

1.1 Slope Hazard Awareness Training



Slope Hazard Awareness Training

Argyle Diamond Mine, Rio Tinto

Vale Base Metals Surface Mines

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Mining 29/03/2022 version 4


Classification of information: confidential information.



1.2 Ontario Regulations

01 Requirements

Requirements



1.3 Ontario Regulations

01 Requirements

*'Any person accessing engineered or natural slopes **must** be trained in geotechnical hazard awareness, response and communication.'*

Vale Base Metals Surface Mine Geotechnical Standard –Clause 11.2



1.4 Ontario Regulations



Salobo Mine, Vale Base Metals

Requirements

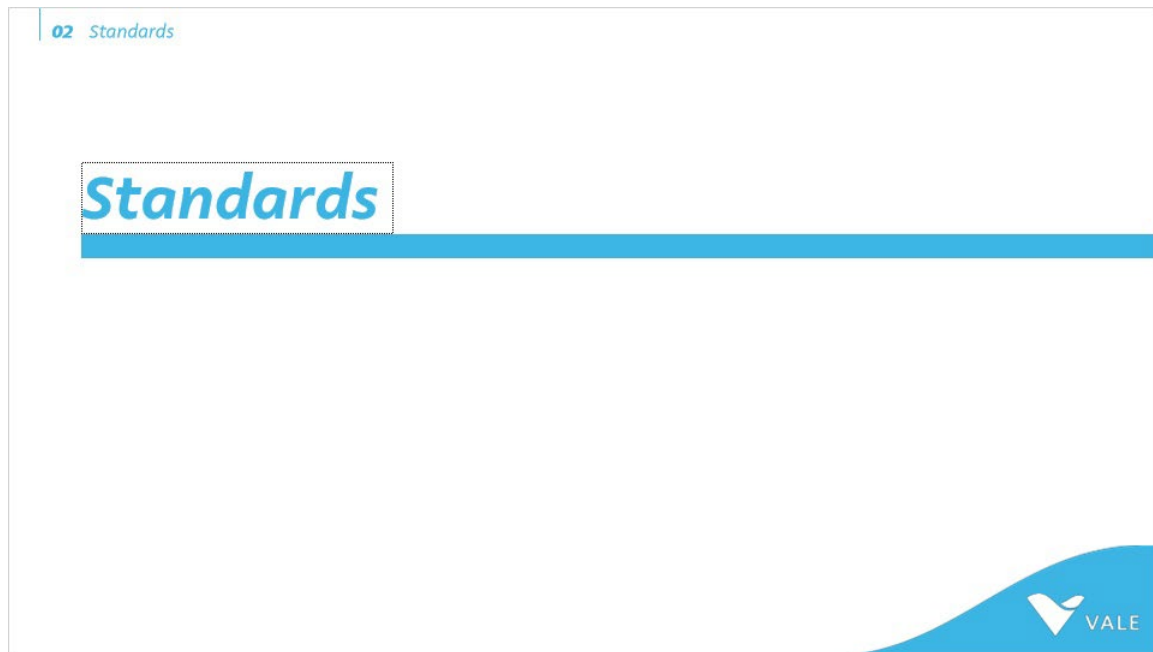
All personnel working near natural and engineered slopes must be either:

- A 'trained person' – a person who has completed this training as part of an induction.
- A Qualified Individual as defined by the Vale Base Metals Surface Mine Geotechnical Standard.
- Accompanied at all times by a trained person.

All slope hazard awareness training shall be administered by the relevant training department, and records maintained.



1.5 Ontario Regulations



1.6 Guidelines for Working on Energized Equipment

02 Standards

Standards

*Effective geotechnical risk management is a **continuous** process.*

There are two documents which should be read and understood:

- PGS-004032 Base Metals Surface Mine Geotechnical Standard

Purpose:
This standard covers the management of geotechnical hazards associated with engineered or natural slopes either temporary or permanent which occur on Vale Base Metals properties. It does not cover the design and management of tailings and/or water storage facilities.

- PGS-004814 Working Near Slope Crests and Toes without FOP Standard

Purpose:
The purpose of this procedure is to explain the process that must be followed when working on foot near slope crests, or without Falling Object Protection, (FOP), within 10 meters, 30 feet of slope toes.

VALE

1.7 Establish Safe Work Practices

02 Standards

Surface Mine Geotechnical Standard

The Surface Mine Geotechnical Standard comprises topic areas that are made up of **critical clauses**.

The Surface Mine Geotechnical Standard does **not** cover the design and management of **tailings** and/or **water storage facilities**.

The Surface Mine Geotechnical Standard will be **reviewed** at least every **2 years**.

Surface Mine Geotechnical Standard



PGS-004832, Rev.: 01-15/01/2021

Issuer Board: Vale Base Metals Executive Committee
Owner: Name: Vale Base Metals Head of Geology, Mine Design and Geotechnical
Target Audience: All Vale Base Metals employees
Training Needed: (x) YES () NO

Purpose:
This standard covers the management of geotechnical hazards associated with engineered or natural slopes either temporary or permanent which occur on Vale Base Metals properties. It does not cover the design and management of tailings and/or water storage facilities.

APPLICATION

This standard applies to Vale Base Metals globally, including its related companies.

PREPARED

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REVIEWED

- All Vale Base Metals 1st Line and Vale 2nd Line senior geotechnical personnel.

CONTENT

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Vale Base Metals Surface Mine Geotechnical Standard



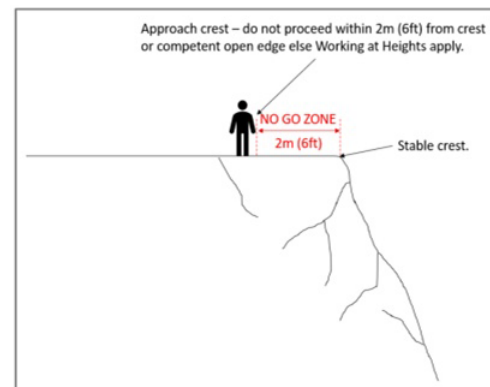
1.8 Working on Energized Equipment

02 Standards

Surface Mine Geotechnical Standard

PGS-004814 explains the process that must be followed when working on foot near slope crests and toes. It describes:

- the **hazards** of entering within or working near slope toes and crests, such as:
 - Open edges;
 - Sudden collapse of the crest of a slope;
 - Slope or Dump instability;
 - Individual, isolated rock falls.
- the **control measures** that must be put in place, such as:
 - Joint Risk Analysis prior to entering;
 - Safe distances;
 - "NO-GO zones".



Example of No GO zone illustration near all open edges



1.9 Select to Continue

02 Standards

Placing and Parking Equipment

All mining equipment shall be operated as per their **Standard Operating Procedures (SOP)**.

In addition to the SOPs and unless specified otherwise, the following general recommendations shall be respected:

- Implement control measures, such as pre-start inspections;
- Respect safety bunds and topographic markers;
- Operate near a slope with tracks facing the slope (avoid being parallel);
- Park in a safe and designated location, away from slope toes and crests.



1.10 Ontario Regulations

03 Incidents

Incidents



1.11 Electrical Energized Work Permit

03 Incidents

Slope Failure Resulting in Fatalities



Corrego do Feijao Mine slope failure resulting in 1 fatality



Wedge failure impacting spotter resulting in 1 fatality



1.12 Electrical Energized Work Permit

03 Incidents

Slope Failure Resulting in Fatalities, Continued



Slope failure impacting haul ramp



Truck has rolled over into lake at pit bottom resulting in 1 fatality



1.13 Electrical Energized Work Permit

03 Incidents

Slope Failure Impacting Equipment



Flatbed truck parked inappropriately. Vehicles should not be parked near slopes. If this can not be avoided, vehicles should be reverse parked.



Slope failure impacting haulage truck.



1.14 Electrical Energized Work Permit

03 Incidents

Other Significant Slope Failures



Carmen Copper Mine slope failure resulting in 4 fatalities, 6 missing



Gamsberg Mine slope failure resulting in 2 fatalities



1.15 Electrical Energized Work Permit

03 Incidents

Other Significant Slope Failures, Continued



Mina Pecket Mine slope failure resulting in cessation of mining
(yellow bar is 200m long for scale)



1.16 Ontario Regulations

04 Common Terms

Common Terms



1.17 Establish Safe Work Practices

04 Common Terms

Access way is a primary route of travel for personnel and equipment.

Batter is an element of a slope formed by excavation or placement and having a uniform inclination.

Bench is an approximately flat surface with extent limited by adjacent batters and formed by excavation of natural ground.

Crest is the edge forming the upper part of the slope (slope crest) or batter (batter crest).

Drop zone is a distance extending from the toe of a batter or slope, which rock fall impacts are possible and beyond, which rock fall impacts are considered very unlikely.

Falling Object Protection (FOP) is additional reinforcement added to a machine's operator cabin to provide protection from falling objects.

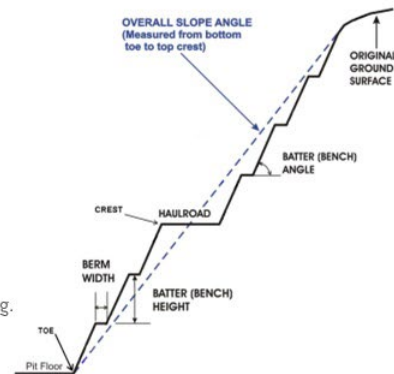
Trained person refers to a person that has completed slope hazard awareness training.

Tip head is a location where spoil or waste material is tipped so that it rolls/slides down a dump face until it reaches a toe.

Toe refers to the edge forming the base of all the sloping sections of a mine slope.

Windrow/Bund/Safety Berm is a formed pile of dirt at the slope toe or crest used to prevent access to the toe of a slope or an open crest.

Open Pit Mining Terms



1.18 IS THIS ELECTRICAL WORK?



Oyu Tolgoi Mine, Rio Tinto

Geological Terms

Discontinuity, or defect, are the terms used to describe a broad range of geological structural features, including:

- Faults.
- Bedding.
- Joints.

The orientation and characteristics of these surfaces may interact with each other or the excavated walls causing the wall to collapse during or following mining.

Photograph of Oyu Tolgoi Open Pit Mine with some defects visible in the excavated walls.

1.19 IS THIS ELECTRICAL WORK?

04 Common Terms

Other Significant Slope Failures



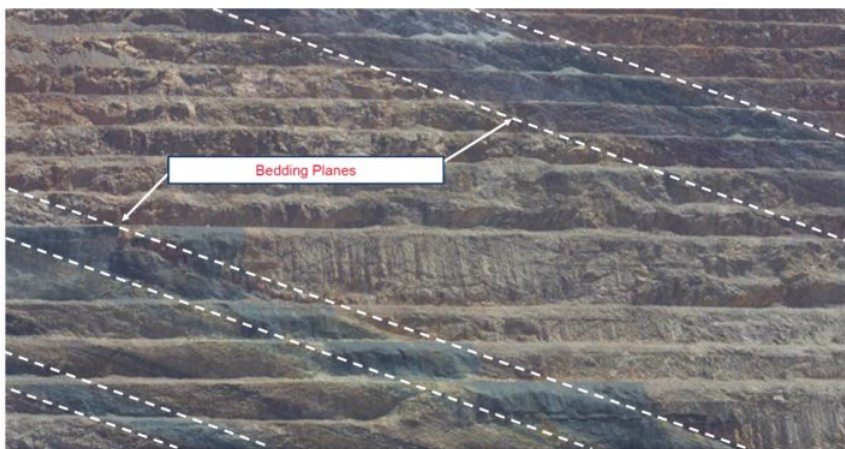
Faults – a fracture along which movement has taken place.



1.20 IS THIS ELECTRICAL WORK?

04 Common Terms

Geological Term – Bedding



Bedding – An arrangement of layers or beds of rock.



1.21 IS THIS ELECTRICAL WORK?

04 Common Terms

Geological Term – Joint



Joint – A fracture along which no movement has taken place.



1.22 Ontario Regulations

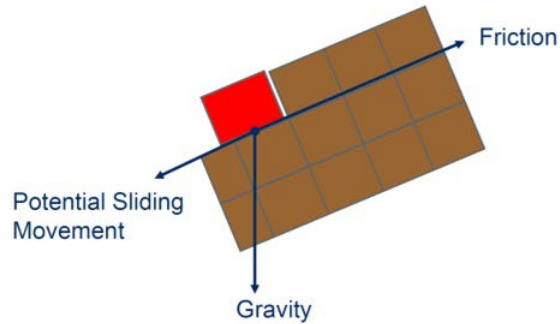
05 Failure Modes

Failure Modes



1.23 IS THIS ELECTRICAL WORK?

05 Failure Modes



Conceptual model of planar sliding failure mode.

Failure Modes

Slope failures may be broadly classified into two types:

Rock type failures – these are generally caused by discontinuities, or defects, within the rock.

Soil type failures – these generally occur due to low strength of the soil mass.



1.24 IS THIS ELECTRICAL WORK?

05 Failure Modes

Planar Sliding



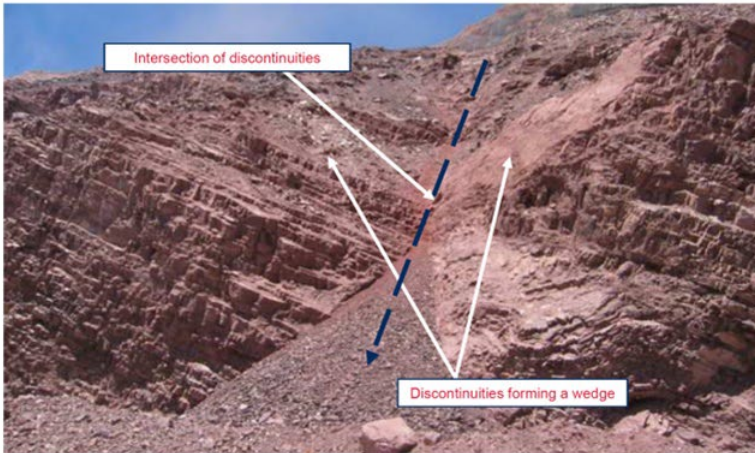
Bedding can be hazardous depending on the orientation with respect to excavated slopes. Avoid undercutting bedding.



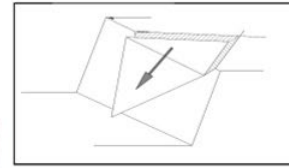
1.25 IS THIS ELECTRICAL WORK?

05 Failure Modes

Wedge Failure



Look out for intersecting defects that form wedges in slopes. These may fail suddenly.



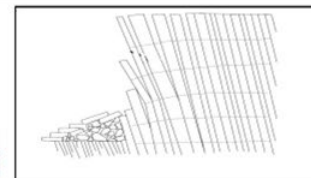
1.26 IS THIS ELECTRICAL WORK?

05 Failure Modes

Toppling Failure



One of the hardest failure mechanisms to manage is toppling failure. Requires continuous defects that dip steeply into the face as well as an orthogonal set which acts as a basal failure plane.



1.27 IS THIS ELECTRICAL WORK?

05 Failure Modes

Instances of multiple failure modes

B-Pit, Thompson



Different sectors of the pit can present different hazards:

- Footwall: mainly planar sliding
- Hanging wall: toppling and wedges failures



Major discontinuities on the footwall, guiding the historical slope angles.



Discontinuities steeply dipping into the pit along with orthogonal set(s). Rockfall hazard mitigation included significant scaling, as well as fencing.



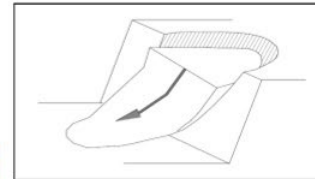
1.28 IS THIS ELECTRICAL WORK?

05 Failure Modes

Circular Failure



Example of a circular failure in weak soil.



1.29 IS THIS ELECTRICAL WORK?

05 Failure Modes

Mining Induced Failures

Slope failures can also be due to:

- Surface and groundwater – can cause movement due to pressure on failure planes, lubrication of failure planes, erosion (undercutting of slope), or additional weight to the failing mass. Precipitation related events, such as intense rainfall and freeze-thaw cycles, can increase these effects.
- Blasting – can cause benches to fail and loosen blocks (vibrations & blast gases).
- Inappropriate slope design – not appropriate for the geotechnical conditions.
- Quality of excavation or slope maintenance – walls left with rocks hanging, over-steepened or without appropriate maintenance in time.
- Subsidence due to underground mining.



1.30 IS THIS ELECTRICAL WORK?

05 Failure Modes

Surface and Groundwater

The presence of water impacts upon stability as follows:

- Changes in effective stress.
- Increase in material weight due to saturation.
- Reduced friction (provides uplift).
- Provision of lateral force.



Ok Tedi Copper-Gold Mine.

The presence of water will always increase risk of instability!

Photograph of Ok Tedi Copper-Gold Mine showing the impact of surface water run-off on slope stability.



1.31 IS THIS ELECTRICAL WORK?

05 Failure Modes

Water and Time

External influences and exposure in time also impact slope stability:

- Erosion, especially from run-off water and major rainfall events.
- Lack or impossibility of access for maintenance.

Conditions of historical or non-active slopes should be assessed with care, especially upon re-entry.



26/04/2006, 12h04 PM: pre-collapse w/ side cracks.



26/04/2006, 12h07 PM: failure



Photographs of 2006 highwall slope failure in Goro, New-Caledonia.



1.32 IS THIS ELECTRICAL WORK?

05 Failure Modes

Subsidence from UG Mining

Underground caving mining methods entail subsidence propagating to the ground surface. Slopes and ground conditions in these areas should always be treated with caution, as:

- Precise definition of the subsidence area is challenging.
- Subsidence areas evolve (extend) with time.
- Caved material is likely heterogenous and with voids.

Do not approach the cracks and the known subsidence boundaries!




Evolution of subsidence area in Frood-Stobie (satellite images).



1.33 Ontario Regulations

06 Monitoring

Monitoring



1.34 Ontario Regulations

06 Monitoring

*'Each asset shall have a formal and adequate **risk-based slope monitoring strategy** and plan in place that has been approved by a Qualified Individual. The requirements shall be aligned with the maturity of the asset.'*

Vale Base Metals Surface Mine Geotechnical Standard – Clause 9.1



1.35 IS THIS ELECTRICAL WORK?

06 Monitoring



Geotechnical hazards are common in open pits and we rely on people who work in the pit to identify and report these hazards.

Geotechnical hazards in open pits include; rockfall, bench failure, inter-ramp failure and overall slope failure.

Visual Observations

The best monitoring tool is the personnel who work within the pit.

We rely on you to use your eyes and ears to report geotechnical hazards to colleagues, supervisors, and geotechnical staff.

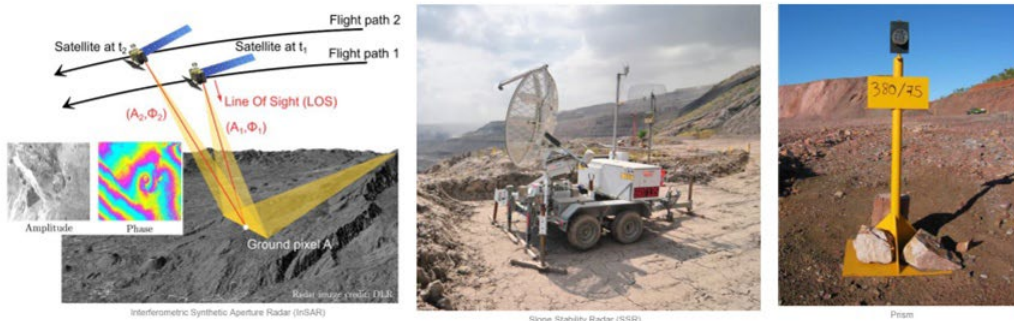
This aim of this training is to increase your awareness of the potential geotechnical hazards.



1.36 IS THIS ELECTRICAL WORK?

06 Monitoring

Instrumentation



Examples of instruments that can be used to monitor slope stability.



1.37 IS THIS ELECTRICAL WORK?

06 Monitoring

Trigger Action Response Plans

'Monitoring systems shall have multi-level alarm thresholds defined with associated Trigger Actions Response Plans (TARPs).' Vale Base Metals Surface Mine Geotechnical Standard – Clause 9.3

Example of simple GO-STOP TARP

Trigger	GO	STOP
Visual observation	No visible signs of deterioration or movement	Visible movement: cracking, rockfall; raveling, etc.
Slope protection	Fence / nets in place and undamaged	Fence / nets displaced, damaged or with fallen material hanging
Weather	Dry	Wet; rain / heavy snow
Radio communications	Clear uninterrupted communications	Poor or no clear communications

Inspection findings and instrumentation results should be checked against pre-defined thresholds. These can be summarized in Trigger Action Response Plans (TARPs), along with roles and responsibilities for the different trigger levels.

Example of Trigger-Levels TARP

Wall Failure – TARP				
TRIGGER LEVEL AND ACTION RESPONSE PLANS / Any one of the triggers will cause an increase in TARP level.				
Trigger / Movement	Level 1 Trigger	Level 2 Trigger	Level 3 Trigger	Level 4 Trigger
Radar Movement	Less than 2 mm/yr.	Rate of rise movement is between 2 to 4 mm/yr.	Rate of rise movement is between 4 to 6 mm/yr.	Rate of rise movement is 6+ mm/yr.
Extensometer	No movement.	The velocity profile is constant.	The velocity profile shows signs of acceleration.	The velocity profile shows signs of acceleration.
Visual	No visible signs of wall degradation.	Cracks observed in catch benches or other faces.	Cracks observed in catch benches or other faces, which is open after grading.	Slope instability equal to or greater than bench top is observed.
Persons Affected	Level 1 Response	Level 2 Response	Level 3 Response	Level 4 Response
Geotechnical	Monitor cracks, monitor cracks in the face. Update daily conditions at Open Pit scheduled daily meetings.	Increase monitoring frequency and potentially install other systems such as crack meters. Notify Geotechnical Superintendent and Operations Supervisor. Update daily conditions at Open Pit scheduled daily meetings.	Increase monitoring frequency over a 24hr period. Update information meeting and observation. Be aware of change in slope behavior with respect to stability. Usually inspect the area if required. Review of available monitoring data. Recommend specific action to P1 Superintendent.	Notify Geotechnical Superintendent. Provide detailed and the operations supervisor. Investigate and analyze the monitoring results. Provide recommendations to Operations Superintendent.
Geotechnical Sup.	Review monitoring data on a weekly basis.	Review data interpretation. Notify Operations Superintendent.	Notify when Technical Service Manager / Operations Support. Set up Geotechnical Hazard Remediation (GHR) meeting.	Evacuate potentially affected personnel and equipment from Open Pit. Provide evacuation point of contact if Geotechnical Engineer can't be reached. Evacuate implementation and monitor progress of GHR remediation.
Pit Operations Supervisor			Isolation of affected area above and below potential failure zone. Inform/Update to Geotechnical Engineer on duty. If geotechnical engineer on duty can't be reached, allow mining operations close to danger. Follow instructions from Geotechnical engineer on duty.	Evacuate potentially affected personnel and equipment from Open Pit. Secure area at risk to prevent entry. Inform/Update Open Pit Superintendent.
Manager - Operations			Notify when Technical Service Manager / Operations Support. Notify General Manager - Operations.	Evacuate personnel and equipment from Open Pit. Secure pit excavation and access control are implemented. Notify General Manager - Operations.

Geotechnical hazards in open pits include; rockfall, bench failure, inter-ramp failure and overall slope failure.



1.38 Ontario Regulations

07 Warning Signs

Warning Signs



1.39 IS THIS ELECTRICAL WORK?

07 Warning Signs

Warning Signs Prior to Failure

What to look for:

- Dribbling of rocks, material or small block falls.
- Cracks or joints opening up in bench or mine floor.
- Changes in line or level of benches.
- Floor heave.
- Unexpected movement of material.
- Overhangs of material.
- Rills of material (stream-like flow) at the wall slope toe.
- Bulging of the wall batters.
- Increase or decrease in water flow and/or water ponding.
- Failure of ground support.



1.40 IS THIS ELECTRICAL WORK?

07 Warning Signs



Bench with visible tension cracks indicating instability.

Tension Cracks



1.41 IS THIS ELECTRICAL WORK?

07 Warning Signs



Rilling

Slope exhibiting active rilling of material; small size material acting similar to a stream, going down the slopes.



1.42 IS THIS ELECTRICAL WORK?

07 Warning Signs

Rock Fall



Rock blocks at base of slope indicating slope instability.



1.43 IS THIS ELECTRICAL WORK?

07 Warning Signs

Slumping



Slumping of slopes is also a sign of instability.



1.44 IS THIS ELECTRICAL WORK?

07 Warning Signs

Floor Heave




Cracks opening up and floor heave may be signs of an imminent large scale slope failure.



1.45 Ontario Regulations

08 Reporting

Reporting



1.46 Ontario Regulations

08 Reporting

*'All geotechnical incidents **must** be addressed, recorded and communicated.' 'A mine-wide geotechnical risk assessment with relevant disciplines must be carried out yearly and results must be captured in a **risk register**. Controls shall be implemented in a timely manner.'*

Vale Base Metals Surface Mine Geotechnical Standard – Clauses 6.5 and 7.1



1.47 Ontario Regulations

08 Reporting

If you see a geotechnical hazard or if you have any concerns, you should move out of the area and report it immediately to colleagues, supervisors and geotechnical staff.

Kennecott Copper Mine, Rio Tinto





1.48 IS THIS ELECTRICAL WORK?

08 Reporting

Reporting Tools

SLAM Managing Risk to ALARA

SAFE PROTECT

Stop-Look-Assess-Manage form (page 1/2).

Appendix X - Check list Perception of Safety and Geotechnical Risks on Slopes

Vale Issuing management: Area: Número da OM/OS: Nº of SWP:


Issuer name: Signature: Date / / Time

Accredited performer name: Signature: Date / / Time

Items to be inspected

1. Are there cracks on the edge of the activity / upper slope?	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> N/A
2. Are there any rebates on the side of the road?	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> N/A
3. Is there a water / saturation stain on the slope?	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> N/A
4. Is there a negative slope or an inadequate slope?	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> N/A
5. Does the slope have an inappropriate height for carrying the equipment?	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> N/A
6. Do the shoulders below and above the workplace not have isolated access?	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> N/A
7. Is the slope at risk of falling blocks or loose blocks on the crest?	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> N/A
8. Is there an accumulation of water on the side of the upper bench?	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> N/A
9. Were any identification marks pertinent to the execution of the activity identified?	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> N/A
10. Is there evidence of material slippage?	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> N/A
11. Don't you feel able to perform the activity?	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> N/A
12. Is the equipment not compatible with the activity?	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> N/A
13. Is the lighting not sufficient to carry out the activity?	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> N/A
14. Are the climatic conditions not suitable for the activity?	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> N/A
Mitigation actions	
Are mitigation actions necessary?	<input type="checkbox"/> Yes <input type="checkbox"/> No
Describe the necessary mitigation actions:	

Safe Work Permit checklist for slopes – extract from Vale PNR-000031



Rock blocks at base of Examples of documentation to support slope or ground condition assessments, by all personnel. slope indicating slope instability.

1.49 Any further questions?

*Any further questions
contact your Supervisor*



1.50 Start The Module Quiz



***Thank you for completing the
Vale Online Module Training.***

To start the module Quiz

[CLICK HERE](#)