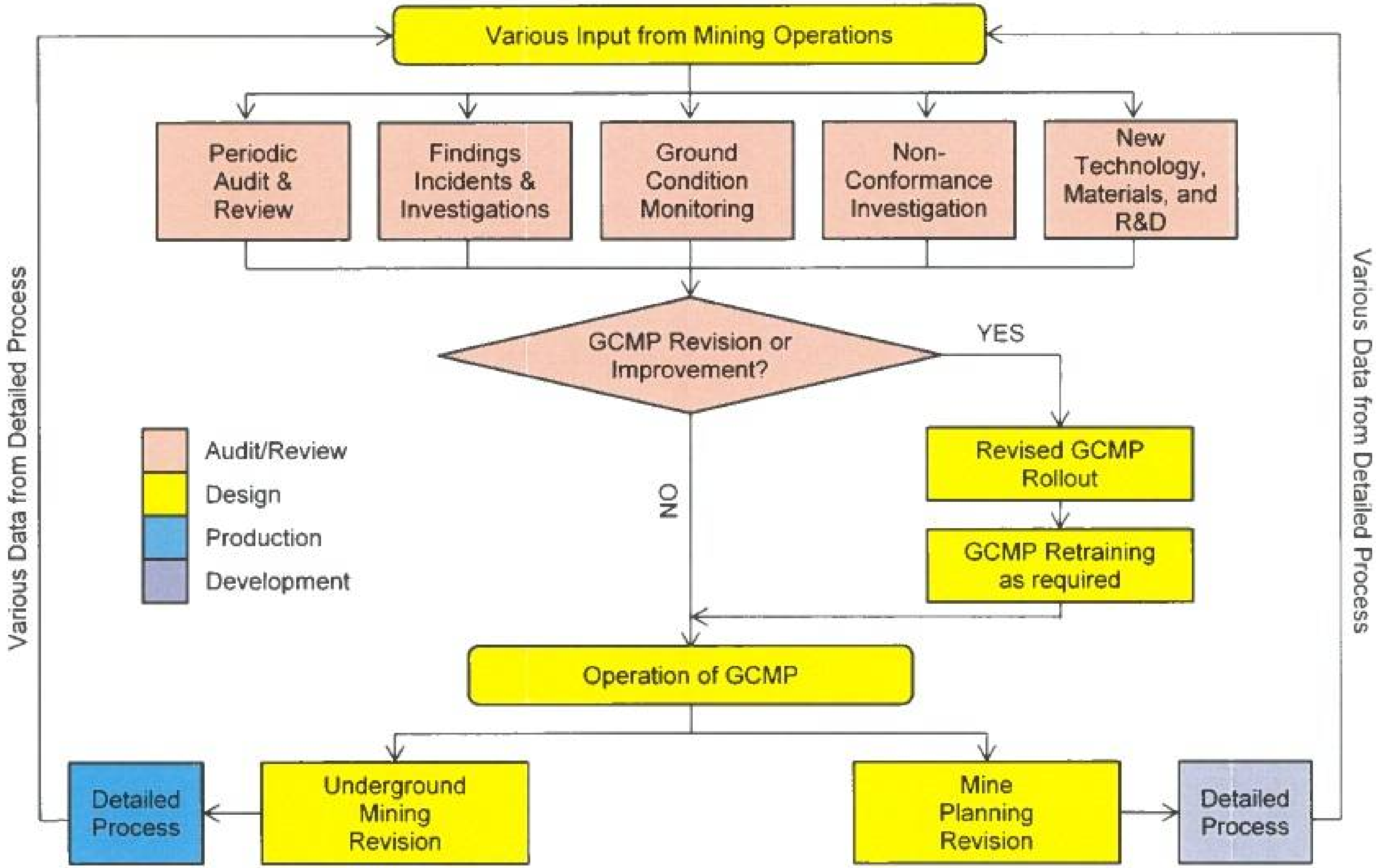


Figure 1. Ground Control Management Process

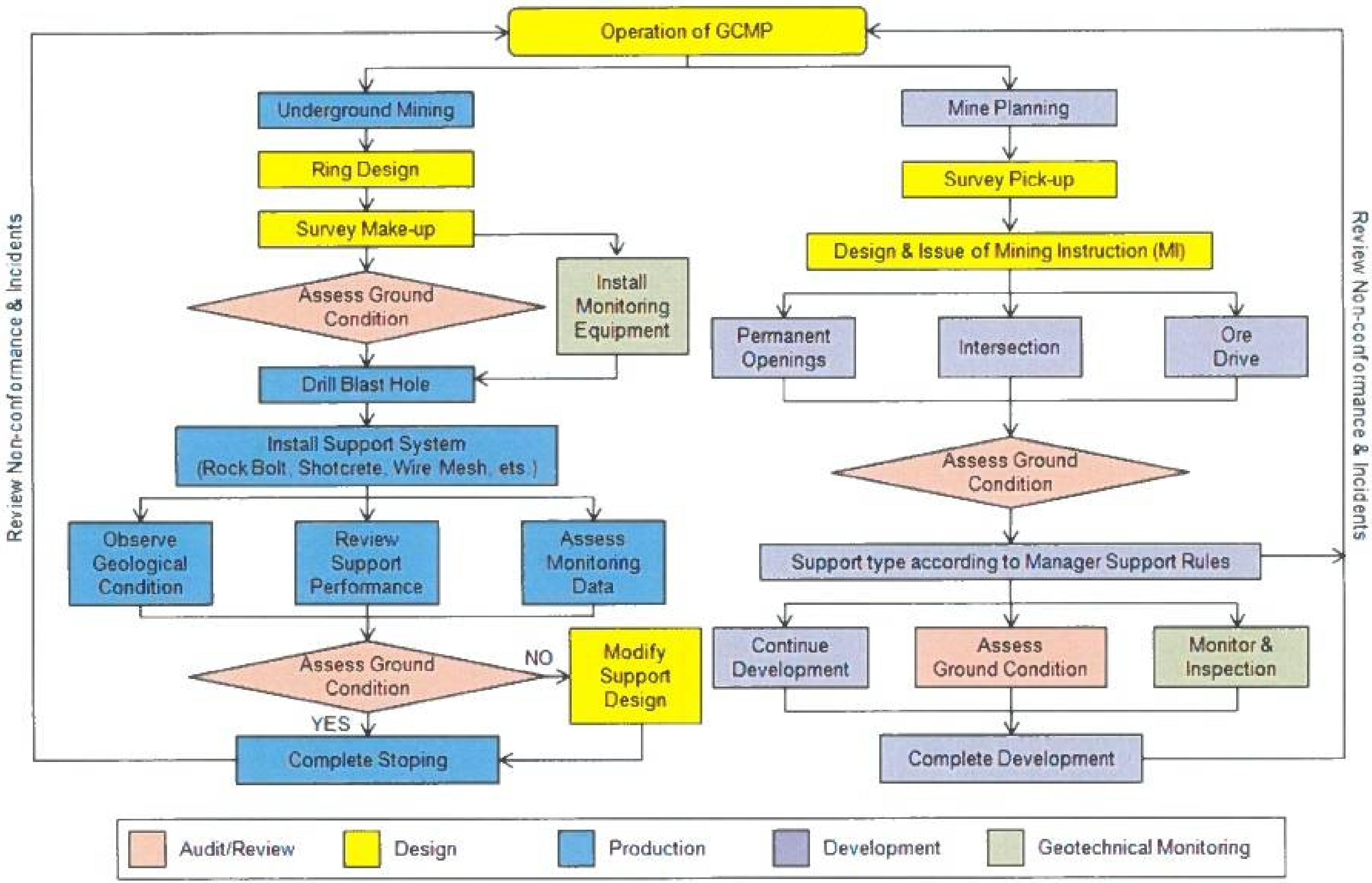


Figure 2. Detailed Underground Mining and Mine Planning processes

8. MANAGER'S SUPPORT RULES

The Manager's Support Rules specify the ground support required in all development.

- There are 11 basic support types depending on ground conditions and development geometry (span, intersections)

The Trigger Action Response Plan (TARP) specifies the circumstances under which a change in support type is to occur.

- The TARP provides a description of ground condition indicators which, where observed separately or individually may indicate a change in Support Type for individual headings;

Copies of the YZC Wolverine Mine underground GCMP shall be kept in the Shift Supervisor's Office and YZC Project Superintendents' office, the Wolverine Underground Main office, the crew crib room and on all jumbos. The Manager's Support Rules and TARP should be prominently displayed.

The Supervisor shall ensure that all Shift Supervisors responsible for ground support during development are familiar with GCMP, Managers Support Rules and TARP.

8.1 Support Type

Each of the Manager's Support Rules currently used at Wolverine Underground is included in Appendix-B. The Manager's Support Rules form the basis for all ground support and are to be installed according to specification. It is the responsibility of the operator to report and deviation to the standard and the reason for it.

In adverse geotechnical ground conditions e.g. poor to extremely poor ground, presence of structural features, expected corrosion, the Manager's Support Rules shall be reviewed and additional support recommendations will be made by Geotechnical Engineer. The Manager's Support Rules cannot be reduced without recommendation by Geotechnical Engineer and approved by UG Mine Manager.

The Manager's Support Rules will be developed and updated as experience is gained upon excavation of Wolverine mine. The support regimes employed at Wolverine Underground are composed of Main Ramp, Stope Access/Drift/Ore Drive, Raises and Intersection as shown in Table 1. In the table, support type can be determined using geological formation, contact orientation and GSI (Ground Strength Index) which is evaluated by rock structure and joint surface (see Table 6).

Intersections pose a higher risk for ground instability than norm development due to the large spans. A specific intersection regime have also been formulated to support the increased span both horizontally as well as vertical (Overcasts).

- 4-way intersections are to be avoided wherever practical.
- Over-excavation should be minimized

Detailed support types for every section with different ground conditions are shown in Appendix-B.

Table 1. The support regimes employed at YZC Wolverine Mine

Type	Section	Ground Condition
Type RAMP-I	Main Ramp	Poor to Fair (GSI > 40)
Type RAMP-II	(4.5 m × 4.8m)	Extremely Poor (GSI<20)
Type - I	SA, Drift, Ore Drive	Pass through Ore, Fair (GSI > 40)
Type - II	(4.5 m × 4.6 m)	FW Drift (FW contact is higher than 1.5 m from the sill)
Type - III		HW Drift (FW contact < 1 m at the back)
Type - IV		HW Drift (1 m ≤ HW exposure < 3 m)
Type - V		HW Drift (HW exposure ≥ 3m)
Type FAR-I	Raise	Fair (GSI > 40)
Type FAR-II	(3.0 m × 3.5 m)	Poor (GSI <40)
Type IS-I	Intersection	Fair (GSI > 40)
Type IS-II		Poor (GSI <40)

8.2 Trigger Action Response Plan

The aim of a TARP is to ensure a response to changed ground conditions at an early stage. The TARP for use in Wolverine mine is shown in Appendix-C. From the empirical guideline and numerical study, 14 different types of ground supporting regimes are recommended for the Wolverine UG mine depending on ground condition, life time of openings and development geometry conditions. The TARP provides a list of indicators, observable at operator level that can be used to guide the selection of the appropriate Support Type as defined by the Manager's Support Rules (see Section 8.1)

The key indicators are;

- Rock qualification (GSI)
- Contact orientations between FW/HW and Ore
- Presence and condition of the FW/HW

In addition the Geotechnical Engineer may dictate extra support based on geotechnical monitoring or visual inspections.

The Geotechnical Engineer or Supervisor will conduct an inspection of the area in the event the ground Support Type is changed.

8.3 Ground Support Installation

8.3.1 Installation

The designed support shall be installed to established standard Wolverine Underground operating procedures and as outlined in Wolverine Underground Managers Support Rules and TARP's.

Operators shall observe the ground conditions and monitor effectiveness of ground support installation (e.g. drilling rates, water loss / gain, bolting problems, voids etc) and report any unusual conditions and action the TARP's. The operators shall only use approved (UG Mine Manager or Supervisor) installation equipment and support hardware.

The requirements for ground support installation are listed below;

8.3.2 Shotcrete

- All Headings are to be hydro scaled prior to shotcrete application to ensure any loose material is washed away and to remove excess dust, both of which contribute to shotcrete fallouts;
- All shotcrete applied to headings will be as per the prescribed mix design.
- Shotcrete thicknesses must be comply with the relevant Ground Support Type currently applicable to that specific heading;
- All headings are considered non-entry for a period of 1 hour after shotcreting to allow the shotcrete to achieve 1MPa, which is the industry standard for shotcrete re-entry strengths;
- Where mesh is not applied fibre reinforced shotcrete as per the prescribed mix design will be used;
- Where shotcrete is unavailable for any reason all development shall use mesh for the relevant Ground Support Type.
- Where ground conditions dictate fiber reinforced shotcrete will be applied before installing mesh with shotcrete then being sprayed over the mesh.

8.3.3 Rock bolts

- Bolt holes must be bored to the manufacturers recommended diameter and length as listed below.

- Water Injected Friction Bolt, 12T
- Water Injected Friction Bolt, 24T
- Split Sets
- Resin Rebar

- All Water Injected Friction Bolts are to be injected to manufactures prescribed pressures and hole diameters.
- All Split Sets are to be installed to manufactures prescribed hole diameters.
- Resin Rebar bolts are to be installed to manufacture prescribed procedures and recommended resins.
- Incorrectly installed rock bolts must have a replacement bolt installed immediately beside it.

8.3.4 Mesh

- Mesh must be 100mm x 100mm #6 welded mesh.
- Mesh may be pinned with friction bolts, but all other bolts must be the prescribed type and at correct bolt spacing and ring spacing.
- Adjacent sheets of mesh must overlap by 3 squares with the bolt pinning them together in the middle (second) row of overlap.
- As far as practicable once installed mesh must be pushed to fit shape of the excavation to guard against voids forming behind the shotcrete once it is applied.

8.3.5 W Strap

- W straps must be installed to apply as much confinement to the ground as possible; this means as tightly as possible across the surface with minimal 'poke outs'; and
- Bolts in W straps are to be no more than 5 holes apart.

8.3.6 Connectable friction bolt

- Connectable friction bolts must be injected to manufacture prescribed pressures and hole diameters.
- Connectable friction bolts must be connected to manufacture prescribed methods.

8.4 Fore-poling (Spilling) Method

8.4.1 Designing of the fore-poling (spilling)

Fore-poling (spilling) method is a pre-support technique for drifting/tunneling through weak ground that has potential to unravel. This procedure covers fore-poling with rebar or hollow core bar. Rebars will be appropriate for weak, soil-like rock masses and hollow core rebars work efficiently in jointed rock, for which grouting is required. The Wolverine Mine engineer / Geotechnical engineer will identify locations that require the installation of fore-poling (spiling) and will issue instructions to Procon superintendent, stating the type of rebars, their pattern, and their length.

8.4.2 Installation procedure (threaded rebar)

Drilling

- Drill holes 0.3 m (1 ft) outside the disigned drift periphery to a depth of 3.5 m.
- Install a 4 m long rebars. A tail of 0.5 m (1 1/2 ft) of the rebar should be left out of the hole.
- Mine engineer / Geotechnical engineer should determine the spacing between the holes, which should between 0.3 m (1 ft) to 0.5 m (1 1/2 ft).
- The operator should drill the spiling along with the perimeter blast holes to ensure they remain parallel at all time.
- The rebars should be installed along with drilling, using the other Jumbo boom, to push them it.
- Holes should be "looked out" slightly from designed grade, with a maximum of 5 degrees.

Pinning the Tails

- The tails of the rebars are to be "pinned back" using 0 gauge straps and 1.8 m (6 ft) Splitsets on a 0.5 m (1 1/2 ft) spacing.

Drilling the remainder of the round

- When the 4 m long rebars have been installed, the remainder of the blast holes can be drilled. Mine engineer / Geotechnical engineer will determine the maximum length of the holes which should be less than 2.5 m.

8.4.3 Installation procedure (hollow core rebar)

Drilling

- Drill holes 0.3 m (1 ft) outside the disigned drift periphery to a depth of 3.5 m. If needed, replace drill steel with a 4 m hollow core bar and attached proper bit.
- Install a 4 m long hollow core threaded rebars. A tail of 0.5 m (1 1/2 ft) of the rebar should be left out of the hole.
- Mine engineer / Geotechnical engineer should determine the spacing between the holes, which should between 0.3 m (1 ft) to 0.5 m (1 1/2 ft).
- The operator should drill the spiling along with the perimeter blast holes to ensure they remain parallel at all time.

- The rebars should be installed along with drilling, using the other Jumbo boom, to push them it.
- Holes should be "looked out" slightly from designed grade, with a maximum of 5 degrees.

Grouting

- Ensure water/cement ratio is between 0.35 and 0.4; e.g. 16 litter of water for every 40 kg bag of cement.
- Mix water cement mortar thoroughly until proper consistency is reached.
- Attach coupler to hollow core bars, and grout only one bar one at a time. Grout until grout appears at the collar of the hole.
- Thoroughly seal the collar with legs or paper towel, and then pump until grout flows out around the collar again. Reseal hole.
- Remove hose from the coupler and seal the centre of the hollow core bar to prevent from emptying hole of currently placed grout.

Pinning the Tails

- The tails of the threaded rebars are to be "pinned back" using 0 gauge straps and 1.8 m (6 ft) Split sets on a 0.5 m (1 1/2 ft) spacing.

Drilling the remainder of the round

- When the 4 m long threaded rebars have been installed, the remainder of the blast holes can be drilled. Mine engineer / Geotechnical engineer will determine the maximum length of the holes which should be less than 2.5 m.
- Blast round after a minimum of 12 hours post grouting.

8.4.4 Record

All location and detailed procedure of Fore-poling (spiling) methods should be recorded in Procon's Shifters Logbook.

8.5 Ground Support Design

The ground support requirements for the different cases of ground formation were evaluated based on empirical charts, numerical modeling methods and Dead Weight analysis. The empirical Q-support guideline [Grimstad and Barton, 1993] method was employed to establish the minimum ground support requirements for three different qualities of rock masses (Ore, FW, and HW). Then, the detailed ground support guidelines for different ground conditions were examined by Phase2 [Rocscience, 2010] and Dead Weight analysis [Pakalnis, 2012]. Depth of failure zone around openings in different ground conditions were assessed using numerical analysis method. Factor of safeties for each ground supports associated with ground conditions were estimated based on Dead Weight analysis.

8.5.1 Rock Mass Qualification

Based on Bazooka drilling core and HQ3 sized Boart's drilling core samples, the average RQD is ranged 0-10 % for HW, 10-25 % for FW and 10-80 % for ore respectively. Other factors for rock qualification using Q-system, such as joint numbers, joint conditions, ground water condition and Stress Reduction Factors) were estimated from face observations. Assuming RQD of 10 for HW, J_n = 20 (J: Crushed rock), J_r = 0.5 (aG: Slickensided, earthlike), J_a = 4 (aE: Softening or low friction clay mineral coatings), J_w = 1 (Minor inflow, less than 5 l/min locally), SRF = 10 (Multiple occurrences of weakness zones containing clay), then Q is calculated as 0.006 and average RQD of 15% for FW with J_n = 12 (G: three joint sets plus random joints), J_r = 1 (aF: smooth, planar), J_a = 3 (aD: clay coatings, small clay particles), J_w = 1 (Minor inflow, less than 5 l/min locally), SRF = 7.5 (Multiple shear zones in competent rock, loose surrounding rock), then Q is calculated as 0.06. Meanwhile, average RQD of 50 % can be assumed for ore with J_n = 6 (E: Tow joint sets plus random joints), J_r = 2 (aC: Smooth, undulating), J_a = 2 (aC: Slightly altered joint walls, non-softening mineral coatings, sandy particles, clay-free disintegrated rock, etc.), J_w = 1 (Minor inflow, less than 5 l/min locally), SRF = 2.5 (single shear zones in competent rock (clay-free), loose surrounding rock), then Q is calculated as 3.33.

Table 2. Rock qualification using Q-system for FW/HW and ore

Parameters for Q-system	HW	FW	ORE
RQD (%)	10	15	50
Joint set number (Jn)	20	12	6
Joint roughness (Jr)	0.5	1	2
Joint alteration (Ja)	4	3	2
Joint water condition (Jw)	1	1	1
Stress reduction Factor (SRF)	10	7.5	2.5
Q - value	**0.006**	**0.06**	**3.3**

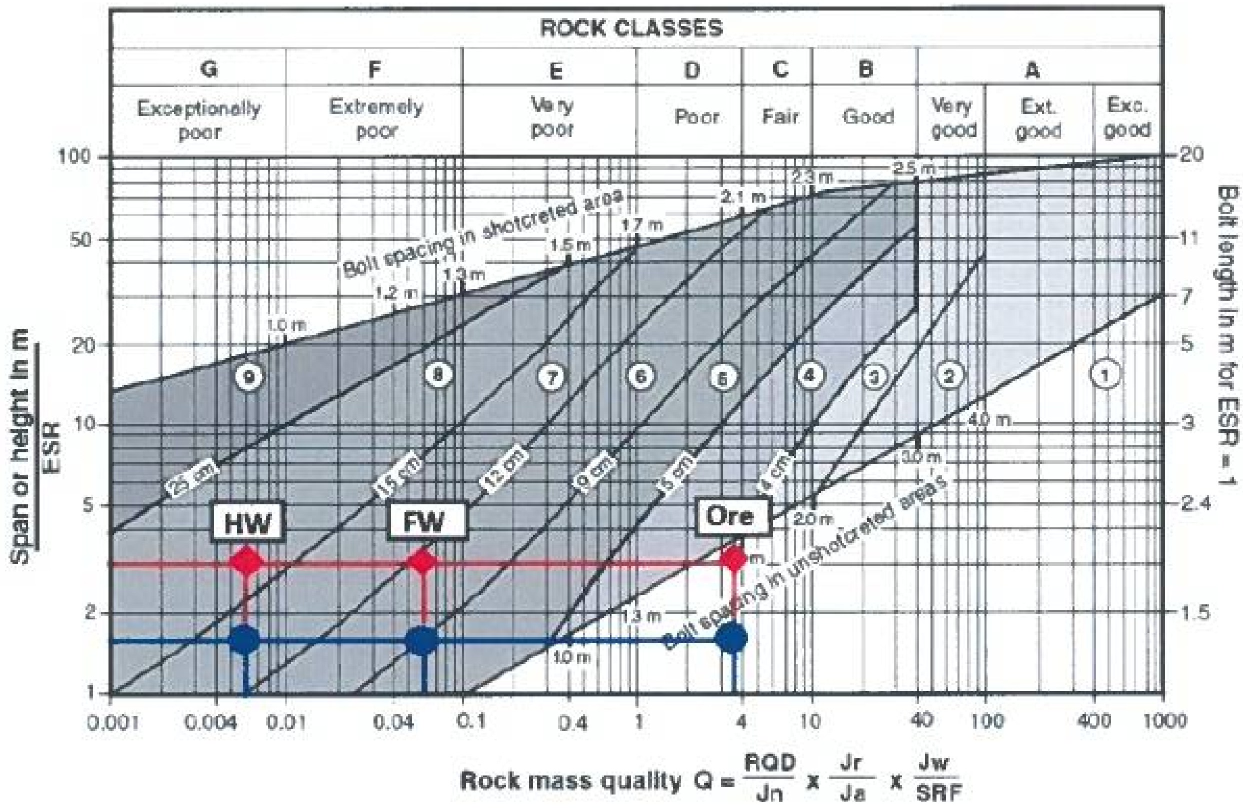
Table 3. The value of ESR related to the intended use of the excavation and to the degree of security which is demanded of the support system installed to maintain the stability of the excavation. [Barton et al, 1974]

	Excavation Category	ESR
A	**Temporary mine openings**	**3 - 5**
B	**Permanent mine openings, water tunnels for hydro power (excluding high pressure penstocks), pilot tunnels, drifts and heading for excavations**	**1.6**
C	Storage rooms, water treatment plants, minor road and railway tunnels, civil defense chambers, portal intersections.	1.3
D	Power stations, major road and railway tunnels, civil defense chambers, portal intersections.	1.0
E	Underground nuclear power stations, railway stations, sports and public facilities, factories	0.8

8.5.2 Ground Support Requirements using Empirical Q Support Guideline

Using the representative opening dimensions of 4.5 m (H) by 4.6 m (W) and ESR =3 for temporary excavations (Table 3), the ground support guidelines for production drifts in different ground conditions (Ore, FW or HW) are plotted in Figure 3 (blue symbols). Ground support guidelines for the main ramp also shown in Figure 3 (red symbols) using opening dimensions of 4.5 m (H) by 4.6 m (W) and ESR =1.6 for permanent mine openings (Table 3). The estimated supporting categories for production drifts are (7), (5) and (1). Meanwhile, support categories for main ramp using Q-system and opening dimension are (8), (6), and (1).

Barton et al [1974] also provide additional information on rock bolt length, maximum span of rock bolt. According to Barton et al [1974], the length, L, of rock bolts and can be estimated from the excavation width (B) and the Excavation Support Ration (ESR), and rock bolt span can be calculated using Q-value and ESR. Both empirical correlations and ground support patterns for different ground conditions using empirical methods are summarized in Table 4 and applied ground support elements at Wolverine mine are shown in Table 5 and Appendix - B. However, drift in whole ore body or FW/HW is not a natural case and presence of numerous faults including shallow dipping faults filled with clay layers are frequently founded in Wolverine mine underground and it is recommendable to use alternative determination methods, such as numerical analysis and Dead Weigh analysis for verifying ground support rules.



REINFORCEMENT CATEGORIES;

1. Unsupported.
2. Spot bolting (SB).
3. Systematic bolting (B).
4. Systematic bolting with 40-100 mm unreinforced shotcrete.(SC)
5. Fiber reinforced shotcrete (RSC), 50-90 mm, and bolting.
6. Fiber reinforced shotcrete (RSC), 90-120 mm, and bolting.
7. Fiber reinforced shotcrete (RSC), 120-150 mm, and bolting.
8. Fiber reinforced shotcrete (RSC), >150 mm, with reinforced ribs of shotcrete and bolting.
9. Cast concrete lining (CCA).

Figure 3. Estimated ground support requirements for 1300, 1280and 1270 drift based on the empirical Q-support guideline.

Table 4. Ground support estimation for production drift and main ramp using empirical correlation suggested by Barton et al [1974]

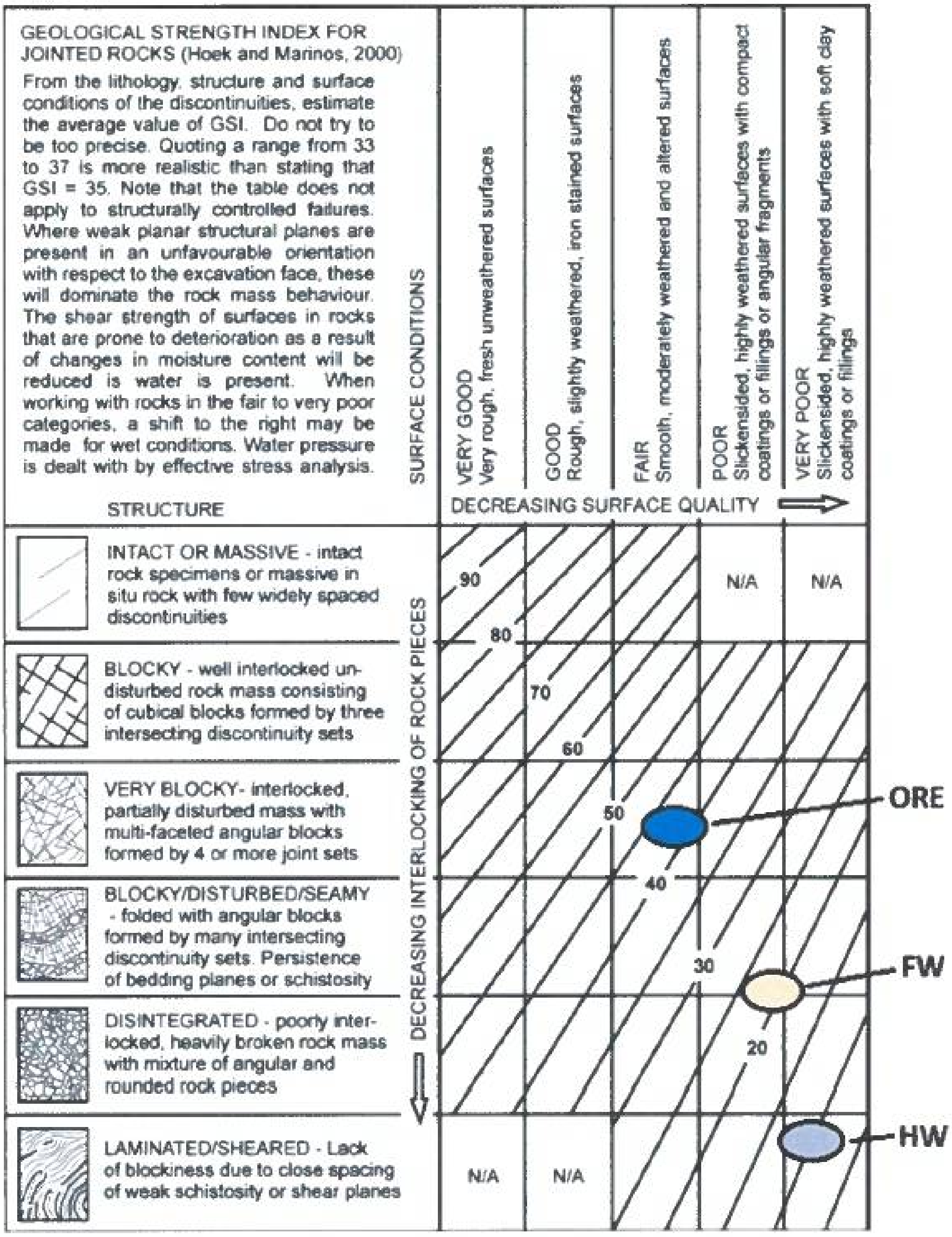
<table>
<tr><th colspan="2"></th><th>Support Category</th><th>Rock bolt length (m)
$L = 2 + 0.15B/ESR$</th><th>Rock bolt spacing (m)
$S = 2 \times ESR \times Q^{0.4}$</th></tr>
<tr><td rowspan="3">Production Drift (ESR=3)</td><td>Ore</td><td>(1) Unsupported</td><td rowspan="3">2.23</td><td>0.8</td></tr>
<tr><td>FW</td><td>(5) 50-90 mm fiber SC + Rock bolt</td><td>2.0</td></tr>
<tr><td>HW</td><td>(7) 120-150 mm fiber SC + Rock bolt</td><td>10.0</td></tr>
<tr><td rowspan="3">Main Ramp (ESR=1.6)</td><td>Ore</td><td>(1) Unsupported</td><td rowspan="3">2.45</td><td>0.4</td></tr>
<tr><td>FW</td><td>(6) 90-120 mm fiber SC + Rock bolt</td><td>1.0</td></tr>
<tr><td>HW</td><td>(8) 90-120 mm fiber SC + Rock bolt</td><td>5.1</td></tr>
</table>

Table 5. The support elements employed at YZC Wolverine Mine

<table>
<tr><th>Type</th><th>Section</th><th>Ground Support Elements</th></tr>
<tr><td>Type RAMP-I
Type RAMP-II</td><td>Main Ramp
(4.5 m × 4.8m)</td><td>12' Super Swellex / 3" fiber shotcrete (pre-shot +recoat)
Spiling / Shotcrete Arch as required</td></tr>
<tr><td>Type – I (Ore)
Type – II (FW)
Type – III (HW)
Type – IV (HW)
Type – V (HW)</td><td>SA, Stope Drift
(4.5 m × 4.6 m)</td><td>8' Regular Swellex
8' Regular (back & wall) + 12' Regular (wall) Swellex
8' Regular (wall)+ 12' Regular (back & wall) Swellex
12' Super Swellex / 3" shotcrete (pre and/or post)
Spiling</td></tr>
<tr><td>Type FAR-I
Type FAR-II</td><td>Raise
(3.0 m × 3.5 m)</td><td>8' Regular Swellex
8' Regular Swellx / 2" Shotcrete</td></tr>
<tr><td>Type IS-I

Type IS-II</td><td>Intersection</td><td>12' Regular Sellex + 12' Super swellex spot bolting / 2" shotcrete as required
12' Super swellex + 5.5m connectable spot bolting 3" fiber shotcrete</td></tr>
</table>

Table 6. Estimated range of representative rock mass for FW/HW and Ore (Table modified after Hoek and Martino, 2000)



8.5.3 Verification of Support Patterns by Numerical Analyses

The properties of the rock mass used in geotechnical modeling analyses were estimated by Hoek-Brown failure criterion [Hoek et al, 2002]. From the geological face observations and borehole logging data, the representative range of Geological Strength Index (GSI) for the Ore, FW and HW were selected from the rock mass descriptions illustrated in Table 4.

From the table 6, GSI = 10, 20 and 40 were estimated for HW, HW and ore respectively. The following rock mass design parameters, as shown in Table 7, were assumed using GSI value for Wolverine mine openings analysis.

Especially, drift holes are located at the contact between FW/HW and ore body for the maximization of mine efficiency and the dip of the faulted contacts show dramatic changes from the geological mapping of every faces after every round of blasts in Wolverine underground mining site. Therefore, 5 different dips of faulted contacts between FW/HW and ore were examined to optimize the support patterns for various ground formations as shown in Table 8.

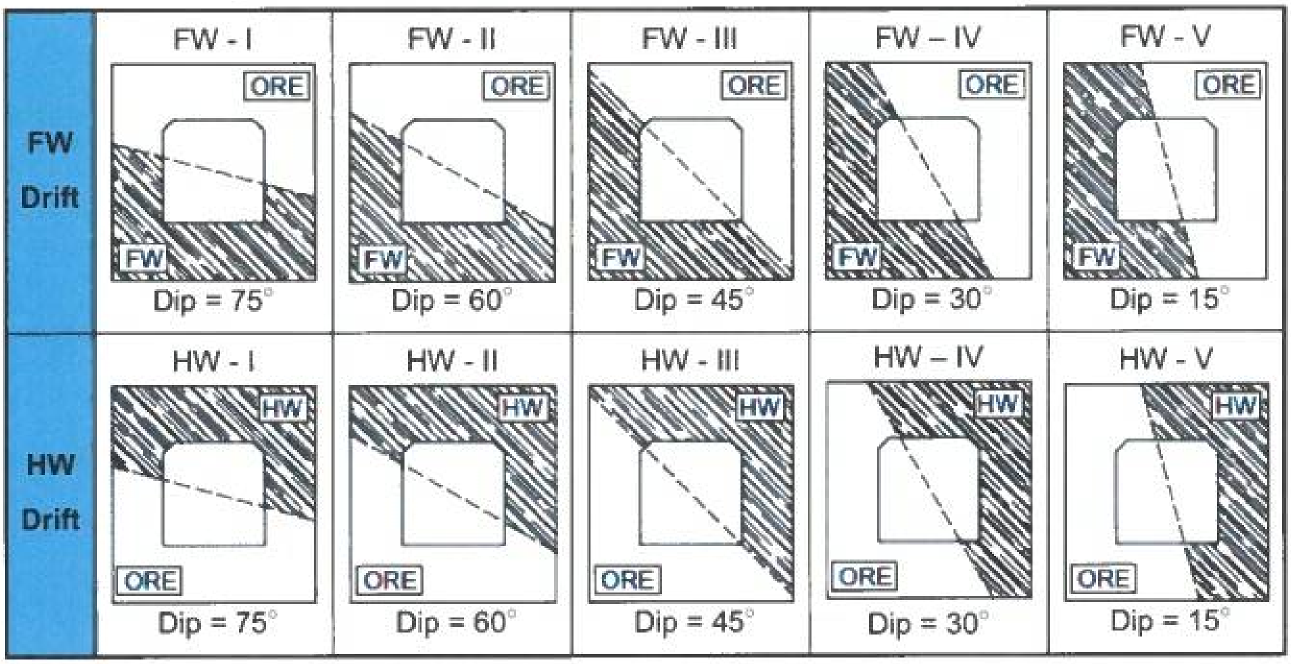
Although, no in-situ stress measurement has been carried out at Wolverine, the hydrostatic condition (horizontal / vertical stress, K, = 1) can be considered for the Wolverine underground because the rock mass were highly fractured and stress released by fracturing activities. Therefore, the hydrostatic condition with variation of ±20 % (K = 0.8, 1.0and 1.2) were considered for the analyses.

Numerical calculation results for different geological formation at Wolverine mine are illustrated in Appendix – D. It is noted that all calculation results using employed ground support element are appropriate for various ground condition at Wolverine mine.

Table 7. Applied rock mass properties for the ground support analyses

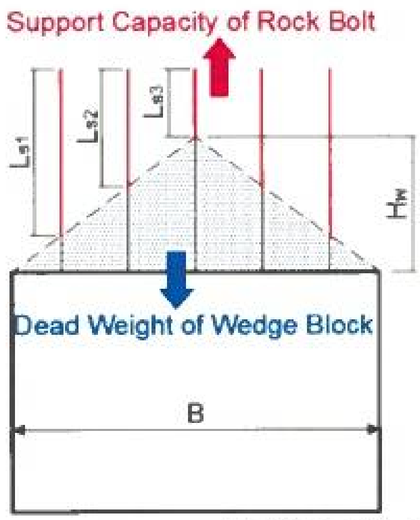
Rock mass properties		HW	FW	Ore
Intact rock strength, UCS (MPa)		25	30	45
Geological Strength Index, GSI		10	20	40
Hoek-Brown constant	m_b	0.23	0.34	1.25
	a	0.59	0.57	0.5
	s	0.00005	0.00014	0.0013
Rock mass modulus, E_{rm} (MPa)		250	400	1250
Poisson's ratio, v		0.3	0.3	0.3

Table 8. Various ground formation examined by Phase2



8.5.4 Verification of Support Patterns by Dead Weight Analyses

Safety factors for every support patterns associate with ground conditions and opening dimensions were estimated by Dead Weight analysis. Outline of Dead Weight analysis is illustrated in Figure 4. Safety factor is the capacity of rock bolts installed at the back against weight of failed wedge block. The weight of wedge can be calculated by opening width and failure depth, capacity of rock bolts should be estimated using the installed length beyond the wedge.



Dead Weigh = $1/2 \times \gamma_{rock\ mass}\ (t/m^3) \times B \times H_w$

Support Capacity = Bond strength × $(2L_{s1}/2 + 2L_{s2} + L_{s3})$

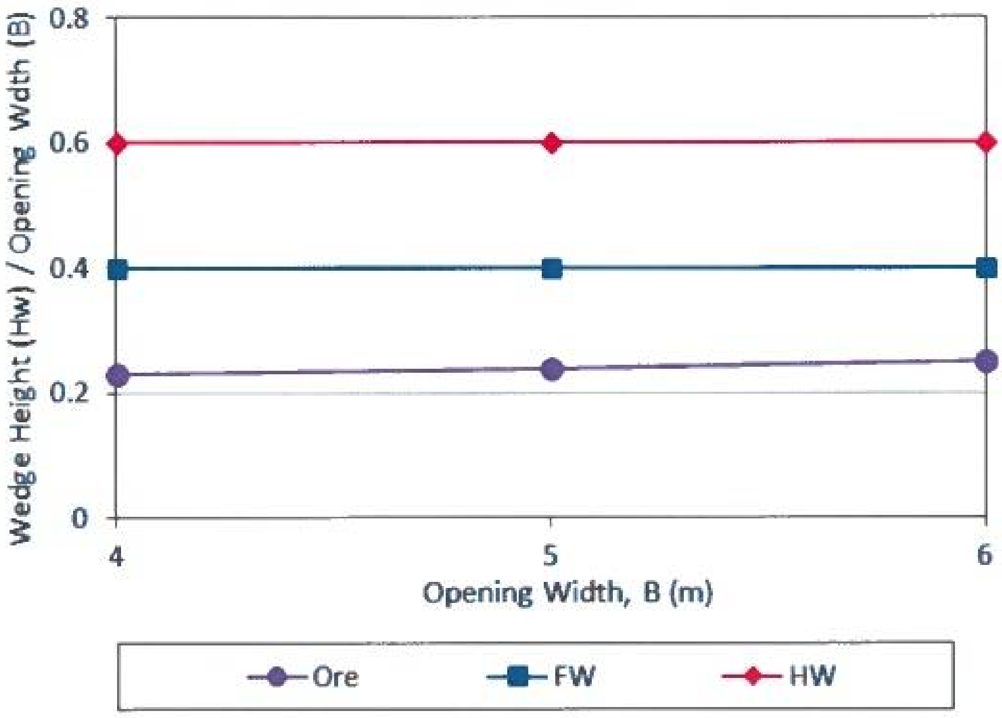
FS = Support Capacity / Dead Weight

FS > 1.5 : permanent opening (Main Ramp)
FS > 1.2 : temporary opening (SA and Stope)

Figure 4. F.S. of ground support from Dead Weight analysis

For the Dead Weight analysis, heights of wedge blocks (H_w) in different ground conditions were estimated by numerical parametric study as summarized in Appendix – E. Using elasto-plastic model in Phase2D, the depth of failure zone around openings can be estimated from maximum deviatoric stress contour because the stress decreases due to stress redistribution in damaged area. From the study it is indicated that the ratio between wedge height (H_w) and opening width (B) changes relate to ground condition as shown in figure 5. For the ground conditions at Wolverine mine 0.3B, 0.4B and 0.6B can be assumed as a failure wedge depth for the Ore, FW and HW ground respectively.

Factor of safety (F.S) for two different dimensions of openings (B < 5 m and 5m < B < 6m) in Ore, FW or HW ground were calculated using Dead Weight analysis (Appendix-E) and the analysis results were summarized in Table 9. Generally, larger than 1.2 of F.S is required for temporary openings and if F.S is larger than 1.5, the ground supports of the opening can be considered appropriate supports for permanent opening such as Main Access Ramp. From the analyses it is indicated that, if opening width is less than 5 m, 8' split sets with 1 m by 1 m are good for ground support for temporary drift in Ore ground. However, if drift width is wider than 5 m and pass through HW ground, 12' super swellex are required for ground supports to get sufficient safety.



Ground Condition	Ore	FW	HW
Failure Wedge Height (H_w)	0.3B	0.4B	0.6B

Figure 5. Parametric study on Failure Wedge Height ratio to Opening width (H_w/B)

Table 9. Factor of Safety from Dead Weight Analyses

Supports (1m × 1m)	B < 5 m			5 m < B < 6 m		
	Ore	FW	HW	Ore	FW	HW
6' Split Set	1.1	-	-	-	-	-
8' Split Set	**1.9**	0.6	-	**1.5**	-	-
8' Regular Swellex	**2.8**	**1.7**	0.7	**2.3**	**1.3**	0.5
10' Regular Swellex	3.0	2.1	1.0	2.6	1.7	0.7
12' Regular Swellex	-	2.3	**1.3**	2.6	2.0	1.0
12' Super Swellex	-	-	2.5	-	3.1	**1.9**

8.6 Stand-up Time

The stand-up time of unsupported spans is one of the fundamental issues in mine development. The Bieniawski diagram (Figure 6) shows the relationship between the unsupported span and stand-up time of an excavation with reference to its rock mass quality. The basic relationship that governs stand-up time is:

- For a given rock mass quality, a stand-up time decrease as the unsupported roof span become wider, and
- For a given roof span, a stand-up time decrease as the rock mass quality becomes poorer.

Using data collected from Wolverine Mine, stand-up time for three different ground conditions and roof span were estimated based on the Bieniawski diagram as shown in Figure 6 and summarized support methods relate to their stand-up time in Table 10.

The stand-up time of a Main Access Ramp in the HW/FW ground can be assumed zero because opening is located at extremely poor to poor ground (GSI < 10). The zero stand-up time means that installation of pre-supports is required before excavation. Fore-poling (spilling) method should be applied for this case as a pre-support method. The other cases, HW contact drift and FW contact drift, stand-up time can be estimated 12hrs and 24hrs, respectively.

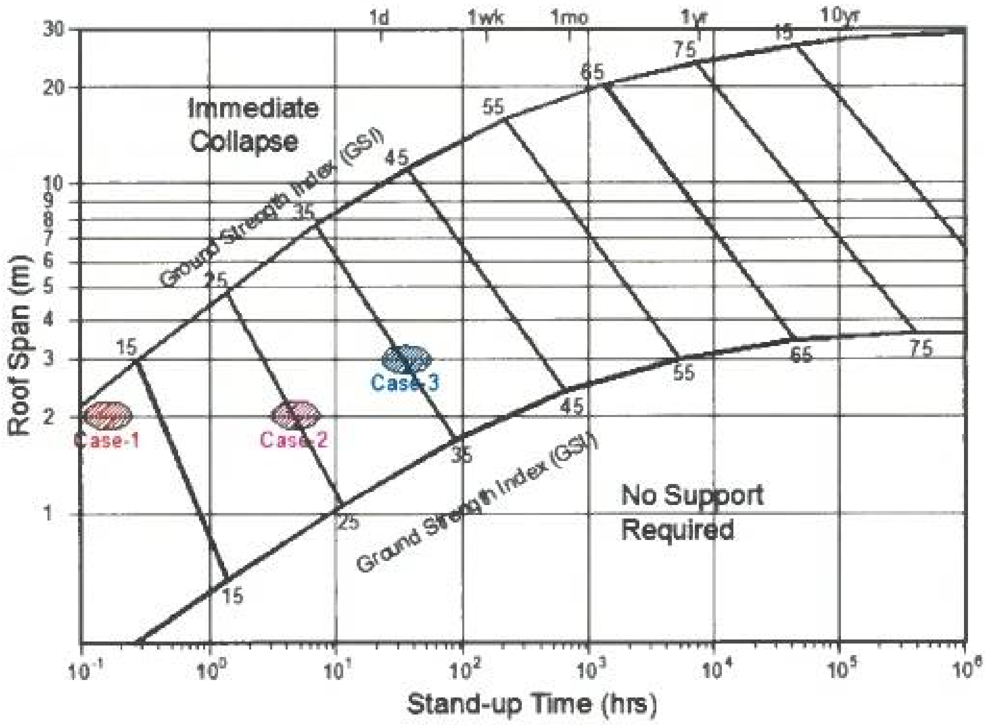


Figure 6. Relationship between Stand-up time, roof span, and GSI after Bieniawski (1989)

8.7 Inspections

Inspections must be conducted regularly by the Underground Geotechnical Engineer in conjunction with the Supervisor.

Other team members are encouraged to conduct their own inspections, informing the Geotechnical Engineer of any issues or concerns.

A heading may be barricaded to address ground control issues or until such times as a Non-Conformance has been addressed.

Table 10. Estimation of stand-up times for three different ground conditions at Wolverine Mine

Case	Ground Condition	Span (m)	Stand-up ime (hrs)	Support
Case-1	Ramp in HW/FW ground	2	0	Pre-support (Spiling)
Case-2	Drift in HW contact	2	12	Rock bolt immediately or pre-shotcrete
Case-3	Drift in FW contact	3	24	Regular support within 24 hrs

8.8 Quality Control

8.8.1 Shotcrete quality control program

Shotcrete is a major and costly component of ground support system. In order to meet optimize the design criteria and reduce cost, a quality control program consisting of the following components should be implemented;

i) Shotcrete material testing
ii) Early age strength testing in site

There are a number of tests available to evaluate shotcrete quality. The following program, as shown in Table 11, should be conducted for Wolverine UG mine shotcrete quality control.

Table 11. Shotcrete quality control program

Test Method	Property	Curing Time (days)	Frequency	Performance Requirement
ASTM C1604 & CSA A23, 2-14C	Compressive strength of shotcrete core	7 28	3 samples Bi-weekly	30 MPa 40 MPa
Short term Strength test	Minimum early age cube compressive strength before re-entry under shotcreted area	Within 6 hours	1 heading per week	1 MPa

8.8.2 Rock bolt quality control program

The pull test of ground support system is normally used for routine quality control of material and installation procedure of rock bolt. The test, in particular in the poor to extremely poor condition at Wolverine, can provide an insight on adequacy of ground support system.

The details of pull test for the regular swellex and super swellex which are installed in Wolverine UG mine are described in Table 12.

Table 12. Rock bolt quality control program

Type of rock bolt	Frequency	Performance Requirement
Regular swellex (12T)	5 tests per week	3000 psi (8.5 ton)
Super swellex (24T)	5 tests per week	6000 psi (17 ton)

9. COMMUNICATION

A communication process that ensures a two-way flow of information between operations and mine management shall be fostered.

9.1 Communication Process

The process shall ensure that;

- Operators are provided with an understanding of expected conditions, anticipated support, mining procedures and any relevant changes in support design prior to implementation.
- Personnel are aware of typical warning signs which suggest that installed support may be inadequate and need review.
- Close communication exists between all members working under the GCMP.
- Management has an early opportunity to respond to unexpected mining conditions and/or support system behavior.

Communication channels may include;

- Geotechnical Daily Logging Book
- Start of roster meeting
- Underground inspections
- Daily/weekly planning meeting
- Support rules and drawings
- Plans and sections
- Shift reports
- Toolbox meeting
- Safety meetings
- TARP's and work procedures
- Tell tale and other monitoring forms
- Incident reports
- Inspection checklists

9.2 Non-conformance and Corrective Action

Treatment of non-conformances and corrective actions under the GCMP will be in accordance with the framework defined bellow;

- Identification and notification of non-conformances
- Documentation of non-conformances using the relevant Yukon Zinc Wolverine mine forms (Appendix-F)
- Identification of potential corrective actions that may be applied

- Determination of required corrective actions (taking into account impacts of change including potential additional hazards and effects on other operations)
- Allocation and recording of responsibilities and target dates for completion of corrective actions
- Monitoring and review of non-conformances and progress of completion of corrective actions (generally conducted at Monthly Planning Meetings, additionally as required or warranted)
- Record of completion and closure of corrective actions by responsible person
- Storage of records

The Geotechnical Engineer shall maintain a Ground Control Non-conformance register.

9.3 Identification of Non-conformances

Non-conformances may be identified through means including;

- Observations and inspections by Yukon Zinc Underground personnel, contractors, consultants and visitors
- Monitoring of ground control performances
- TARP
- Incidents and incident investigations
- Internal audits (including systematic and non-systematic audits by Yukon Zinc Corp., materials and equipment suppliers and routine inspection)
- External audit typically done by 3rd party consultants (including by the Mining Inspectorate and systematic periodic audit)

Non-conformances will be reviewed at the Monthly Planning Meetings.

9.4 Corrective Action

The adequacy and effectiveness of corrective actions, allocation of responsibility, target completion date and progress towards completion will be reviewed and adjusted as appropriate/required at the Monthly Planning Meetings.

10. TRAINING

A training module will be developed for employees and contractors and outlines their duties with regard to ground control. Training will consist of an initial course followed by periodic refresher training and will cover;

- Factors involved in ground control
- Detection of structural changes in the ground
- Ground support theory and practice
- Ground monitoring
- Reporting
- Installation of support
- Responsibilities of personnel under GCMP

Modules to be included in training are,

- Barring and sounding
- Basic ground control
- Outline of various aspects of ground support, designed for mining personnel

11. INCIDENT INVESTIGATION

Following the occurrence of an incident related to uncontrolled ground movement, general priorities will be;

- Removal of personnel from positions of potential harm
- To eliminate hazards sufficiently to enable safe recovery or treatment of injured personnel
- Investigation, data collection and reporting
- Securing the back and walls
- Recovering equipment and resumption of development/production

Yukon Zinc Health and Safety guidelines provide guidance as to responsibilities, communications, reporting and other requirements for incident investigation (Appendix-A).

Incidents will be reviewed at Special Meetings, Safety Meetings and Monthly Planning Meetings.

11.1 Guideline for Incident Investigation

Appropriately experienced personnel will be used in incident investigation. Consideration should be given to whether external opinion or other particular skills are also required.

Records of all investigations, including associated analysis, conclusions, recommended actions and action completion will be maintained by the Geotechnical Engineer.

As relevant, ground control incident investigation may include;

- Inspection of the incident site
- Photography and sketches of the incident site
- Soliciting of verbal and written statements from personnel involved in the incident
- Soliciting of verbal and written statements from personnel associated with the incident (e.g. Supervisor, Shift Supervisors, Leading Hands, Operators)
- Compilation of a chronology of events
- Review of equipment and materials in use
- Assessment of compliance with the GCMP
- Review of data
- Review of design
- Back analysis
- Review of ground support design or operating practice
- Review the GCMP

11.2 Incident Statutory Reporting Requirements

Ground related incidents will be reported to the relevant authorities by the Mine Manager as required by the appropriate regulations.

12. GEOTECHNICAL MONITORING

The current mine design is based on a number of geotechnical assumptions based on test results, geotechnical borehole data, numerical modeling and engineering judgements. Moving away from the current ground support standards requires monitoring to assess ground response.

Current monitoring is to confirm that the current mining method is feasible and that the ground support standards and their applications are appropriate. The location of the instrumentations at Wolverine used to monitor any ground response is shown in Appendix-F.

Monitoring currently underway includes;

- 17 extensometers at main ramp crossover to monitor ground response at the complex geometry underground regions
- 9 tilt meters at steel sets in the portal area to monitor ground movement relate to surface slope sliding
- Daily convergence measurements of stopes and ore drives to test brow stability and to confirm the safety of mining personnel working in the vicinity of headings
- Shotcrete crack monitoring
- Visual inspection
- Numerical modeling using Phase2, Unwedge and Dips software

Future monitoring programs may target;

- Deployment of 'telltales' in targeted locations (intersections, strategic wide openings, etc.) and other locations where ground conditions or structures required monitoring
- Deformation of the rock mass during development and production
- The reaction or effect of ground support on the rock mass
- Long term excavation stability (assessment of actual vs. planned/modeled)

The installation of monitoring devices will be primarily managed by the Geotechnical Engineer with inputs from the technical team and external parties as necessary. In general monitoring falls into two categories,

- Planned monitoring on a project scale
- On an as required basis

Where possible the location(s) of all monitoring equipment to be installed shall be agreed in advance of development/production in the Weekly Planning Meetings.

A formalized monitoring recording schedule shall be documented and maintained. This schedule shall document the location and type of monitoring to be carried out, whom is to perform the readings, time last read and the reading frequency.

13. GEOTECHNICAL MINE MAPPING

The Geotechnical Engineer shall ensure all development covered by the GCMP is mapped and analyzed as soon as possible. Mapping should aim to identify all hazards related to ground conditions at the time of mapping. Retrospective or periodic retrospective mapping shall also be performed and stored.

The mapping shall be recorded on paper or field note book, entered into an electronic format and interpreted by a suitably qualified and experienced geotechnical engineer or geologist. All paper and electronic copies shall be kept in perpetuity.

The mapping interpretation shall attempt to assess future hazards in all areas of the mine on two scales;

- Development scale
- Stope scale

Any potential hazards shall be conveyed to all staff as they become apparent and used for planning purposes, particularly with regard to safety of personnel and stope production.

14. GCMP AUDIT & REVIEW

14.1 Audit

The purpose of auditing the GCMP is;

- To confirm that provisions of the GCMP are implemented, effective and operating in practice
- To provide feedback on performance as input to the review process
- To identify those aspects of the plan requiring revision and/or improvement
- To identify GCMP non-conformances
- To initiate discussion and recognition of improvement opportunity

The system of auditing will include but is not limited to;

- Formal scheduled audits
- Formal event based audits (incident/non-compliance)
- Informal daily/weekly inspections
- Determination of the type (compliance, system, technical, other) and frequency of (regular/routine and scheduled periodic) audits required
- Determination of suitable persons to complete audits (internal/external, competencies etc)
- Coverage of suitable subject matter including the plan, systems under the plan, training and competence, communications, materials and equipment, records and document management, reviews, performance and effectiveness. The scope of audits may range from consideration of all aspects of the GCMP to consideration of specific aspects
- Documentation of process, findings and recommendations of audit
- Management of records in accordance with the GCMP
- Addressing of non-conformance and corrective action in accordance with the GCMP

A summary of audits required under this plan includes the following;

AUDIT	RESPONSIBLE	TYPE	FREQUENCY	OBJECTIVE
TARP – internal	Geotechnical engineer	Review	Periodic	Confirm suitability of indicators and responses and modify TARP where necessary
TARP – internal	All UG staff	Compliance Observation	Informally – daily/weekly Formally – event based	Appropriate actions as required by the TARP are being followed
Material stock levels	Procon	Compliance	In accordance with stores stocktaking or otherwise maximum monthly	Provide accurate accounting of the type, number, current max/min stock levels and expiry date of support materials

AUDIT	RESPONSIBLE	TYPE	FREQUENCY	OBJECTIVE
Excavation dimensions – internal	Supervisor Mine surveyor	Inspection Technical / Survey measure up	Daily Daily/weekly	Identify areas exceeding design dimensions
Managers Support Rules – internal	All UG staff	Compliance	Informally – daily/weekly Formally – event based	Support is being installed in accordance with support rules
Equipment fitness for duty - internal	Maintenance manager, mining engineer	Technical / Compliance	Informally – daily/weekly Formally – event based	Support installation equipment is fit for purpose
Support installation – internal	Geotechnical engineer and Supervisor	Technical / Compliance	Informally – daily/weekly Formally – event based	Support is being installed in accordance with support rules and associated procedures. Pull testing conducted on an ongoing basis. Shotcrete sampling & testing.
Quality of support installation – external	Geotechnical engineer supported by material supplier	Technical / Measurement & Testing	At least 6 month or more often as determined by the Geotechnical engineer / UG mine manager	Installed support is to the anticipated standard applied in design consideration.
GCMP – internal / external	UG Mine Manager	System	Event based	That the system established under the GCMP is implemented as outlined, resourced and functioning
Records – internal	Geotechnical engineer	Compliance	Event based	Record required to be kept under the plan are completed and stored in the appropriate place and form
Legislation	UG Mine Manager	Compliance	In accordance with changed management procedure	The GCMP addressed all requirements of the relevant regulations
Consistency with H&S – internal	Safety & training officer	System	In accordance with changed management procedure	The GCMP is consistent with the current site safety systems

14.2 Reviews

The purpose of review of the GCMP is;

- To provide a structured approach to reassessing the hazards and controls addressed by the GCMP, including consideration of relevant additional data that has come to hand since the previous review
- To assess the ongoing suitability and effectiveness of the GCMP in light of performance indicators, changing conditions, occurrence of non-conformances/incidents and developments in technology, methods, experience and materials

A review of the GCMP may include;

- Determination of the type and frequency of review required
- Determination of suitable persons to complete reviews
- Coverage of suitable subject matter including the plan, systems under the plan, training and competence, communications, materials and equipment, records and document management, audits, performance and effectiveness
- The scope of reviews may range from consideration of all aspects of the GCMP to consideration of specific aspect/s
- Documentation of process, findings and recommendations of review
- Management of records in accordance with the GCMP
- Addressing of non-conformance and corrective action in accordance with the GCMP

Documents related to the GCMP which may be reviewed and form revisions from time to time include;

- The GCMP (main framework)
- Procedures and guidelines
- Hazard identification
- Opening and pillar design
- Manager Support Rule
- Risk assessment
- TARP
- Training modules and assessments
- Forms

14.3 Timing

Internal and external audits shall be done yearly, offset by 6 months.

14.4 Auditors

14.4.1 Internal

- UG Mine Manager
- UG Mine Planner
- UG Senior Engineer
- UG Geotechnical Engineer
- UG Geologist
- Health and Safety Superintendent
- Procon Superintendent
- Supervisor
- Others as required

14.4.2 External

- Rimas Pakalnis, Ph. D, P. Eng
- Malcolm Swallow, P. Eng
- Mining Inspectorate
- Other as required

14.5 Agenda

A generic agenda is to be drafted for GCMP audits encompassing any operational requirements or deficiencies, incidents, monitoring results, lines of communication, reporting lines and design issues/amendments.

15. REFERENCES

Barton, N.R., Lien, R. and Lunde, J. 1974. Engineering classification of rock masses for the design of tunnel support. *Rock Mech.*

Grimstad, E. and Barton, N. 1993, Updating the Q-system for MMT. *Proceedings of International Symposium on Sprayed Concrete*, Fagernes, Oslo, Norwegian Concrete Association.

Hoek, E., Marinos, P. and Benissi, M. 1998. Applicability of the Geological Strength Index (GSI) classification for very weak and sheared rock masses. The case of the Athens Schist Formation. *Bull. Engng. Geol. Env.* 57(2), 151-160.

Phase2 v7.0. 2010. Two-dimensional finite element program. Rocsience Inc.

Oceana Gold (NZ) Ltd. 2007. Frasers Underground Ground Control Management Plan.

Rockland Ltd. 2010. Inspection report – Stope accesses, stope and fresh air raises. Wolverine Mine, Yukon Zinc Corporation. September 6.

Rockland Ltd. 2011. Memorandum – Ground support recommendation for 1300 footwall drift – next 31 m. January 25.

16. DOCUMENT CONTROL

Document / Issue / Revision	Action	Responsibility	Initial
Draft document for Management Review	Prepared	W. Shin	
Reviewed by Mine Engineer	Reviewed	N. Yugo	
Health & Safety Superintendent	Reviewed	D. Shalansky	
UG Mine Technical Superintendent	Reviewed	P. Christman	
Final document prepared	Edited	W. Shin	
Final Document Reviewed by UG Mine Manager	Reviewed	F. Varley	

UG GEOTECHNICAL ENGINEER AUTHORISATION

Authorized

....

Woo Shin, Ph. D, P. Eng **Date**
UG Geotechnical Engineer

UG MINE MANAGER AUTHORISATION

Authorized

....

Floyd Varley **Date**
UG Mine Manager

APPENDIX – A.

RISK EVALUTION TABLE
AND
ASSESSMENT MATRIX

Team-Based Risk Assessment – Consequence, Exposure & Probability Risk Evaluation Tables

1	CONSEQUENCE						SEVERITY
Level	Financial	Compliance	Reputation	Communities Impact	Health and Safety	Environment	FACTOR
C1	>$100M one off or NPV, or >$40M annually	Potential jail terms for executives. Very high company fines. Operations suspended or severely reduced by authorities. Loss of water licence and/or forfeiture of land lease.	Extended and widespread international condemnation. Yukon Zinc board exposure	Total social breakdown, significant damage to highly valued cultural objects or structures Irreparable and prolonged impact	Multiple fatalities; multiple cases of fatal chronic disease	Massive widespread, irreversible environmental damage. Could close mine permanently	100
C2	$20M - $100M NPV, or $8M - $40M annually	Major regulatory breach; potential for severe fines and prosecutions; Multiple, serious litigation.	Serious public or media attention with international coverage Yukon Zinc CEO exposure	Very serious social impacts ; Irreparable and widespread	Single fatality, Quadriplegia, paraplegia; fatal chronic disease	Significant, local, irreversible impact; likely short-term mine closure	50
C3	$5M - $20M NPV, or $2M - $8M annually	Potential for significant prosecution and fines. Very serious litigation, including class action.	Serious national media, NGO attention and public concern. Product Group CEO exposure	Significant social impacts and/or damage to culturally significant objects.	Serious permanent disabling injury or disease eg. blindness	Potential prosecution/ conviction. Negative perception. Significant but reversible	25
C4	$1M - $5M NPV, or $400K - $2M annually	Major breach of regulation; Potential for major fines; Major litigation or major legal issue.	Significant adverse national media, public and NGO attention. YZC Managing Director exposure	Ongoing social impacts and damage to culturally significant objects. Major non-compliance with PA's or SEMA. Mostly reparable	Serious disabling injury. (Rehabilitation required) Loss of an arm or leg. Noise induced hearing loss	Non or compromised compliance with environmental obligations; generally reversible impact	10
C5	$100K - $1M NPV, or $40K - $400K annually	Serious internal non-compliance; serious regulatory breach; prosecution with moderate fines; Potential for investigation or report to authority.	Attention from media and/or heightened concern by local community. Criticism by NGOs; DDMI General Manager exposure	Medium term social impacts on local community. Serious non-compliance with PA's. Mostly reparable	Loss of a finger, broken leg or arm, asthma (e.g. LTI >2 wks)	Serious degradation or harm to environment but reversible.	5
C6	$20K - $100 NPV, or $5K - $40K annually	Minor legal issue, minor infraction of regulation; no fines (warning), no litigation.	Minor adverse local public or media attention and complaints. YZCI Manager exposure	Minor impact to social structures. Minor non-compliance with PA's. Fully reparable	Medical treatment injuries or illness (e.g. MTI or LTI <2 wks)	Minor impact requiring regulatory reporting	1
C7	$5K - $20K NPV, or $2K - $5K annually	Minor non-compliance with internal policy.	Public concern restricted to local complaints. YZC manager issue	Very minor impact. Fully reparable.	Minor medical/first aid treatment eg. Dust in eye (no MTI/LTI)	Nuisance only; minimal impact	0.5

2. EXPOSURE TO THE RISK		
LEVEL	**EXPOSURE DESCRIPTION**	**S.F**
E1	Continuous or several times per day or several employees once per day	10
E2	Approximately once per day	6
E3	Once per week to once per month	3
E4	Once per month to once per year	2
E5	Once a year to once every ten years	1
E6	Rarely, but it has been know to occur	0.5
E7	No exposure identified	0.1

3. PROBABILITY OF OCCURRENCE OF UNWANTED EVENT		
LEVEL	**PROBABILITY DESCRIPTION**	**S.F**
P1	Always 90% to 100%	10
P2	Frequent 51% to 90%	9
P3	Common: heard of it happening a number of times 30% to 50%	5
P4	Probable – Have heard of it happening 11% to 30%	3
P5	Possible – Could happen 6%to 10%	1
P6	Unlikely 1% to 5%	0.5
P7	Extremely Unlikely (less than 1%)	0.1

Risk Evaluation

Risk Rating = 1 Consequence x 2 Exposure x 3 Probability

DDMI Risk Rating	Risk Level	YZC Risk Determination	Action	Minimum Notification and Accountability
>3000	Extreme	Class V	Risks that significantly exceed the risk acceptance threshold and need urgent and immediate attention	President / COO
1501 - 3000	Very High	Class IV	Risks that exceed the risk acceptance threshold and require proactive management	General Manager / VP Responsible
501 - 1500	High	Class III	Risks that exceed the risk acceptance threshold and require proactive management	General Manager
101 - 500	Moderate	Class II	Risks that exceed the risk acceptance threshold and require review of controls and required mitigations.	Department Manager
0 -100	Low	Class I	Risks that are below the risk acceptance threshold and do not require active management	

YZC Wolverine Underground Mine Project Risk Ranking Matrix for Job Hazard Analysis

		PROBABILITY					RISK ASSESSMENT CATEGORY
		A	B	C	D	E	
CONSEQUENCE	1	1	2	4	7	11	CRITICAL
	2	3	5	8	12	16	HIGH
	3	6	9	13	17	20	MODERATE
	4	10	14	18	21	23	LOW
	5	15	19	22	24	25	

Potential sequence and probability details

Potential **CONSEQUENCE** of the incident	
1	Could kill, permanently disable or cause very serious damage
2	Could cause serious injury (major LTI) or major damage
3	Could cause typical MTC / LTI or moderate damage
4	Could cause First Aid injury or minor damage
5	Could not cause injury or damage

PROBABILITY of this occurring again	
A	ALMOST CERTAIN to happen
B	LIKELY to happen at some point
C	MODERATE, POSSIBLE, it might happen
D	UNLIKELY, not likely to happen
E	RARE, practically impossible

YZC Wolverine Project Risk Assessment

(green)	Minimum impact – Work your plan
(blue)	Some disruption – Re-evaluate the control measures in order to reduce the overall risk
(yellow)	Unacceptable major disruption likely – Re-evaluate the control measures with the Supervisor. Determine lower risk options
(red)	Unacceptable major disruption likely – Job sut down for re-evaluation with Superintendent and the job team

YZC Wolverine Project Priority of Risk Controls

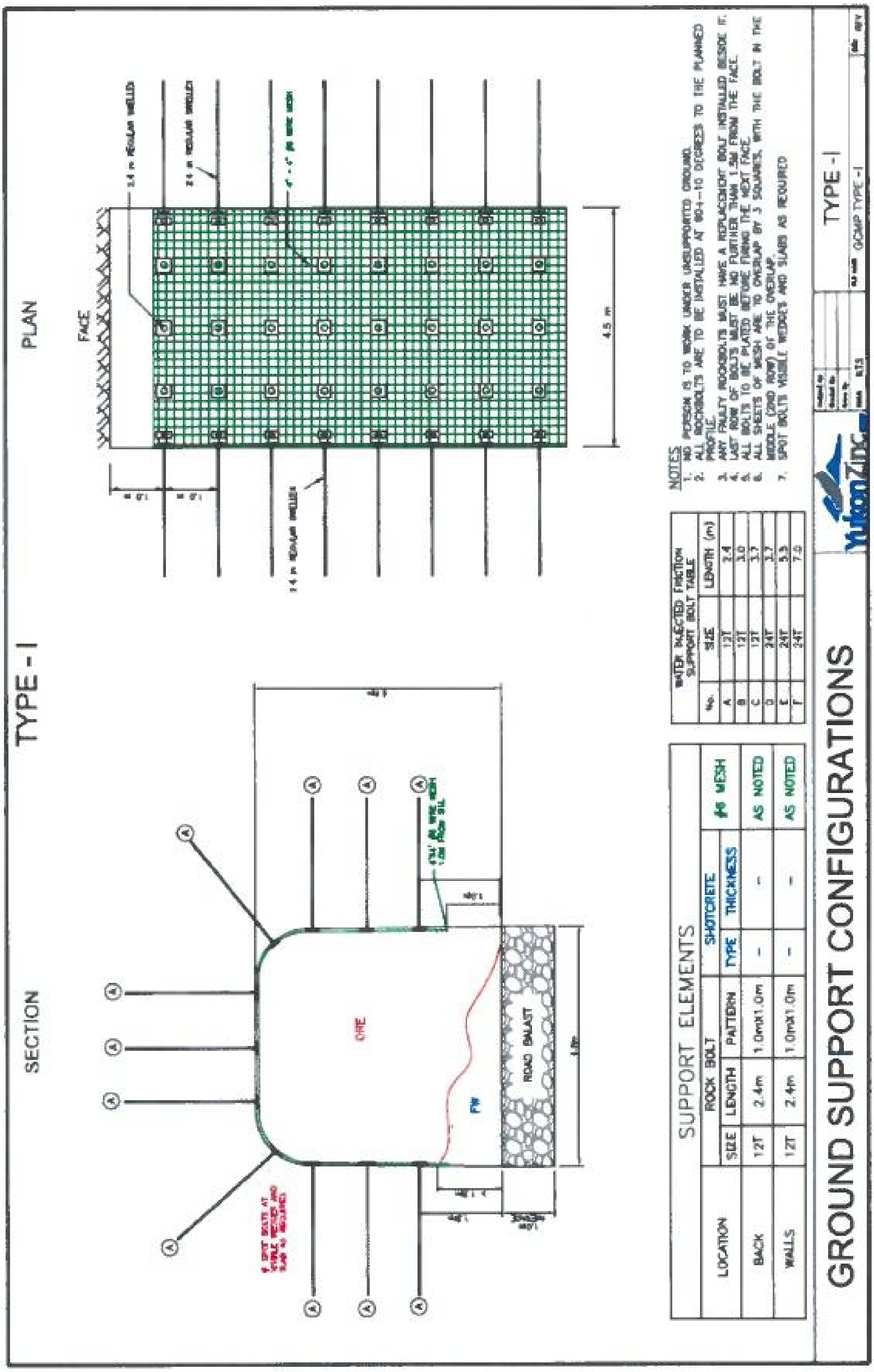
1. **Elimination** – Controlling the hazard at source
2. **Substitution** – Replacing one substance or activity with a less hazardous
3. **Engineering** – Installing guards on machinery
4. **Administration** – Policies and procedures for safe work practices
5. **Personal Protective Equipment** – Respirators, earplugs, etc.

YZC Ground Control Risk Assessment Form

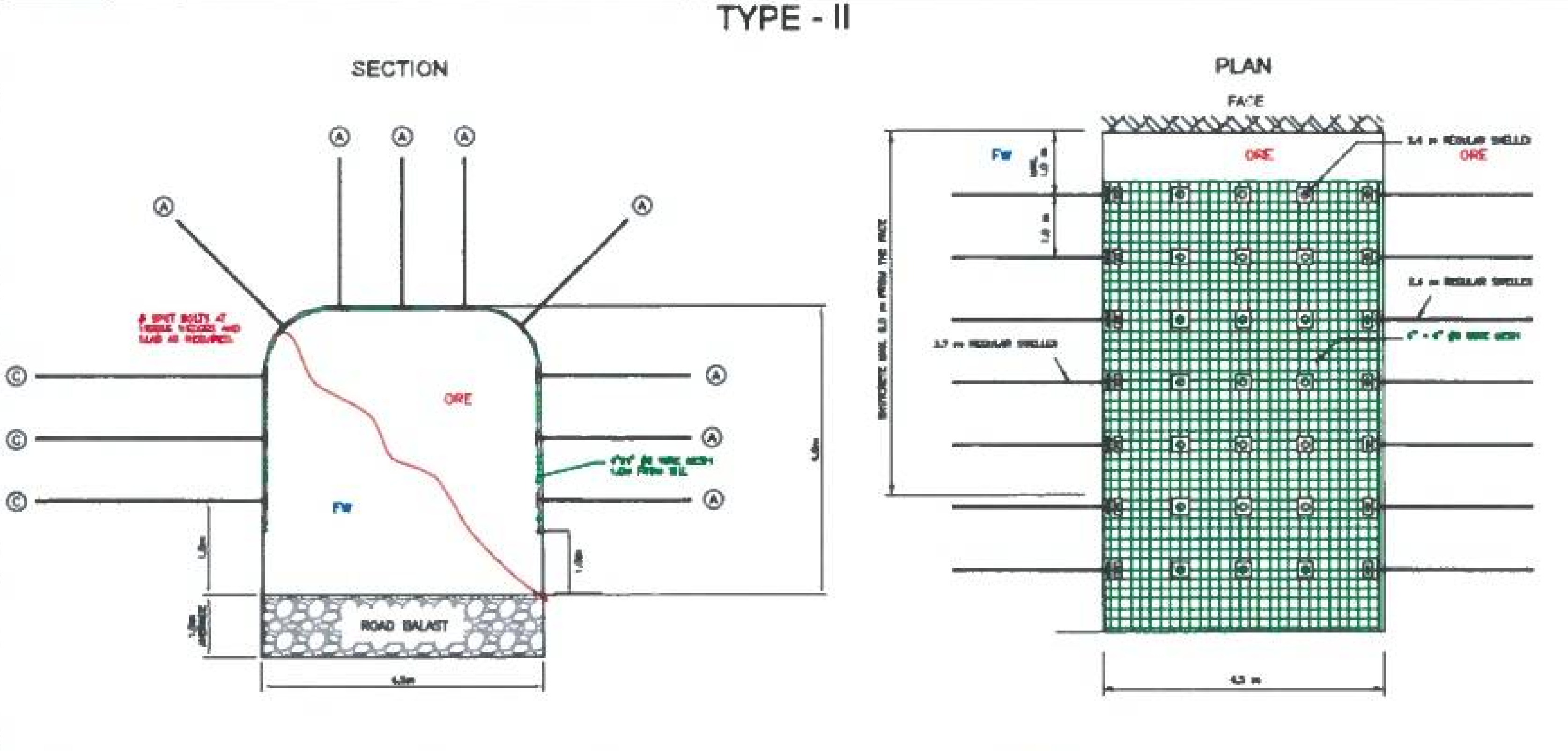
Area/Location/Activity		
Unwanted Events/Potential Loss		
Cause/s		
Impacts		
Inherent Risk	Type of Loss	
	Consequence	
	Exposure	
	Probability	
	Risk Ranking	
	Risk Level	
Controls		
Contingency		
Residual Risk	Type of Loss/Benefit	
	Consequence	
	Exposure	
	Probability	
	Risk Ranking	
	Risk Level	
Recommendations/Actions		
Who		
When		

APPENDIX – B.

SPECIFICATION OF SUPPORT TYPES


TYPE - I
SECTION
PLAN
FACE
ORE
FW
ROAD BALAST
4.5 m
2.4 m REGULAR SWELLEX
4" x 4" #6 WIRE MESH
SUPPORT ELEMENTS
LOCATION
ROCK BOLT
SIZE
LENGTH
PATTERN
SHOTCRETE
TYPE
THICKNESS
#6 MESH
BACK
12T
2.4m
1.0mX1.0m
AS NOTED
WALLS
12T
2.4m
1.0mX1.0m
AS NOTED
WATER INJECTED FRICTION SUPPORT BOLT TABLE
No.
SIZE
LENGTH (m)
A
12T
2.4
B
12T
3.0
C
12T
3.7
D
24T
3.7
E
24T
5.3
F
24T
7.0
NOTES
1. NO PERSON IS TO WORK UNDER UNSUPPORTED GROUND.
2. ALL ROCKBOLTS ARE TO BE INSTALLED AT 90+-10 DEGREES TO THE PLANNED PROFILE.
3. ANY FAULTY ROCKBOLTS MUST HAVE A REPLACEMENT BOLT INSTALLED BESIDE IT.
4. LAST ROW OF BOLTS MUST BE NO FURTHER THAN 1.5M FROM THE FACE.
5. ALL BOLTS TO BE PLATED BEFORE FIRING THE NEXT FACE.
6. ALL SHEETS OF MESH ARE TO OVERLAP BY 3 SQUARES, WITH THE BOLT IN THE MIDDLE (2ND ROW) OF THE OVERLAP.
7. SPOT BOLTS VISIBLE WEDGES AND SLABS AS REQUIRED
GROUND SUPPORT CONFIGURATIONS
YukonZinc
TYPE - I
GCMP TYPE - I

TYPE - II



SUPPORT ELEMENTS						
LOCATION	ROCK BOLT			SHOTCRETE		#8 MESH
	SIZE	LENGTH	PATTERN	TYPE	THICKNESS	
BACK & ORE SIDE WALL	12T	2.4m	1.0mX1.0m	–	–	AS NOTED
FW SIDE WALLS	12T	3.7m	1.0mX1.0m	–	–	AS NOTED

WATER INJECTED FRICTION SUPPORT BOLT TABLE

No.	SIZE	LENGTH (m)
A	12T	2.4
B	12T	3.0
C	12T	3.7
D	24T	3.7
E	24T	5.5
F	24T	7.0

NOTES

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7. SPOT BOLTS VISIBLE WEDGES AND SLABS AS REQUIRED

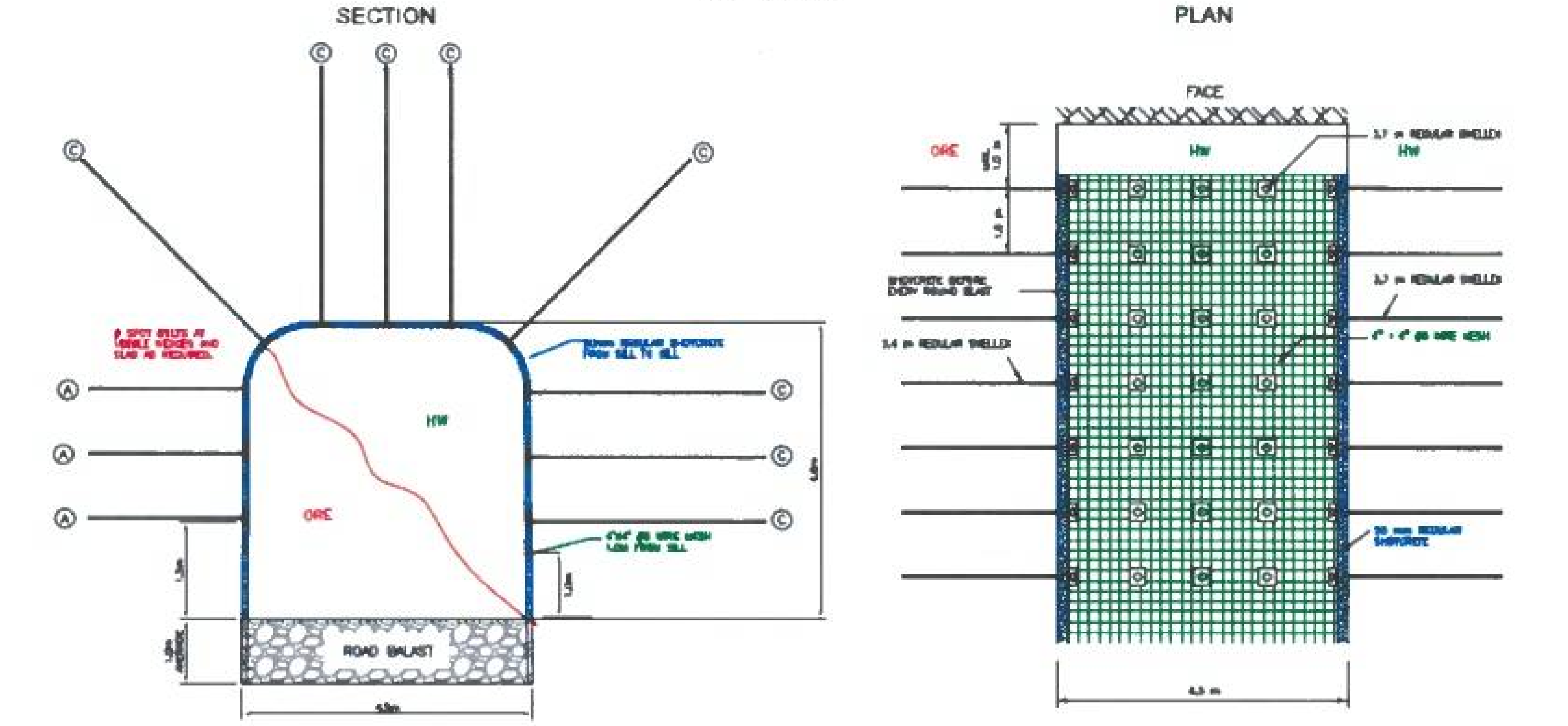
GROUND SUPPORT CONFIGURATIONS

YukonZinc

TYPE -II

GCMP TYPE - II

TYPE - III



LOCATION	ROCK BOLT SIZE	ROCK BOLT LENGTH	ROCK BOLT PATTERN	SHOTCRETE TYPE	SHOTCRETE THICKNESS	#6 MESH
BACK & ORE SIDE WALL	12T	2.4m	1.0mX1.0m	REG.	50mm	AS NOTED
FW SIDE WALLS	12T	3.7m	1.0mX1.0m	REG.	50mm	AS NOTED

SUPPORT ELEMENTS

WATER INJECTED FRICTION SUPPORT BOLT TABLE

No.	SIZE	LENGTH (m)
A	12T	2.4
B	12T	3.0
C	12T	3.7
D	24T	3.7
E	24T	5.5
F	24T	7.0

NOTES

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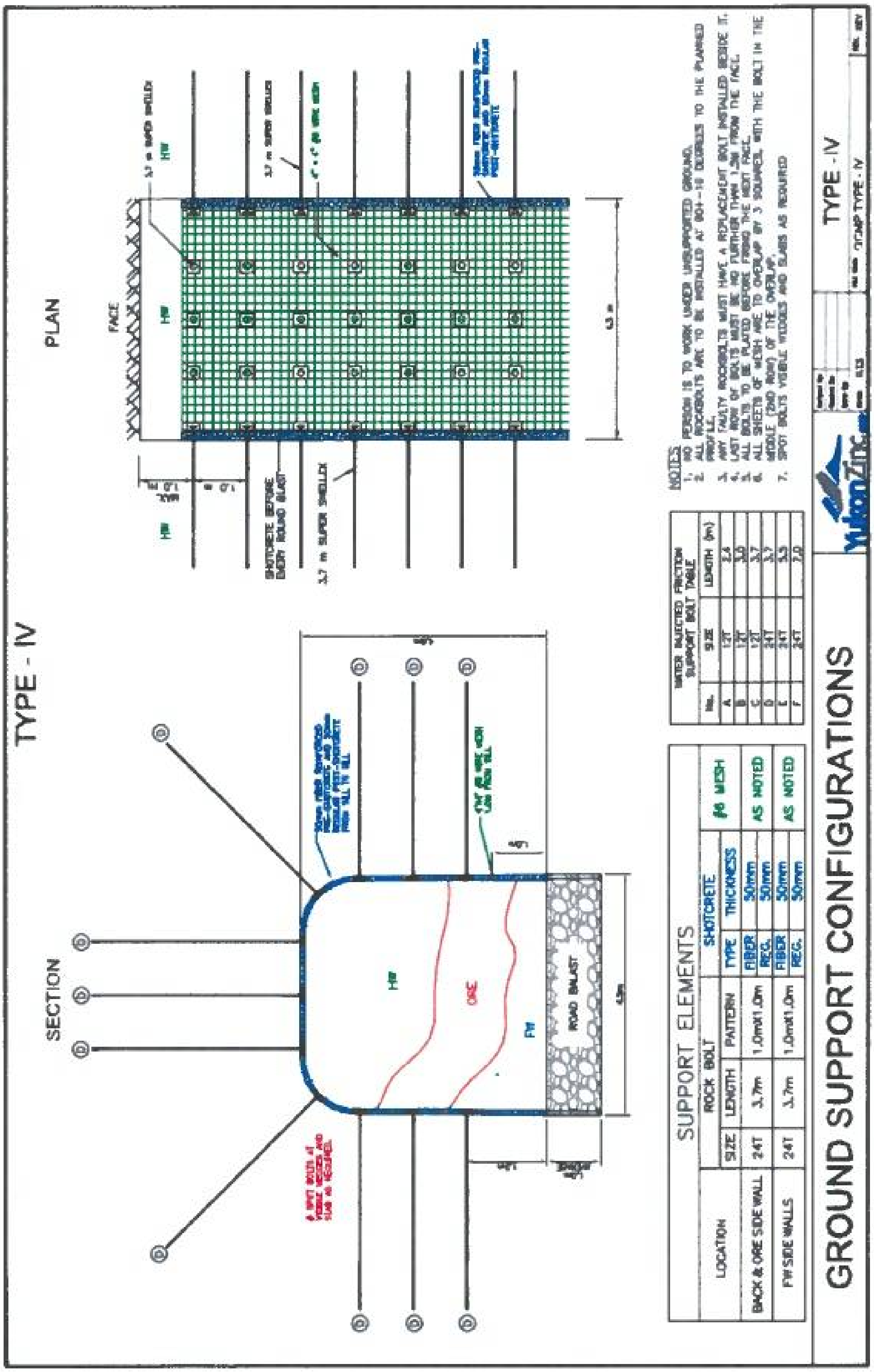
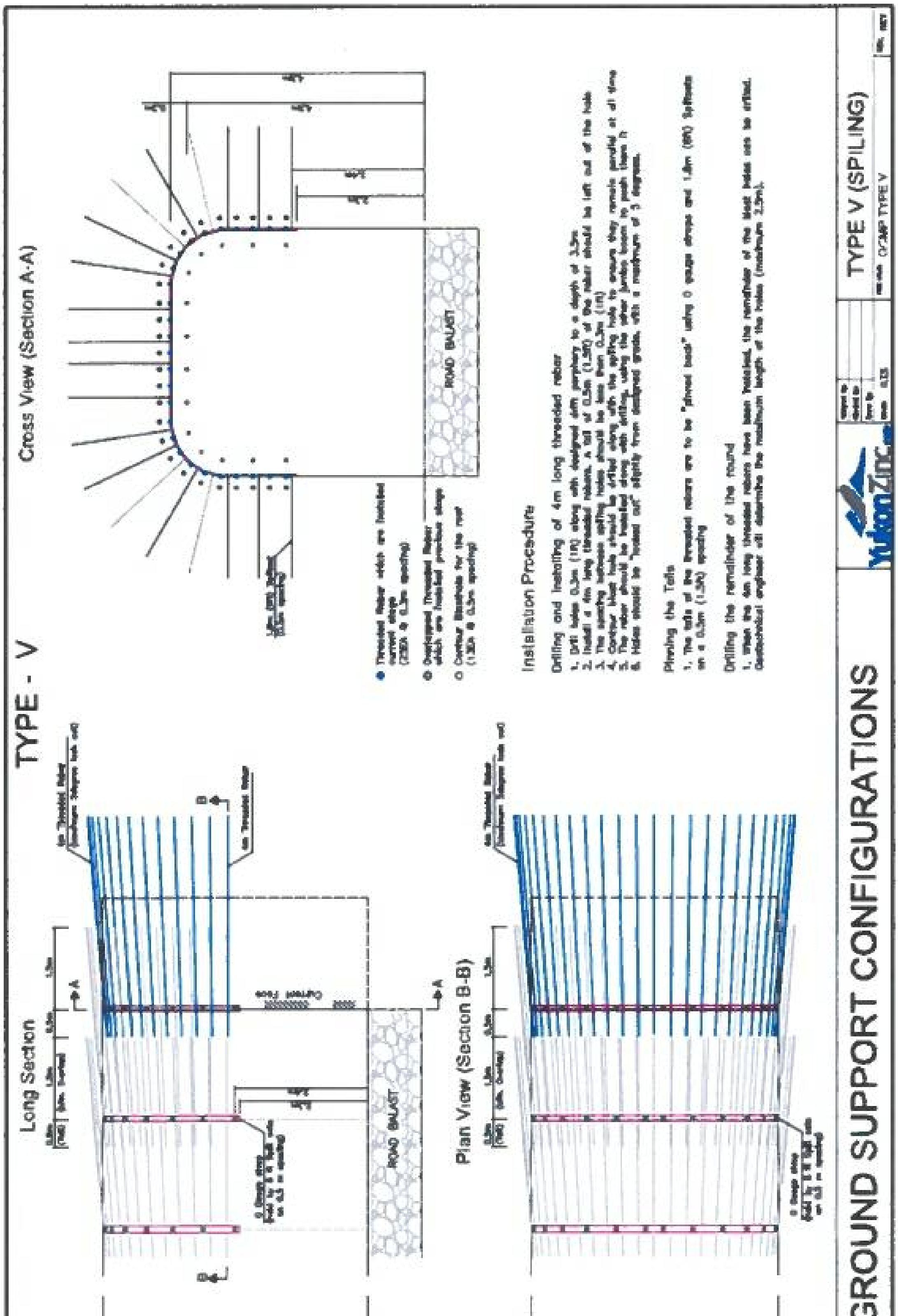
6. ALL SHEETS OF MESH ARE TO OVERLAP BY 3 SQUARES, WITH THE BOLT IN THE MIDDLE (2ND ROW) OF THE OVERLAP.
7. SPOT BOLTS VISIBLE WEDGES AND SLABS AS REQUIRED

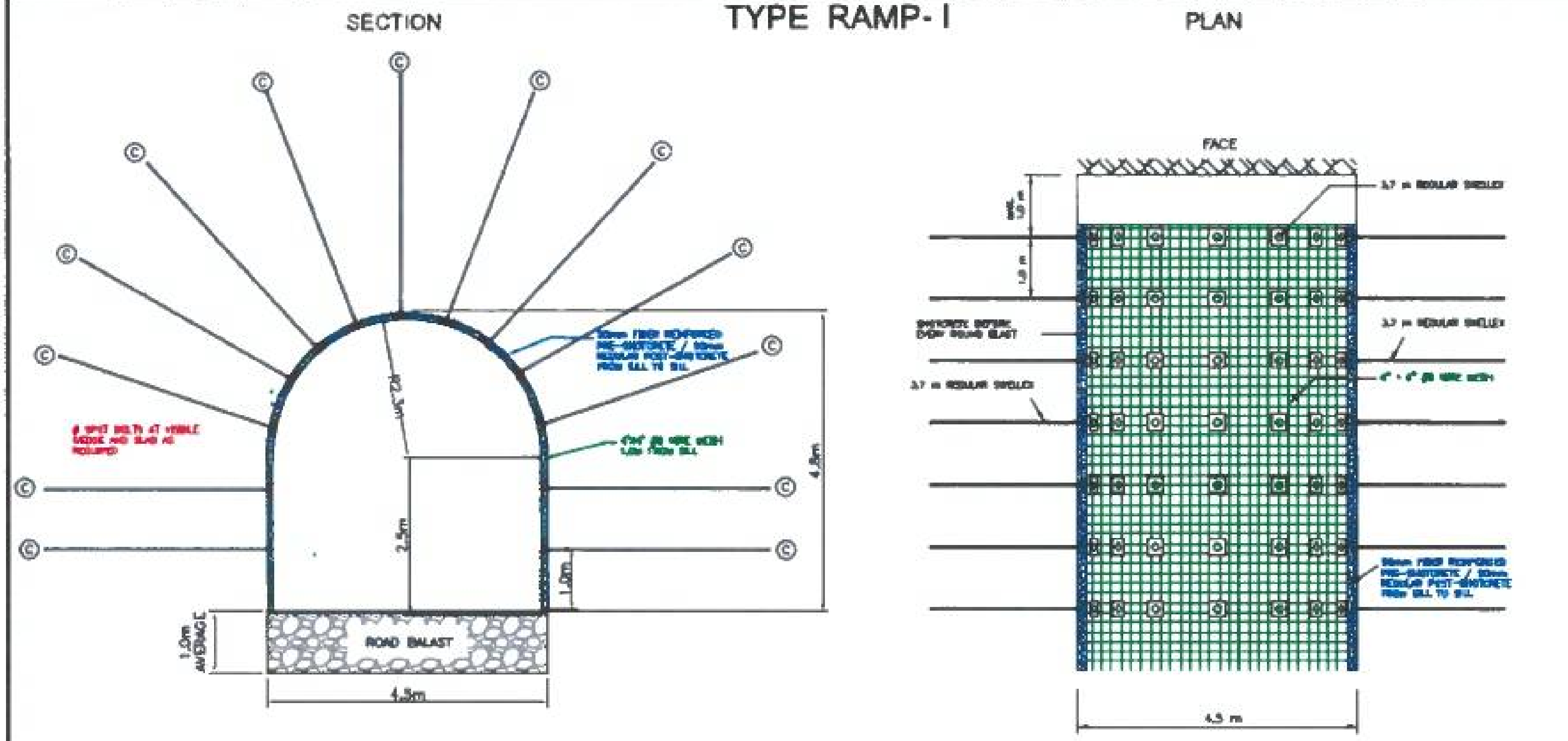
GROUND SUPPORT CONFIGURATIONS

YukonZinc corp — TYPE -III


TYPE - IV
SECTION
PLAN
FACE
HW
ORE
FW
ROAD BALLAST
NOTES
SUPPORT ELEMENTS
LOCATION
ROCK BOLT
SIZE
LENGTH
PATTERN
SHOTCRETE
TYPE
THICKNESS
#6 MESH
BACK & ORE SIDE WALL
24T
3.7m
1.0mX1.0m
FIBER
REG.
50mm
AS NOTED
FW SIDE WALLS
WATER INJECTED FRICTION SUPPORT BOLT TABLE
GROUND SUPPORT CONFIGURATIONS
TYPE - IV


TYPE - V
Long Section
Plan View (Section B-B)
Cross View (Section A-A)
ROAD BALLAST
Installation Procedure
GROUND SUPPORT CONFIGURATIONS
TYPE V (SPILING)

TYPE RAMP-I



SUPPORT ELEMENTS						
LOCATION	ROCK BOLT			SHOTCRETE		#6 MESH
	SIZE	LENGTH	PATTERN	TYPE	THICKNESS	
BACK	24T	3.6m	1.0mX1.0m	FIBER / REG	5.0cm(PRE) / 5.0cm(POST)	AS NOTED
WALLS	24T	3.6m	1.0mX1.0m	FIBER / REG	5.0cm(PRE) / 5.0cm(POST)	AS NOTED

WATER INJECTED FRICTION SUPPORT BOLT TABLE		
No.	SIZE	LENGTH (m)
A	12T	2.4
B	12T	3.0
C	12T	3.7
D	24T	3.7
E	24T	3.5
F	24T	7.0

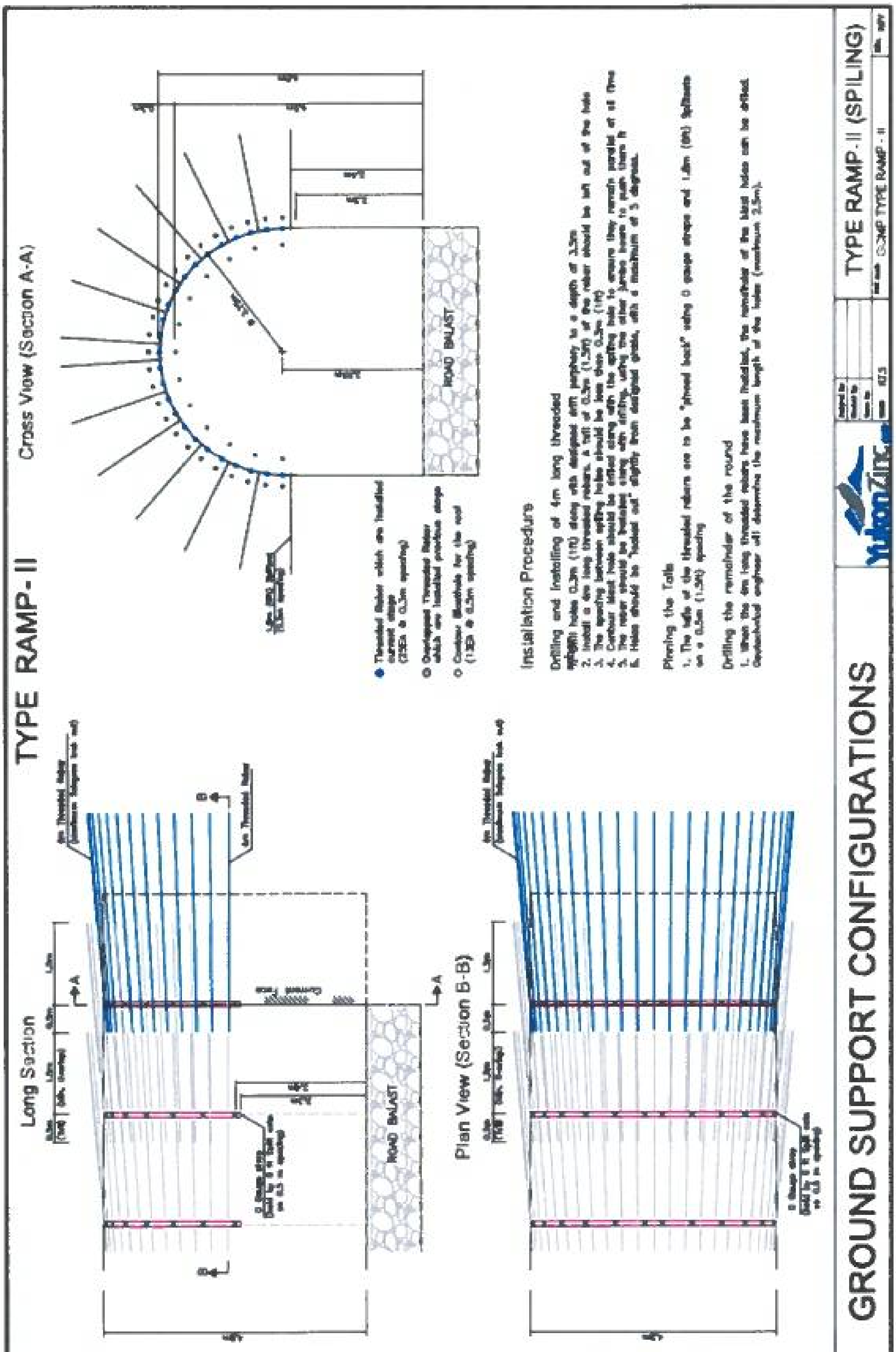
NOTES
1. NO PERSON IS TO WORK UNDER UNSUPPORTED GROUND.
2. ALL ROCKBOLTS ARE TO BE INSTALLED AT 90+-10 DEGREES TO THE PLANNED PROFILE.
3. ANY FAULTY ROCKBOLTS MUST HAVE A REPLACEMENT BOLT INSTALLED BESIDE IT.
4. LAST ROW OF BOLTS MUST BE NO FURTHER THAN 1.5M FROM THE FACE.
5. ALL BOLTS TO BE PLATED BEFORE FIRING THE NEXT FACE.
6. ALL SHEETS OF MESH ARE TO OVERLAP BY 3 SQUARES, WITH THE BOLT IN THE MIDDLE (2ND ROW) OF THE OVERLAP.
7. SPOT BOLTS VISIBLE WEDGES AND SLABS AS REQUIRED

GROUND SUPPORT CONFIGURATIONS

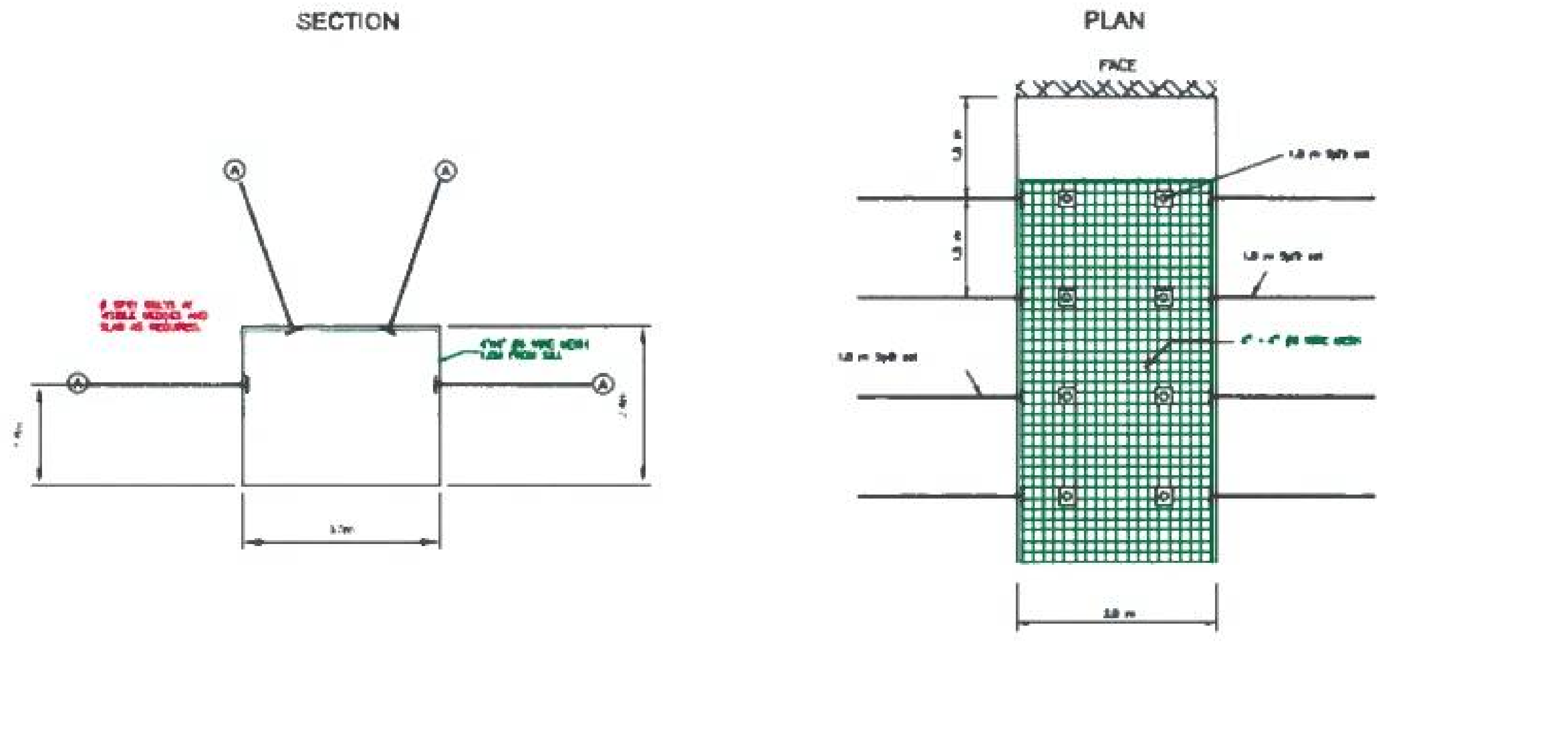
YukonZinc corp

TYPE RAMP-I

GCMP TYPE RAMP - I


TYPE RAMP-II
Long Section
Plan View (Section B-B)
Cross View (Section A-A)
ROAD BALAST
Installation Procedure
Drilling and Installing of 4m long threaded
Pinning the Tails
Drilling the remainder of the round
GROUND SUPPORT CONFIGURATIONS
TYPE RAMP-II (SPILING)

TYPE RAISE-I



SUPPORT ELEMENTS						
LOCATION	ROCK BOLT			SHOTCRETE		#6 MESH
	SIZE	LENGTH	PATTERN	TYPE	THICKNESS	
BACK	Split	1.8m	1.5mX1.5m	-	-	AS NOTED
WALLS	Split	1.8m	1.5mX1.5m	-	-	AS NOTED

WATER INJECTED FRICTION SUPPORT BOLT TABLE		
No.	SIZE	LENGTH (m)
A	Split Set	1.8
B	12T	2.4
C	12T	3.0
D	12T	3.7
E	24T	3.7
F	24T	3.5

NOTES
1. NO PERSON IS TO WORK UNDER UNSUPPORTED GROUND.
2. ALL ROCKBOLTS ARE TO BE INSTALLED AT 90+-10 DEGREES TO THE PLANNED PROFILE.
3. ANY FAULTY ROCKBOLTS MUST HAVE A REPLACEMENT BOLT INSTALLED BESIDE IT.
4. LAST ROW OF BOLTS MUST BE NO FURTHER THAN 1.5M FROM THE FACE.
5. ALL BOLTS TO BE PLATED BEFORE FIRING THE NEXT FACE.
6. ALL SHEETS OF MESH ARE TO OVERLAP BY 3 SQUARES, WITH THE BOLT IN THE MIDDLE (2ND ROW) OF THE OVERLAP.
7. SPOT BOLTS VISIBLE WEDGES AND SLABS AS REQUIRED

GROUND SUPPORT CONFIGURATIONS

YukonZinc

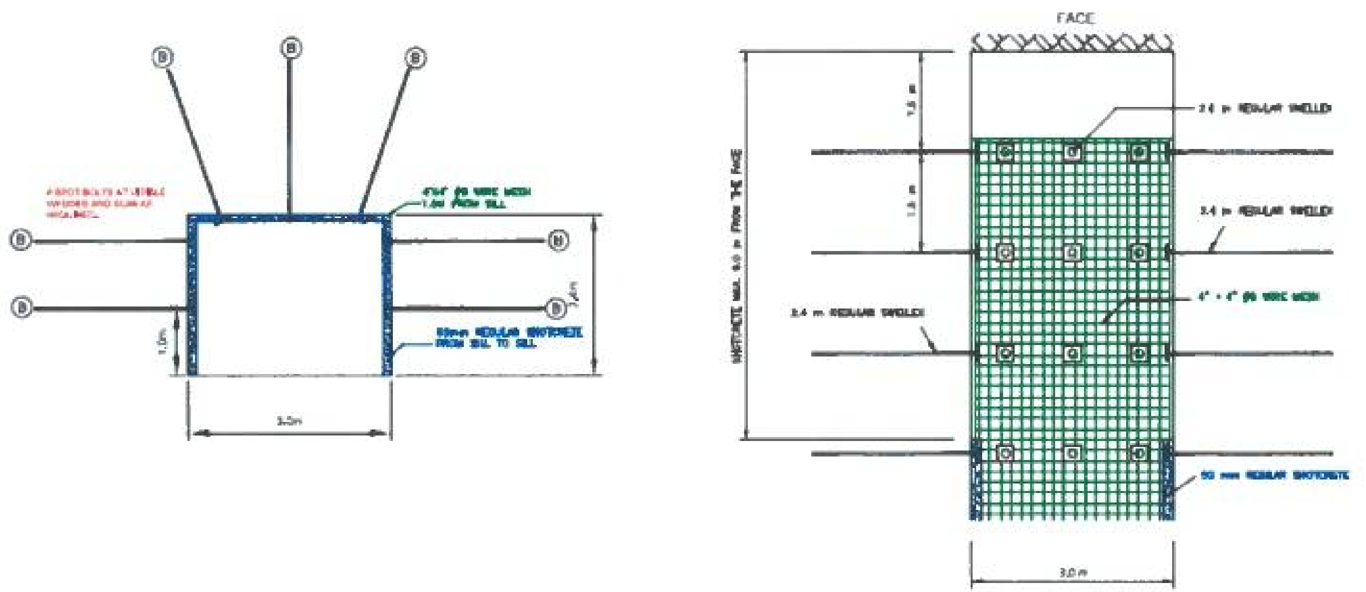
TYPE RAISE-I

GCMP TYPE RAISE - I

TYPE RAISE- II

SECTION

PLAN



SUPPORT ELEMENTS						
LOCATION	ROCK BOLT			SHOTCRETE		#6 MESH
	SIZE	LENGTH	PATTERN	TYPE	THICKNESS	
BACK	Split	1.8m	1.5mX1.5m	REG.	5.0cm	AS NOTED
WALLS	Split	1.8m	1.5mX1.5m	REG.	5.0cm	AS NOTED

WATER INJECTED FRICTION SUPPORT BOLT TABLE

No.	SIZE	LENGTH (m)
A	Split Set	1.8
B	12T	2.4
C	12T	3.0
D	12T	3.7
E	24T	3.7
F	24T	5.5

NOTES

1. NO PERSON IS TO WORK UNDER UNSUPPORTED GROUND.
2. ALL ROCKBOLTS ARE TO BE INSTALLED AT 90+-10 DEGREES TO THE PLANNED PROFILE.
3. ANY FAULTY ROCKBOLTS MUST HAVE A REPLACEMENT BOLT INSTALLED BESIDE IT.
4. LAST ROW OF BOLTS MUST BE NO FURTHER THAN 1.5M FROM THE FACE.
5. ALL BOLTS TO BE PLATED BEFORE FIRING THE NEXT FACE.
6. ALL SHEETS OF MESH ARE TO OVERLAP BY 3 SQUARES, WITH THE BOLT IN THE MIDDLE (2ND ROW) OF THE OVERLAP.
7. SPOT BOLTS VISIBLE WEDGES AND SLABS AS REQUIRED

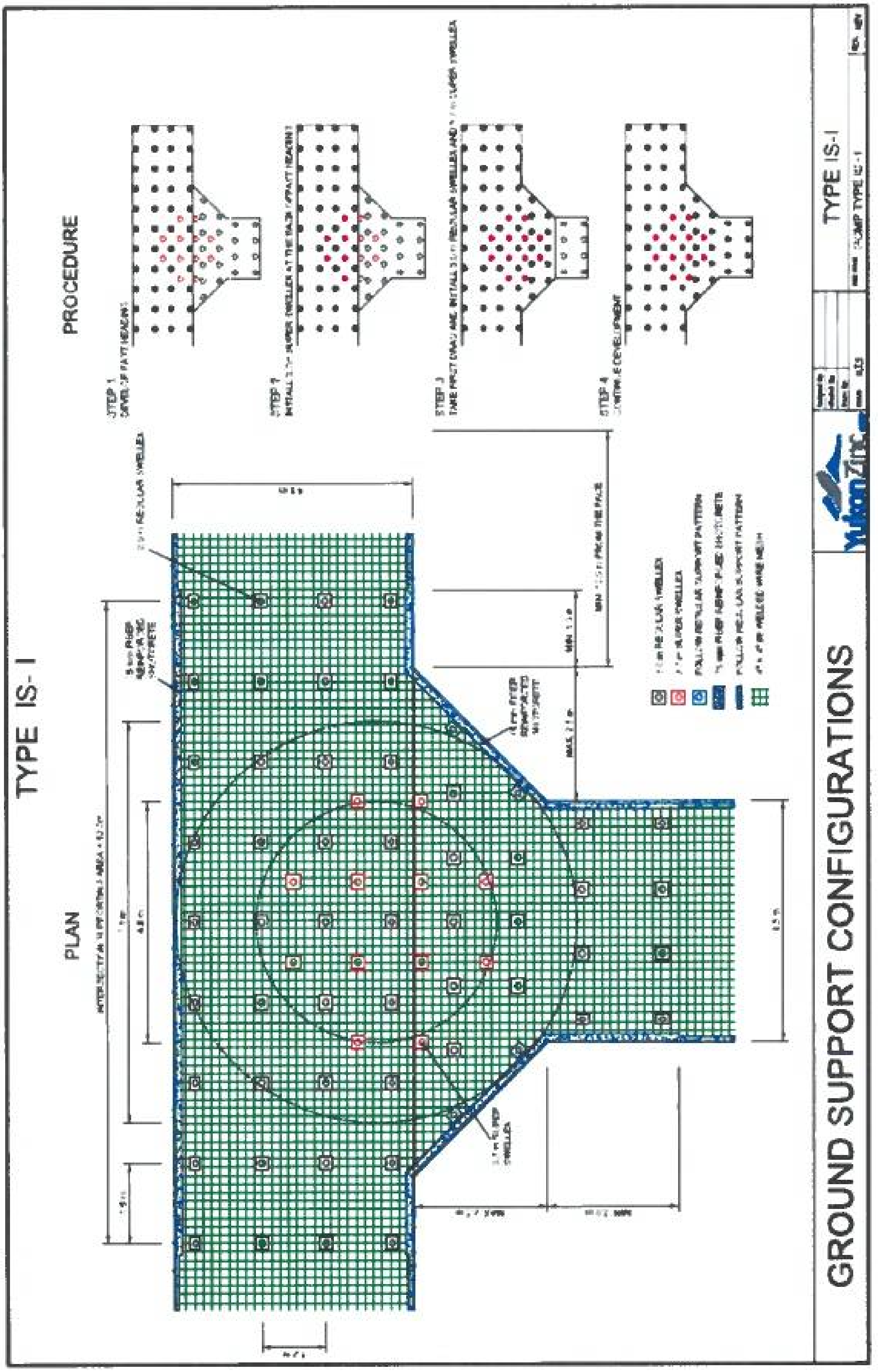
GROUND SUPPORT CONFIGURATIONS

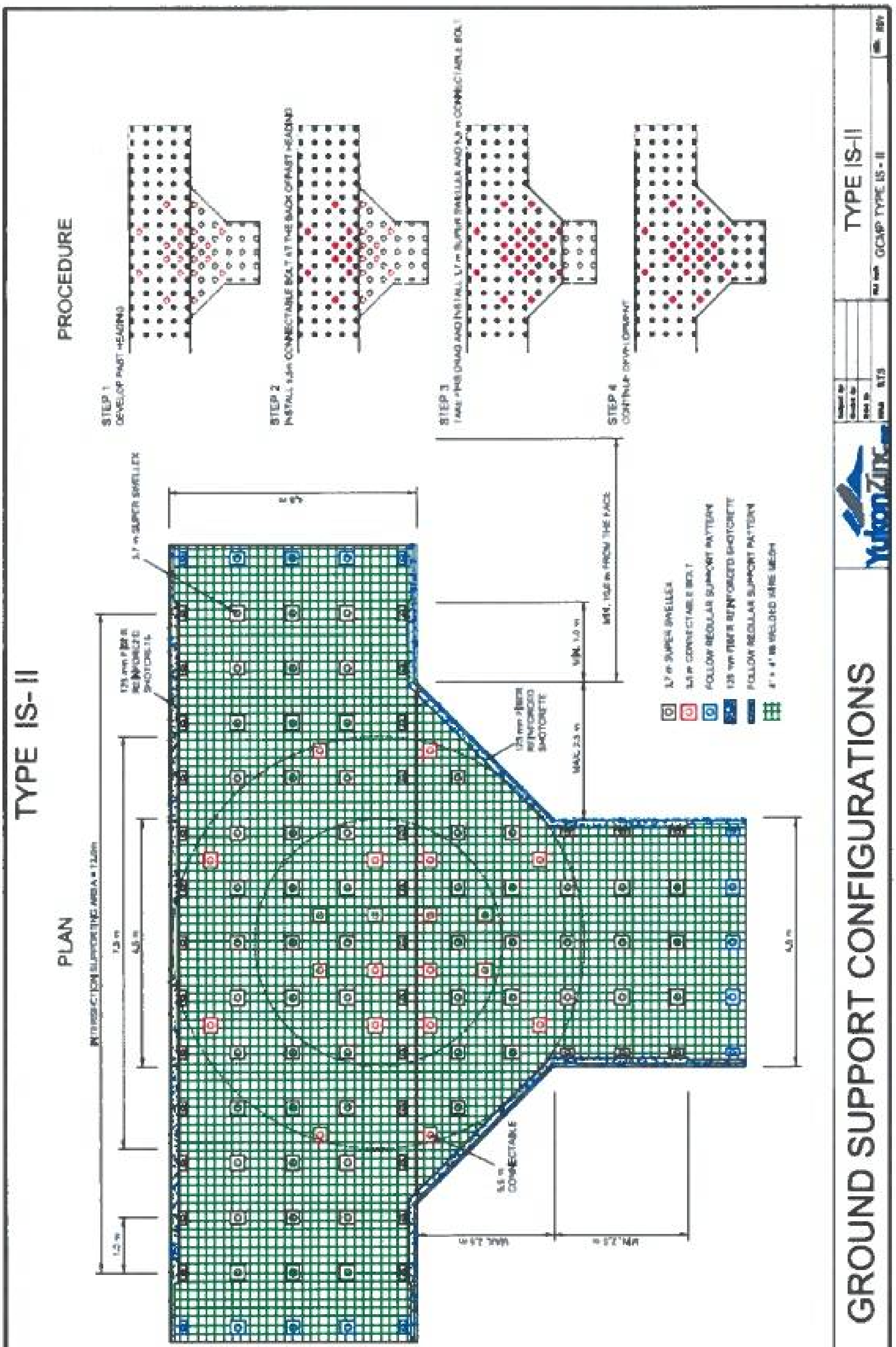
YukonZinc CORP

Scale: N.T.S

TYPE RAISE-II

GCMP TYPE RAISE - II


TYPE IS- I
PLAN
PROCEDURE
GROUND SUPPORT CONFIGURATIONS
TYPE IS-I


TYPE IS-II
PLAN
PROCEDURE
GROUND SUPPORT CONFIGURATIONS
TYPE IS-II

APPENDIX – C.

TRIGGER ACTION RESPONSE PLAN

TARP Guideline for main SA and Stope

Section	Ground Condition				Support Type	Support Element							Comments
	Drilling Condition	Ore body Condition	Contact Orientation (from vertical)	FW/HW Condition		Rock Bolt (friction bolt)			Wire Mesh	Shotcrete		Extra Support	
						Type	Length (m/ft)	Pattern (m×m)		Type	Thick (cm/ft)		
SA Stope Ore Drive (4.5m W × 4.6m H)	Fair	Drive pass through ore ground – ground condition is better than interlocked, partly disturbed rock mass with multi faced angular block (GSI >40)			Type - I	Regular	2.4(8)	1×1	#6	-	-	Spot Bolt	12' Regular spot bolt as required
	Fair/Poor	Massive, discontinuous, Roughand irregular joints (GSI > 40)	60°>Dip> 30°	FW contact height in FW side wall lower than 1.5m	Type - I	Regular	2.4(8)	1×1	#6	-	-	Spot Bolt	12' Regular spot bolt as required
				FW contact height in FW side wall higher than 1.5m	Type - II	Regular Regular	2.4(8) 3.7(12)	1×1 1×1	#6	-	-	Shotcrete if required	12' RB for FW side wall, 8' RB for ore side wall and back
			Dip < 30°	FW contact height in FW side wall lower than 1.5m	Type - I	Regular	2.4(8)	1×1	#6	-	-	Spot Bolt	12' Regular spot bolt as required
				FW contact height in FW side wall higher than 1.5m	Type - II	Regular Regular	2.4(8) 3.7(12)	1×1 1×1	#6	-	-	Shotcrete if required	12' RB for FW side wall, 8' RB for ore side wall and back
			60° > Dip	FW contact height in FW side wall lower than 3.5m	Type - I	Regular	2.4(8)	1×1	#6	-	-	Spot Bolt	12' Regular spot bolt as required
				FW contact height in FW side wall lower than 3.5m	Type - II	Regular Regular	2.4(8) 3.7(12)	1×1 1×1	#6	-	-	Shotcrete if required	12' RB for FW side wall, 8' RB for ore side wall and back
	Poor/Fair	Massive, discontinuous, Rough and irregular joints (GSI > 40)	60°>Dip> 30°	HW contact in the back	Type - III	Regular Regular	3.7(12) 2.4(8)	1×1 1×1	#6	Regular	5.0(2)		12' RB for HW side wall and back, 8' RB for ore side wall
				HW contact in the Ore side wall	Type - IV	Regular	3.7(12)	1×1	#6	Fiber	5.0(2)	Post SC if required	2" fiber SC before RB 2" regular SC after RB as required
			Dip < 30°	HW contact in the back further than 1m from the Ore side wall	Type - IV	Regular	3.7(12)	1×1	#6	Fiber	5.0(2)	Post SC if required	2" fiber SC before RB 2" regular SC after RB as required
				HW contact in the back closer than 1m from the Ore side wall	Type - IV	Regular	3.7(12)	1×1	#6	Regular Fiber	5.0(2) 5.0(2)	Spilling	2" fiber Pre-SC 2" regular Post-SC
			60° > Dip	HW contact in HW side wall closer than 1m from the back	Type - III	Regular Regular	3.7(12) 2.4(8)	1×1 1×1	#6	Regular	5.0(2)		12' RB for HW side wall and back, 8' RB for ore side wall
				HW contact in ore side wall further than 1m from the back	Type - IV	Regular	3.7(12)	1×1	#6	Fiber	5.0(2)	Post SC if required	2" fiber SC before RB 2" regular SC after RB as required
	Very Poor	Drive pass through FW/HW ground – folded and/or faulted with angular blocks formed by four or more discontinuities. Soft clay or slikenside joints (GSI<40)			Type - V	Regular	3.7(12)	1×1	#6	Regular Fiber	5.0(2) 5.0(2)	Spilling	2" fiber Pre-SC 2" regular Post-SC

TARP Guideline for Small Stope, Main Ramp, Raise, and Intersection

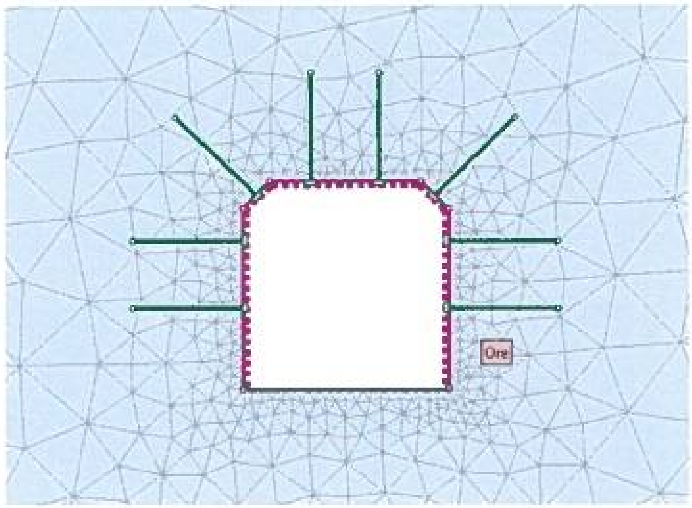
Section	Ground Condition				Support Type	Support Element							Comments
	Drilling Condition	Ore body Condition	Contact Orientation (from vertical)	FW/HW Condition		Rock Bolt (friction bolt) Type	Length (m/ft)	Pattern (m×m)	Wire Mesh	Shotcrete Type	Thick (cm/ft)	Extra Support	
Main Ramp (4.5m W × 4.8m H)	Fair	Drive pass through ore ground – ground condition is better than interlocked, partly disturbed rock mass with multi faced angular block (GSI >40)			Ramp-I	Super	3.7(12)	1×1	#6	Fiber	10(4)	Spot Bolt	18' connectable spot bolt as required
	Poor	Drive pass through at least one side of FW/HW contact ground – folded and/or faulted with angular blocks formed by four or more discontinuities. Soft clay or slikenside joints (GSI<40)			Ramp-I	Super	3.7(12)	1×1	#6	Fiber	10(4)	Spot Bolt	18' connectable spot bolt as required
	Extremely Poor	Drive pass through all extremely poor ground - Thinly laminated or foliated and tectonically sheared weak rock. Closely spaced shistosity prevails over other discontinuity set, resulting in complete lack of blockiness			Ramp-II	Super	3.7(12)	1×1	#6	Fiber	10(4)	Spiling	18' connectable spot bolt as required
Raise (3.0m W × 3.5m H)	Fair	Drive pass through ore ground – ground condition is better than interlocked, partly disturbed rock mass with multi faced angular block (GSI >40)			Raise-I	Regular	2.4(8)	1.5×1.5	#6	Regular	As required	Spot Bolt	8' regular spot bolt as required
	Poor	Drive pass through at least one side of FW/HW contact ground – folded and/or faulted with angular blocks formed by four or more discontinuities. Soft clay or slikenside joints (GSI<40)			Raise-II	Regular	3.0(10)	1.2×1.5	#6	Fiber	7.5(3)	Spot bolt	12' regular spot bolt as required
Intersection	Fair	Drive pass through ore ground – ground condition is better than interlocked, partly disturbed rock mass with multi faced angular block (GSI >40)			IS-I	Regular Super	3.0(10) 3.7(12)	1.5×1.5 1.5×1.5	#6	Fiber	7.5(3)	Spot bolt	18' connectable spot bolt as required
	Poor	Drive pass through at least one side of FW/HW contact ground – folded and/or faulted with angular blocks formed by four or more discontinuities. Soft clay or slikenside joints (GSI<40)			IS-II	Super Connect.	3.7(12) 5.5(18)	1×1 1×1	#6	Fiber	12.5(5)	Spot bolt	18' connectable spot bolt as required

APPENDIX – D.

NUMERICAL CALCULATION

SA, Stope and Ore Drives

- Drives pass through Ore ground
- Drives with 75° dip contact between FW and Ore
- Drives with 60° dip contact between FW and Ore
- Drives with 45° dip contact between FW and Ore
- Drives with 30° dip contact between FW and Ore
- Drives with 15° dip contact between FW and Ore
- Drives with 75° dip contact between HW and Ore
- Drives with 60° dip contact between HW and Ore
- Drives with 45° dip contact between HW and Ore
- Drives with 30° dip contact between HW and Ore
- Drives with 15° dip contact between HW and Ore
- Drives pass through FW/HW ground



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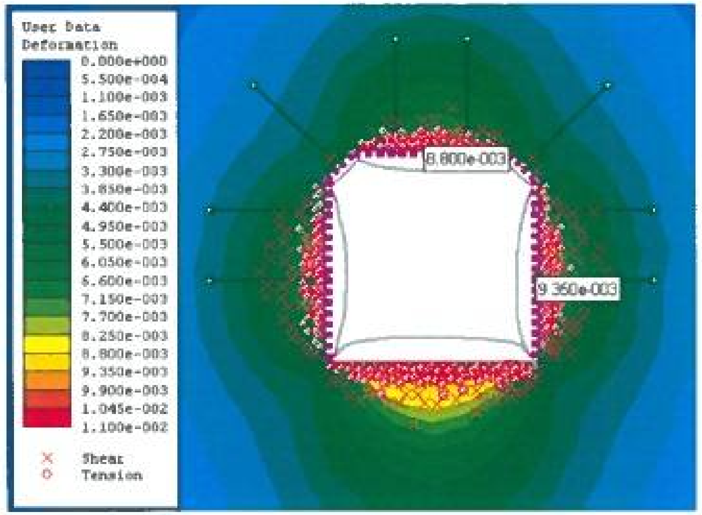
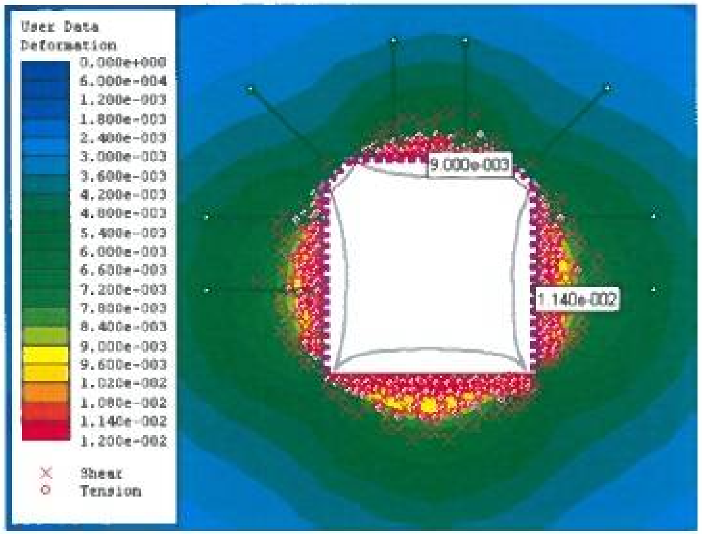
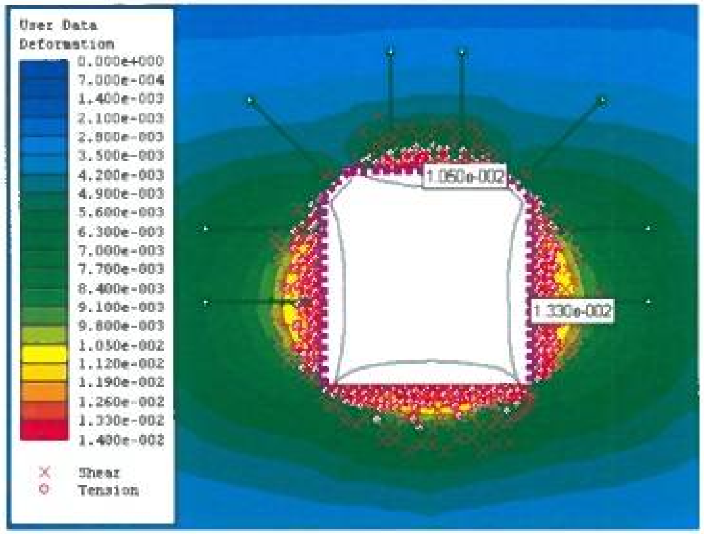


(b) Deformation & Yielded zone (K=0.8)

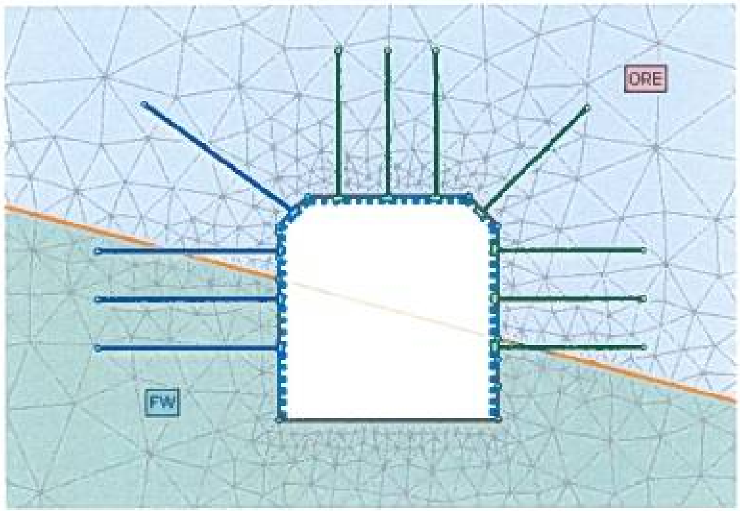


(c) Deformation & Yielded zone (K=1.0)



(d) Deformation & Yielded zone (K=1.2)

Drives pass through Ore ground



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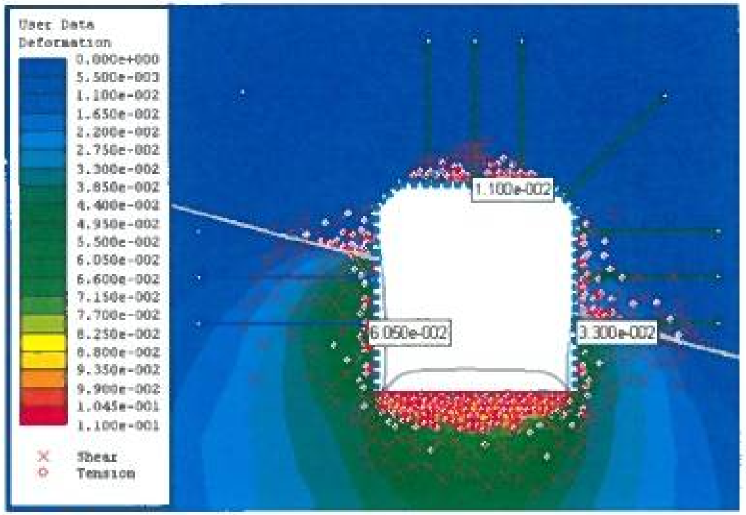

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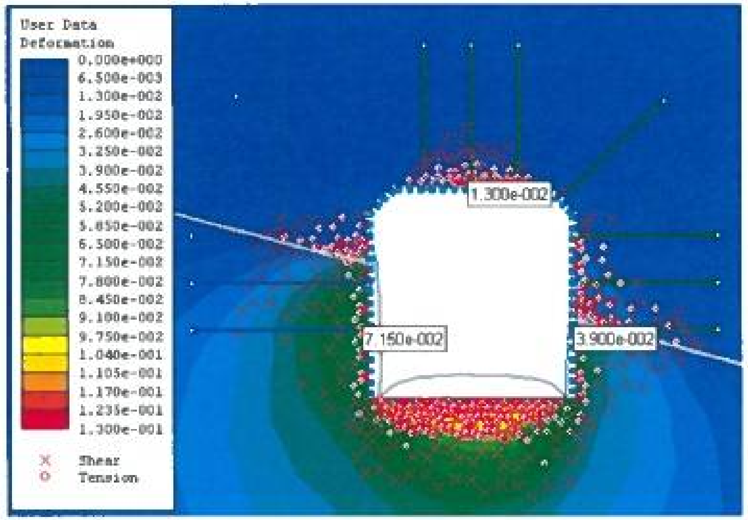

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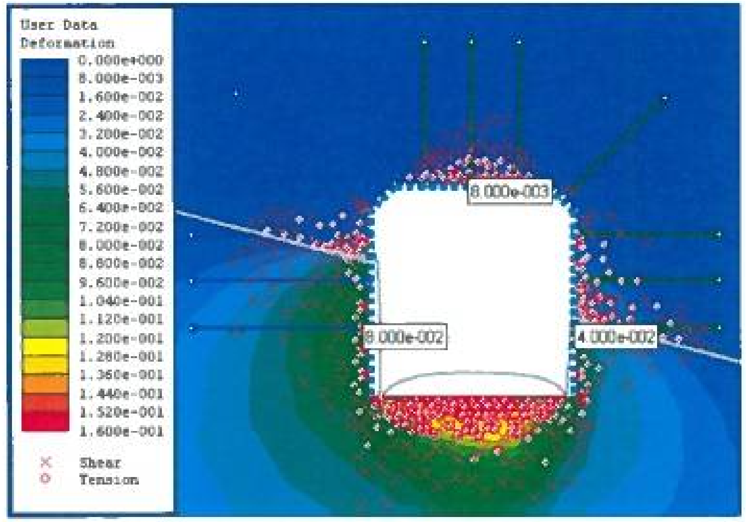
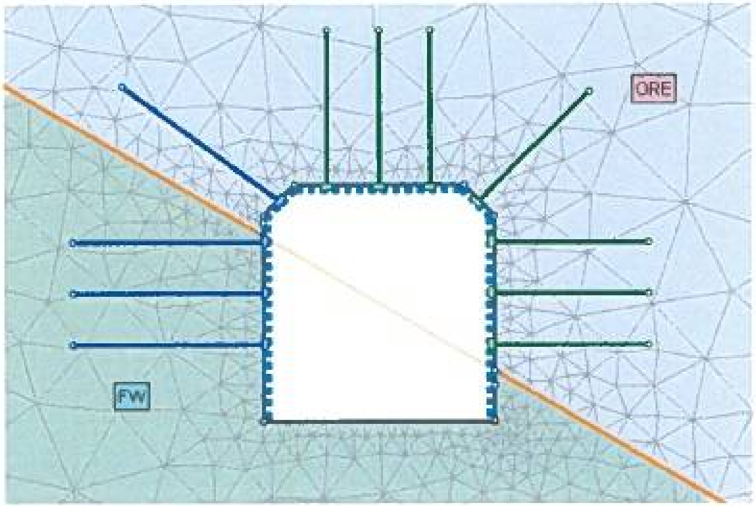


(d) Deformation & Yielded zone (K=1.2)

Drives with 75° dip contact between FW and Ore



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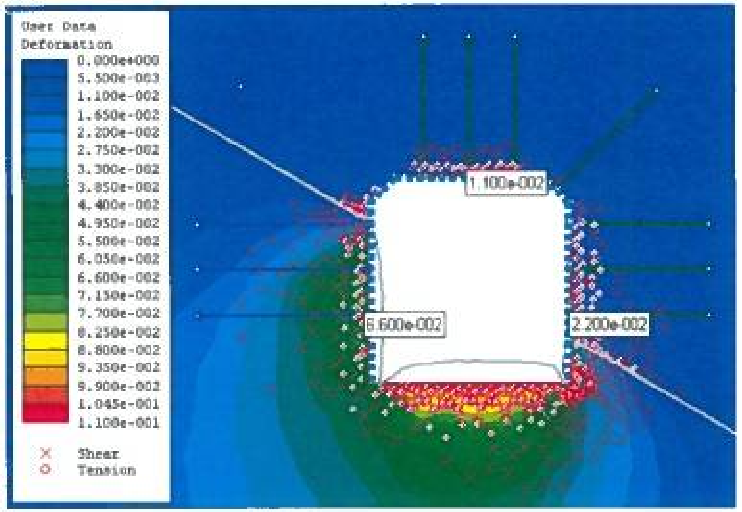

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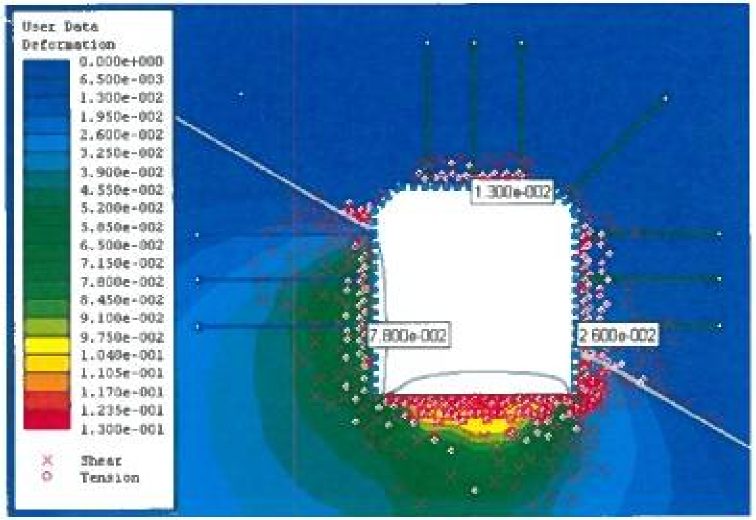

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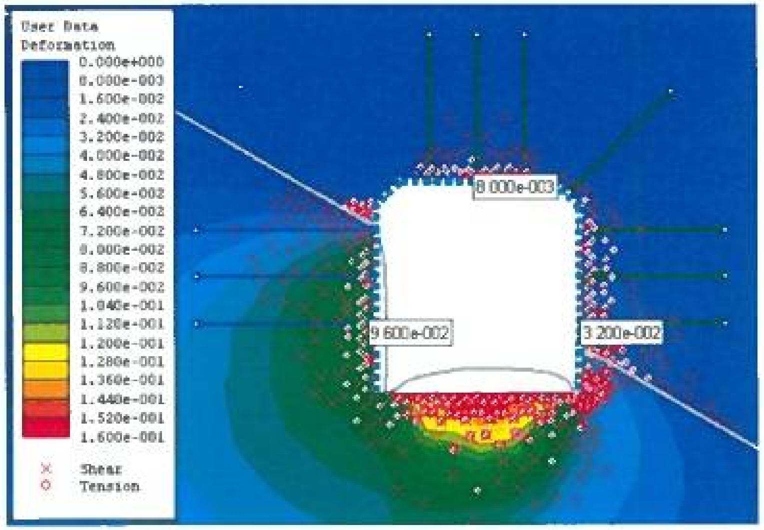
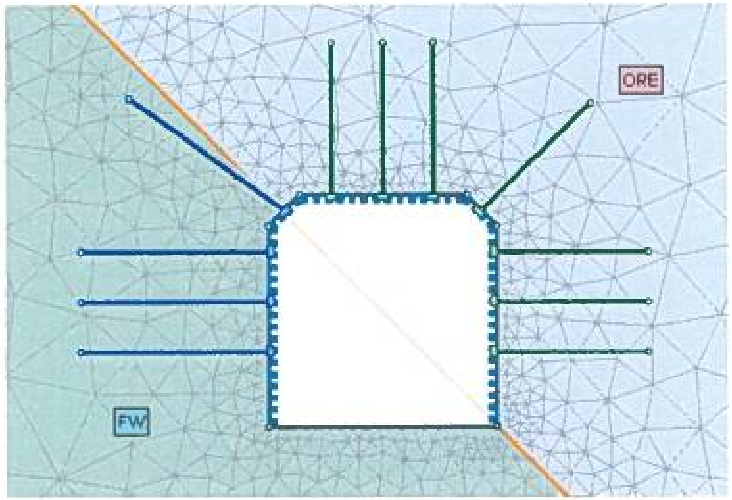


(d) Deformation & Yielded zone (K=1.2)

Drives with 60° dip contact between FW and Ore



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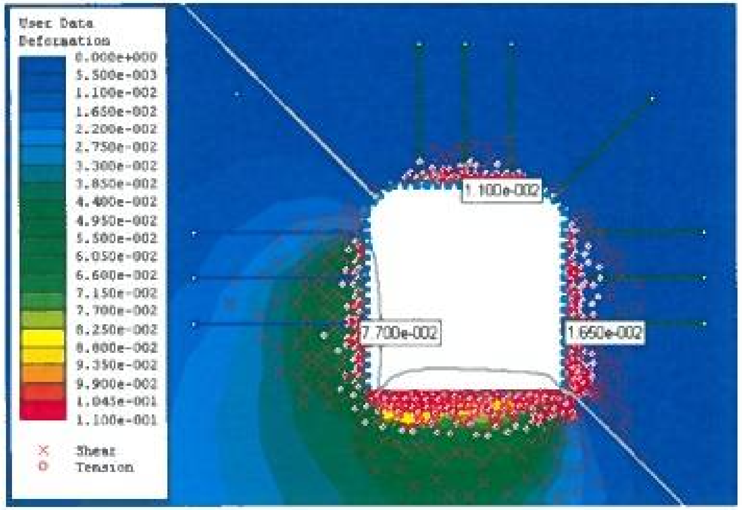

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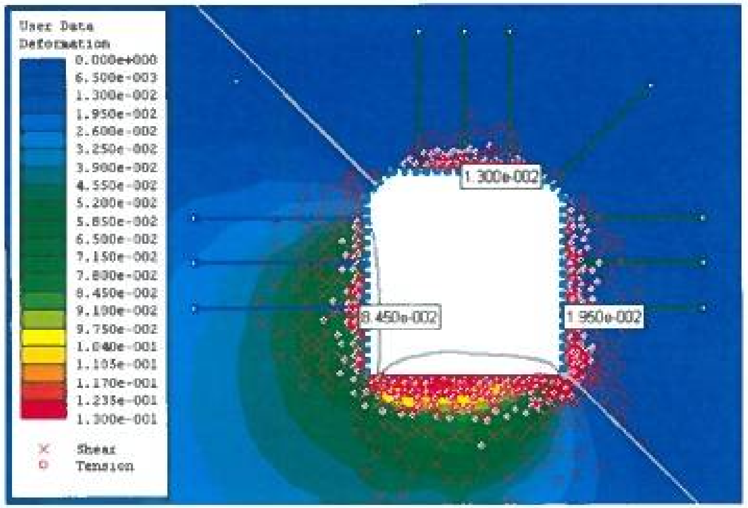

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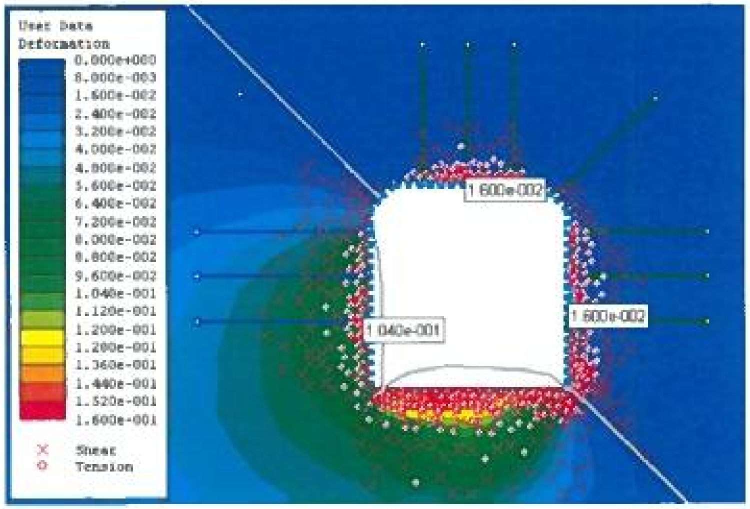
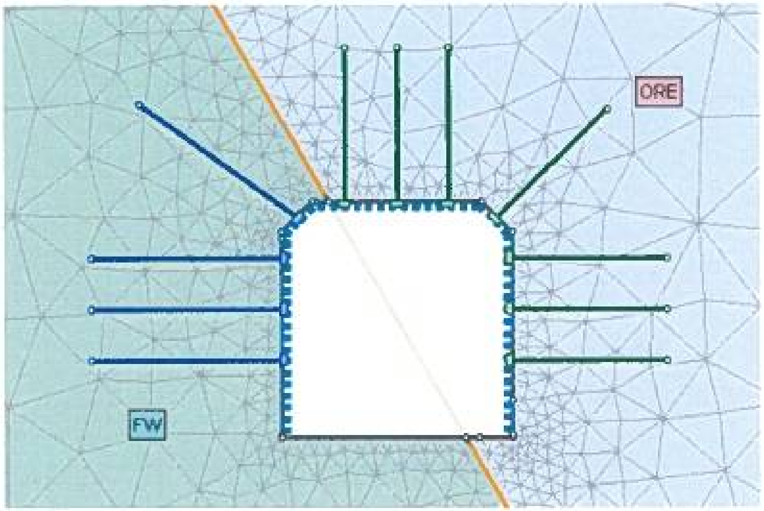


(d) Deformation & Yielded zone (K=1.2)

Drives with 45° dip contact between FW and Ore



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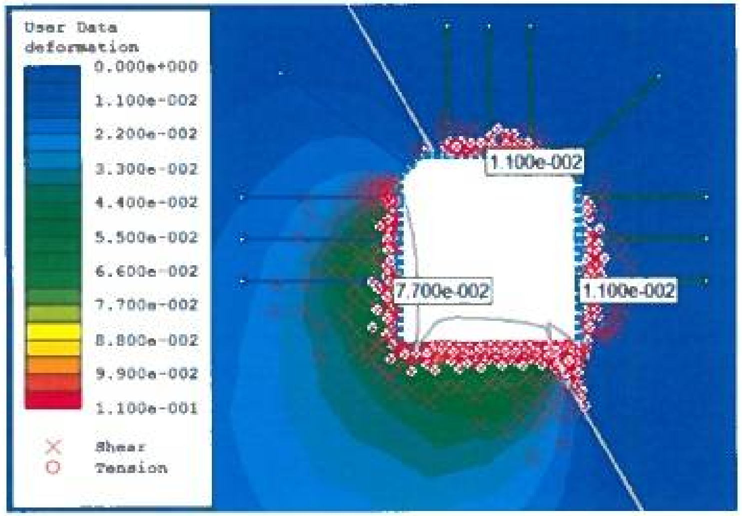

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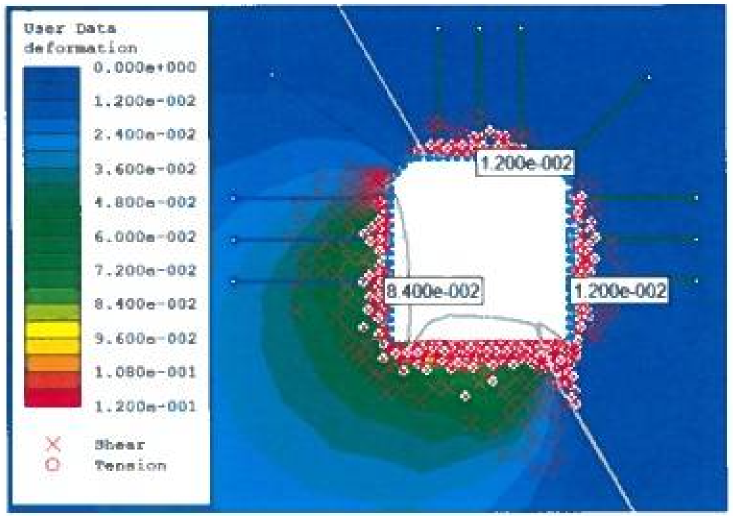

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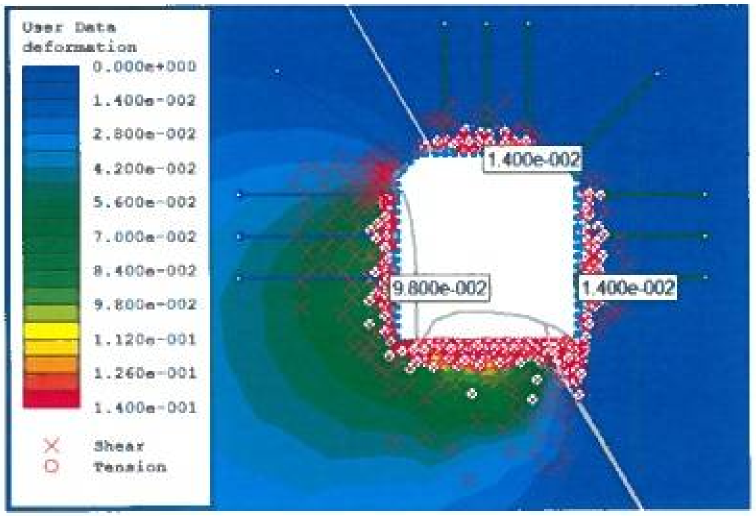
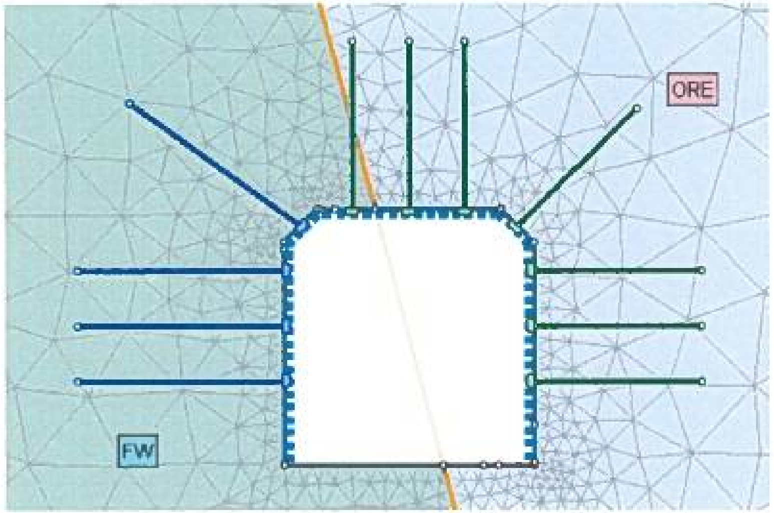


(d) Deformation & Yielded zone (K=1.2)

Drives with 30° dip contact between FW and Ore



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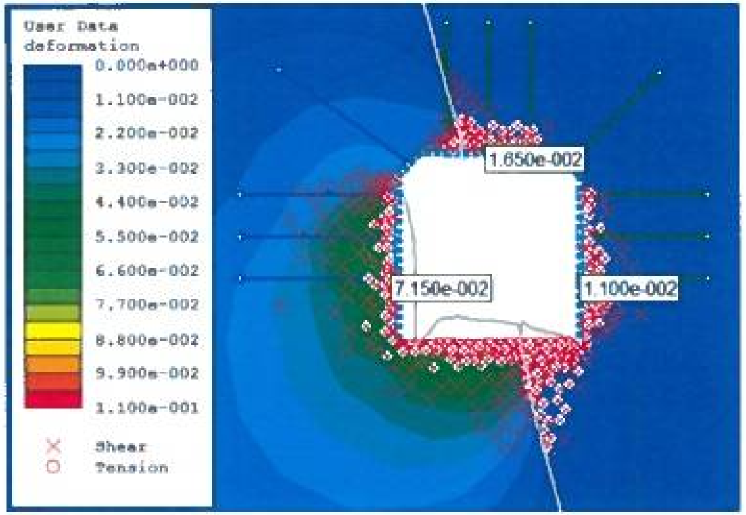

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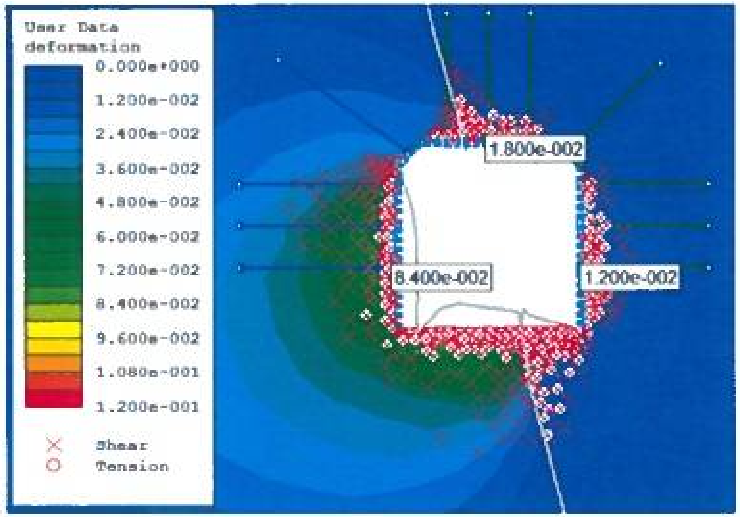

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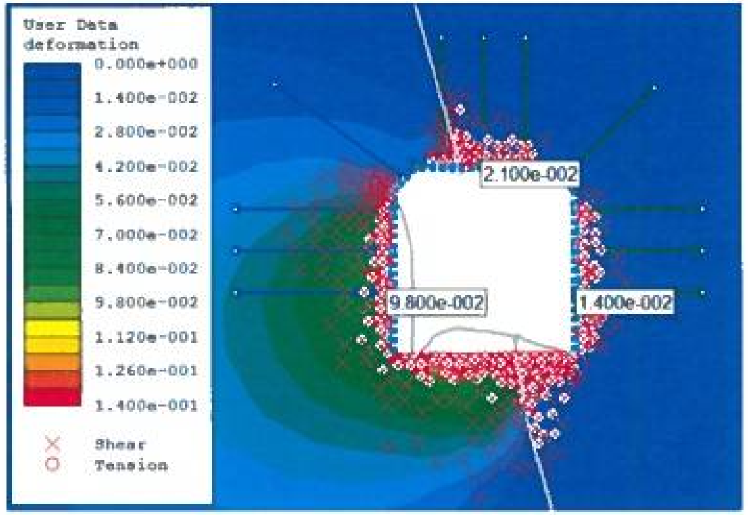
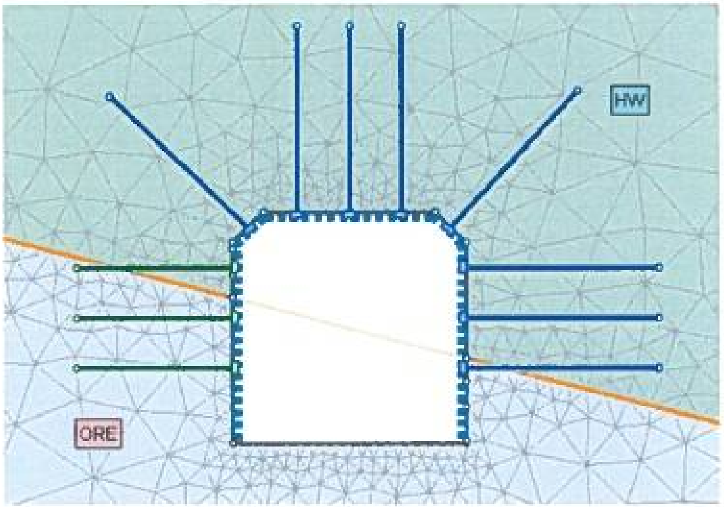


(d) Deformation & Yielded zone (K=1.2)

Drives with 15° dip contact between FW and Ore



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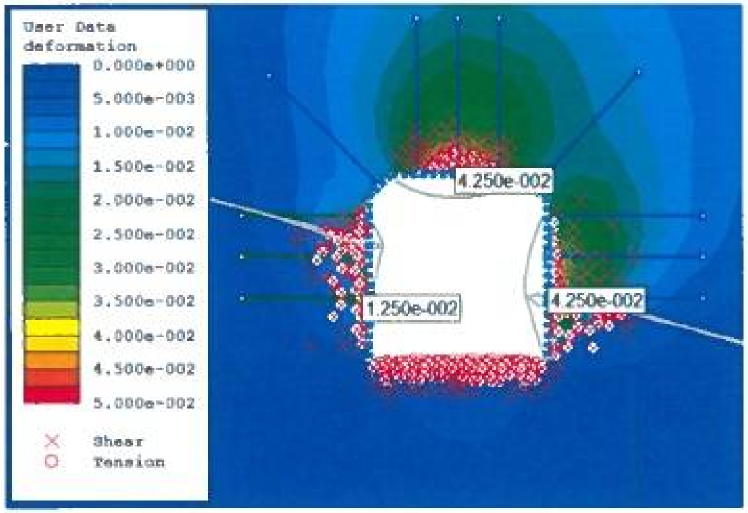

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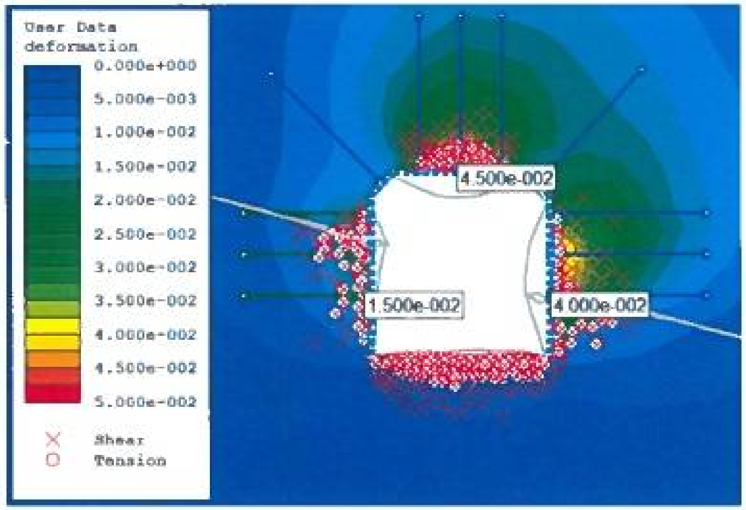
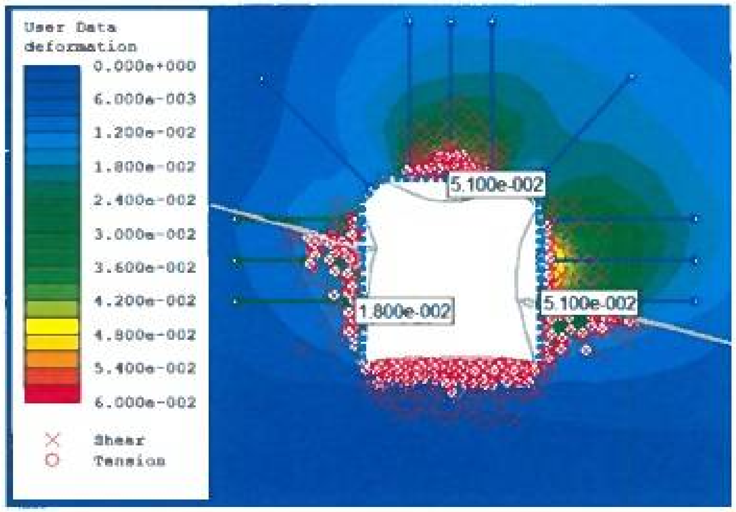
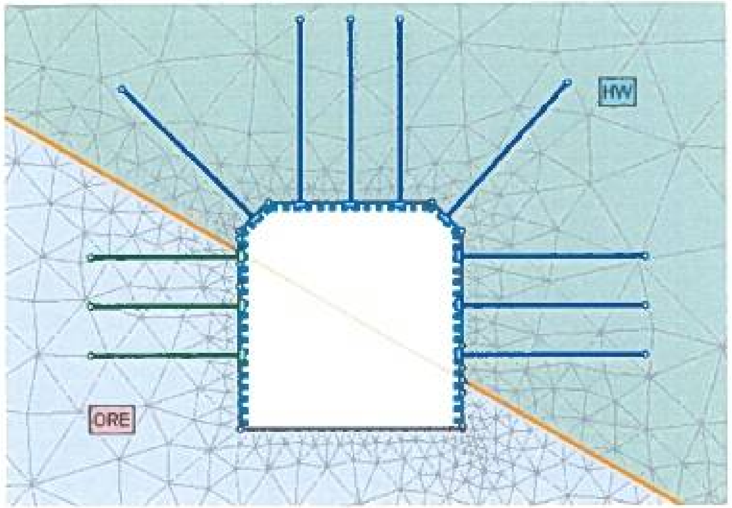


(c) Deformation & Yielded zone (K=1.0)

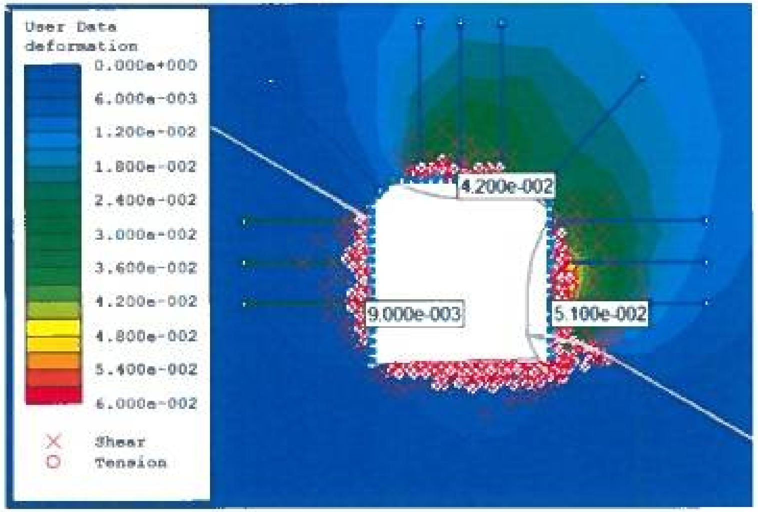


(d) Deformation & Yielded zone (K=1.2)

Drives with 75° dip contact between HW and Ore



(a) Applied Supports



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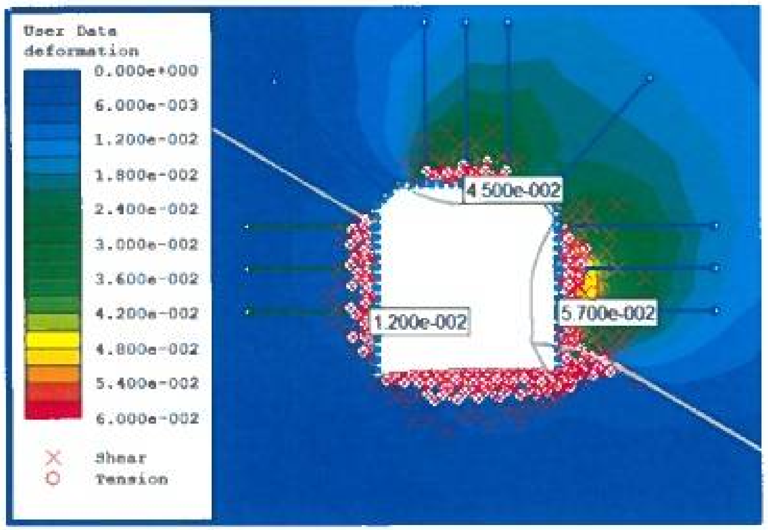
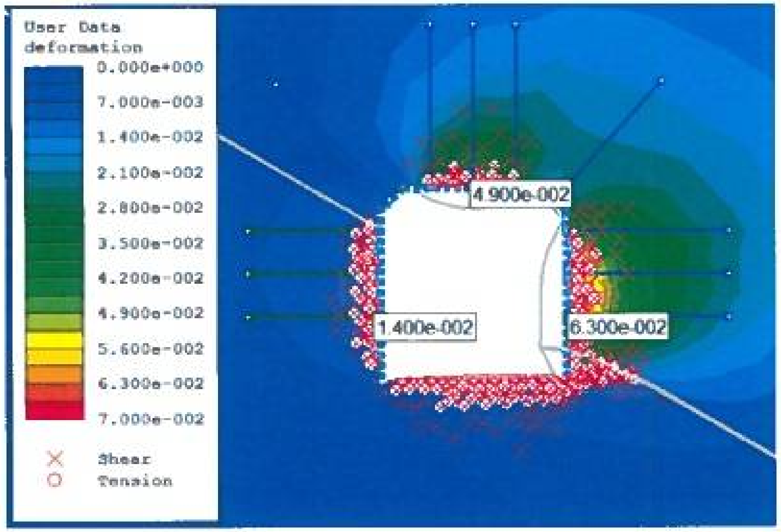
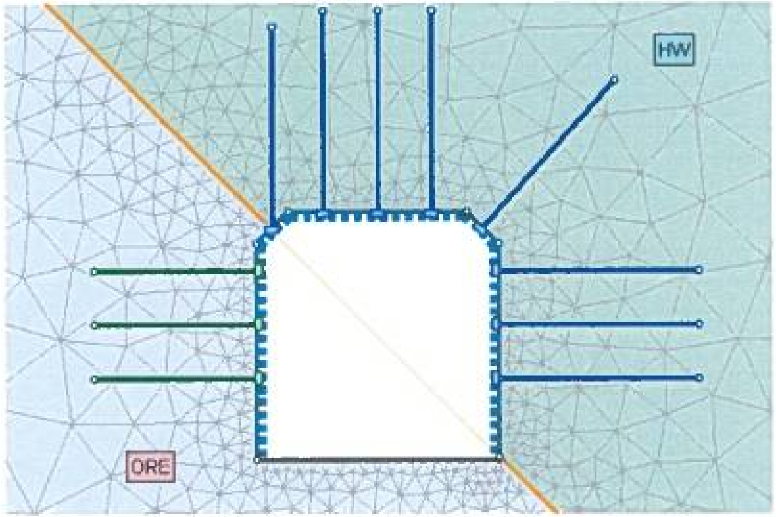


(c) Deformation & Yielded zone (K=1.0)



(d) Deformation & Yielded zone (K=1.2)

Drives with 60° dip contact between HW and Ore



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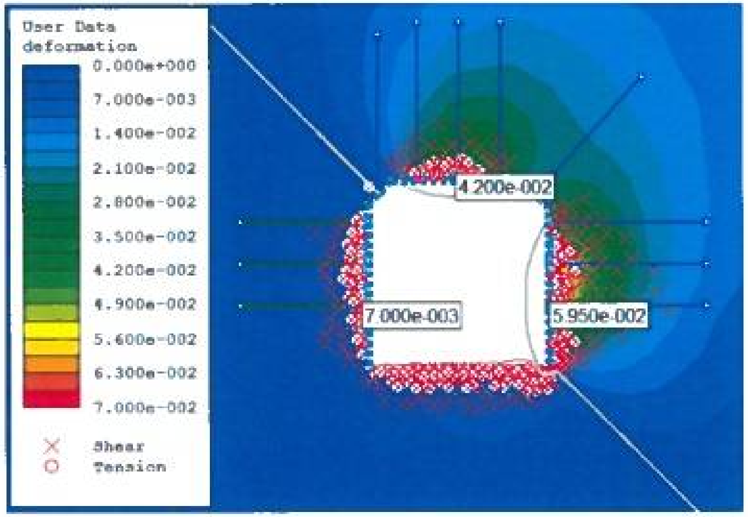
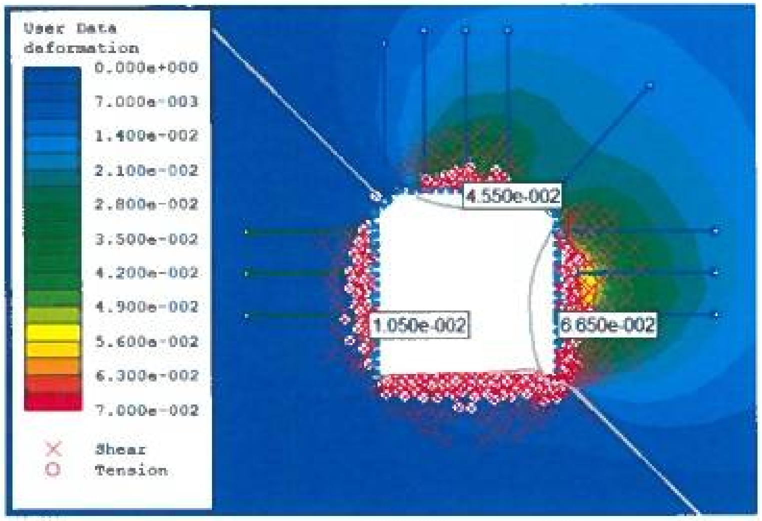
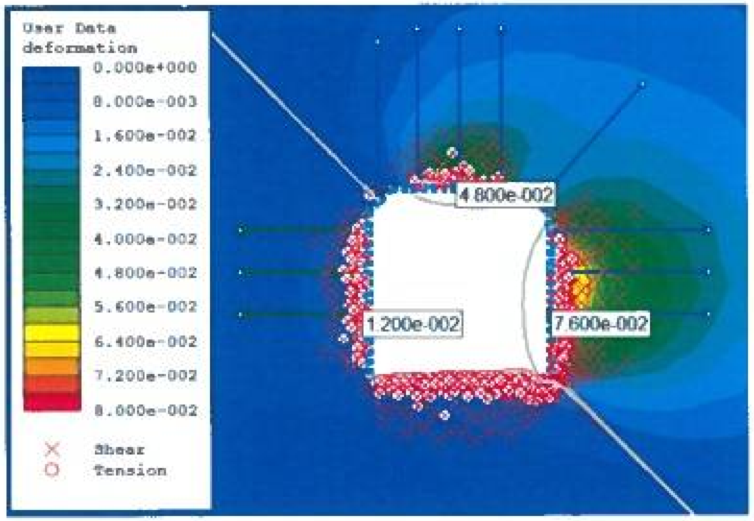


(b) Deformation & Yielded zone (K=0.8)

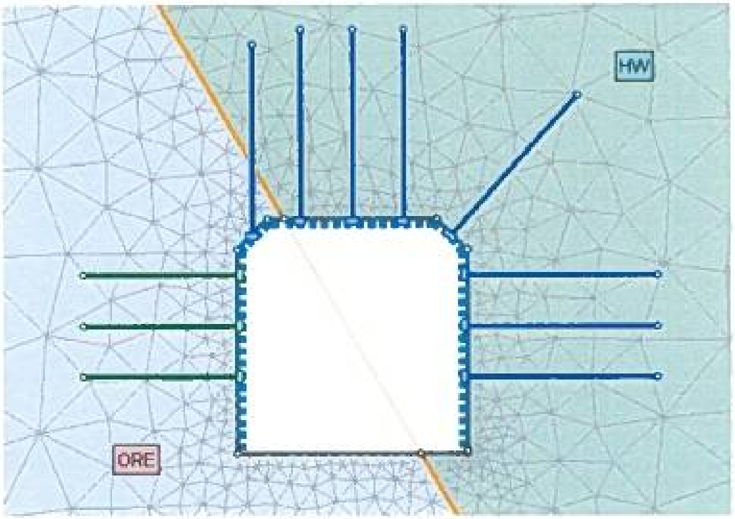


(c) Deformation & Yielded zone (K=1.0)

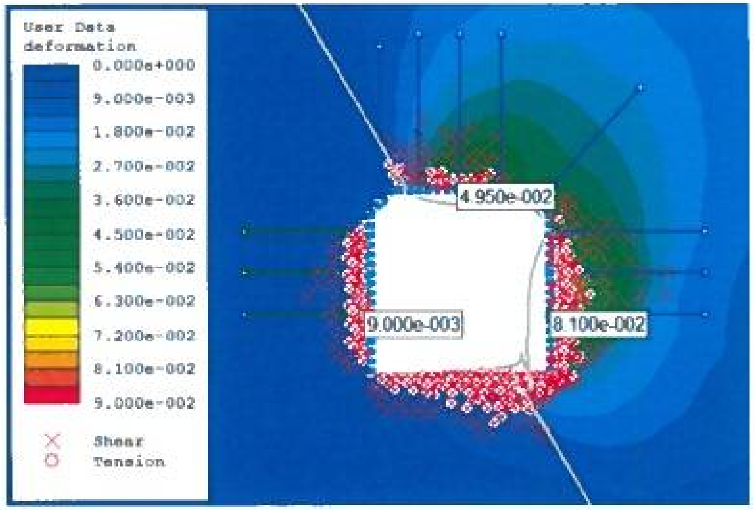


(d) Deformation & Yielded zone (K=1.2)

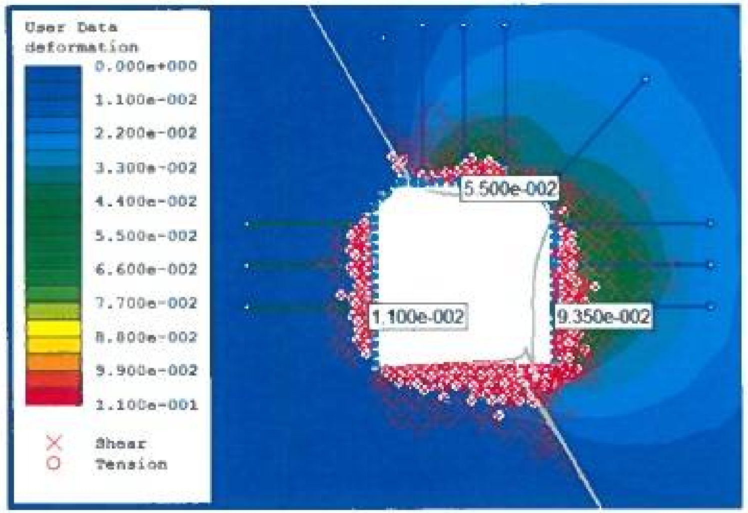
Drives with 45° dip contact between HW and Ore



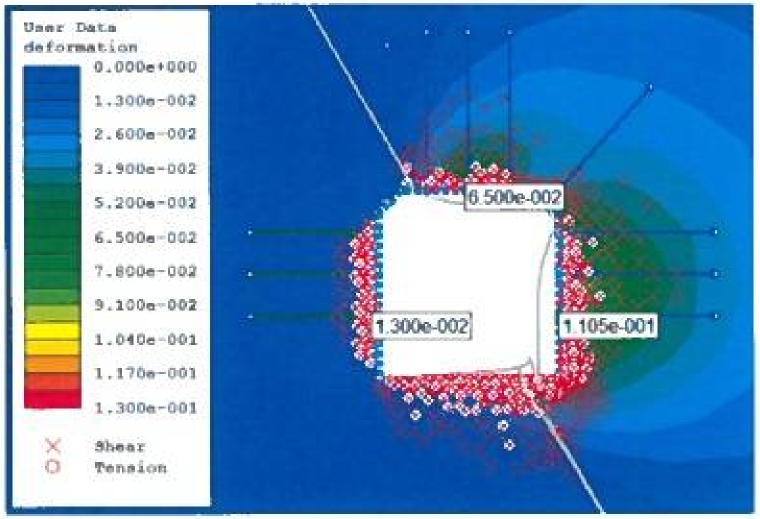
(a) Applied Supports



(b) Deformation & Yielded zone (K=0.8)

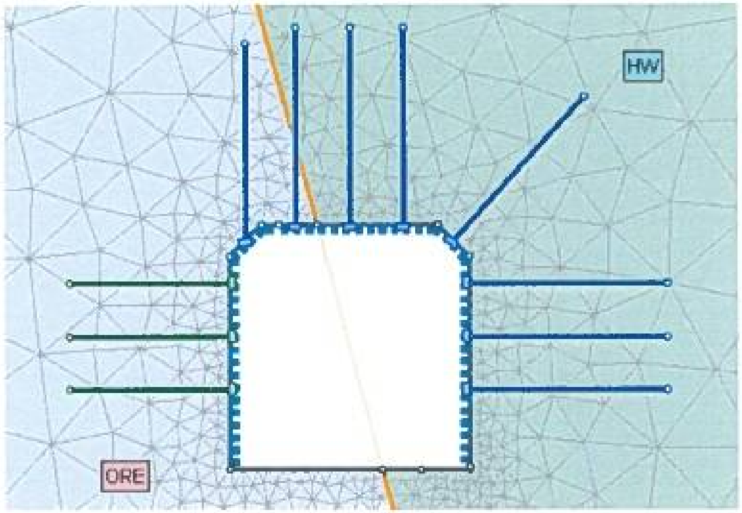


(c) Deformation & Yielded zone (K=1.0)

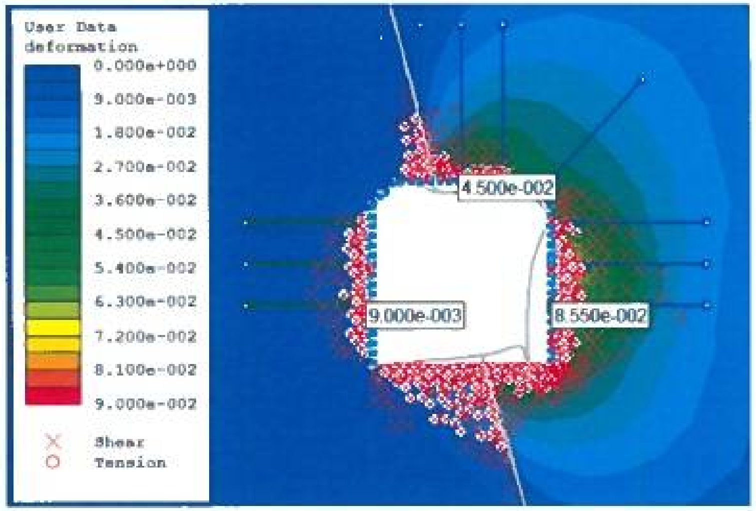


(d) Deformation & Yielded zone (K=1.2)

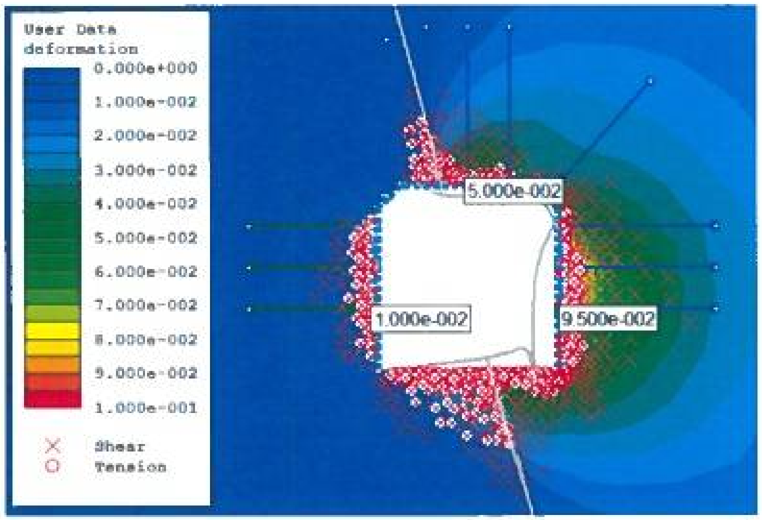
Drives with 30° dip contact between HW and Ore



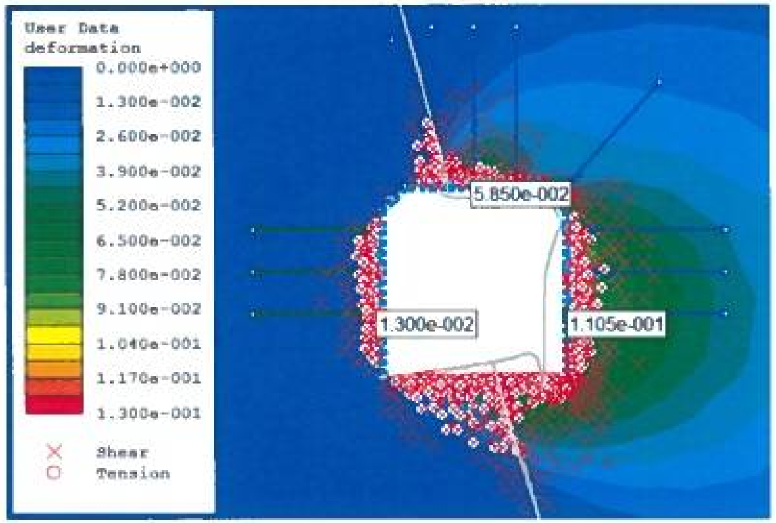
(a) Applied Supports



(b) Deformation & Yielded zone (K=0.8)

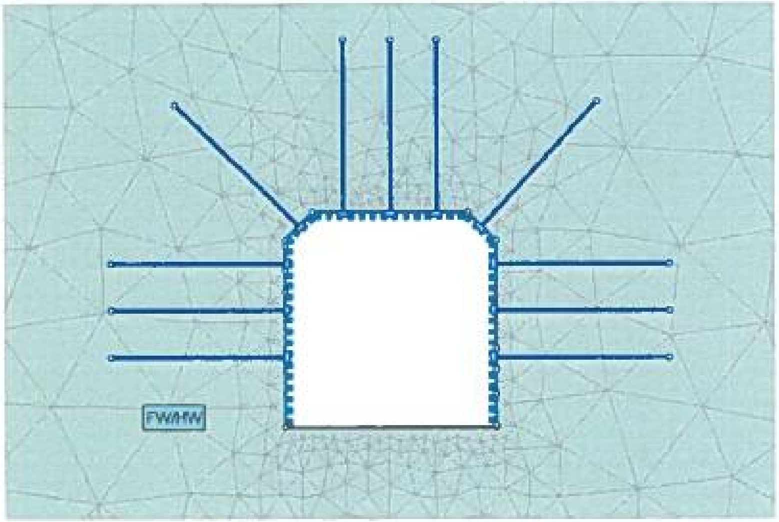


(c) Deformation & Yielded zone (K=1.0)

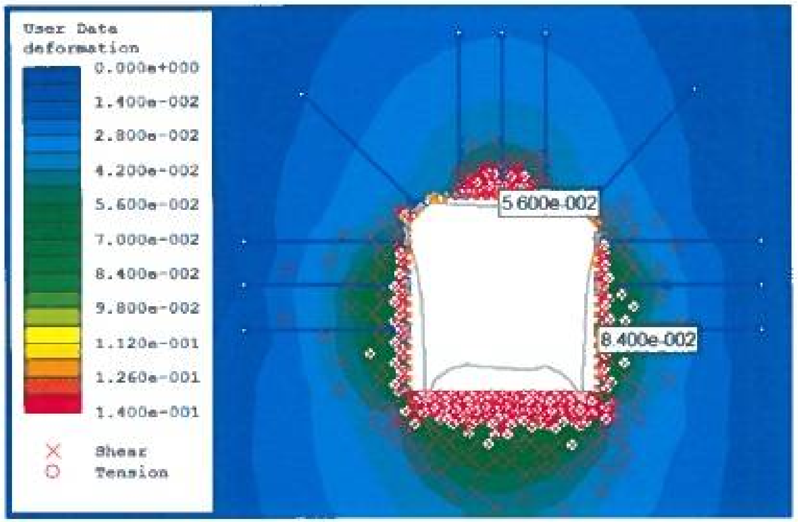


(d) Deformation & Yielded zone (K=1.2)

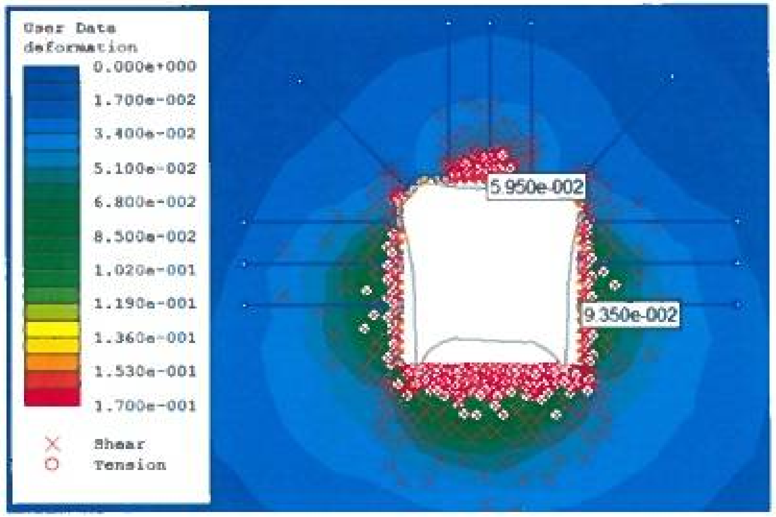
Drives with 15° dip contact between HW and Ore



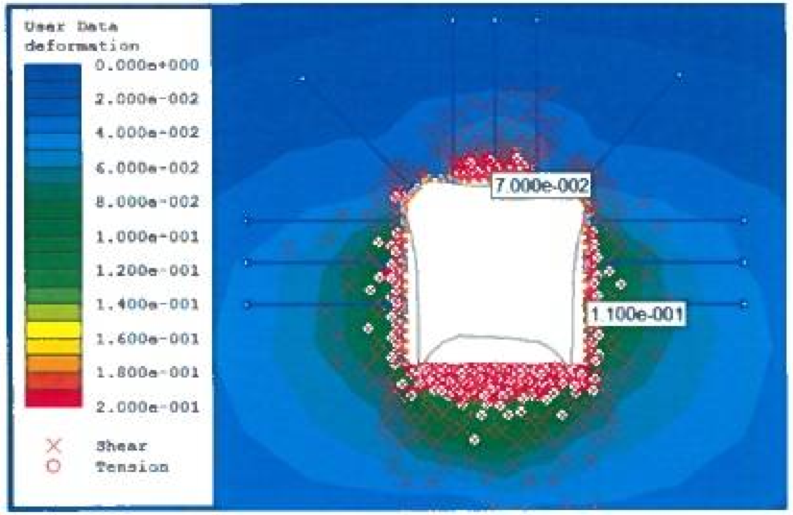
(a) Applied Supports



(b) Deformation & Yielded zone (K=0.8)



(c) Deformation & Yielded zone (K=1.0)

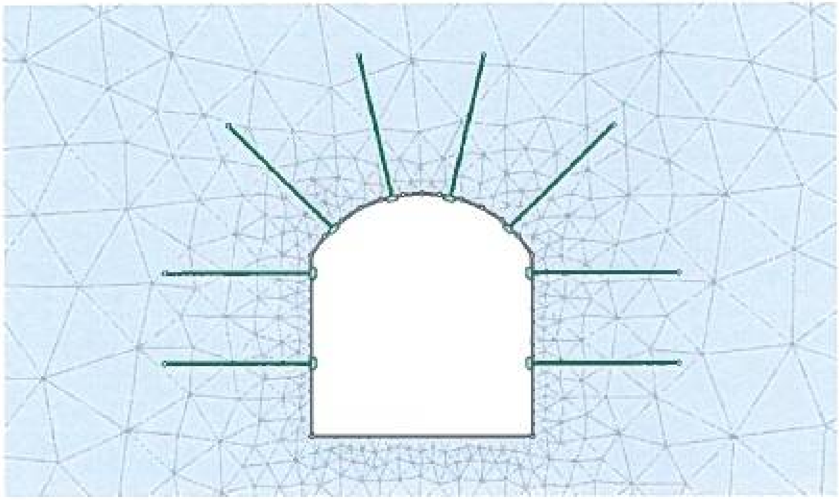


(d) Deformation & Yielded zone (K=1.2)

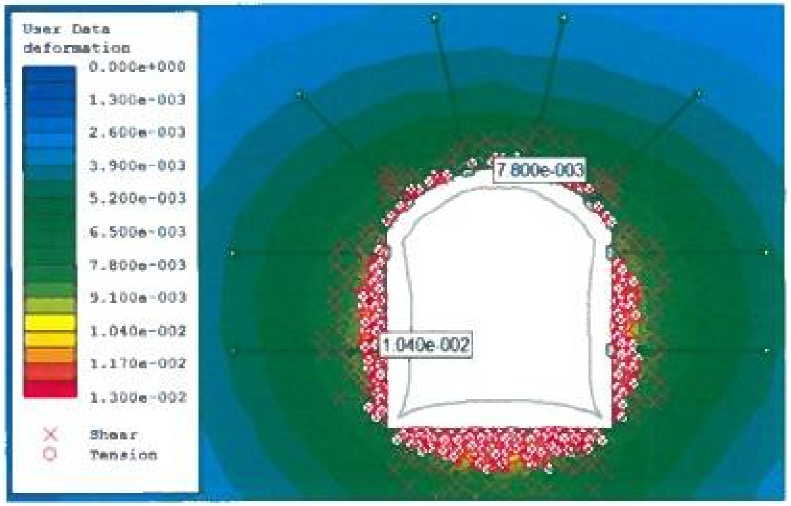
Drives pass through FW/HW ground

Small Stope

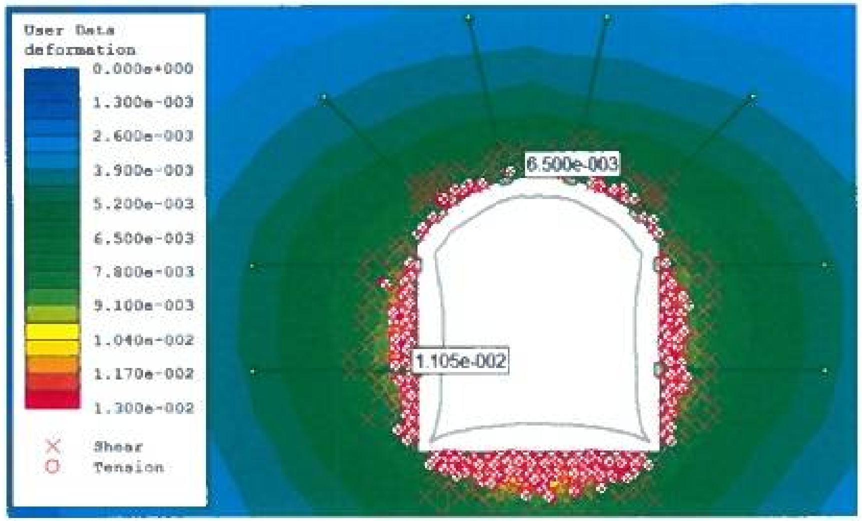
- Drives pass through Ore ground
- Drives pass through FW/HW ground



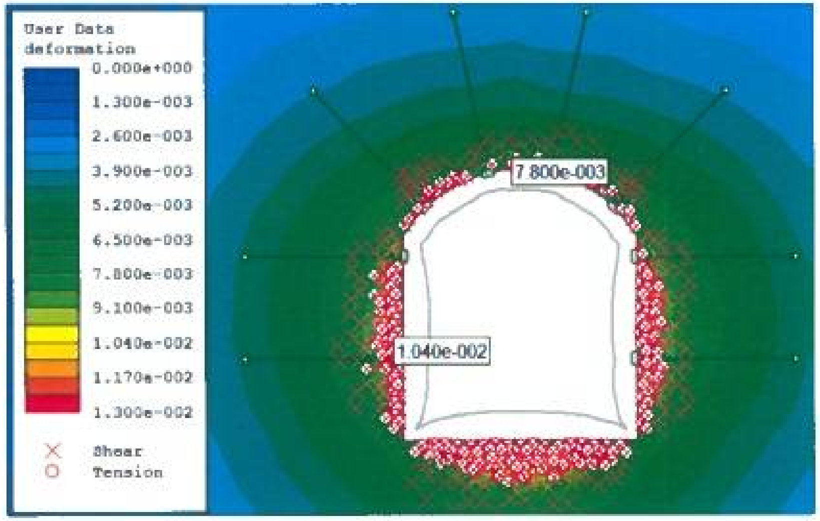
(a) Applied Supports



(b) Deformation & Yielded zone (K=0.8)

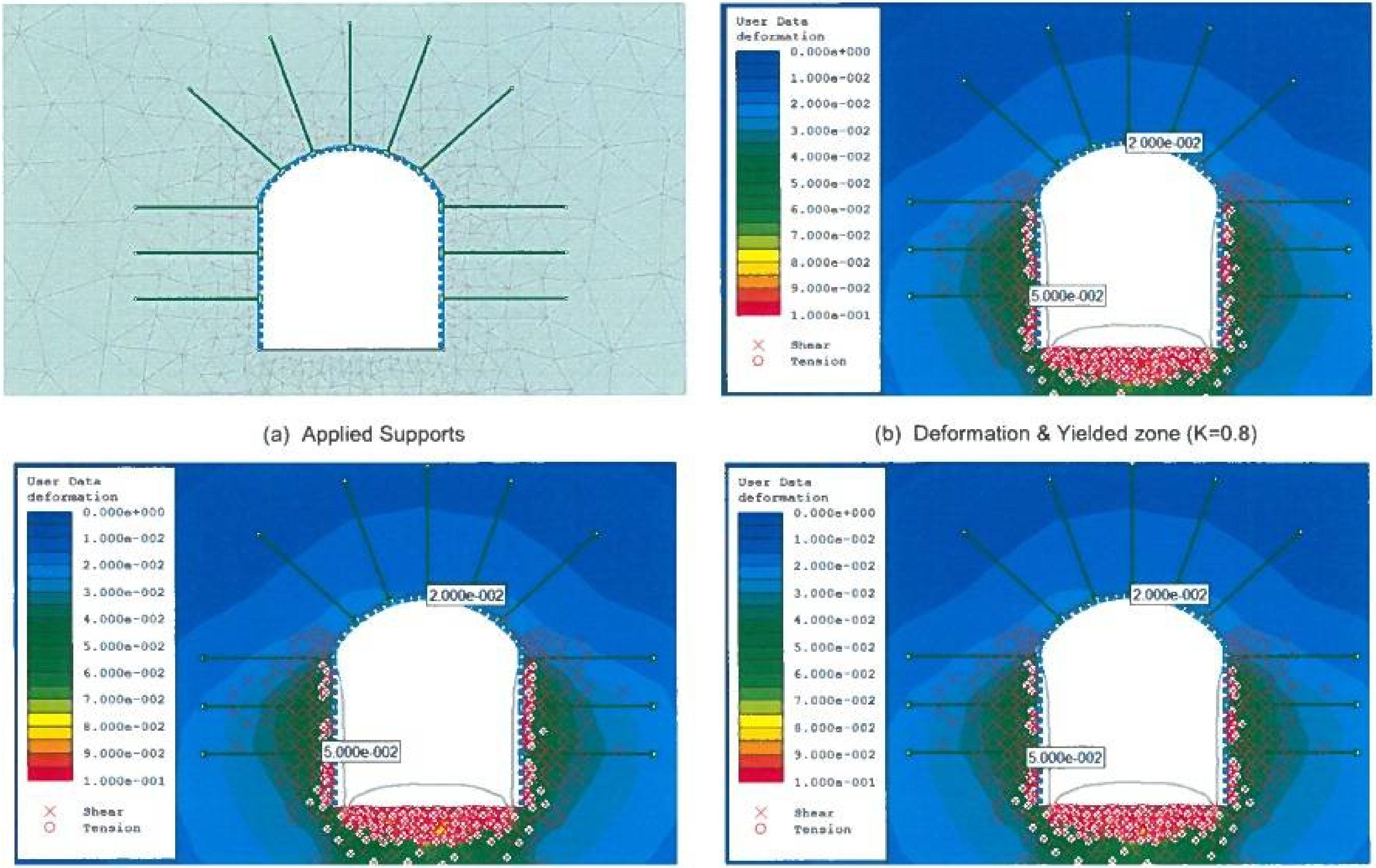


(c) Deformation & Yielded zone (K=1.0)



(d) Deformation & Yielded zone (K=1.2)

Drives pass through Ore ground



(a) Applied Supports

(b) Deformation & Yielded zone (K=0.8)

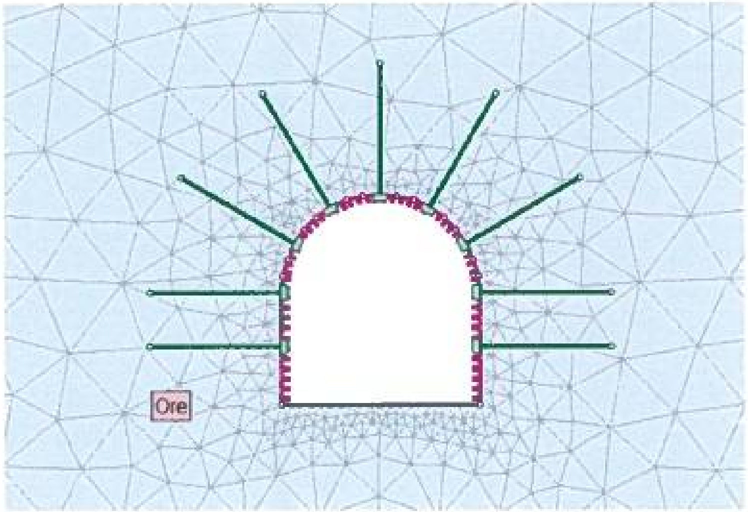
(c) Deformation & Yielded zone (K=1.0)

(d) Deformation & Yielded zone (K=1.2)

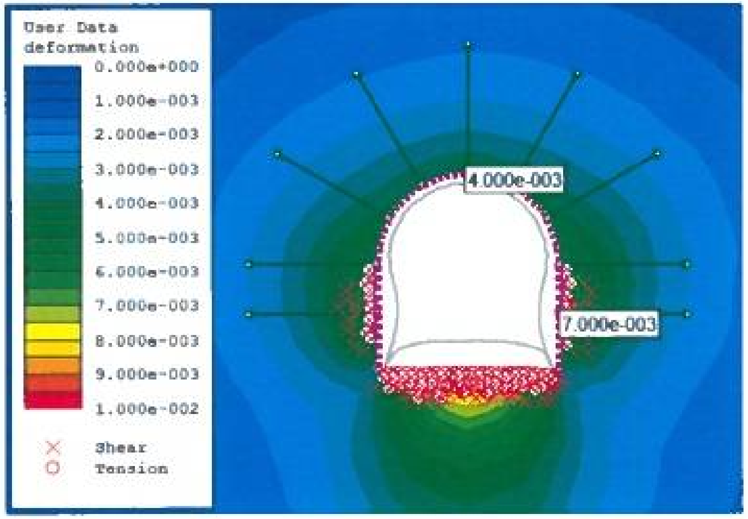
Drives pass through FW/HW ground

Main Ramp

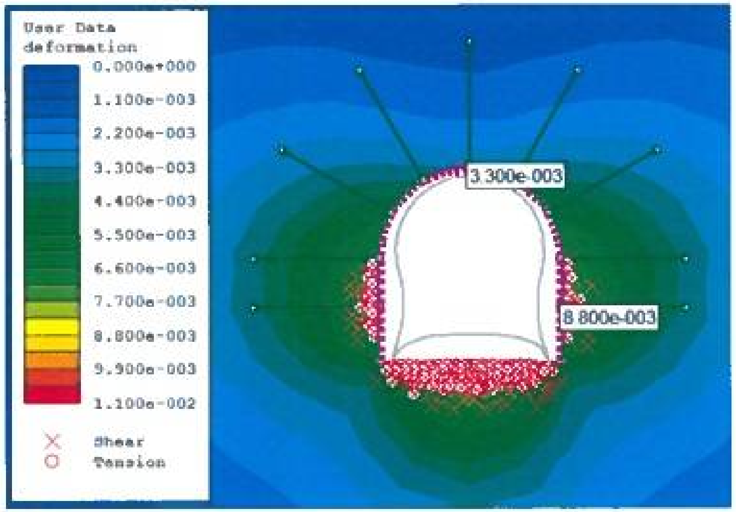
- Drives pass through Ore ground
- Drives pass through FW/HW ground



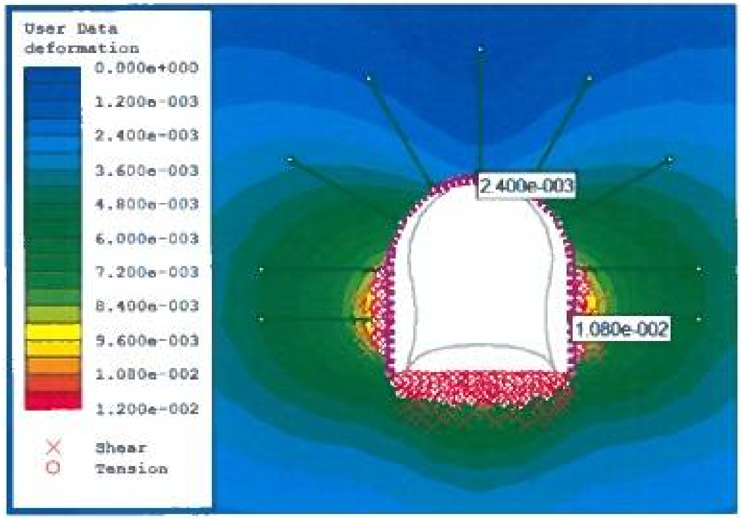
(e) Applied Supports



(f) Deformation & Yielded zone (K=0.8)

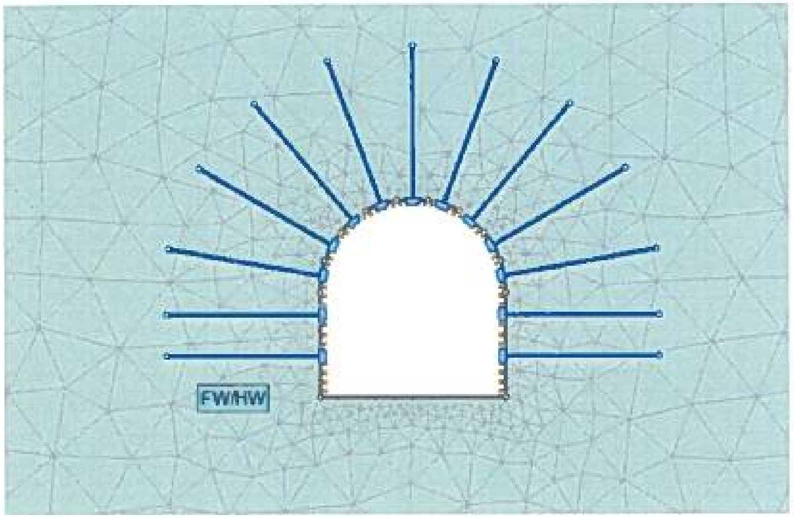


(g) Deformation & Yielded zone (K=1.0)

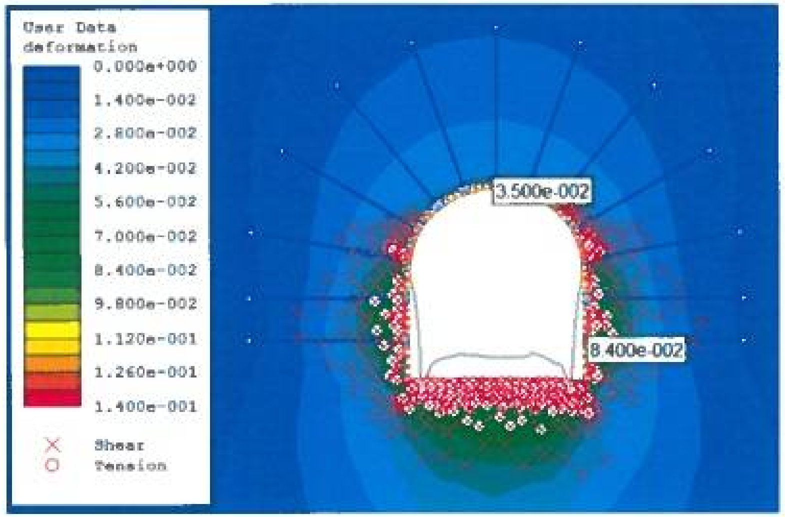


(h) Deformation & Yielded zone (K=1.2)

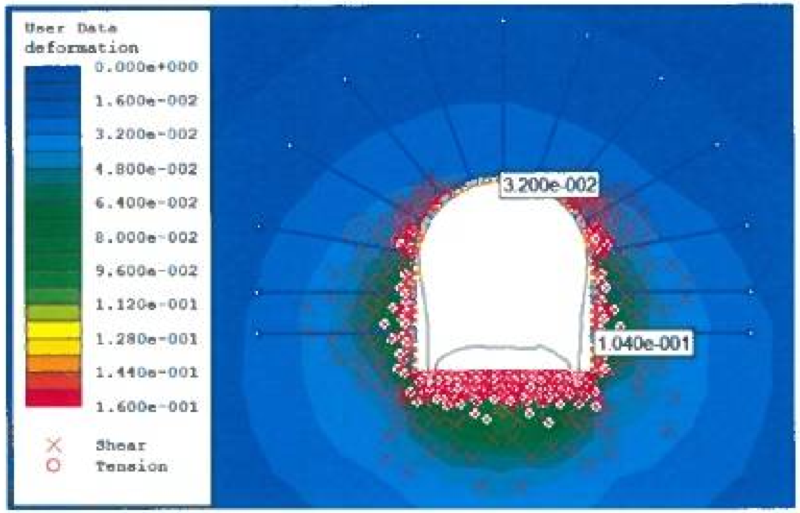
Drives pass through Ore ground



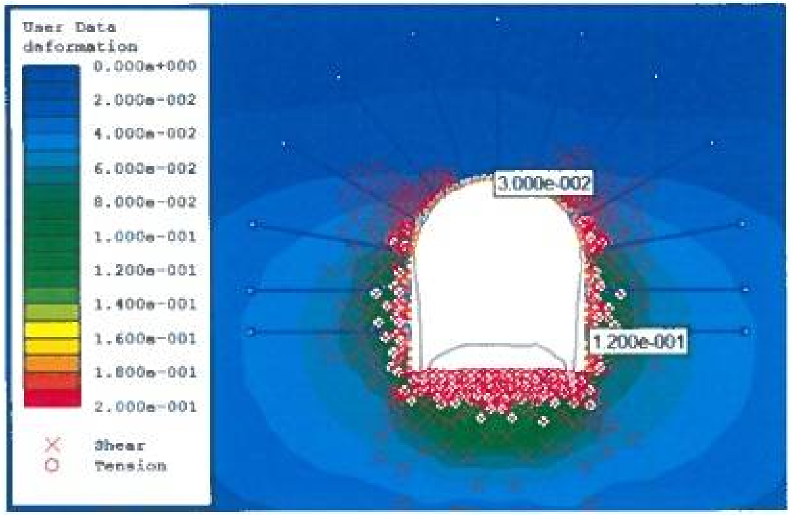
(e) Applied Supports



(f) Deformation & Yielded zone (K=0.8)



(g) Deformation & Yielded zone (K=1.0)

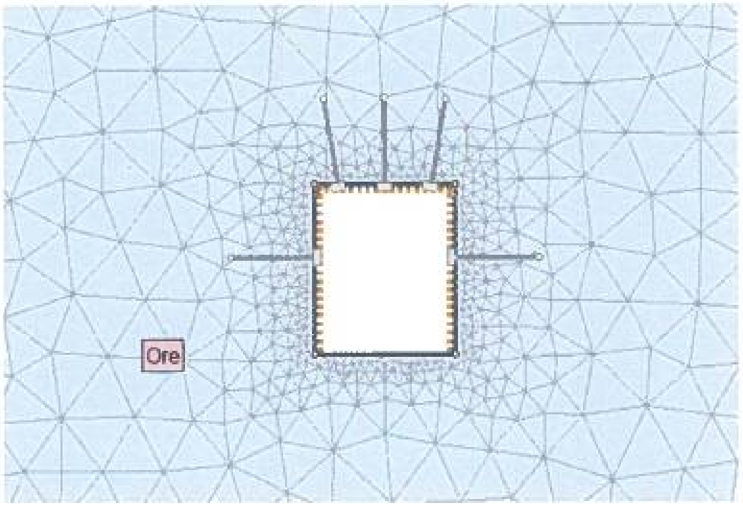


(h) Deformation & Yielded zone (K=1.2)

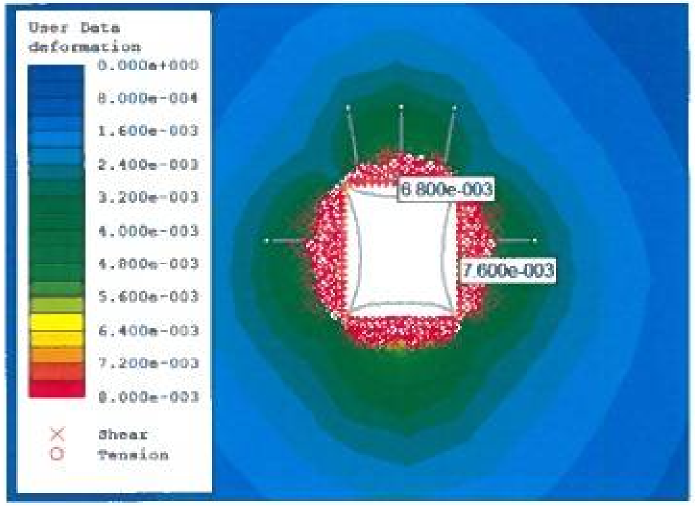
Drives pass through FW/HW ground

Raise

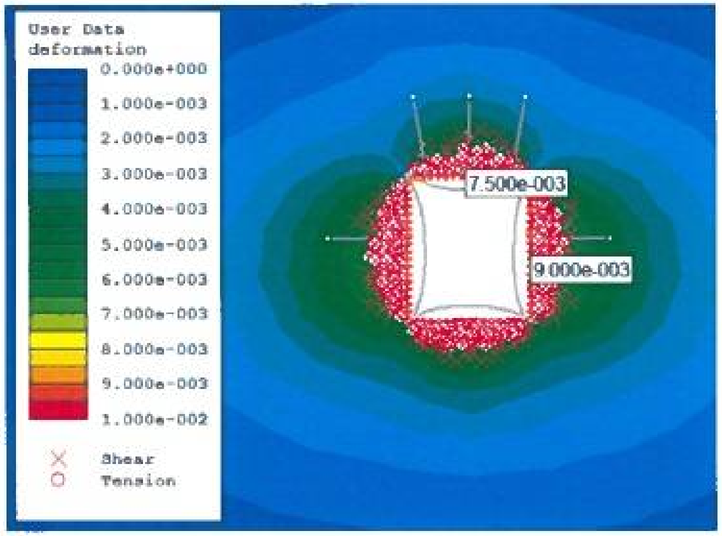
- Drives pass through Ore ground
- Drives pass through FW/HW ground



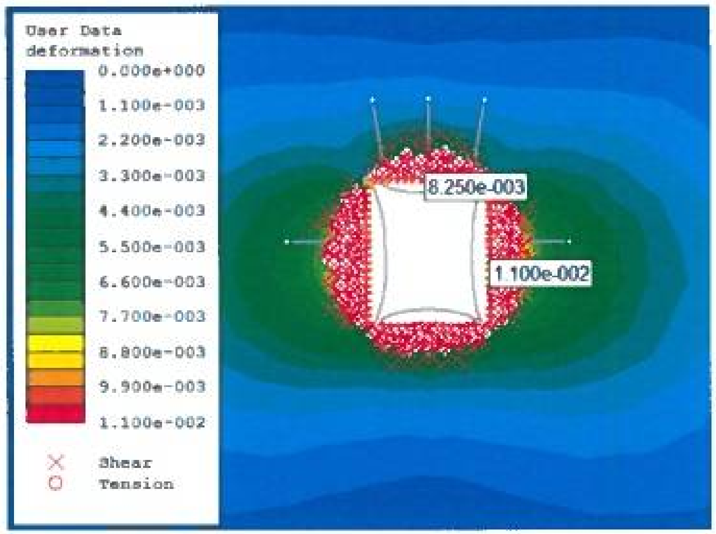
(a) Applied Supports



(b) Deformation & Yielded zone (K=0.8)

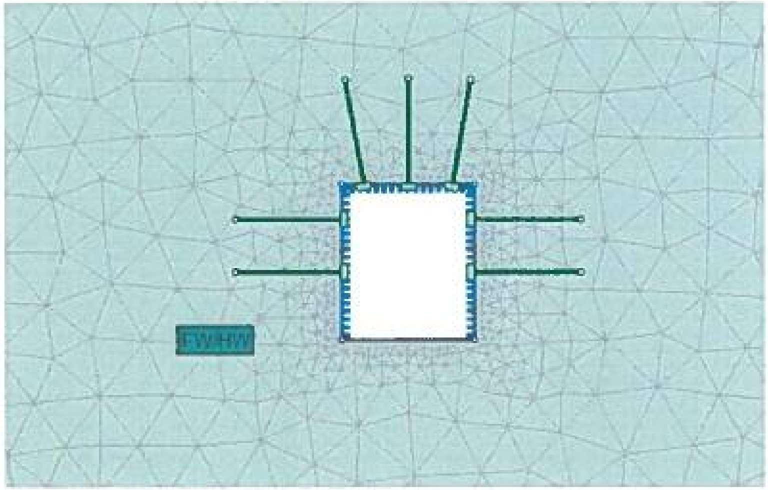


(c) Deformation & Yielded zone (K=1.0)

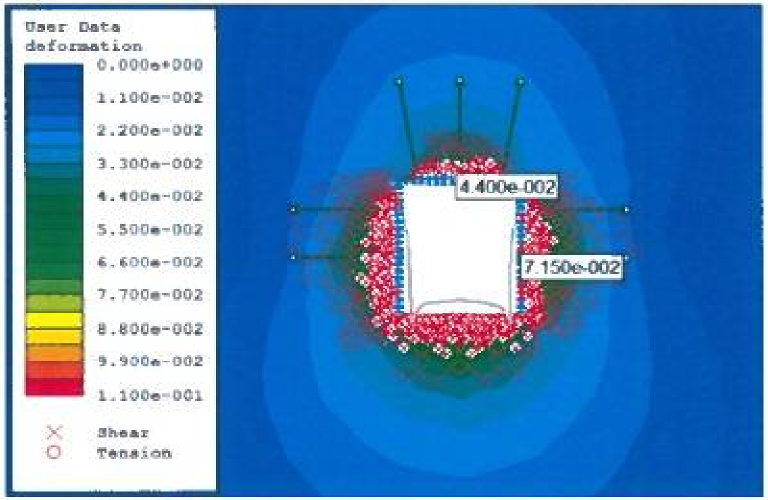


(d) Deformation & Yielded zone (K=1.2)

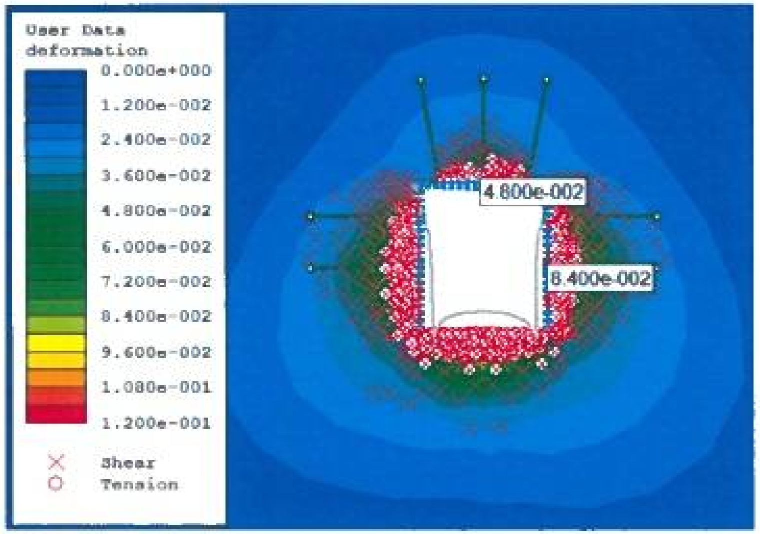
Drives pass through Ore ground



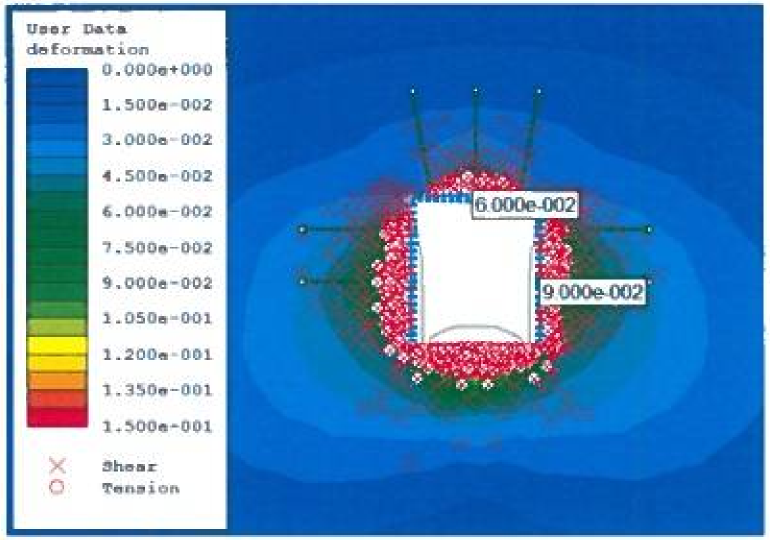
(a) Applied Supports



(b) Deformation & Yielded zone (K=0.8)



(c) Deformation & Yielded zone (K=1.0)

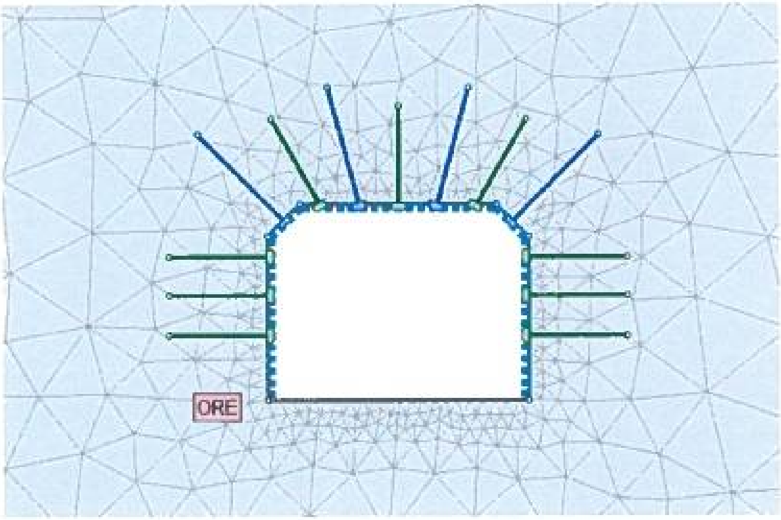


(d) Deformation & Yielded zone (K=1.2)

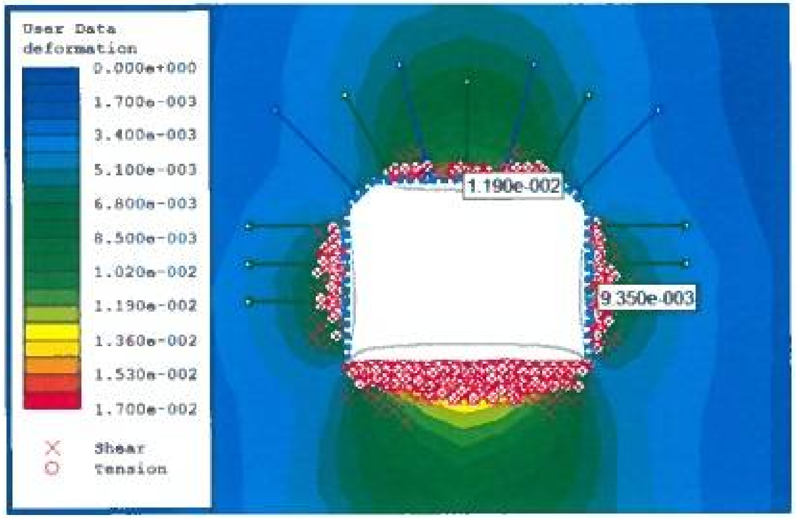
Drives pass through FW/HW ground

Intersection

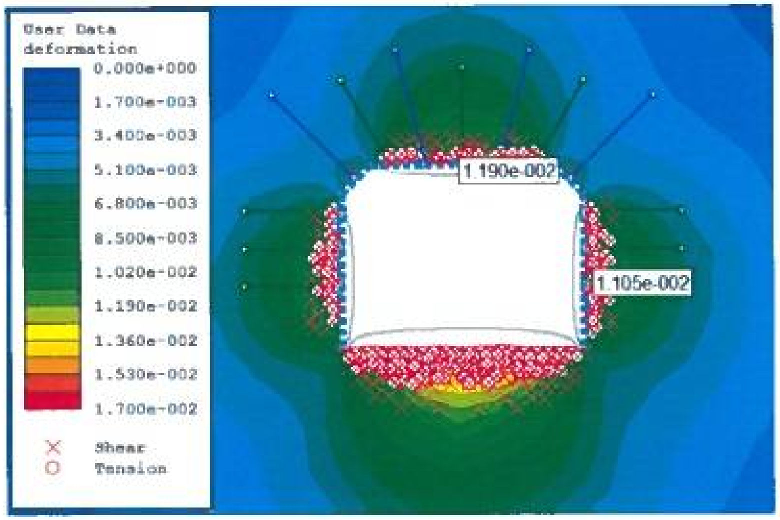
- 8.0 m width × 6.0 m height section in Ore ground Intersection
- 8.0 m width × 6.0 m height section in FW/HW ground Intersection



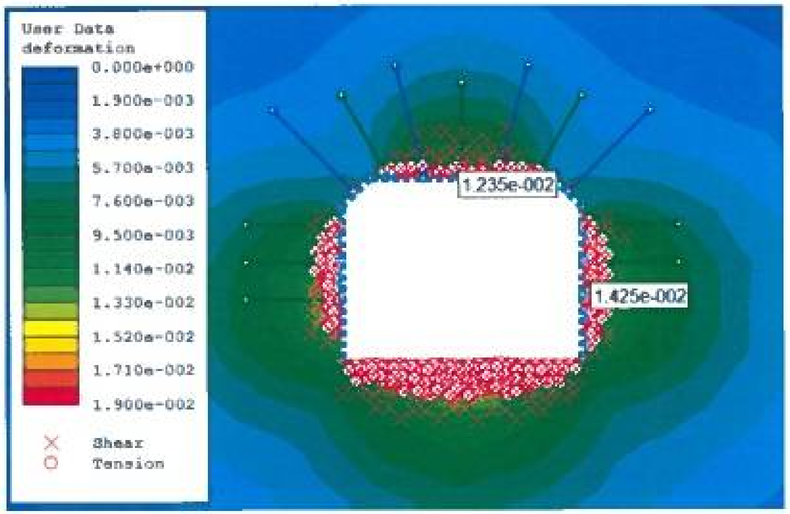
(a) Applied Supports



(b) Deformation & Yielded zone (K=0.8)

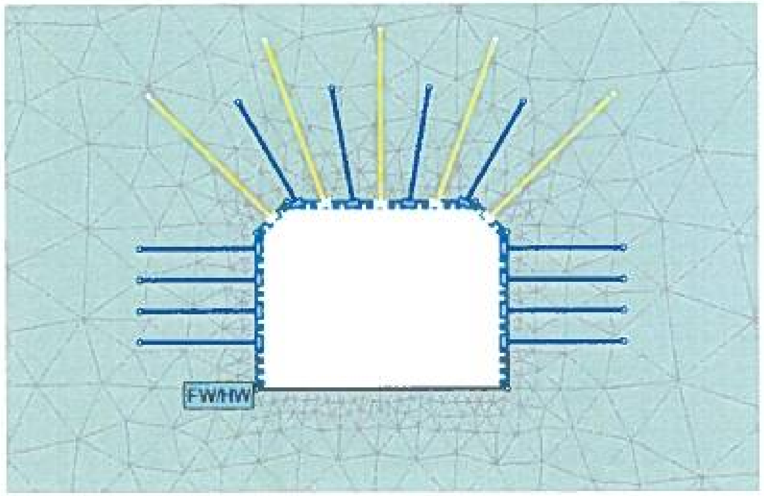


(c) Deformation & Yielded zone (K=1.0)

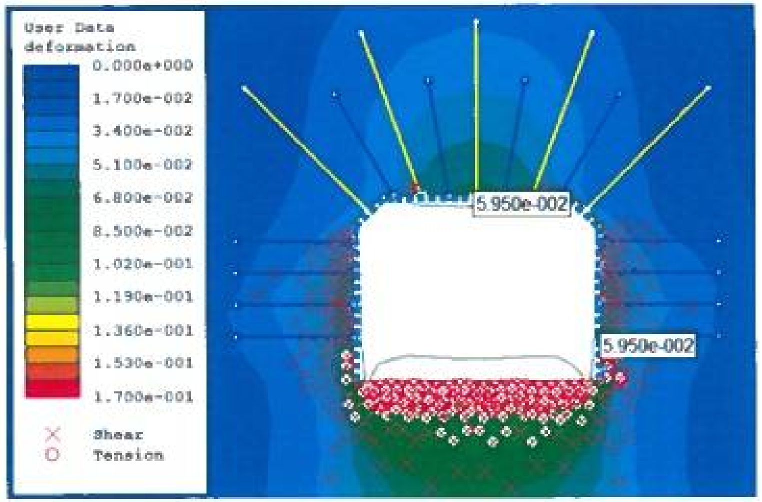


(d) Deformation & Yielded zone (K=1.2)

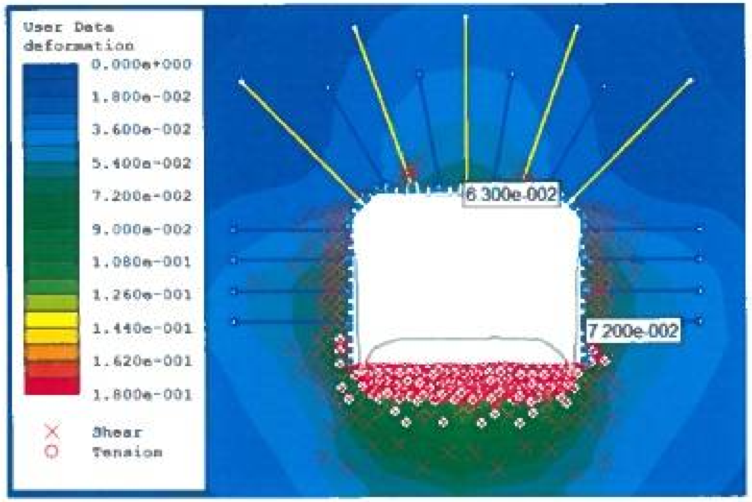
8.0 m width × 6.0 m height Section in Ore Ground Intersection



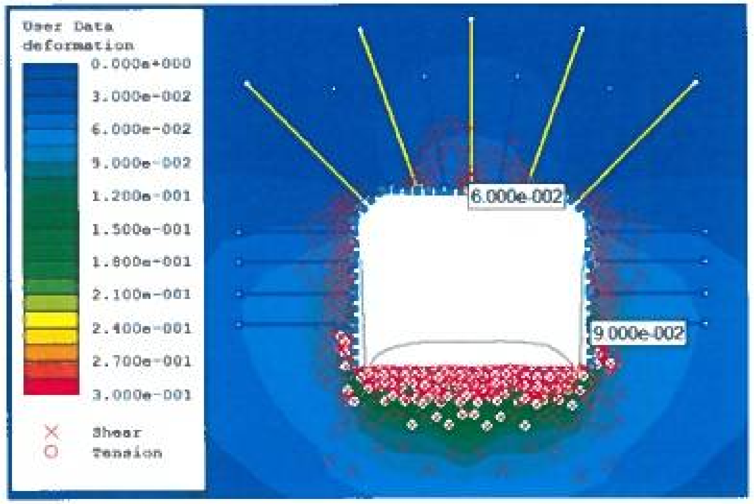
(a) Applied Supports



(b) Deformation & Yielded zone (K=0.8)



(c) Deformation & Yielded zone (K=1.0)

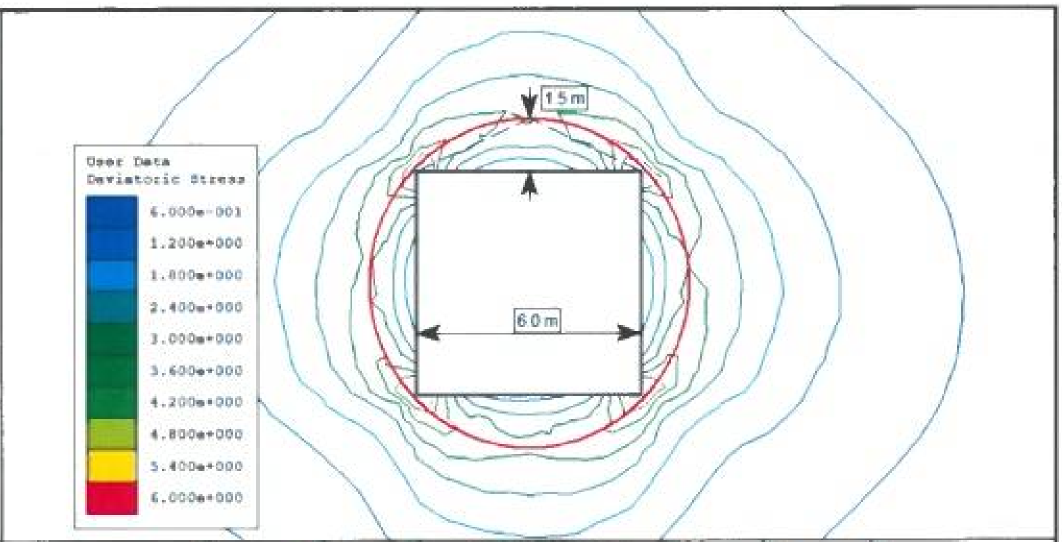
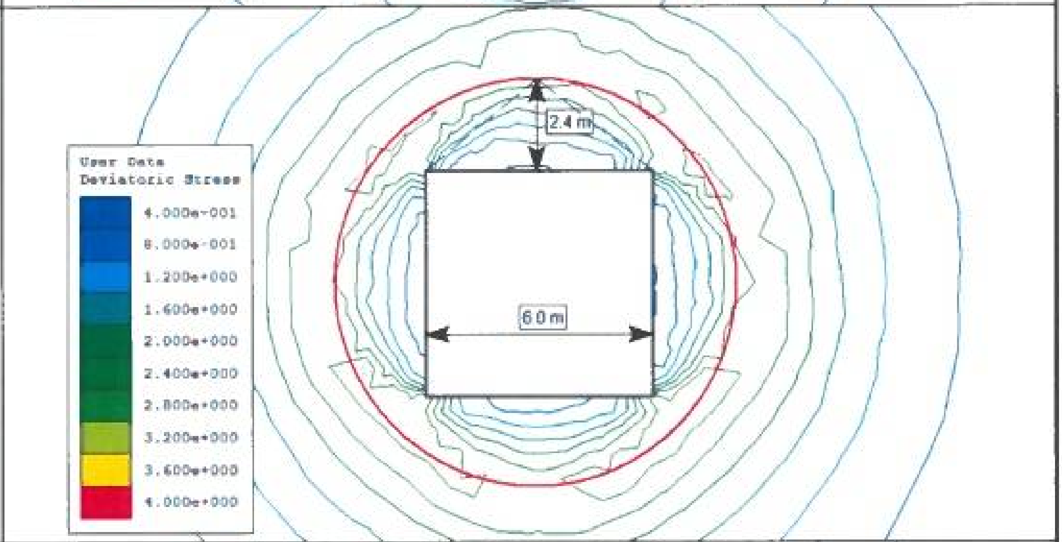
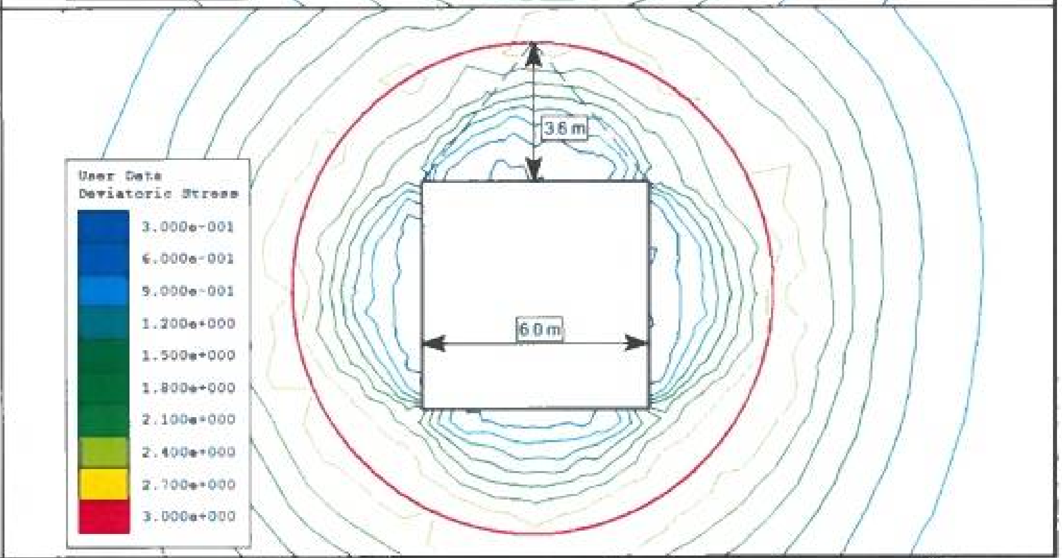


(d) Deformation & Yielded zone (K=1.2)

8.0 m width × 6.0 m height Section in FW/HW Ground Intersection

APPENDIX – E.

DEAD WEIGHT ANALYSIS

ORE B = 6.0 m H_w = 1.5 m **Hw / B = 0.25**	
FW B = 6.0 m H_w = 2.4 m **Hw / B = 0.40**	
HW B = 6.0 m H_w = 3.6 m **Hw / B = 0.60**	

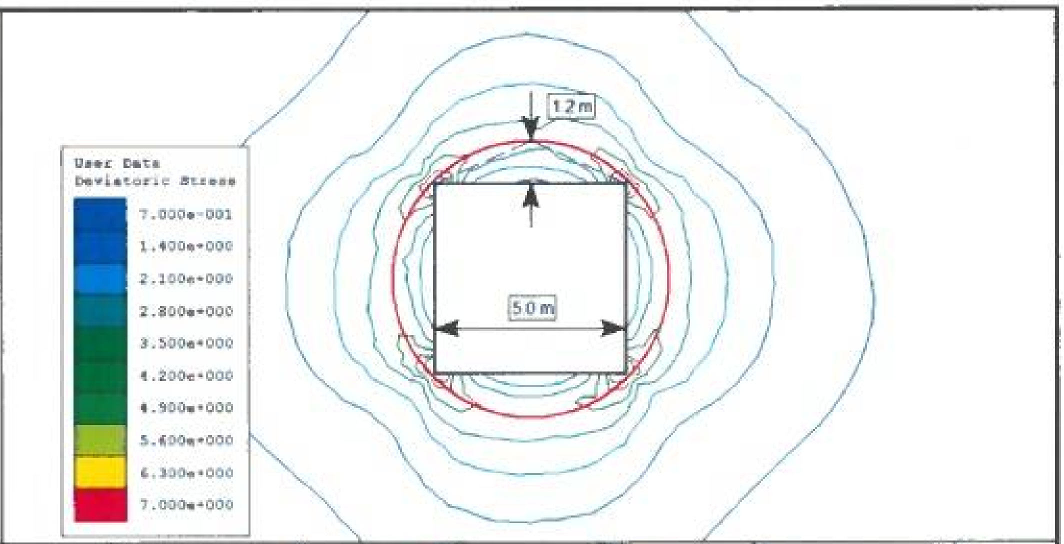
Wedge height of 6 m wide drift in different ground conditions

ORE

B = 5.0 m

H_w = 1.2 m

Hw / B = 0.24

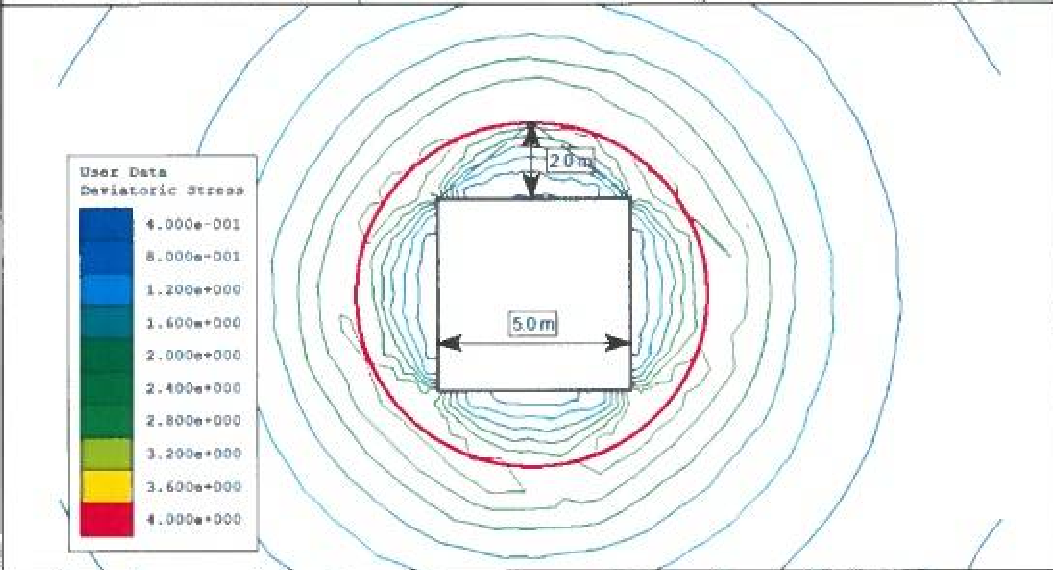


FW

B = 5.0 m

H_w = 2.0 m

Hw / B = 0.40

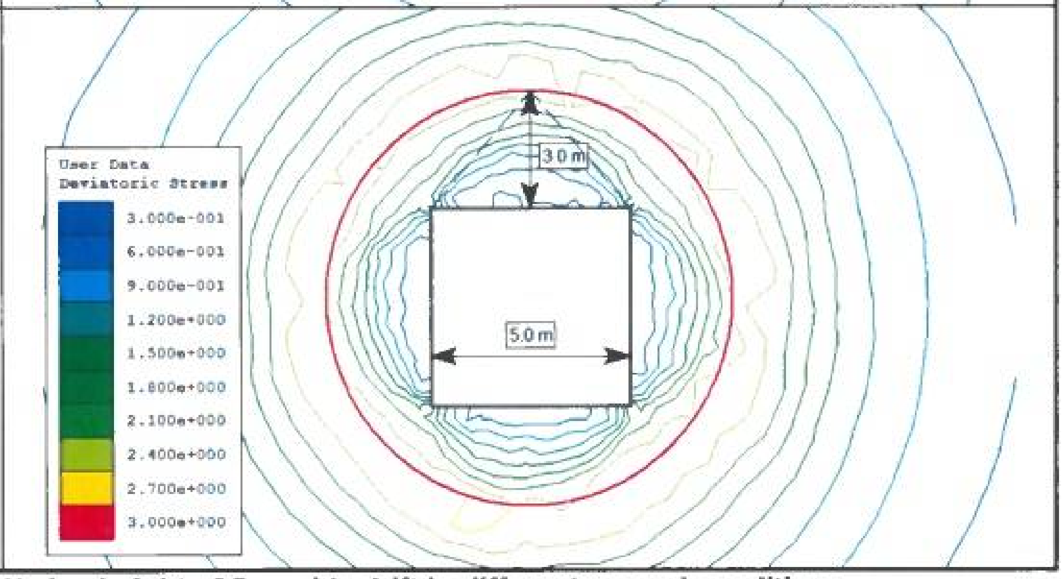


HW

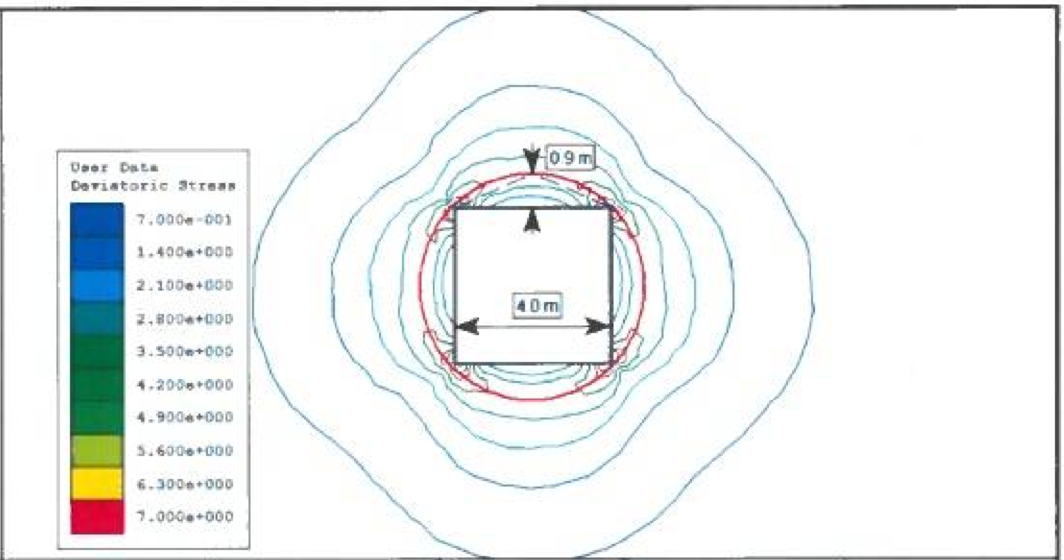
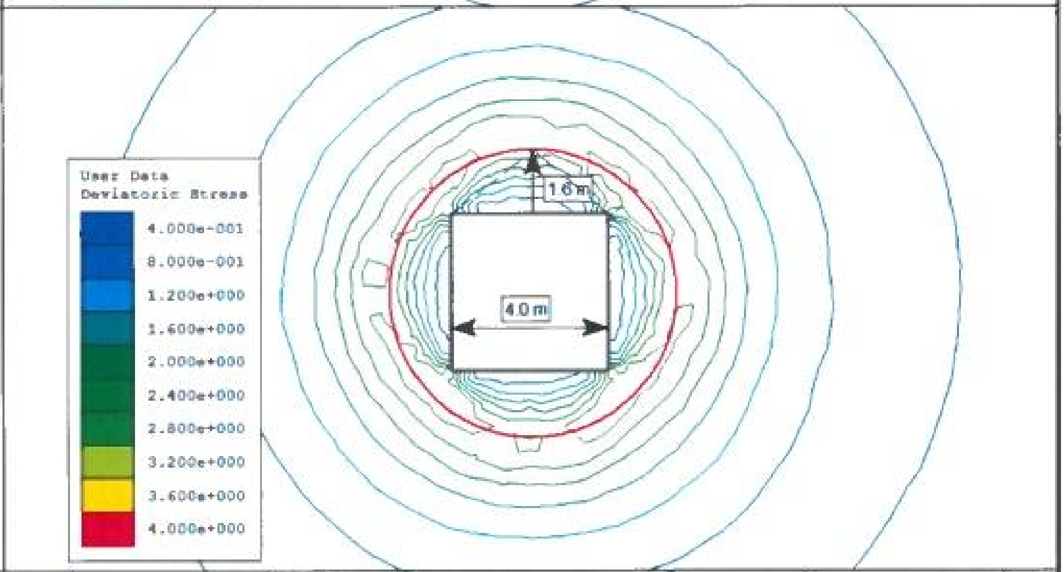
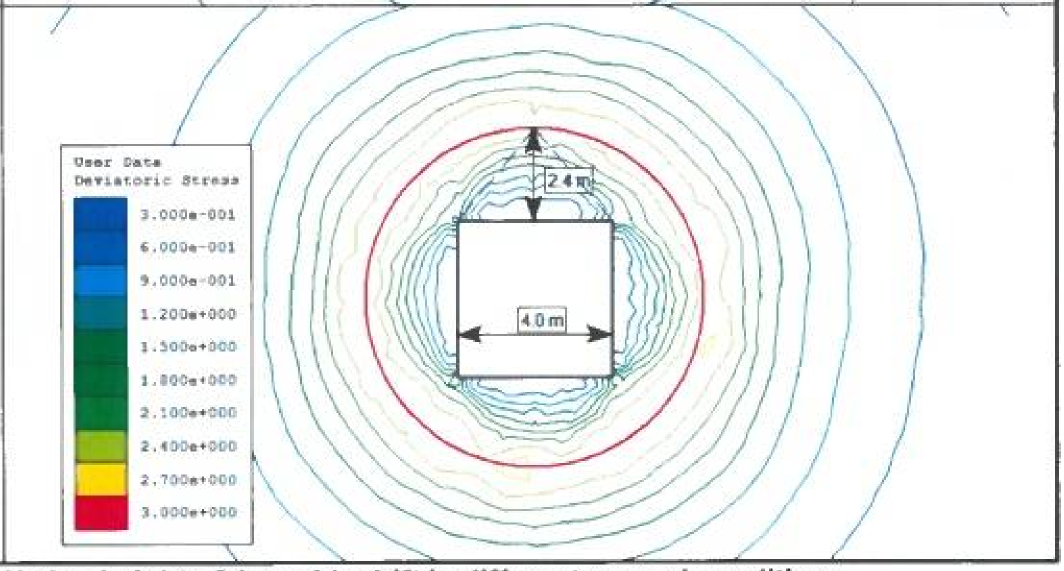
B = 5.0 m

H_w = 3.0 m

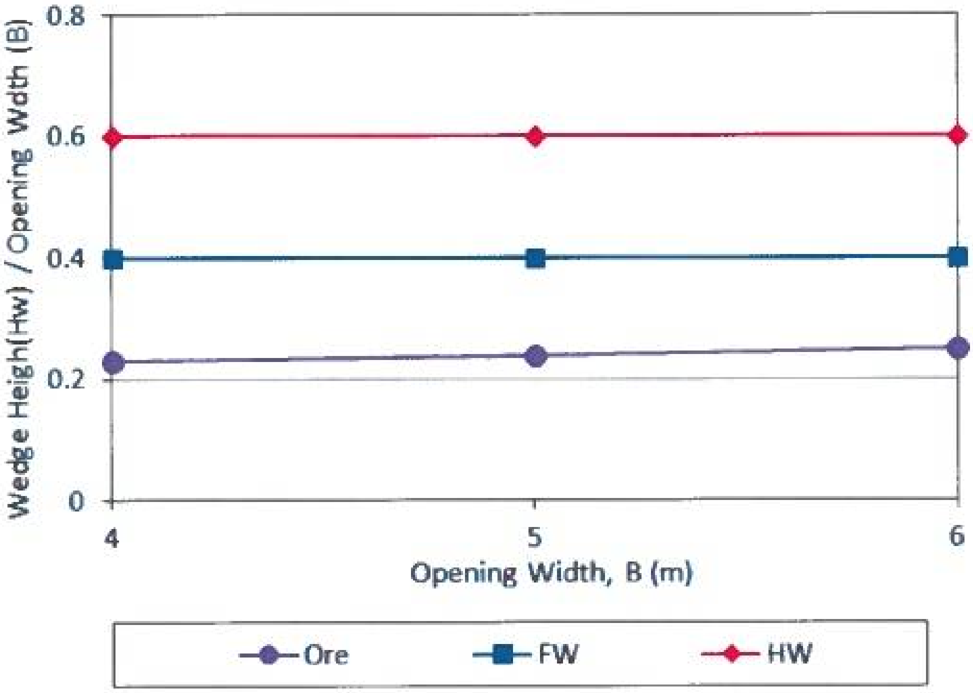
Hw / B = 0.60



Wedge height of 5 m wide drift in different ground conditions

ORE B = 4.0 m H_w = 0.9 m **<u>Hw / B = 0.23</u>**	
FW B = 4.0 m H_w = 1.6 m **<u>Hw / B = 0.40</u>**	
HW B = 4.0 m H_w = 2.4 m **<u>Hw / B = 0.60</u>**	

Wedge height of 4 m wide drift in different ground conditions

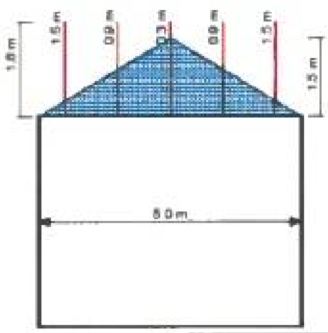
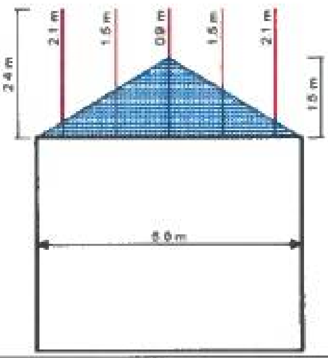
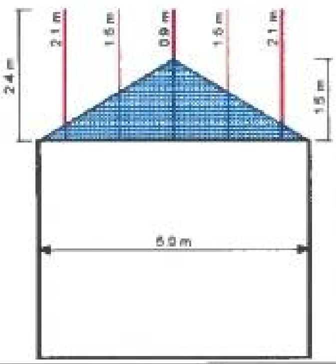
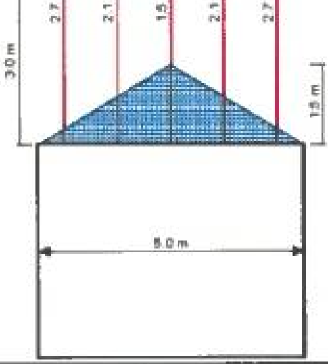


Parametric study on Wedge height/Opening width (Hw/B) versus Opening width (B) in different ground conditions (Ore, FW and HW)

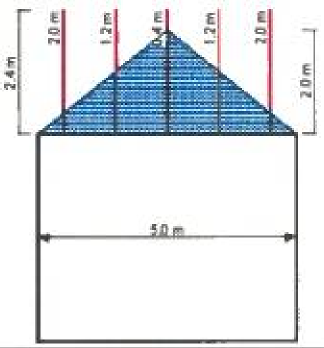
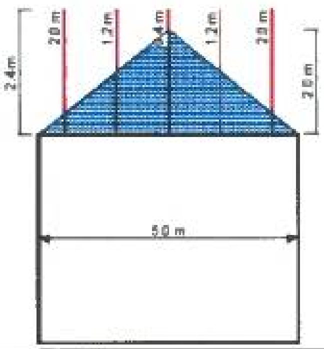
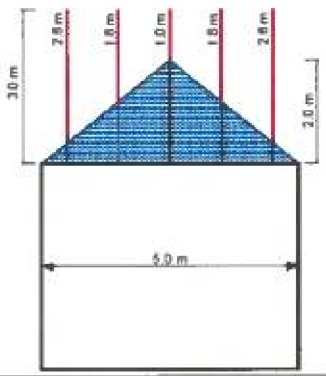
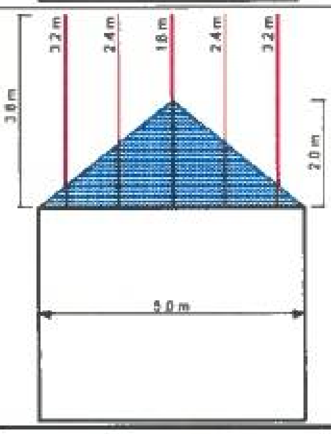
Applied Hw/B for different ground condition at Wolverine UG Mine

Ground Condition	ORE	FW	HW
Hw/B for Dead Weight Analysis	**0.3**	**0.4**	**0.6**

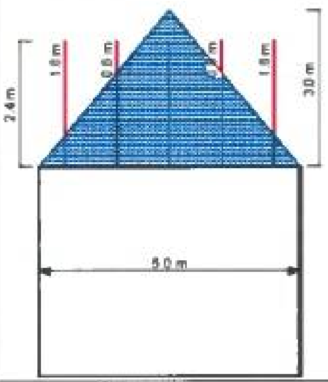
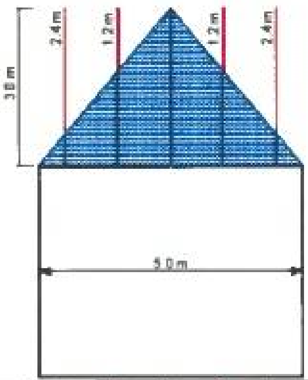
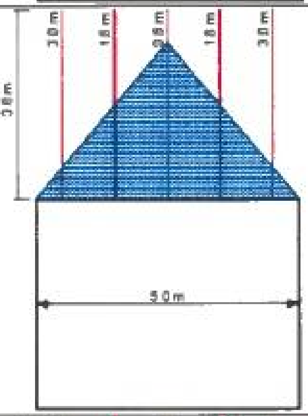
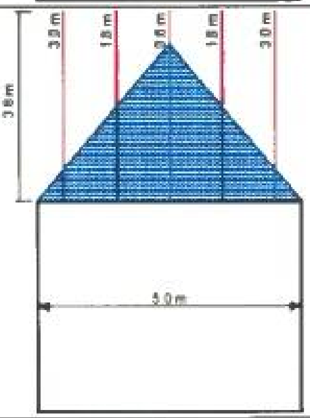
Factor of Safety (Opening Width < 5 m in Ore ground)

6' Split set		***Dead Weight of Wedge Block*** (5.0m × 1.5m) / 2 × 3.9 t/m^3 = 14.6 t ***Support Capacity*** (1.5×4.5×2×0.5 + 0.9×4.5×2 + 0.3×4.5) = 16.2 t Bond strength = 4.5 t/m (hard rock) Breaking strength = 10.6 t Max. effective length = 10.6/4.5 = 2.36 m **F.S = 16.2 / 14.6 = 1.1 (N.G)**
8' Split set		***Dead Weight of Wedge Block*** (5.0m × 1.5m) / 2 × 3.9 t/m^3 = 14.6 t ***Support Capacity*** (2.1×4.5×2×0.5 + 1.5×4.5×2 + 0.9×4.5) = 27.1 t Bond strength = 4.5 t/m (hard rock) Breaking strength = 10.6 t Max. effective length = 10.6/4.5 = 2.36 m **F.S = 27.1 / 14.6 = 1.9 (O.K)**
8' Reg. Swellex		***Dead Weight of Wedge Block*** (5.0m × 1.5m) / 2 × 3.9 t/m^3 = 14.6 t ***Support Capacity*** (11×2×0.5 + 11×2 + 0.9×9) = 41.1 t Bond strength = 9 t/m (hard rock) Breaking strength = 11 t Max. effective length = 11/9 = 1.2 m **F.S = 41.1 / 14.6 = 2.8 (O.K)**
10' Reg. Swellex		***Dead Weight of Wedge Block*** (5.0m × 1.5m) / 2 × 3.9 t/m^3 = 14.6 t ***Support Capacity*** (11×2×0.5 + 11×2 + 11) = 44 t Bond strength = 9 t/m (hard rock) Breaking strength = 11 t Max. effective length = 11/9 = 1.2 m **F.S = 44 / 14.6 = 3.0 (O.K)**

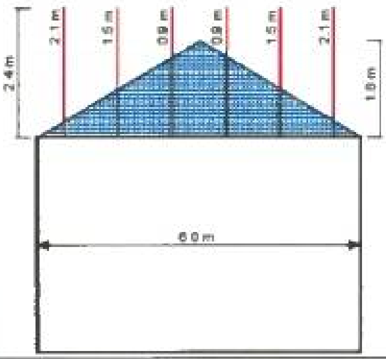
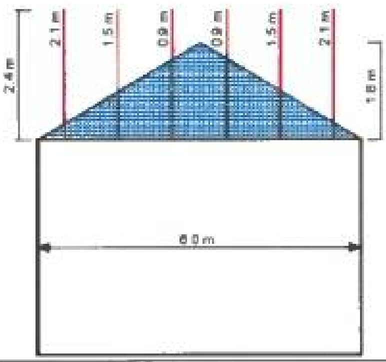
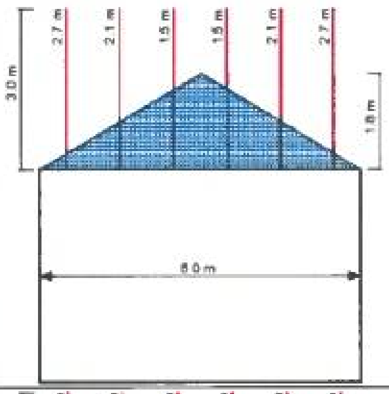
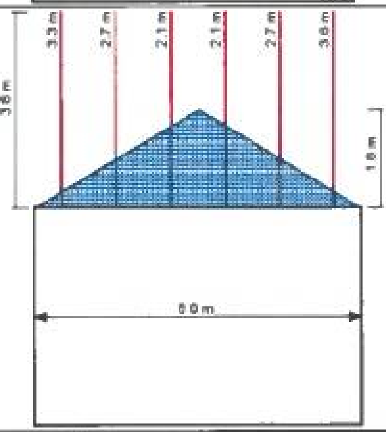
Factor of Safety (Opening Width < 5 m in FW ground)

8' Split set		***Dead Weight of Wedge Block*** (5.0m × 2.0m) / 2 × 3.9 t/m^3 = 19.5 t ***Support Capacity*** (2.0×2.5×2×0.5 + 1.2×2.5×2 + 0.4×2.5) = 12.0 t Bond strength = 2.5 t/m (weak rock) Breaking strength = 10.6 t Max. effective length = 10.6/2.5 = 4.24 m **F.S = 12.0 / 19.5 = 0.6 (N.G)**
8' Reg. Swellex		***Dead Weight of Wedge Block*** (5.0m × 2.0m) / 2 × 3.9 t/m^3 = 19.5 t ***Support Capacity*** (11×2×0.5 + 1.2×8×2 + 0.4×8) = 33.4 t Bond strength = 8 t/m (weak rock) Breaking strength = 11 t Max. effective length = 11/8 = 1.4 m **F.S = 33.4 / 19.5 = 1.7 (O.K)**
10' Reg. Swellex		***Dead Weight of Wedge Block*** (5.0m × 2.0m) / 2 × 3.9 t/m^3 = 19.5 t ***Support Capacity*** (11×2×0.5 + 11×2 + 1×8) = 41 t Bond strength = 8 t/m (weak rock) Breaking strength = 11 t Max. effective length = 11/8 = 1.4 m **F.S = 41 / 19.5 = 2.1 (O.K)**
12' Reg. Swellex		***Dead Weight of Wedge Block*** (5.0m × 2.0m) / 2 × 3.9 t/m^3 = 19.5 t ***Support Capacity*** (11×2×0.5 + 11×2 + 11) = 44 t Bond strength = 8 t/m (weak rock) Breaking strength = 11 t Max. effective length = 11/8 = 1.4 m **F.S = 44 / 19.5 = 2.3 (O.K)**

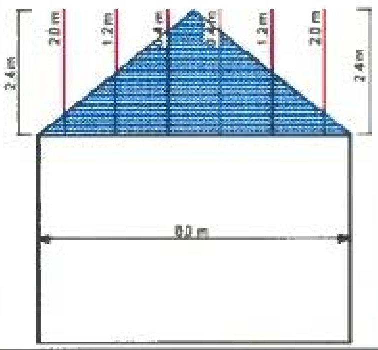
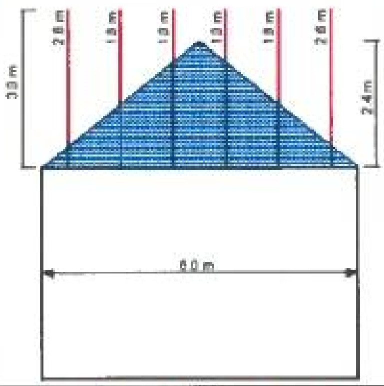
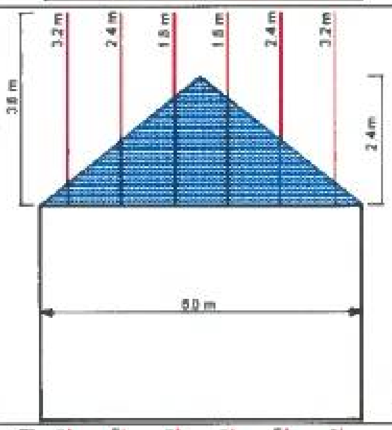
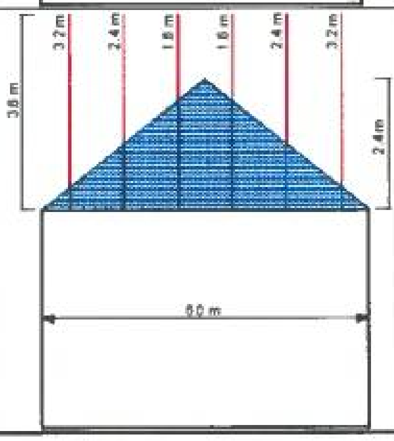
Factor of Safety (Opening Width < 5 m in HW ground)

8' Reg. Swellex		***Dead Weight of Wedge Block*** (5.0m × 3.0m) / 2 × 3.9 t/m^3 = 29.3 t ***Support Capacity*** (11×2×0.5 + 0.6×8×2) = 20.6 t Bond strength = 8 t/m (weak rock) Breaking strength = 11 t Max. effective length = 11/8 = 1.4 m **F.S = 20.6 / 29.3 = 0.7 (N.G)**
10' Reg. Swellex		***Dead Weight of Wedge Block*** (5.0m × 3.0m) / 2 × 3.9 t/m^3 = 29.3 t ***Support Capacity*** (11×2×0.5 + 1.2×8×2) = 30.2 t Bond strength = 8 t/m (weak rock) Breaking strength = 11 t Max. effective length = 11/8 = 1.4 m **F.S = 30.2 / 29.3 = 1.0 (N.G)**
12' Reg. Swellex		***Dead Weight of Wedge Block*** (5.0m × 3.0m) / 2 × 3.9 t/m^3 = 29.3 t ***Support Capacity*** (11×2×0.5 + 11×2 + 0.6×8) = 37.8 t Bond strength = 8 t/m (weak rock) Breaking strength = 11 t Max. effective length = 11/8 = 1.4 m **F.S = 37.8 / 29.3 = 1.3 (O.K)**
12' Super Swellex		***Dead Weight of Wedge Block*** (5.0m × 3.0m) / 2 × 3.9 t/m^3 = 29.3 t ***Support Capacity*** (22×2×0.5 + 22×2 + 0.6×12) = 73.2 t Bond strength = 12 t/m (weak rock) Breaking strength = 22 t Max. effective length = 22/12 = 1.8 m **F.S = 73.2 / 29.3 = 2.5 (O.K)**

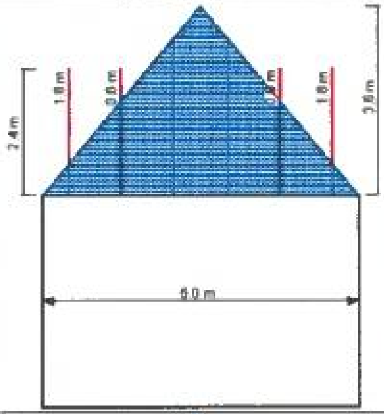
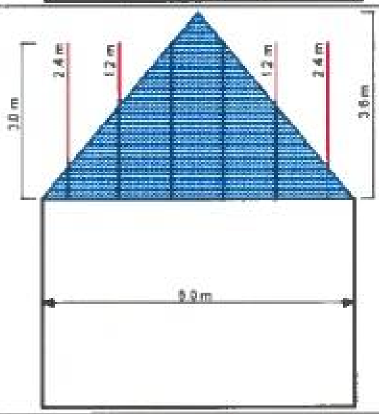
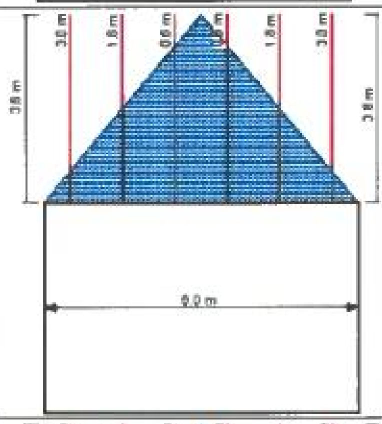
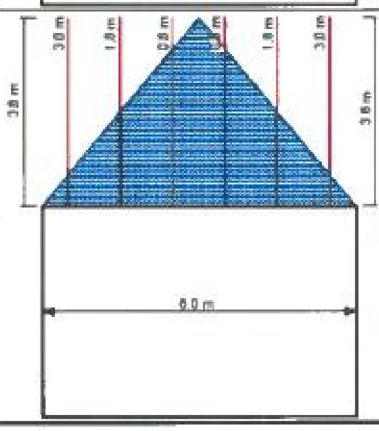
Factor of Safety (5 m < Opening Width < 6 m in Ore ground)

8' Split Set		***Dead Weight of Wedge Block*** (6.0m × 1.8m) / 2 × 3.9 t/m^3 = 21.1 t ***Support Capacity*** (2.1×4.5×2×0.5 + 1.5×4.5×2 + 0.9×4.5×2) = 31.1 t Bond strength = 4.5 t/m (hard rock) Breaking strength = 10.6 t Max. effective length = 10.6/4.5 = 2.36 m **F.S = 31.1 / 21.1 = 1.5 (O.K)**
8' Reg. Swellex		***Dead Weight of Wedge Block*** (6.0m × 1.8m) / 2 × 3.9 t/m^3 = 21.1 t ***Support Capacity*** (11×2×0.5 + 11×2 + 0.9×9×2) = 49.2 t Bond strength = 9 t/m (hard rock) Breaking strength = 11 t Max. effective length = 11/9 = 1.2 m **F.S = 49.2 / 21.1 = 2.3 (O.K)**
10' Reg. Swellex		***Dead Weight of Wedge Block*** (6.0m × 1.8m) / 2 × 3.9 t/m^3 = 21.1 t ***Support Capacity*** (11×2×0.5 + 11×2 + 11×2) = 55.0 t Bond strength = 9 t/m (hard rock) Breaking strength = 11 t Max. effective length = 11/9 = 1.2 m **F.S = 55.0 / 21.1 = 2.6 (O.K)**
12' Reg. Swellex		***Dead Weight of Wedge Block*** (6.0m × 1.8m) / 2 × 3.9 t/m^3 = 21.1 t ***Support Capacity*** (11×2×0.5 + 11×2 + 11×2) = 55.0 t Bond strength = 9 t/m (hard rock) Breaking strength = 11 t Max. effective length = 11/9 = 1.2 m **F.S = 55.0 / 21.1 = 2.6 (O.K)**

Factor of Safety (5 m < Opening Width < 6 m in FW ground)

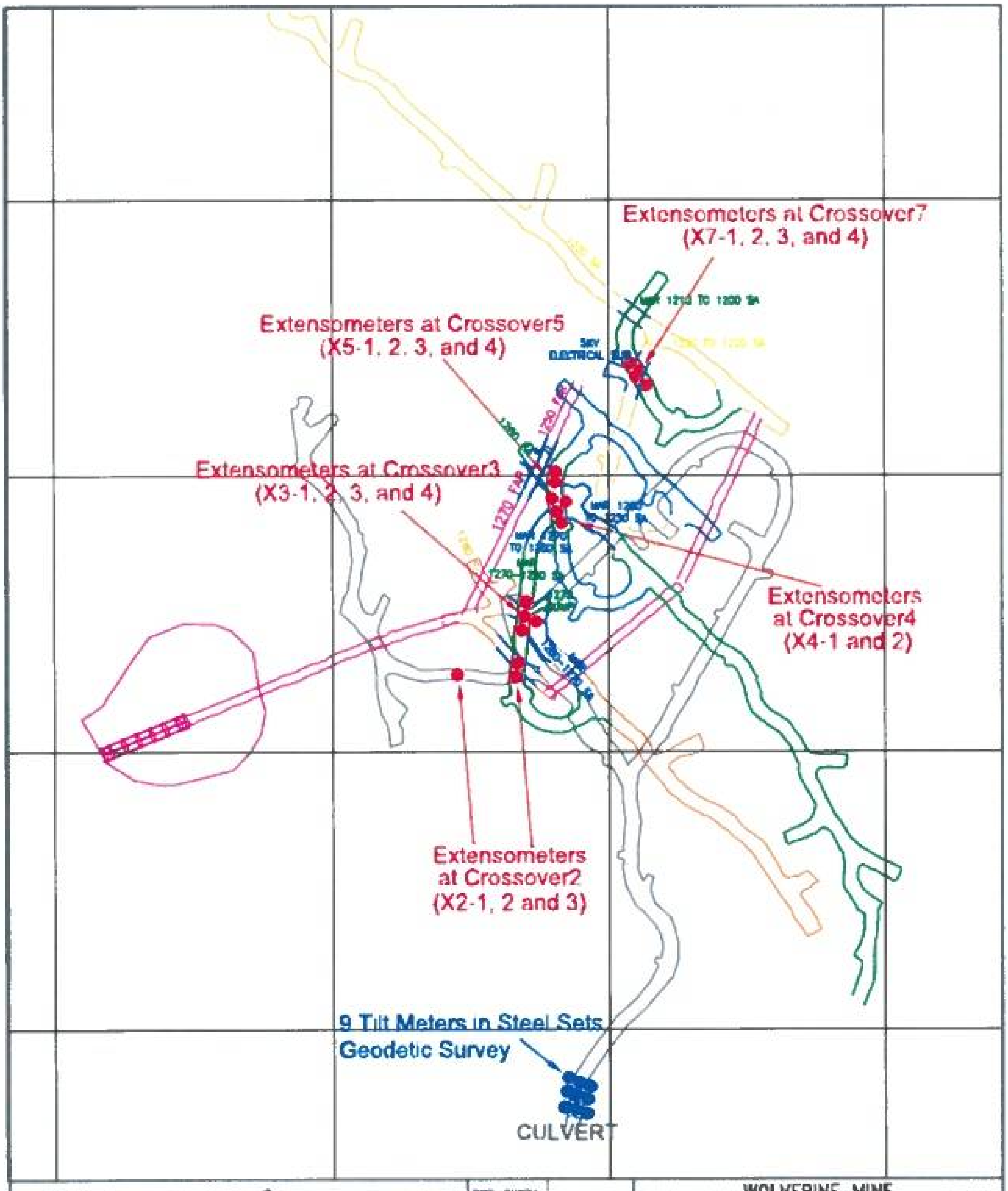
8' Reg. Swellex		***Dead Weight of Wedge Block*** (6.0m × 2.4m) / 2 × 3.9 t/m^3 = 28.1 t ***Support Capacity*** (11×2×0.5 + 1.2×8×2 + 0.4×8×2) = 36.6 t Bond strength = 8 t/m (weak rock) Breaking strength = 11 t Max. effective length = 11/8 = 1.4 m **F.S = 30.2 / 29.3 = 1.3 (O.K)**
10' Reg. Swellex		***Dead Weight of Wedge Block*** (6.0m × 2.4m) / 2 × 3.9 t/m^3 = 28.1 t ***Support Capacity*** (11×2×0.5 + 11×2 + 1.0×8×2) = 49.0 t Bond strength = 8 t/m (weak rock) Breaking strength = 11 t Max. effective length = 11/8 = 1.4 m **F.S = 49.0 / 29.3 = 1.7 (O.K)**
12' Reg. Swellex		***Dead Weight of Wedge Block*** (6.0m × 2.4m) / 2 × 3.9 t/m^3 = 28.1 t ***Support Capacity*** (11×2×0.5 + 11×2 + 11×2) = 55.0 t Bond strength = 8 t/m (weak rock) Breaking strength = 11 t Max. effective length = 11/8 = 1.4 m **F.S = 55.0 / 29.3 = 2.0 (O.K)**
12' Super Swellex		***Dead Weight of Wedge Block*** (6.0m × 2.4m) / 2 × 3.9 t/m^3 = 28.1 t ***Support Capacity*** (22×2×0.5 + 22×2 + 22) = 88.0 t Bond strength = 12 t/m (weak rock) Breaking strength = 22 t Max. effective length = 22/12 = 1.8 m **F.S = 73.2 / 29.3 = 3.1 (O.K)**

Factor of Safety (5 m < Opening Width < 6 m in HW ground)

8' Reg. Swellex		***Dead Weight of Wedge Block*** (6.0m × 3.6m) / 2 × 3.9 t/m^3 = 42.1 t ***Support Capacity*** (11×2×0.5 + 0.6×8×2) = 20.6 t Bond strength = 8 t/m (weak rock) Breaking strength = 11 t Max. effective length = 11/8 = 1.4 m **F.S = 20.6 / 42.1 = 0.5 (N.G)**
10' Reg. Swellex		***Dead Weight of Wedge Block*** (6.0m × 3.6m) / 2 × 3.9 t/m^3 = 42.1 t ***Support Capacity*** (11×2×0.5 + 1.2×8×2) = 30.2 t Bond strength = 8 t/m (weak rock) Breaking strength = 11 t Max. effective length = 11/8 = 1.4 m **F.S = 30.2 / 42.1 = 0.7 (N.G)**
12' Reg. Swellex		***Dead Weight of Wedge Block*** (6.0m × 3.6m) / 2 × 3.9 t/m^3 = 42.1 t ***Support Capacity*** (11×2×0.5 + 11×2 + 0.6×8×2) = 42.6 t Bond strength = 8 t/m (weak rock) Breaking strength = 11 t Max. effective length = 11/8 = 1.4 m **F.S = 30.2 / 42.1 = 1.0 (N.G)**
12' Super Swellex		***Dead Weight of Wedge Block*** (6.0m × 3.6m) / 2 × 3.9 t/m^3 = 42.1 t ***Support Capacity*** (22×2×0.5 + 22×2 + 0.6×12×2) = 80.4 t Bond strength = 12 t/m (weak rock) Breaking strength = 22 t Max. effective length = 22/12 = 1.8 m **F.S = 80.4 / 42.1 = 1.9 (O.K)**

APPENDIX – F.

INSTRUMENT LOCATIONS



YukonZinc CORP	DWG. CHECK		WOLVERINE MINE
	DESIGNED BY		Ground Monitoring Instrumentation Location
	DRAWN BY		
	DATE		
	SCALE:		DRAWING NO. / REV.
	PROJECT NO.	1614	

APPENDIX – G.

NON-CONFORMANCE RECORD FORM

GROUND CONTROL NON-CONFORMANCE RECORD

YukonZinc CORP

To:

From:

CC:

Date:

Re:

Date Non-conformance Recognised:____________________________

Location of Non-conformance: ____________________________
(see attached plan)

Type of Non-conformance:____________________________

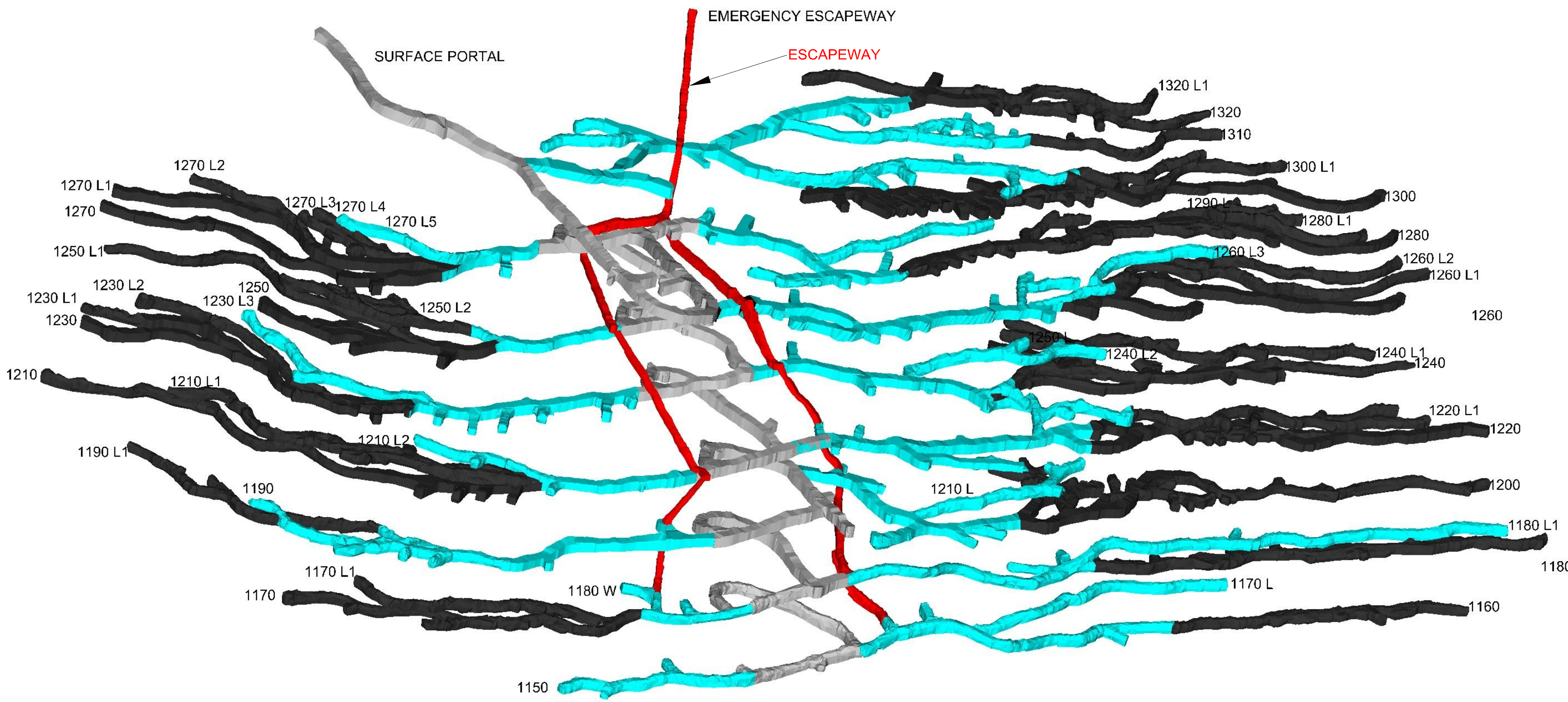
Required Corrective action: ____________________________
See attached support plan

Person(s) Responsible for Corrective Actions:____________________

Date Corrective Action Completed:____________________________

Signoff that Corrective action has been completed:

UG Geotechnical Engineer	
UG General Foreman	
Procon Superintendent	
Technical Superintendent	
UG Mine Manager	



BLUE - ACTIVE DRIFTS
BLACK - BACK FILLED DRIFTS

REFERENCE	
DWG No.	DESCRIPTION

REVISIONS					
No.	DATE	DESCRIPTION	BY	DES. LEAD APPL.	DES. AUTH. APPL.

YZC

SCALE :	1:1000	DATE	
DESIGNED:	C. REDMOND	130710	
DRAWN:			
CHECKED:			
DESIGN LEAD APPROVAL:			
DESIGN AUTH. APPROVAL:			

LOC. **WOLVERINE MINE**

AREA

TITLE
3D AS BUILT
ACTIVE AND BACK FILLED DRIFTS
JULY 10, 2013

DWG. No.

REV