P

APPENDIX P

Pit Stability Assessment from the Martha Underground Mine (PSM)

Anderson Lloyd

PROJECT MARTHA

ASSESSMENT OF THE IMPACT OF PROPOSED UNDERGROUND MINING ON THE MARTHA OPEN PIT PHASE 4

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1 INTRODUCTION

This report contains an assessment of the potential impacts of the proposed Martha Underground mine on the stability of Martha Phase 4 Pit (MP4). The geological and geotechnical conditions; and material properties adopted in this report are based on previous PSM investigations and analyses for the Waihi Operations (summarised in Section 2.3 of this report). Extracts of previous reports have been reproduced here where relevant.

Reference should be made to a companion report on the MP4 for detail on the geotechnical conditions and the rock mass model, PSM125-282R.

An aerial view of the Site is shown in Figure 1. The proposed MP4 and Martha Underground are shown in Figures 2 to 4.

2 BACKGROUND

2.1 General

The Waihi Gold operation (OcenaGold) consists of a mineral and mining complex located within the township of Waihi, approximately 125 km south east of Auckland, New Zealand.

Gold was first discovered in Martha in 1878 and was mined by underground method between 1882 and 1952. The Martha open pit operation (Martha Pit) began in 1988, mining remnant material adjacent to historical mining areas and backfill material (of ore grade) from historical cut and fill workings. The pit began in 1988 as the Licenced Pit, progressing to the Extended Pit, the South Stability Cutback and the East Layback; before the pit was closed temporarily in 2015. The closure resulted from the north wall failure.

The underground workings comprise a number of mineralised veins termed lodes, of which the main ones are the Martha, Empire, Royal and Albert and lodes. Workings within these loads are commonly referred to the “Martha Workings”, etc.

Detailed records are available for the period of open cut mining (approaching 30 years), while only limited records of varying quality are available for the 70 year period of underground mining.

OceanaGold is proposing to cutback the north wall failure and complete the East layback pit at depth. The current and proposed Martha Pits are shown in Figures 5 and 6.

2.2 Historical Martha Underground Mine Impacts

Mining at Waihi started in 1878 and comprised two main phases:

- Underground mining, 1878 to 1952.
- Open cut mining 1988 to present.

The Martha Mine and it immediate environs have experienced a very long period of deformation and subsidence due to the historical underground mining. This has been collectively referred to in this report as subsidence.

The classic model for deformations of the rock mass around a planned underground caving operation entails three concentric zones:

Zone 1 Caved Zone

The central zone comprising a completely broken rock mass, with particle sizes ranging from very large blocks to silt size.

Zone 2 Disturbed Zone

A zone around the central zone comprising a disturbed rock mass, possibly with block sliding on shears, opening and weathering of joints, noticeably increased fracturing and minor local caved zones. In places the intact rock appears altered or weathered.

Zone 3 Deformed Zone

An outer zone surrounding the inner two zones within which there have been smaller displacements. The rock appears intact, but there is noticeable staining of rock substance and defects; together with an increase in fracturing compared to fresh intact rock at depth.

In simple terms, the overall underground system at Waihi can be conceptualised in terms of this classic model, with the exceptions that because of geometry and layout of the underground workings the zones are skewed towards the south, southeast and east.

Zones 2 and 3 (the Disturbed and Deformed Zones) were thought to be poorly developed in the north. However, the North Wall Failure has now shown this is not the case and the northeast area did lie in a Disturbed Zone. There is no evidence of any of these Zones in the west and northwest of the pit. Further to the east where the more recent volcanic layers (Ignimbrite Zone) overlies the Andesite these zones are masked.

Historical records indicate that caving around the Milking Cow region first occurred accidentally due to loss of ground control during mining. Thereafter caving of selected areas of the Martha Lode was carried out. In addition because of historical re-mining, other large scale collapses of other stopes also occurred during early underground mining.

In summary the underground deformation model as it is currently understood comprises the following elements:

1. Widespread but small magnitude subsidence over caved zones.
2. Creep movement of large blocks of deformed and disturbed rock masses.
3. Block subsidence or settlement, with some block rotation.
4. Local chimney development leading to sinkhole collapse formation at the surface.

2.3 Investigations and Analyses Undertaken to Date

PSM has been providing advice and slope design for the Waihi Operations since 1985 and that experience forms the basis of the understanding of the geotechnical behaviour of Martha Pit. Listed below in chronological order are the main documents. These documents have been selected principally because they include important information on data, testing, geotechnical drilling, rock mass logging, geotechnical parameters and studies carried out to evaluate the zones of the rock mass adversely affected by underground mining.

July, 2003 – 2002-2003 Geotechnical Investigations (PSM125.R28):

a. The report was undertaken in response to a number of subsidence events in 1999 and 2001 related to historical underground workings.

b. The report bought together all elements of historical and current information at that time to provide an overall understanding of events to assess the future stability related to underground workings.

c. The report included:

   - a review of subsidence events,
   - new drilling, mapping, geophysics, monitoring, laboratory testing, groundwater data and development of the geological, geotechnical and hydrogeological models,
   - development of a model for understanding caving, subsidence and collapse, and
   - stability assessment of the southeast wall including the Pump House.

April, 2006 – Report on Pit Closure Studies (PSM125.R34):

a. This study, also termed the South Stability Cutback (SSC), was undertaken for the planned pit closure based on Mining Licence Conditions.

b. The report included:

   - a summary of geotechnical information gathered since 1999,
   - updating of the geotechnical model including rock mass parameters and further delineation of zones potentially affected by underground workings,
   - reassessment of the long term factors of safety of all pit walls at final depth and flooding depths, and
   - recommendations on ongoing safety, stability and monitoring following closure.

January, 2010 – East Layback, Pit 66D (PSM125.R39):

a. This report presented the design for the Eastern Layback, Pit 66D.

b. The report included:

- a review of historical slope performance at Martha,
- a review of the major destabilising influences that have resulted from the legacy of underground workings,
- an update of geological and geotechnical conditions in the cutback,
- an update of the geotechnical model following additional drilling, and
- stability assessment of the pit walls.

January, 2011 – Strength Zones Interpretation, Pit 64A and 66D (PSM125-207M):

Presentation of the interpreted deformed and disturbed zones as exposed in Pit 64A, and the proposed pit, Pit 66D.

March, 2015 – North Wall Stability Review (PSM125-235R):

Review of the North Wall including recent and historical movements together with geotechnical and groundwater information to inform the current geotechnical model and recommendations on implications of future mining.

May, 2015 – North Wall Stability Update (PSM125-237R):

An updated assessment of the eastern half of the North Wall.

October, 2016 – Report on the North Wall Failure (PSM125-252R):

A comprehensive report that summarises and discusses the North Wall Failure in relation to previous studies and geotechnical understanding of the North Wall.

3 AIMS AND OBJECTIVES

The main objective of this study is to assess the potential impacts of the proposed Martha Underground mine on MP4 and surrounding areas.

The analysis includes the latest data describing topography, lithology, previous underground workings, proposed underground workings and major structures. Other inputs include the compressibility and the strength of the rock mass and major structures, the mining sequence, the influence of stope backfill, and in-situ stress regime. The sensitivity of material parameters and assumptions adopted in this assessment were tested using a number of cases.

The focus for the analyses was on assessing:

- The magnitude and distribution of displacements due to Martha Underground development,
- The potential for localised failure of the rockmass,
- The degree of interaction between existing underground workings, Martha Underground and MP4; and
- The sensitivity of the results to changes in parameters or assumptions.

4 DATA SOURCES

The 3D wire frame surfaces listed below were provided by OceanaGold and used to set up the geometry of the numerical model. These comprised:

- Geotechnical units (100_AQF.00T.dwg, 101_UPPER ANDESITE.00T.dwg,300_TUFF.00T.dwg,400_UWIG.OOT.dwg, 401_WIG.00T.dwg);
- Existing pit surface (May2017_Pit_Topo.dxf),
- Phase4 pit surface (Surface Final Ph4.dxf),
- Existing filled stopes (UG_Filled_Stope_01.dxf),
- Existing unfilled stopes (UG_Unfilled_Stope_01.dxf),
- Existing unfilled stopes to be filled (backfilledtri.dm),
- Proposed new stopes (R Stp WF v4 Avoca.dxf, R Stp WF v4 Remnant.dxf, R Stp WF v4 Remnant.dxf); and
- Underground mining sequence (OCG-Monthly Schedule.pdf).

5 GEOLOGY

5.1 Lithologic Units

The following description of the geology is taken in part from Newmont Waihi Gold (NWG) *"Notes on the Geology of Martha Mine".* The descriptions are of a general nature and some lithology and their descriptions may differ from the geotechnical descriptions provided later in this report.

Gold mineralisation is mainly contained in quartz veins within a low sulphidation epithermal vein system hosted by Miocene calc-alkaline volcanics of the Coromandel Volcanic Zone. Locally this host rock is termed Andesite.

The main east-north-east trending veins are (from north to south): Martha, Welcome, Empire and Royal. The Martha dips steeply south while the other veins dip steeply north. The Albert and Edward Lodes trend north. Numerous smaller veins and veinlets between the major lodes also contain gold. Ore grade mineralisation extends for 1600 metres along strike with a width of 500 metres and was mined to 600 metres below surface.

After erosion of some hundreds of metres of the hydrothermal system, the andesite formed a fossil hill with a thin layer of eluvial and alluvial deposits. Subsequently, the hill and its surrounds were covered with a sheet of ignimbrite to 50 m thickness. In turn, the hill was eroded from the top of Martha Hill, leaving a window of andesitic outcrop containing the vein system, surrounded by ignimbrites on three sides.

A blanket of geologically recent rhyolitic ash to 4 m thickness covers another layer of eluvial quartz over ignimbrite.

The latest stratigraphic column for the Waihi area describes three main geological units within the pit:

- Andesite: this is a variably jointed, high strength rock with a surficial layer of variable weathering/alteration and a zone of deep oxidation along the main lode. This unit contains the gold mineralisation. In local areas of the pit, the andesite is extensively clay-altered in which rock clasts are contained by and within a soft clay matrix, forming a low strength soil mass.
- Younger (contact) andesite, also termed the Younger Andesite or the “Blue Shear”: this unit immediately overlies and is distinguishable from the main andesite as a low to high strength, blue grey coloured, variably sheared and variably clay altered rock.
- Ignimbrite Zone: this forms the more recent overburden overlying the mineralised andesite host rocks. It is thickest in the east south-east but also extends into the west of the pit. The Ignimbrite Zone includes a range of material types including welded and un-welded ignimbrites, tuff, alluvium, and recent brown ash. The welded ignimbrite is a relatively high strength rock while the other units exhibit a range of engineering strengths. Minor amounts of non-engineered fill overlie the Ignimbrite Zone.

5.2 Geologic Structure

The Martha Pit is intersected by a relatively minor number of geological faults, the majority of which exhibit parallel trends to the mineralisation zones and are steeply inclined. These faults have had minimal influence on pit stability over the last 20 years of open pit mining. The exception to this was the north wall failure, which occurred partly along a structure dipping to the south.

6 MODEL DEVELOPMENT

6.1 General

The base component of this study was the development of a 3D mechanical model to allow assessment of the potential impacts of past and proposed Martha Underground on the MP4 and surrounding areas. The 3D mechanical model was based on a 3D geometric model that included the latest geometric data describing topography, lithology, existing open pit, Phase 4 open pit, previous underground workings and proposed underground workings. The plan extent of the model is shown in Figure 1.

The geometric model was discretised down to a minimum characteristic length of around 5m for numerical analysis. The numerical analysis of the mechanical model was carried out using the commercial software *FLAC3D by Itasca*. Collectively the geometric and mechanical models are referred to in this report simply as the numerical model

6.2 Geometry

The geometry of the numerical model is shown in Figure 7. This region represents a block of ground 2000 m wide and 1500 m long in plan and varying in thickness from 710 to 730 m. North-south and East-west sections through the numerical model are shown in Figures 8 and 9. The existing and MP4 pits are shown in Figure 10 and 11. The historical and proposed stopes are shown in Figures 13 to 16.

Unit and pit geometries for the numerical model were developed using the following procedure:

1. Extrapolation and partial smoothing of the unit boundary and topographic surfaces provided.
2. Repair, interpolation and smoothing of pit shells provided to remove geometric anomalies and facilitate integration with unit boundaries
3. Intersection of boundary surfaces and interpolated pit shells to form a solid block model.

Generally interpolated surfaces closely match the surfaces provided. However, some modifications were required and consequently some areas of the pit are slightly different to design in some locations. The maximum variation is around 5 to 10m.

Stopes and cave affected zones were identified using the following procedure:

1. Input the geometry surfaces of stopes and cave affected zones based on mine design wire frames, as developed in PSM125-282R.
2. Subdivide and densify elements selected by their proximity to the design or historical surfaces.
3. Group the elements inside and within a specified distance of the design or historical surfaces.

An example of the local element densification based on proximity to geometry is shown in Appendix A. This approach is commonly adopted to approximate the material property changes on a very irregular boundary, when exact conformation to the surface is not critical. In this case exact matching was not considered critical because it was assessed this would not affect the predicted performance of the MP4 or surrounding areas, which is one focus of this study.

The method used to model stope geometries means that there will be some geometric differences between the numerical model and design. The numerical model is generally geared to be conservative by capturing a greater volume than the design in order to ensure the predictions are conservative. Comparisons of the volumes of the modelled stopes with the design volume, provides a means of quantifying the degree of conservatism. This comparison is shown in Table 6.1. Two different volumes of stopes have been simulated in different runs to assess the impact of changes in the stope volumes on the results.

TABLE 6.1
COMPARISON OF STOPE DESIGN AND MODEL VOLUMES

STOPES	VOLUMES ESTIMATED FROM DESIGN (m^3)	% OF TOTAL DESIGN VOLUME OF STOPES	INITIAL VOLUME 1 MODELLED (m^3 and % difference compared with design)	SENSITIVITY VOLUME 2 MODELLED (m^3 and % difference compared with design)
Proposed New Stopes	1,722,097	54%	1,779,271 (103%)	2,887,357 (168%)
Historical Unfilled Stopes	1,012,899	31%	1,519,550 (150%)	2,481,311 (245%)
Historical Filled Stopes	482,719	15%	729,889 (151%)	1,332,726 (276%)
Total Volume	3,217,715	100%	4,028,710 (125%)	6,701,394 (208%)

6.3 Material Properties

Geological and geotechnical conditions for the 3D numerical model are based on previous studies carried out by PSM and the recent geotechnical update contained in PSM125-282R. The main geotechnical units included in the numerical model are:

- Welded Ignimbrite,
- Unwelded Sandy Ignimbrite,
- Tuff,
- Younger Andesite, and
- Andesite.

Rock mass properties for all units are shown in Table 6.2. The unit weight, Young's modulus, cohesion and friction angle of the rock units are taken from PSM125.R39 Table 10.2 identified as softened strengths. These softened strengths were derived from back analysis of the two east wall failures and then checked against residual strengths from multi-stage shear box testing of intact material. The tensile strengths of the rock units are calculated based on the assumption of tensile/cohesion ratio of 0.25. The Poisson's ratios of the rock units are taken from previous *FLAC3D* modelling. These values were based on PSM experience.

TABLE 6.2
MATERIAL PARAMETERS FOR MATERIAL UNITS

UNIT	UNIT WEIGHT (KN/M^3)	YOUNG'S MODULUS (MPA)	POISSON'S RATIO	STRENGTH		
				COHESION (kPa)	FRICTION ANGLE (°)	TENSILE (kPa)
Welded Ignimbrite	25	8000	0.2	330	60	82.5
Unwelded Ignimbrite	21	1000	0.2	35	30	8.75
Tuff	17	1000	0.25	20	40	5
Younger Andesite	20	700	0.2	40	25	10
Andesite - Undisturbed	27	8700	0.2	400	65	100
Andesite - Deformed	26	5800	0.2	70	40	17.5
Andesite - Disturbed	26	2200	0.2	50	40	12.5
Andesite - Caved	22	600	0.2	5	35	1.25

The backfill material properties used for the stopes are shown in Table 6.3. The properties for stiff silty clay and loose rockfill were based on PSM experience. The properties for cemented aggregate rockfill (CAF) were based on published research and advice from AMC.

TABLE 6.3
MATERIAL PARAMETERS FOR BACFILL MATERIALS OF STOPES

BACKFILL MATERIALS	UNIT WEIGHT (kN/m^3)	YOUNG'S MODULUS (MPa)	POISSON'S RATIO
Historical Filled Stopes – Stiff Silty Clay	19	30	0.3
Proposed New Stopes – Loose Rockfill	20	10	0.25
Proposed New Stopes – Cemented Aggregate Fill (CAF)	22	200	0.25

Stopes voids were modelled as a highly compressible elastic material rather than a true open void. This is to avoid numerical instability and prevent over closure of the stope walls.

6.4 Discretisation

The model mesh adopted used increasing element sizes from about 5 m in the vicinity of the open pits and stopes to around 30 m at the model boundaries. This resulted in a total mesh density of about 3.4 million elements for the model. The meshes of the geotechnical units, pits and stopes are shown in Figures 7, 10 to 16. This mesh density allowed a multitude of model and sensitivity runs without unduly penalising the accuracy.

6.5 In-situ Stress

Site-specific in-situ stress data for the site is limited to acoustic emissions measurements on oriented core by Curtin University of Technology. PSM are not aware of any direct stress measurements. As a consequence of this uncertainty the in-situ stress field was assumed based on the assessment of in-situ stress made by AMC in the Favona Underground Mine (AMC 2007), the Curtin University of Technology summary findings and published data on regional stress distribution. The two stress regimes adopted in the modelling are shown in Table 6.4. Different runs were carried out to assess the sensitivity of displacements to the change in magnitude of the in-situ stress.

TABLE 6.4
STRESS REGIME (AMC, 2007)

REGIME A (MOST LIKELY)		REGIME B (MOST ADVERSE)	
Magnitude	**Direction**	**Magnitude**	**Direction**
S1 = 2.5 Sv	NE-SW	S1 = 2.5 Sv	NE-SW
S2 = 1.0 Sv	NW-SE	S2 = 1.5 Sv	NW-SE
S3 = 1.0 Sv	Vertical down	S3 = 1.0 Sv	Vertical down

Notes: S1 is the major principal stress, S2 is the intermediate principal stress, S3 is the minor principal stress and Sv is the vertical stress.

7 NUMERICAL ANALYSIS

7.1 General

The numerical model was used to predict changes in stress and displacement as a consequence of proposed mining development. Analyses included an initial equilibration step to allow in-situ stress to reach equilibrium followed by multiple development stages.

7.2 Staging

The numerical analysis consisted of the following stages:

- Initialisation of in-situ stresses using the pre-mining topography,
- Excavation of the historical underground stopes and pit
- Placement of backfill in historically filled stopes
- Simulating the North Wall failure as loose rock fill,

- Staged excavation of the proposed MP4,
- Staged mining of Martha Underground in yearly progressions from 2020 (Year 2) to 2027 (Year 9).

The Martha Underground sequence modelled was based on a simplification and interpretation of the planned staging. Yearly stages were deemed sufficient to capture time dependent stress changes. An exploded view of underground mining sequence is shown in Figure 17. It should be noted that Year 1 mainly includes the underground drive development, which is not explicitly simulated in the model. The sensitivity of the responses of a staged excavation compared to a single complete excavation was checked by a sensitivity analysis. The sensitivity of the sequence of excavation of the historical underground stopes and pit is also investigated by a sensitivity analysis.

7.3 Sensitivity Analyses

Sensitivity analyses were undertaken to bracket the effects of parameters with the least confidence and potentially highest impact. Based on the understanding of the site and previous experience the sensitivity studies focused on:

- Sequencing of the underground workings,
- The presence or absence of backfill for the historical and planed stopes;
- Variation in parameters for the stope backfill materials,
- Changes in magnitude of in-situ stress,
- Variations in the volume of the stopes; and
- The extent of the Caved Zones.

7.4 Model Cases

A summary of the model cases is presented in
Table 7.1. If the input parameter is not mentioned in Runs 2 to10, it is the same as the condition in Run 1. A summary of the backfill condition is presented in Table 7.2.

TABLE 7.1
SUMMARY OF MODELLING CASES

RUNS	COMMENTS
Run 1	The base case to model planned mining and provide a basis for comparison with other runs: • Stope backfill material with loose rockfill as shown in Table 6.3 • Stope volumes modelled as Volume 1 in Table 6.1 • Caved Zones are in Andesite only as shown in Figure 11 • In-situ stress Regime A in Table 6.4 • Excavation of the historical pit before the historical underground workings
Run 2	Assessment of the sensitivity to the sequence of the underground mining: • Stope excavation simulated as one single stage
Run 3	Assessment of the absence of backfill for the proposed stopes: • New stopes modelled as voids
Run 4	Assessment of the sensitivity to stope backfill properties: • Stope backfill modelled as CAF, Table 6.3.
Run 5	Assessment of the sensitivity to in-situ stress: • Changing in-situ stress to Regime B, Table 6.4.
Run 6	Assessment of backfilling historical unfilled stopes near the pit surface: • Backfilling historical unfilled stopes 30 m below MP4 pit surface with CAF before commencing proposed underground workings
Run 7	Assessment of impacts of large changes in stope volume: • Stope volumes modelled as Volume 2 in Table 6.1
Run 8	Assessment of extending the Caved Zones: • Caved Zones extended to Younger Andesite as shown in Figure 12
Run 9	Assessment of the sensitivity to historical mine sequence • Excavation of the historical underground workings before the historical pit
Run 10	Assessment of the effects of backfilling historical unfilled stopes near the pit surface with the historical mine sequence as in Run 9: • Excavation of the historical underground workings before the historical pit • Backfilling historical unfilled stopes 30m below MP4 pit surface with CAF before commencing proposed underground workings

TABLE 7.2
SUMMARY OF MODELLED BACKFILL CONDITIONS

RUNS		BACKFILL CONDITION		
		HISTORICAL FILLED STOPES	**HISTORICAL UNFILLED STOPES**	**PROPOSED NEW STOPES**
1	Backfill Type	Stiff Silty Clay	None	Loose Rockfill
2	Backfill type	Stiff Silty Clay	None	Loose Rockfill
3	Backfill type	Stiff Silty Clay	None	None
4	Backfill type	Stiff Silty Clay	None	CAF
5	Backfill type	Stiff Silty Clay	None	Loose Rockfill
6	Backfill type	Stiff Silty Clay	CAF only in the top 30m of the MP4 pit surface	Loose Rockfill
7	Backfill type	Stiff Silty Clay	None	Loose Rockfill
8	Backfill type	Stiff Silty Clay	None	Loose Rockfill
9	Backfill type	Stiff Silty Clay	None	Loose Rockfill
10	Backfill type	Stiff Silty Clay	CAF only in the top 30m of the MP4 pit surface	Loose Rockfill

Note: The material properties of Stiff Silty Clay, Loose Rockfill and CAF are referred to Table 6.3.

8 RESULTS

8.1 General

The assessment of the modelling results has focussed on the predicted displacements and strains. Displacements reflect movement in response to stress change while strains reflect the rate of change of displacement over distance. High strains represent areas where there is a rapid change in displacement over a short distance but not necessary large displacements overall. Strains, therefore, do not reflect actual instability but highlight areas where material may be over stressed and therefore close to available capacity. Consequently, emphasis has been placed on displacement results as:

- It is a more direct measure of potential pit wall instability and
- It can be compared to measured data from the existing pit.

Given the pit scale and rockmass properties PSM expect that displacements of the order of up to 0.5 m and strains up to 2% or less unlikely to result in stabilities larger than bench scale.

Analyses have incorporated a number of mine sequencing assumptions as some details are not explicitly known at this time. These details include the exact sequence of historical underground mining and which stopes are to be backfilled with CAF under the design allowance of 30%. In most cases the assumed model sequence reflects the more adverse impact of global pit wall stability. Sensitivity of these assumptions is tested in other runs. A further conservatism is that the method of simulating stopes generally incorporates a volume of elements that exceeds the design volume as shown in Table 6.1.

A more comprehensive set of results for Runs 1 to 10 is included in Appendices B to K. All reported displacements (shown in metres) and strains in the appendixes are incremental changes. For each run, the following predictions are included in each appendix:

- Total displacement Year 9,
- Total yearly displacements,
- Maximum shear strain Year 9,
- Maximum yearly shear strain,
- Total displacement of Section 1 Year 9,
- Total yearly displacement of Section 1,
- Maximum shear strain of Section 2 Year 9,
- Maximum yearly shear strain of Section 2,
- Maximum shear strain of Section 3 Year 9 and
- Maximum yearly shear strain of Section 3.

The locations and geology conditions of Sections 1, 2 and 3 are shown in Figures 21, 25 and 28.

8.2 Base Case – Run 1

Run 1 is considered to be the base case of the planned Martha Underground. This run includes a number of assumptions that provide a relatively conservative prediction of global pitfall stability including:

- Loose rockfill material (in Table 6.3) for stope backfilling everywhere, and
- A more adverse historical mine sequence whereby excavation of the historical pit occurs before the historical underground workings.

These assumptions are considered to be less conservative for the assessment of the local stability around the stopes as this reverse historical mine sequence means the historical stopes are not subjected to full development of the historical pit.

The predicted total displacements for Year 9 (final stage) are around 0.2 m and occur in the east wall, with the maximum occurring in the disturbed zone of the east wall. There are also localised displacements in the historical unfilled stopes at the toe of the north wall.

These results are shown in:

- Plan in Figure 18,
- Section 1 (through the maximum total displacement on the east wall) in Figure 19,

- Displacement vectors of the section is shown in 20, and
- Relation to the geology in Figure 21.

Figure 22 and 23 show the annual displacements in plan and section for Run 1. The displacements increase steadily from Year 2 to Year 9. The predicted maximum total displacement Year 9 (final stage) is about twice the predicted displacement after Year 5.

Maximum shear strains on the south wall are predicted to be about 1% in the deformed zone of the south wall. There are localised strains greater than 1% predicted in the historical unfilled stopes at the bottom part of the pit. These results are shown in:

- Plan in Figure 24,
- Two sections (Section 2 and Section 3) in Figures 25 and 28,
  - Section 2 is cut through the maximum shear strain on the south wall,
  - Section 3 is cut through the maximum shear strain on the east wall,
- Displacement vectors of these two sections are shown in Figures 26 and 29.
- The strains in relation to geology along these two sections are shown in Figures 27 and 30.

Figures 31 to 33 show in plan and section respectively the predicted maximum shear strain per stage for Run 1. It is noted the strains on the south wall start to develop after Year 5.

The maximum displacements and strains occur at different locations of the pit surface. From the geology section cutting through the maximum displacements on the east wall (Figure 21), it can be seen that the historical and proposed stopes are further away from the pit surface in that location so there are smaller strains developed from the yielding of the rock mass. While from the geology section cutting through the maximum strains on the south and east wall (Figures 27 and 30), the historical and proposed stopes are closer to the pit surface so greater yielding and strains are resulted in these locations.

Overall, there is no global slope instability found in MP4 based on the displacement and strain results discussed above. However, there is the potential for localised (bench scale) instabilities at the pit surface in some areas above the historical stoping. When the actual historical mine sequence (excavation of historical underground workings before the historical pit) is simulated there are more locations in the lower part of the north wall showing the potential localised instabilities. This will be further discussed in Section 8.10.

From the displacement results the extent of these localised instabilities is up to 60 m on the pit surface in the model. However, it is expected that the modelled size is overstated as the modelled volume of the historical stopes is greater than design as shown in Table 6.3. Furthermore, the historical unfilled stopes are modelled as effectively open using a highly compressible material. This results in relatively high closures and localised strains in historical stopes in the elements close to the stope boundaries. These localised displacements and strains can be reduced by backfilling the historical unfilled stopes.

However, this has no material effect on the displacements and strains on the pit walls. This is discussed further in Section 8.7.

8.3 Effect of Proposed Mine Sequencing – Run 2

For Run 2 all underground development was simulated as a single stage. This allows the impact of staging to be assessed by comparing Run 2 with analysis runs with staging. The total displacements of the final stage (after Year 9) of Runs 1 and 2 are shown in Figures 18 and 34. The maximum shear strain for the final stage (after Year 9) of Runs 1 and 2 are shown in Figures 24 and 35. The full sets of the results of Run 1 and Run 2 are included in Appendices B and C.

Comparison of the Run 1 and 2 results shows that Run 2 (without modelling the detailed sequence of the underground mining) slightly increases the predicted displacements (from 0.2 m to 0.23 m) and strains. This is expected as the use of a single excavation step results in more rapid stress development. Logically any increase in the number of stages such as a change from yearly to quarterly stages would show a further reduction in predicted displacements. In reality mine development will be continuous and therefore stress transference and displacements will be gradual.

8.4 Effect of Backfilling of Stopes – Run 3

The impact of no backfill within the proposed new stopes is simulated in Run 3. This effect was modelled by filling the new stopes with a highly compressible elastic fill. The total displacement of the final stage (Year 9) of Runs 1 and 3 are shown in Figures 18 and 36. The maximum shear strain of the final stage (Year 9) of Runs 1 and 3 are shown in Figures 24 and 37. The full sets of the results of Run 1 and Run 3 are shown in Appendices B and D.

Comparison of the predicted displacements and strains between Run 1 and Run 3 indicates that the backfilling of the proposed stopes has a very strong influence on the inferred stability of the pit. The results presented here suggest a significant increase in displacements (from 0.2 m to 0.8 m) and strains would occur if proposed stopes were not backfilled. These results emphasise the integral role of backfill in proposed mining to limit displacements well below these hypothetical values.

8.5 Effect of Backfilling Properties – Run 4

Different sets of properties were used to assess the sensitivity of the results to stope backfill properties, namely stiffness. An elastic compressibility of 10 MPa was used in Run 1 to simulate loose rockfill while 200 MPa was used in Run 4 to simulate CAF. The total displacement of the final stage (Year 9) of Run 1 and Run 4 are shown in Figures 18 and 38 being a maximum of 0.2 m and 0.08 m respectively. The maximum shear strain of the final stage (Year 9) of Runs 1 and 4 are shown in Figures 24 and 39. The full sets of the results of Runs 1 and 4 are shown in Appendices B and E.

Runs 1 and 4 are identical except for the backfill properties. Comparison of the predicted displacements and strains between Runs 1 and 4 indicates that the results are sensitive to the backfill properties. Comparison of the results of Run 1 (loose rockfill) with Run 4 (CAF) shows a reduction in the maximum displacements (from 0.2 m to 0.08 m) and maximum shear strains (from 1 % to 0.2 %) on the pit wall. Overall a 20 fold increase in backfill stiffness only resulted in a 2.5 fold reduction in displacement and a 5 fold reduction strain. To a large extent it is the presence of backfill alone that causes the most significant reduction in displacement and strain rather than it's stiffness.

8.6 Effect of In-situ Stress – Run 5

The effect of higher in-situ stress regime is simulated in Run 5. These results should be compared to Run 1. The total displacement of the final stage (Year 9) of Runs 1 and 5 are shown in Figures 18 and 40. The maximum shear strain of the final stage (Year 9) of Runs 1 and 5 are shown in Figures 24 and 41. The full sets of the results of Run 1 and Run 5 are shown in Appendices B and F.

The predicted deformations and strains are very similar between Run 1 and Run 5, which suggests that the modelling is not very sensitive to in-situ stress magnitude assumptions.

8.7 Effect of Backfilling Historical Unfilled Stopes near the MP4 Pit Surface - Runs 6 & 10

The effect of backfilling historical unfilled stopes near the MP4 pit surface is simulated in Run 6 and 10. In these runs, the historical unfilled stopes 30 m below the MP4 pit surface were modelled as backfilled with CAF prior to starting Martha Underground. These two runs show similar effect so only Run 6 is discussed here.

The effect of backfilling historical unfilled stopes near the pit surface can be seen by comparing the results between Run 1 and Run 6. The total displacement of the final stage (Year 9) of Runs 1 and 6 are shown in Figures 18 and 42. The maximum shear strain of the final stage (Year 9) of Runs 1 and 6 are shown in Figures 24 and 43. A more complete set of results for Runs 1 and 6 are included in Appendices B and G.

Comparing the predicted results between Runs 1 and 6 shows that both magnitude and extent of localised displacements and strains at the base of the pit are predicted to be reduced by backfilling the historical unfilled stopes with CAF. The predicted reduction in strain is around 0.5%.

The modelling indicates that backfilling of stopes in the toe of the north wall of MP4 would reduce the possibility of local crushing and or pillar/stope stability at the foot of the north wall. However, without backfill the predicted movements in the north wall are generally small. The inclusion of CAF at the base of the pit, therefore, has a limited effect on reducing some localised displacements and strains.

8.8 Effect of Stope Volume – Run 7

The effect of changing the volume of stopes being modelled is simulated in Run 7 – almost a doubling of the design stope volumes and those estimated for the historical workings or an 70% increase over the base case void volumes. The total displacement of the final stage (Year 9) of Runs 1 and 7 are shown in Figures 18 and 44. The maximum shear strain of the final stage (Year 9) of Runs 1 and 7 are shown in Figures 24 and 45. The full sets of the results of Run 1 and Run 7 are included in Appendices B and H.

Comparison of the predicted displacements and strains between Runs 1 and 7 indicates that very large increases in stope volumes of around 60% to 70% resulted in an increase in the predicted displacements of around 200% (from 0.2 m to 0.45 m). Obviously more deformations and strains occur for greater volumes of the stopes. However, the stope volume increases were so large as to not be realistic. This sensitivity study shows that smaller inaccuracies in the actual stope volumes will not significantly affect the results.

8.9 Effect of Extent of Caved Zones – Run 8

The effect of the extent of Caved Zones is simulated in Run 8. In Run 1, the Caved Zones are located in Andesite only as shown in Figure 11. In Run 8, the Caved Zones are extended to Younger Andesite as shown in Figure 12. The total displacement of the final stage (Year 9) of Runs 1 and 5 are shown in Figures 18 and 46. The maximum shear strain of the final stage (Year 9) of Runs 1 and 8 are shown in Figures 24 and 47. The full sets of the results of Run 1 and Run 8 are included in Appendices B and I.

The displacements and strains of Runs 1 and 8 are similar, which suggests that the results are not sensitive to the local extensions of the Caved Zones.

8.10 Effect of Historical Mine Sequencing – Run 9

The effect of historical mine sequencing is simulated in Run 9. The actual historical mine sequence (excavation of historical underground workings before the historical pit) is simulated in Run 9. The effect of historical mine sequencing can be seen by comparing the results between Run 1 and Run 9. The total displacement of the final stage (Year 9) of Runs 1 and 9 are shown in Figures 18 and 48. The maximum shear strain of the final stage (Year 9) of Runs 1 and 9 are shown in Figures 24 and 49. The full sets of the results of Run 1 and Run 9 are included in Appendices B and J.

Comparison of the predicted displacements and strains between Run 1 and Run 9 indicates that the actual sequence increases the localised displacements and strains around the historical stopes. The displacements and strains on the pit walls are not sensitive to the historical mine sequence. The localised displacements and strains around the historical stopes can be reduced by backfilling the historical unfilled stopes, which is simulated in Run 10 and can be seen in Figures 50 and 51.

9 CONCLUSIONS

The main conclusions arising from this study are:

1. The numerical model has been able to be carried out in sufficient detail and complexity to assess the geotechnical performance of MP4 in response to the Martha Underground.
2. The model predicts a response to Martha Underground that is aligned with the experience and previous performance of the Martha Pits in terms of magnitude, location and distribution of movements.
3. The presence and properties of backfill and increased stope volume were found to have the largest impacts on displacements and strains.
4. Very large (60% to 70%) increases in stope volumes did result in doubling of the displacements. However, the volume increases were so large as to

not be realistic. This means the results of this study are insensitive to smaller inaccuracies in the actual stope volumes modelled.

5. Variation in in-situ stress magnitude was not found to have a significant influence on predicted performance.

6. Without any backfill (historic or proposed) maximum displacements were up to 0.8 m with increased likelihood of longer term creep movements during and post mining. However, no large scale instability was predicted.

7. The base case (Run 1) simulating planned mining was found to result in relative small displacements and strains with maximums of around 0.2 m and 1% respectively. Backfill also reduced localised areas of higher displacements and strains when compared to the no backfill case.

8. The use of a significantly stiffer backfill to simulate CAF resulted in only a modest reduction in maximum displacement to around 0.08 m and maximum strains of around 0.2%.

9. The displacements and strains occur mainly on the pit walls and around the underground stopes due to the proposed underground workings. There is little to no disturbance to the areas away from these locations on surrounding areas.

10. Overall, the Martha Underground is predicted to result in relatively small displacements and strains, provided stopes are backfilled. The maximum displacements would be around 0.2 m in the MP4 pit walls based on simulated loose rockfill. The backfill stiffness used in this analysis is considered to be conservative.

11. The modelling indicates that backfilling of historical unfilled stopes in the north wall of MP4 would reduce the possibility of local crushing and or pillar/stope collapse potentially leading to local stability problems with the north wall of MP4. However, such backfilling has little to no effect on the overall displacements and strains on the pit walls.

The mathematical formulation behind the numerical model is based on behaviour of materials approaching either equilibrium or steady plastic deformations. As a result, the model is unable to reliably predict large post-failure deformations for situations which are far-off from equilibrium state and for situations with non-steady plastic deformations. Therefore, it is emphasised that the model is likely to underestimate the post-failure displacements. The displacement predictions will mainly be used to assess the deformation trend and to identify locations of relatively higher displacement.

It is also noted that the analyses do not capture the ongoing creep movements that are known to exist at the mine. These movements are the consequence of ongoing relaxation, stope closure associated with the historical stopes and strain softening associated with time and weathering. At worst the magnitude of creep is expected to be similar to that experienced currently, this being up to 10 mm/year this being typical of open pits of this size. However there are two positive elements of the planned Martha Underground that will assist with reducing the long term creep of the rock mass:

1. 30% of the existing unfilled historical stopes will be stabilised by filling with rockfill and approximately half of these are located in the upper levels immediately below the MP4 Pit; and

2. In addition, 30% of the planned mining will entail re-mining of historical stopes (remnant mining) comprising:

   a) Mining from the top down,

   b) A very large proportion of these stopes are located immediately below the MP4 Pit; and

   c) CAF will be used extensively in this mining.

These factors will result in a significant improvement in overall rock mass conditions in the zone underlying the MP4 Pit. This will have two positive impacts on MP4 Pit, firstly by improving pit stability conditions in both in the short and long term and secondly by reducing any impacts of the Martha Underground mining in general.

For and on behalf of
PELLS SULLIVAN MEYNINK

GARETH SWARBRICK
Principal

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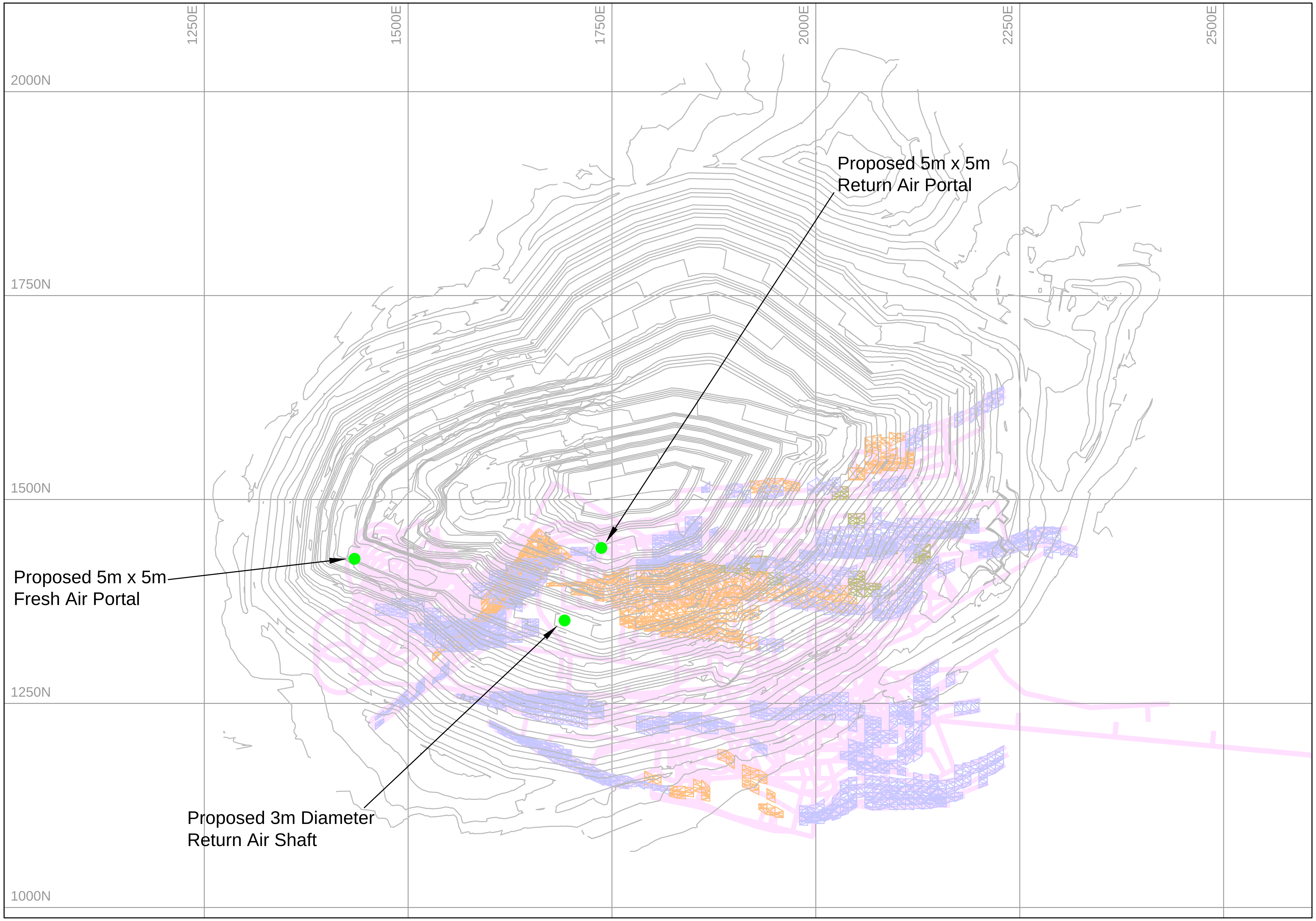
Waihi, New Zealand

AERIAL VIEW OF THE SITE
SHOWING MODEL EXTENT

PSM125-283R	Figure 1



LEGEND

- Phase 4 Final Pit - 5m Contours
- Proposed Underground Drives
- Avoca Stopes
- Backfilled Remnant Stopes
- Remnant Stopes
- Proposed Underground Portals

0 50 100 150 200

Scale (m)

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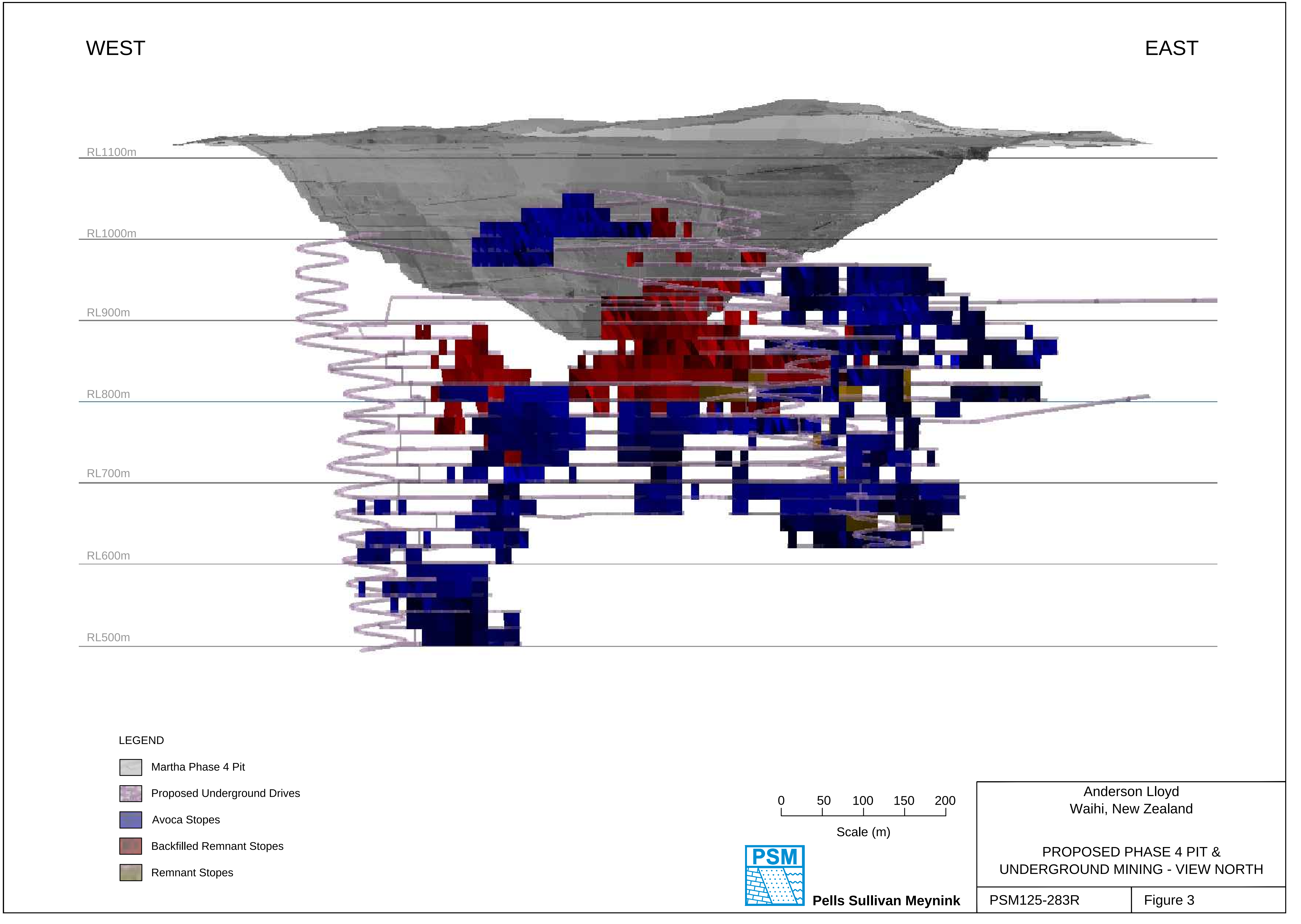
Anderson Lloyd Waihi, New Zealand PROPOSED PHASE 4 PIT & UNDERGROUND MINING - PLAN VIEW	
PSM125-283R	Figure 2


WEST
EAST
RL1100m
RL1000m
RL900m
RL800m
RL700m
RL600m
RL500m
LEGEND
Martha Phase 4 Pit
Proposed Underground Drives
Avoca Stopes
Backfilled Remnant Stopes
Remnant Stopes
0 50 100 150 200
Scale (m)
PSM
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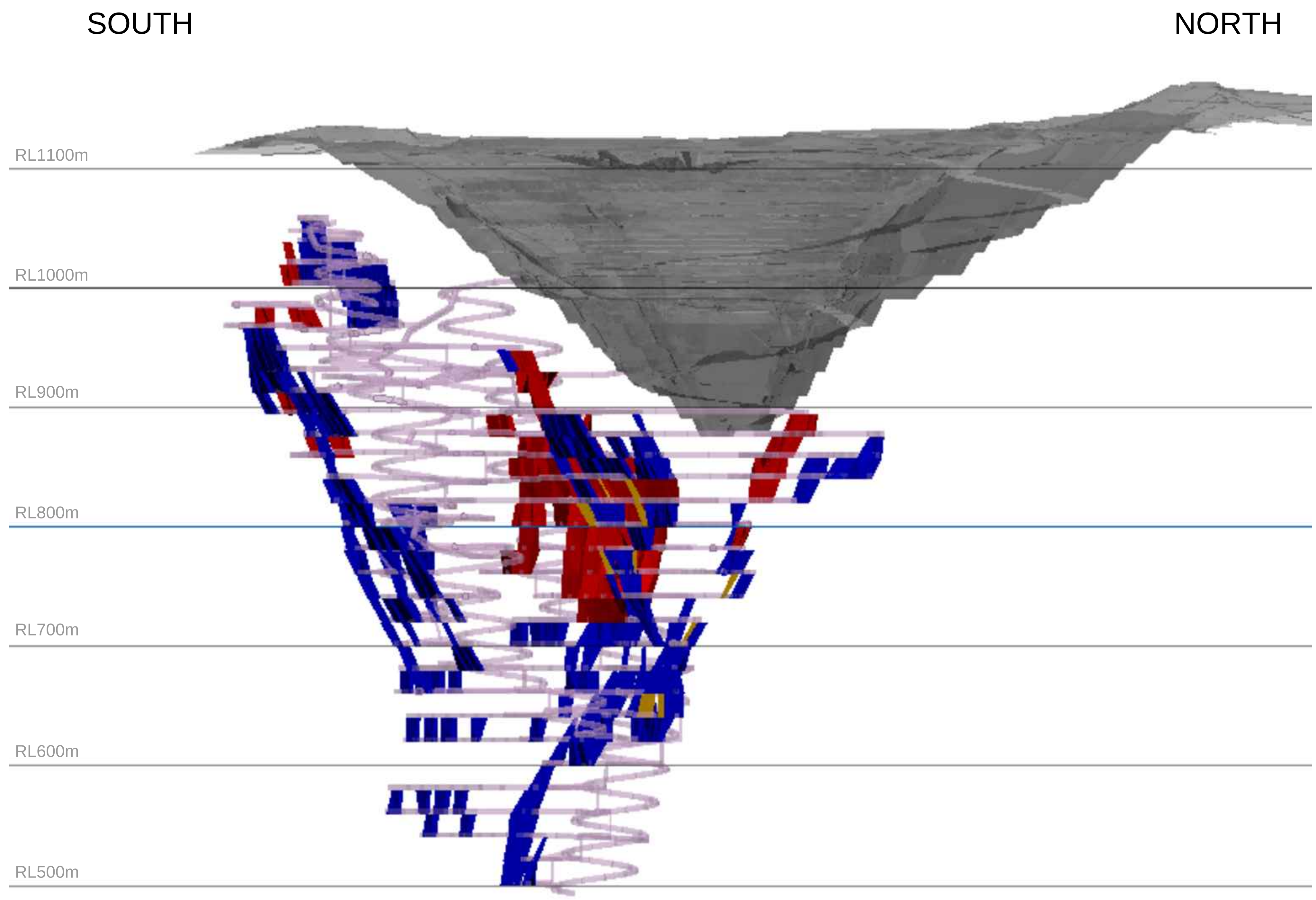
Anderson Lloyd
Waihi, New Zealand
PROPOSED PHASE 4 PIT &
UNDERGROUND MINING - VIEW NORTH
PSM125-283R
Figure 3



LEGEND

- Martha Phase 4 Pit
- Proposed Underground Drives
- Avoca Stopes
- Backfilled Remnant Stopes
- Remnant Stopes

0 50 100 150 200

Scale (m)

PSM

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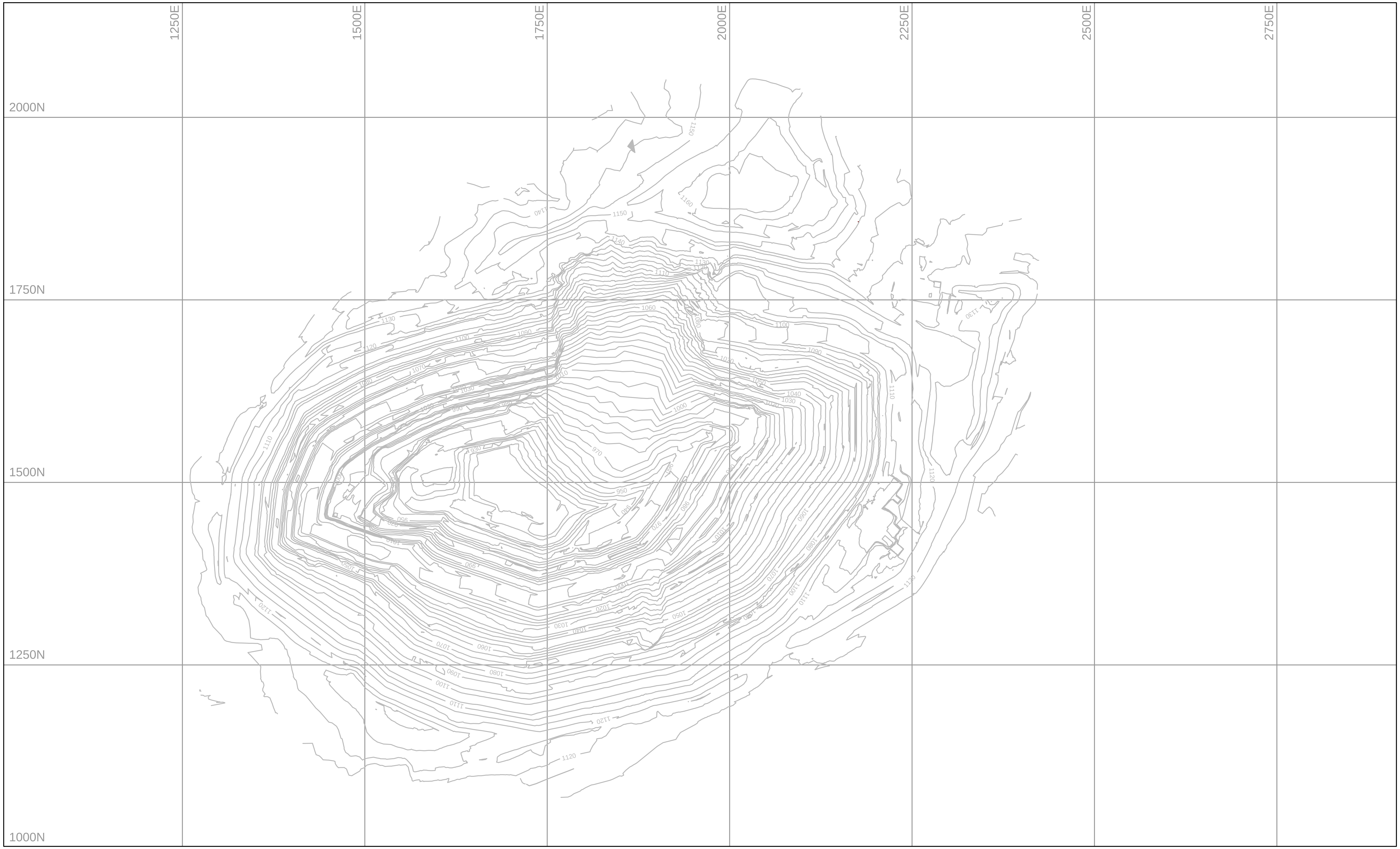
PROPOSED PHASE 4 PIT &
UNDERGROUND MINING - VIEW WEST

PSM125-283R

Figure 4



Note: 5m contours are shown

0 50 100 150 200
Scale (m)

PSM

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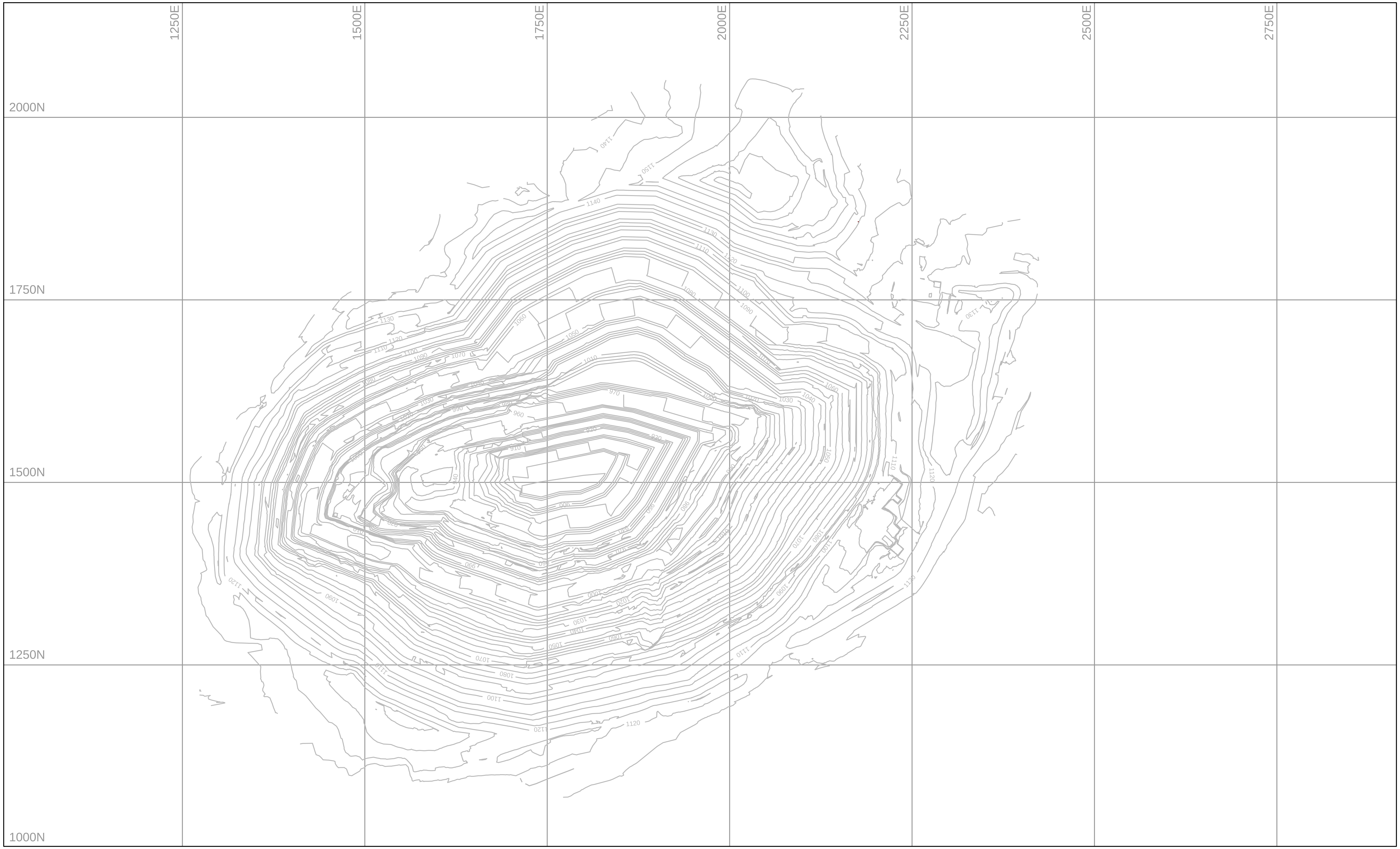
Anderson Lloyd Waihi, New Zealand CURRENT PIT - 31 AUGUST 2017	
PSM125-283R	Figure 5



Note: 5m contours are shown

0 50 100 150 200

Scale (m)

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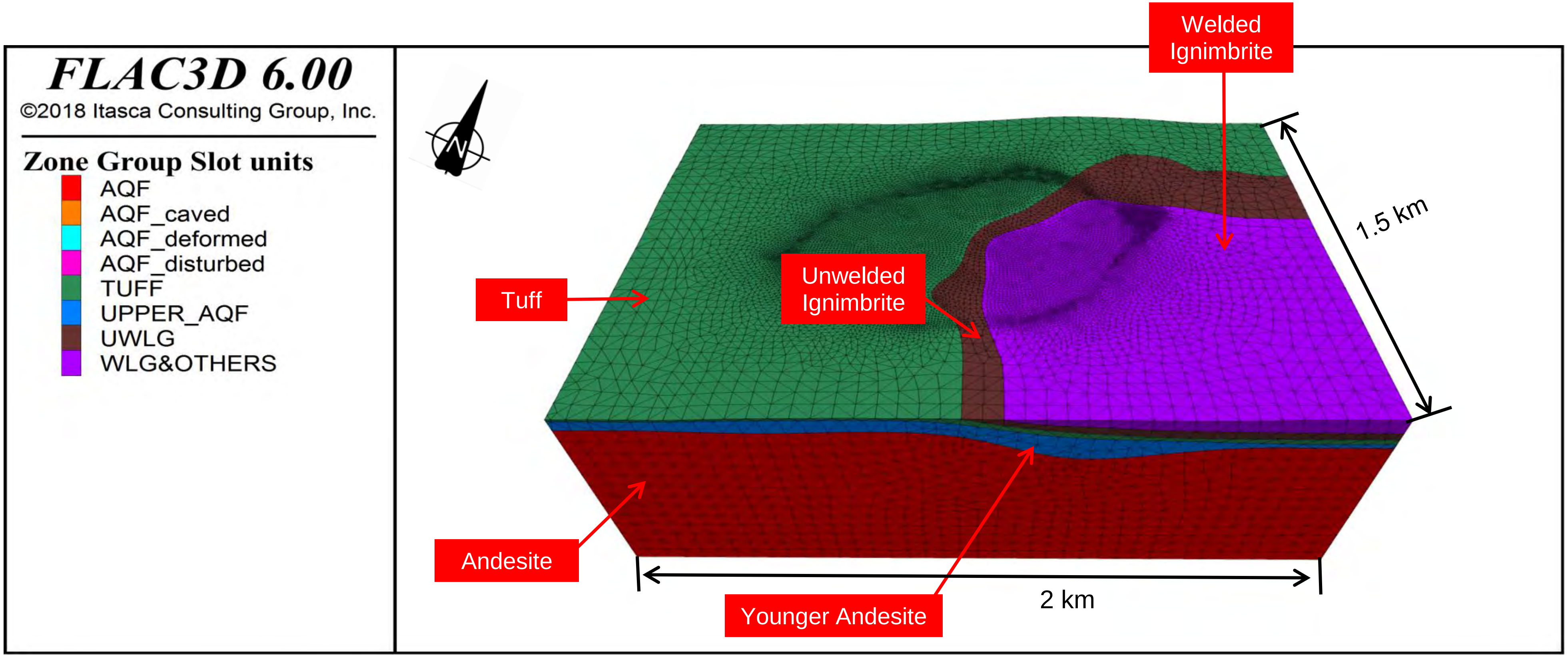
PHASE 4 FINAL PIT

PSM125-283R	Figure 6



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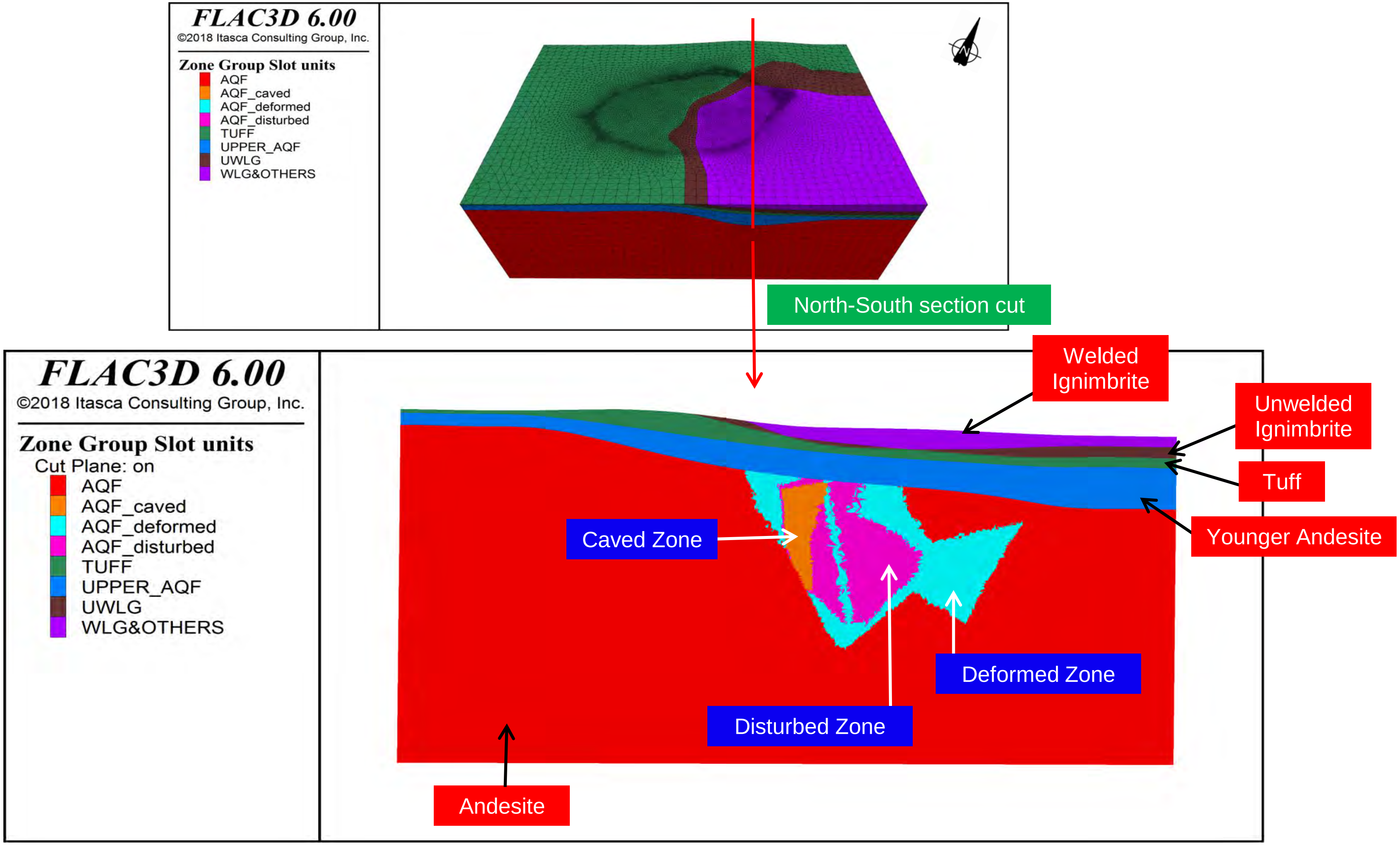
Anderson Lloyd Waihi, New Zealand NUMERICAL MODEL GEOMETRY & MESH WHOLE MODEL	
PSM125-283R	Figure 7



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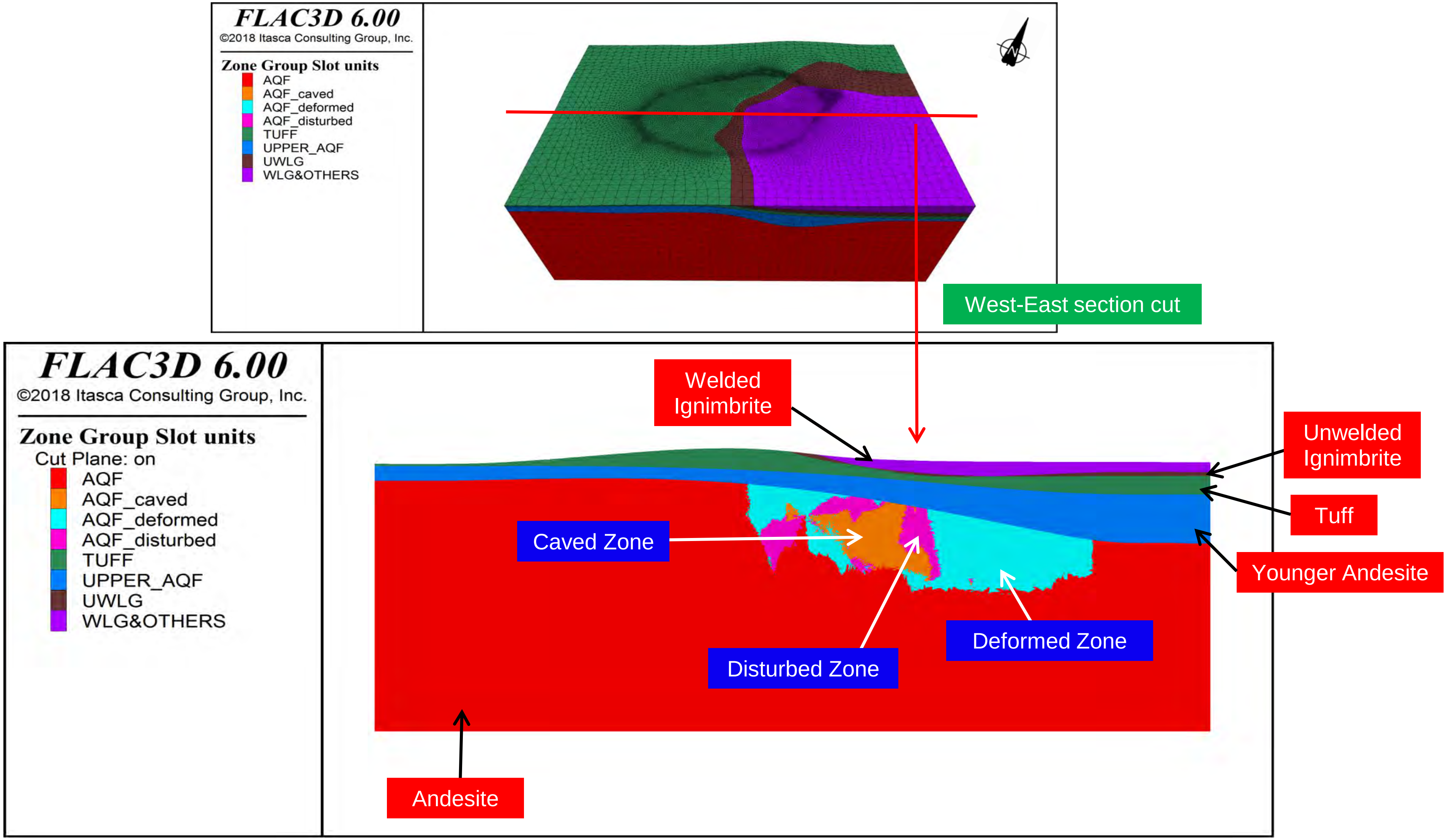
Anderson Lloyd Waihi, New Zealand NUMERICAL MODEL GEOMETRY & MESH NS SECTION	
PSM125-283R	**Figure 8**



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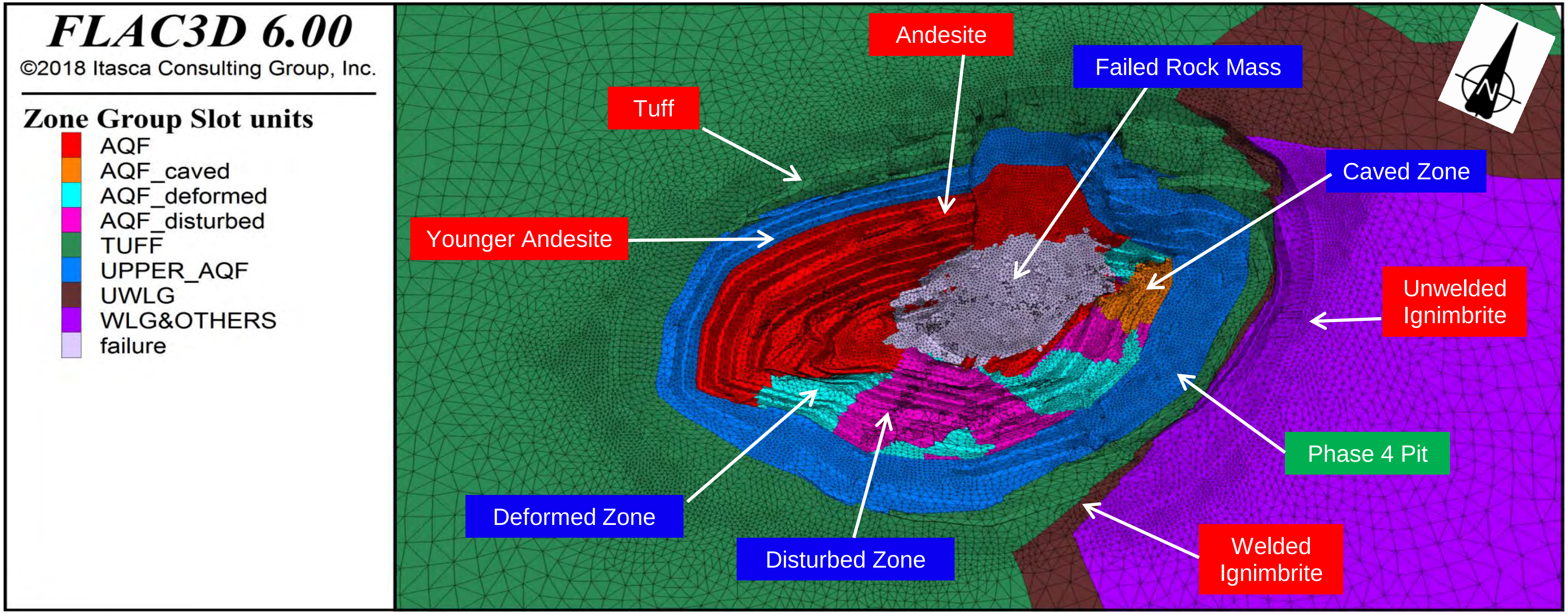
Anderson Lloyd Waihi, New Zealand NUMERICAL MODEL GEOMETRY & MESH WE SECTION	
PSM125-283R	Figure 9



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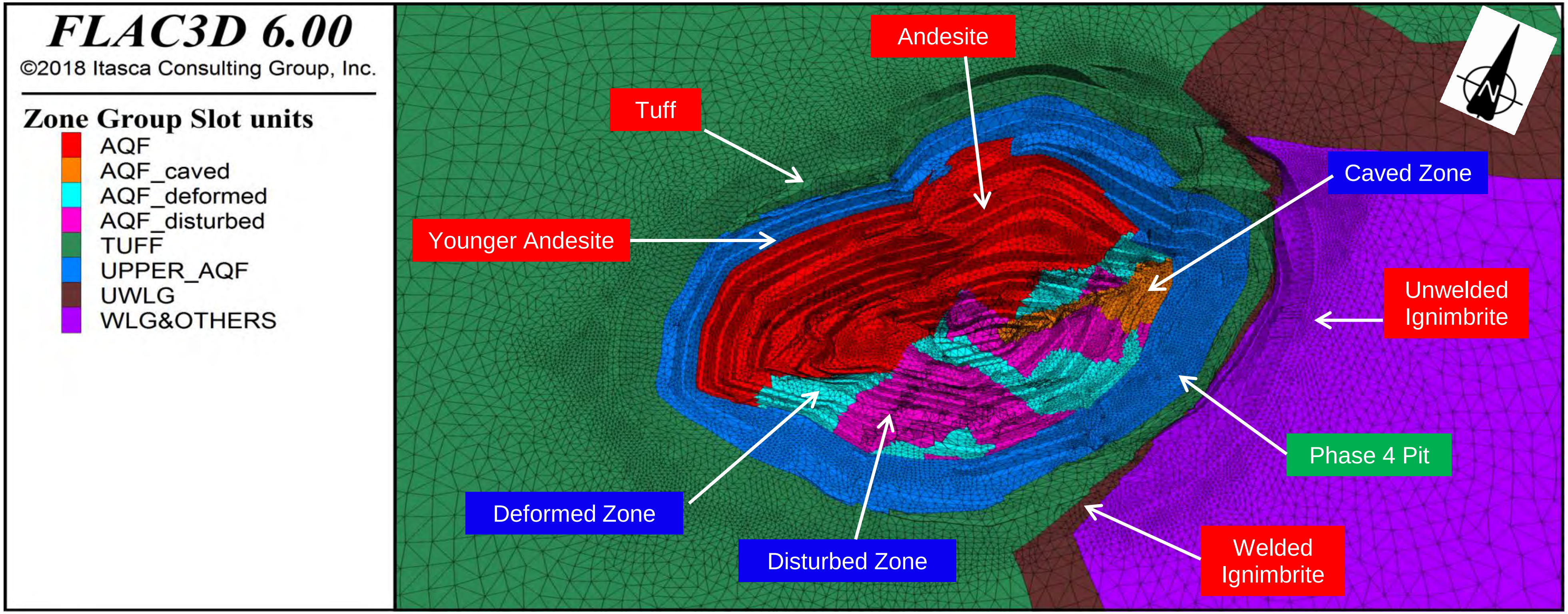
Anderson Lloyd Waihi, New Zealand NUMERICAL MODEL GEOMETRY & MESH EXISTING PIT	
PSM125-283R	Figure 10



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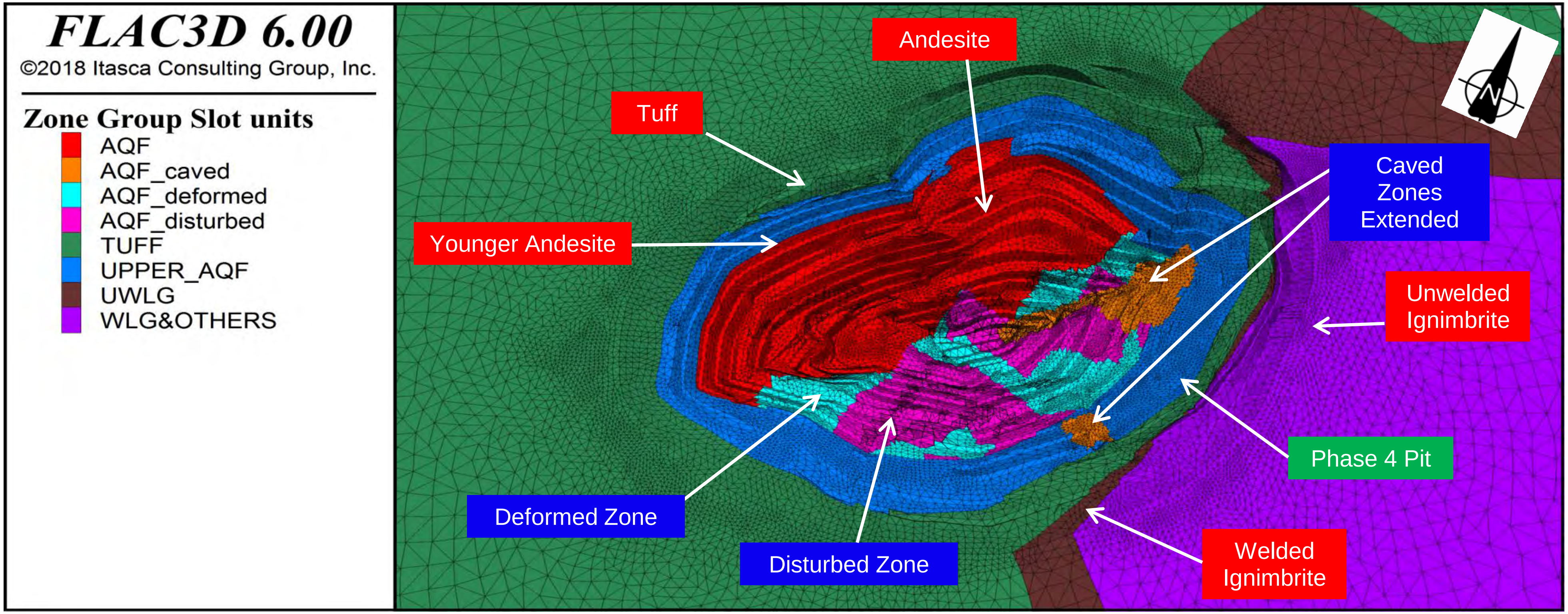
Anderson Lloyd **Waihi, New Zealand** **NUMERICAL MODEL GEOMETRY & MESH** **PHASE 4 PIT**	
PSM125-283R	**Figure 11**



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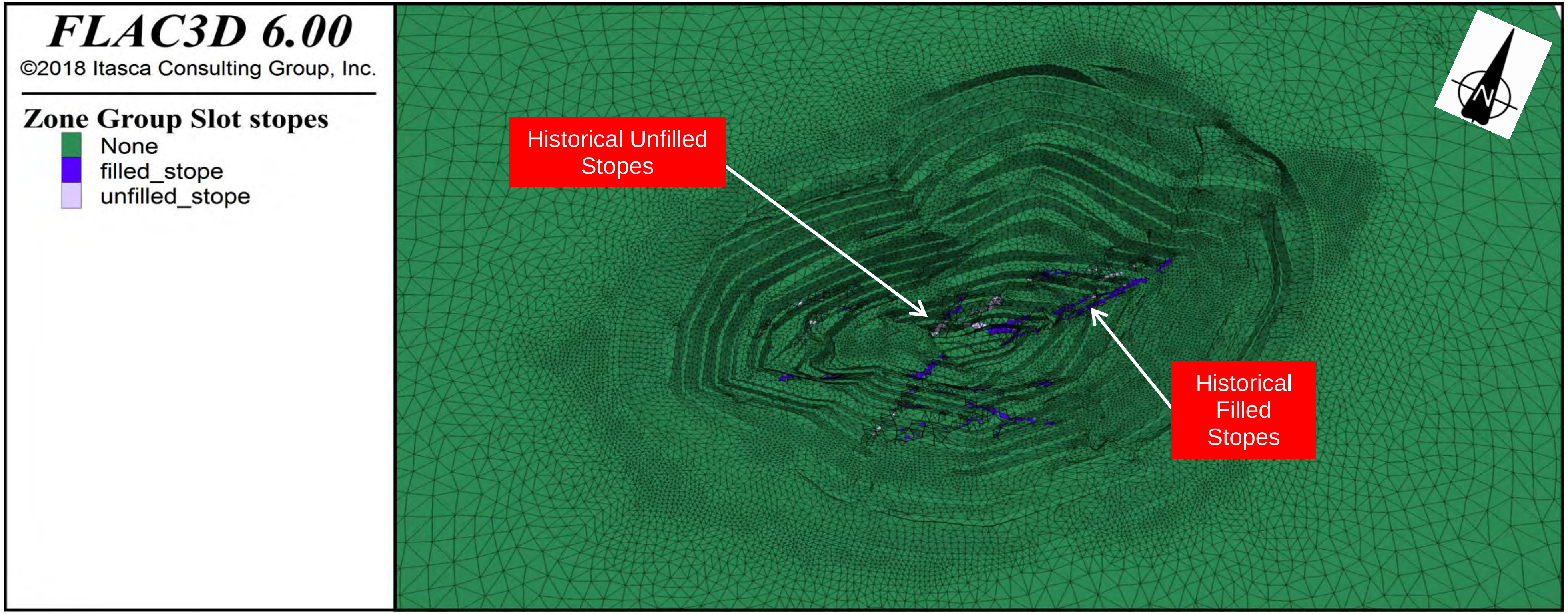
Anderson Lloyd Waihi, New Zealand NUMERICAL MODEL GEOMETRY & MESH PHASE 4 PIT WITH EXTENDED CAVED ZONES	
PSM125-283R	Figure 12



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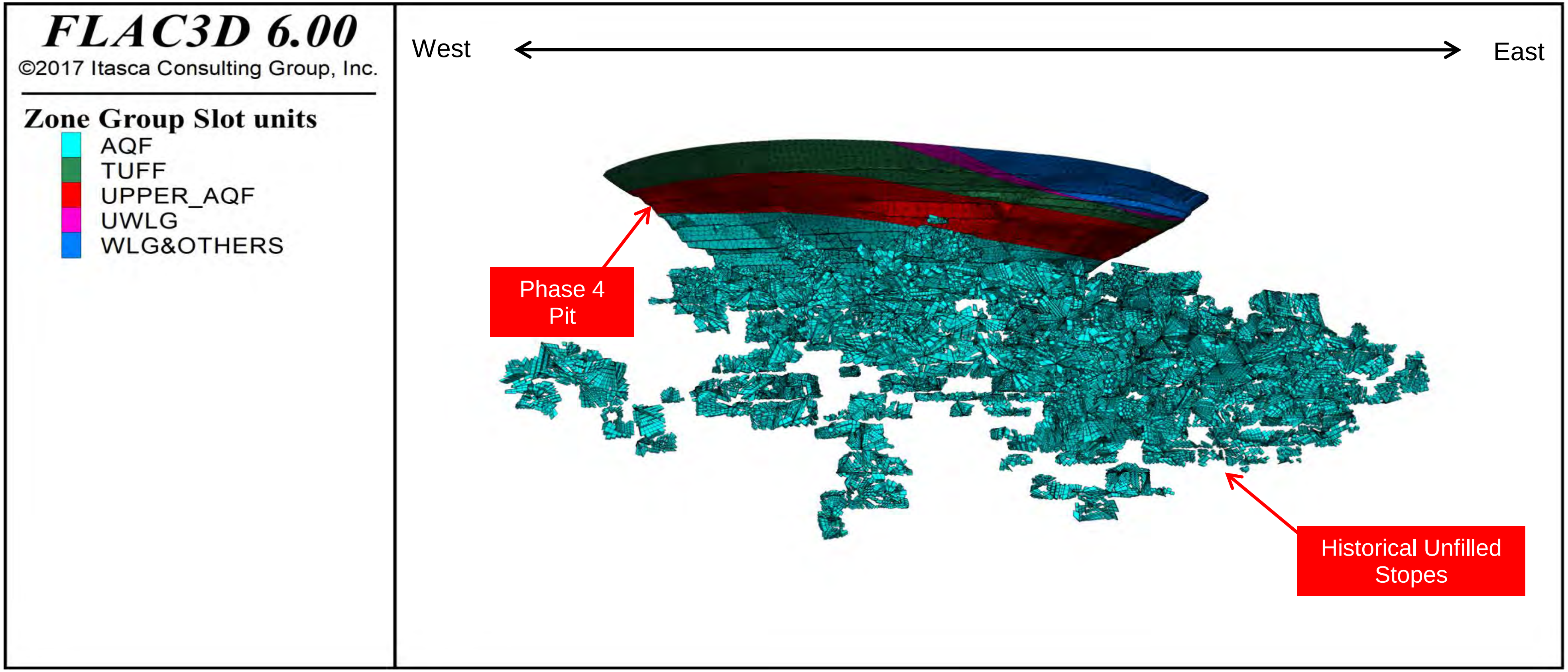
NUMERICAL MODEL GEOMETRY & MESH

PHASE 4 PIT WITH HISTORICAL STOPES

PSM125-283R	**Figure 13**

Pells Sullivan Meynink



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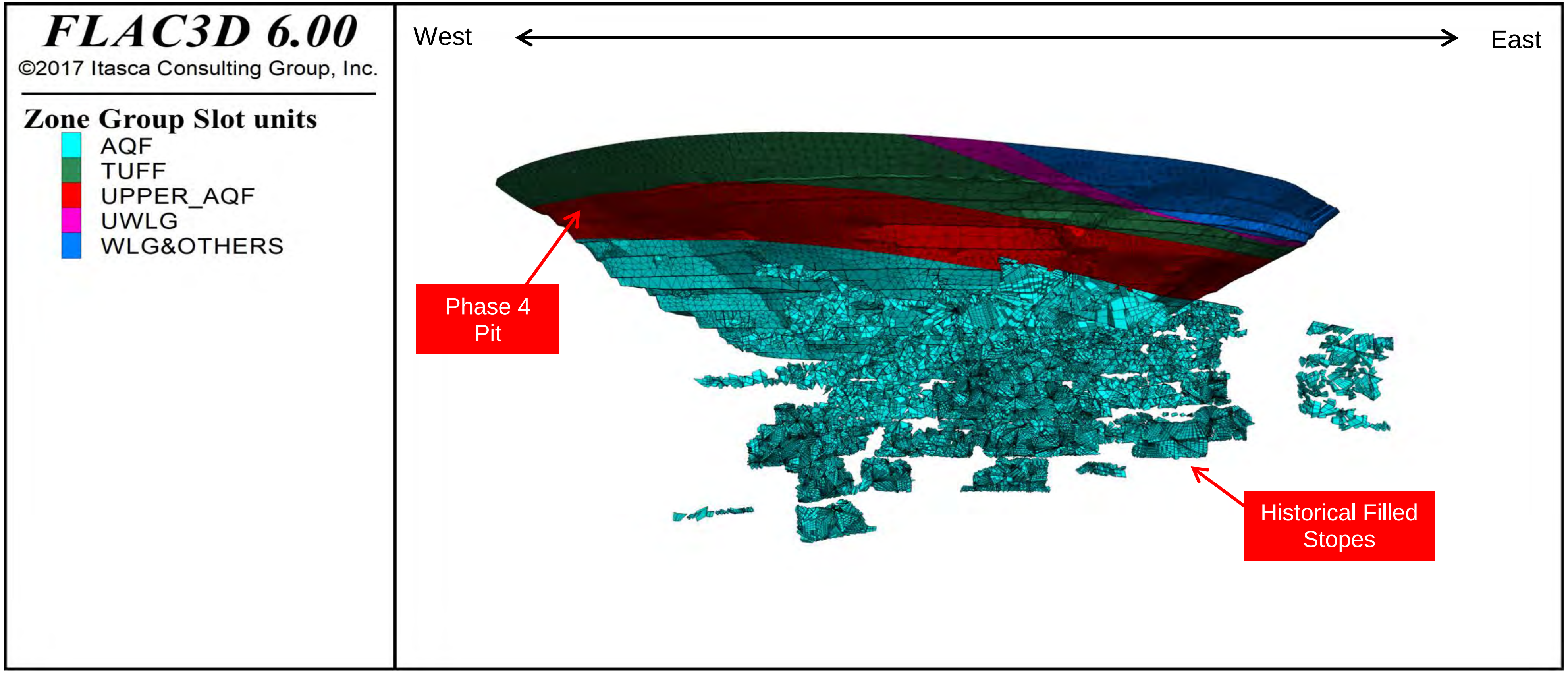
NUMERICAL MODEL GEOMETRY & MESH

HISTORICAL UNFILLED STOPES

PSM125-283R	**Figure 14**



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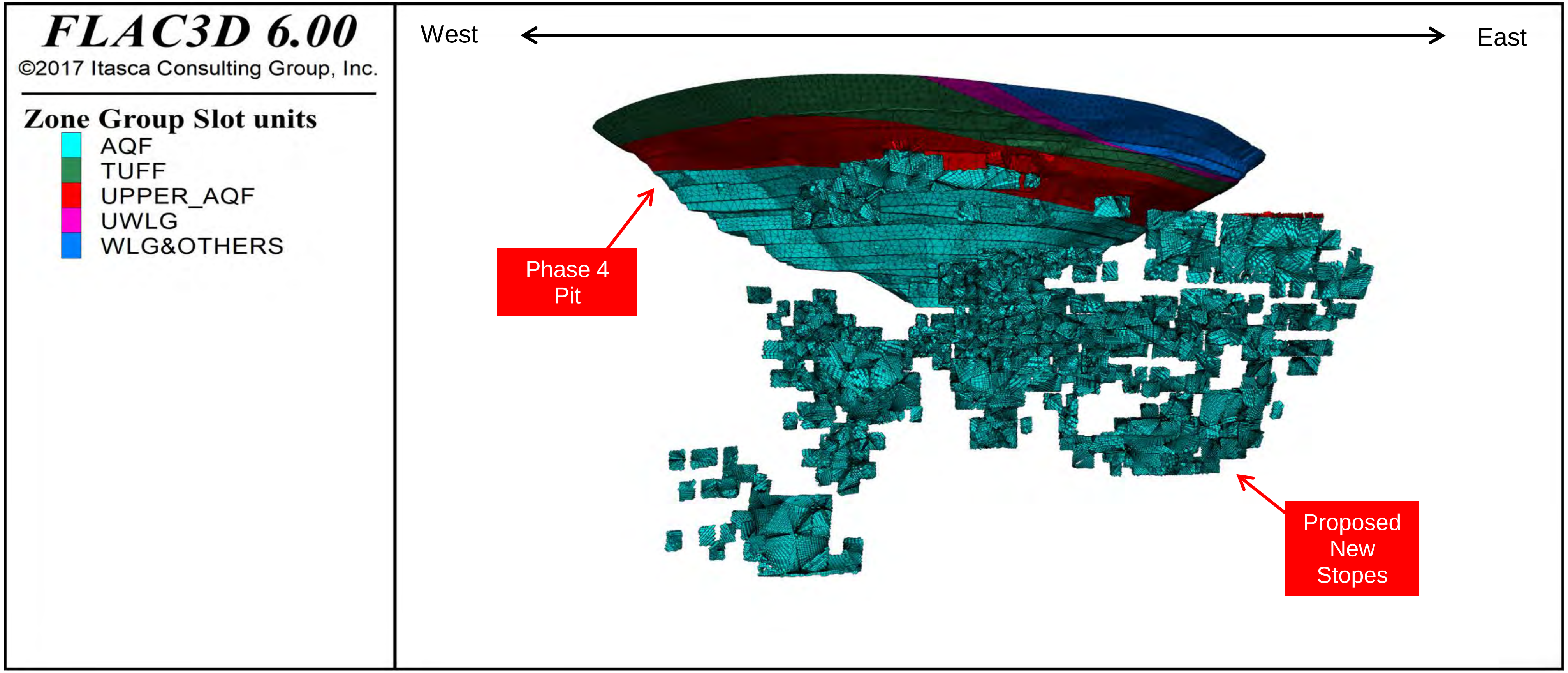
Anderson Lloyd Waihi, New Zealand NUMERICAL MODEL GEOMETRY & MESH HISTORICAL FILLED STOPES	
PSM125-283R	Figure 15



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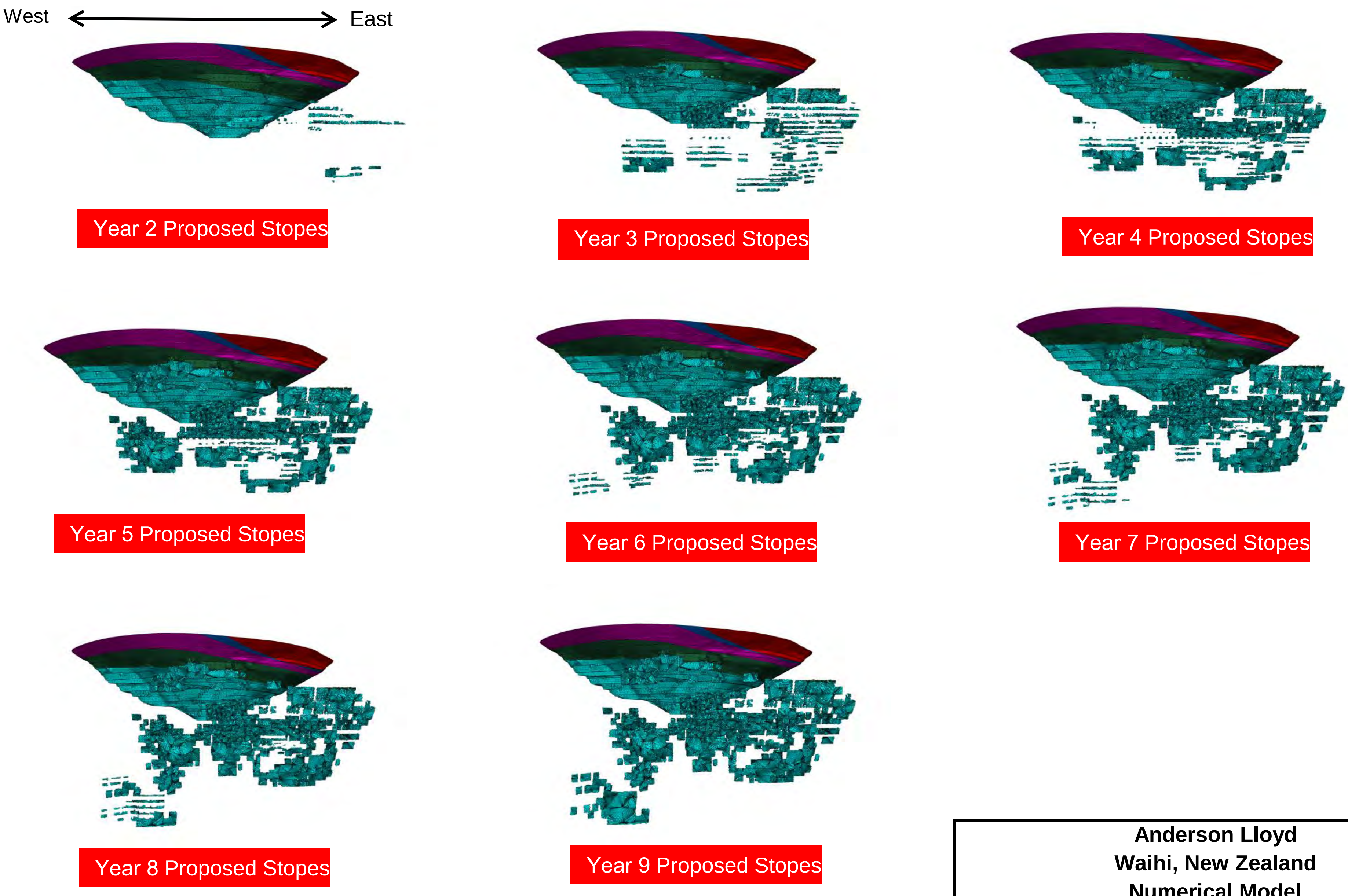
NUMERICAL MODEL GEOMETRY & MESH

PROPOSED NEW STOPES

PSM125-283R	**Figure 16**



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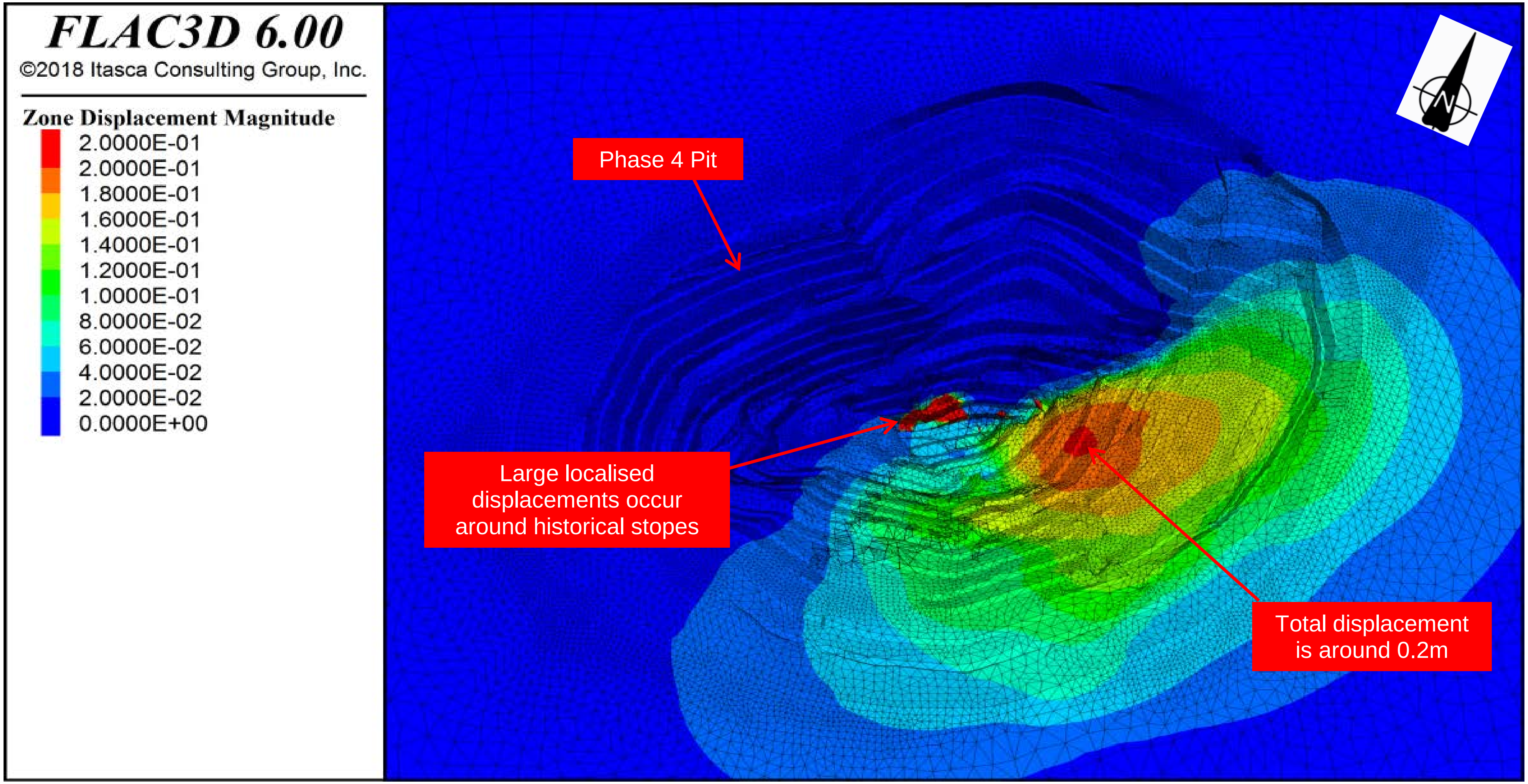
Numerical Model
PROPOSED YEARLY SEQUENCE FOR UNDERGROUND MINING

PSM125-283R	**Figure 17**

PSM **Pells Sullivan Meynink**



Anderson Lloyd Waihi, New Zealand Numerical Model - Run 1 PREDICTED TOTAL DISPLACEMENT AFTER YEAR 9	
PSM125-283R	Figure 18

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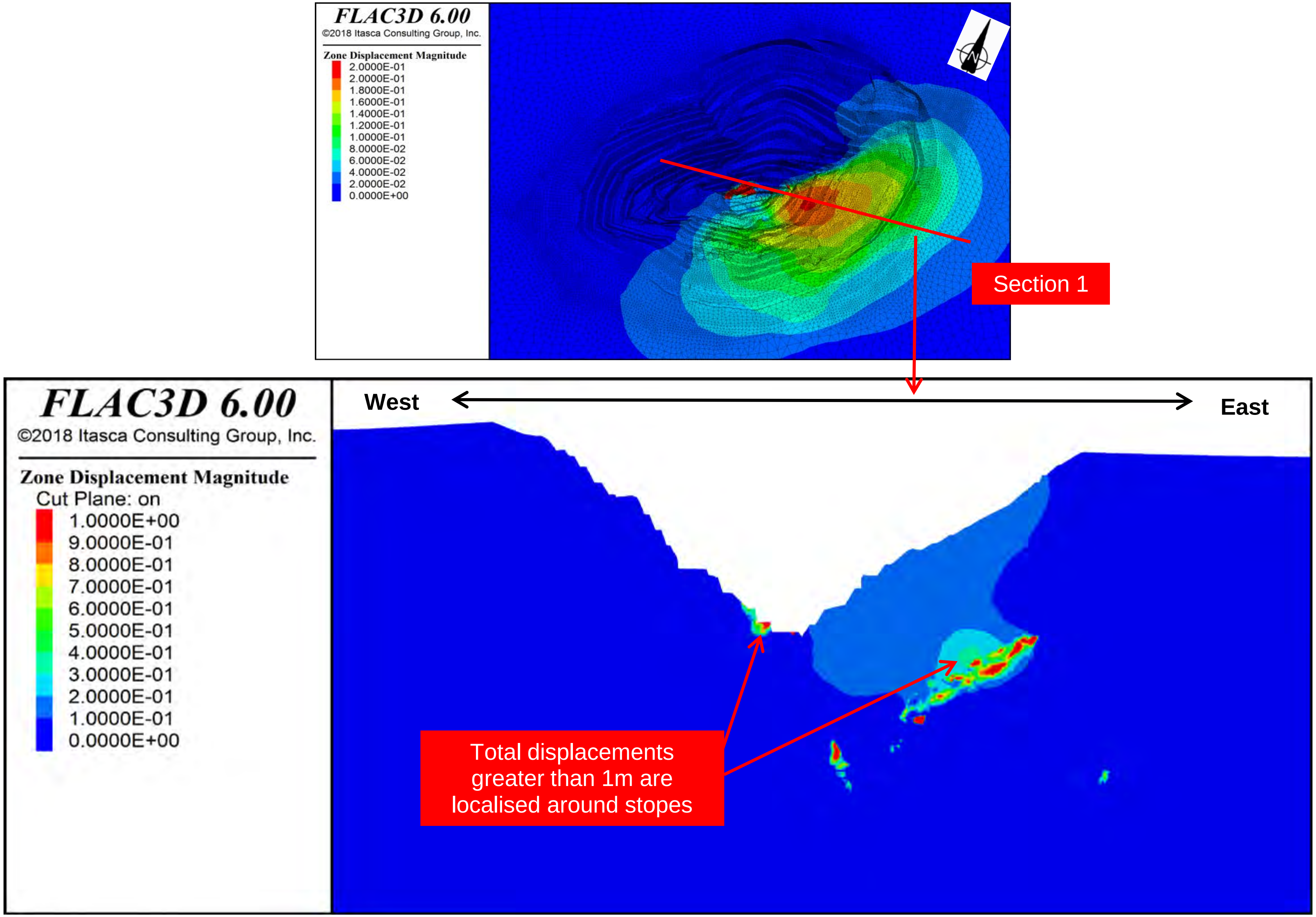

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Numerical Model - Run 1
PREDICTED TOTAL DISPLACEMENT OF SECTION 1 AFTER YEAR 9

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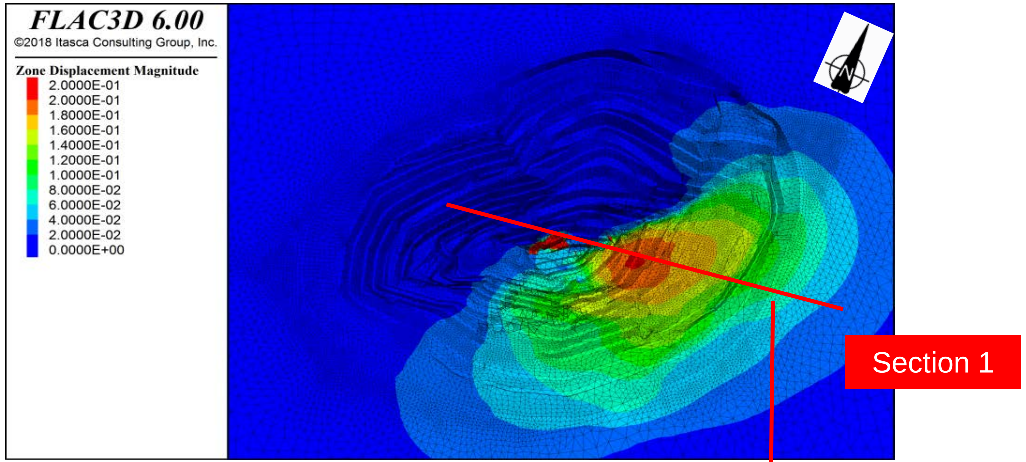
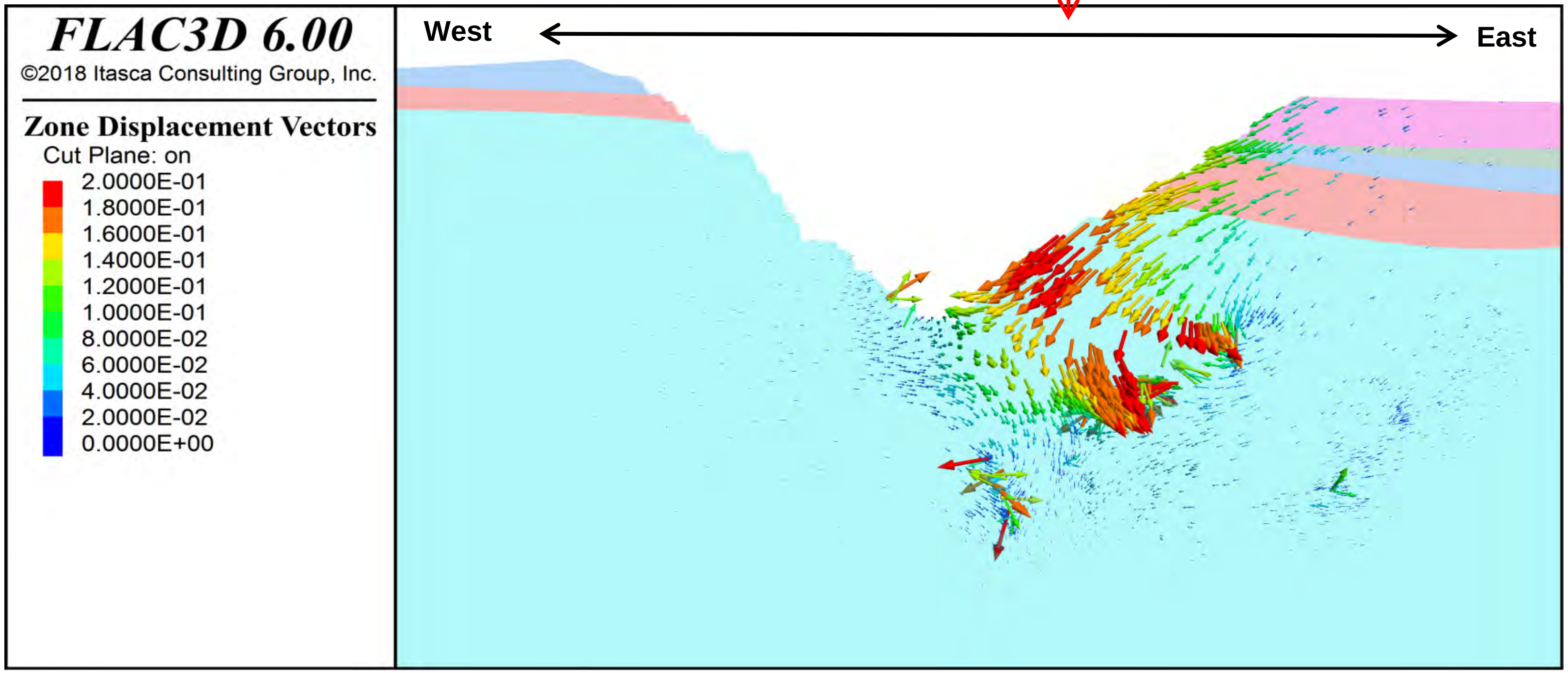
PSM125-283R | Figure 19





Anderson Lloyd Waihi, New Zealand Numerical Model - Run 1 **PREDICTED DISPLACEMENT VECTOR OF SECTION 1 AFTER YEAR 9**	
PSM125-283R	Figure 20

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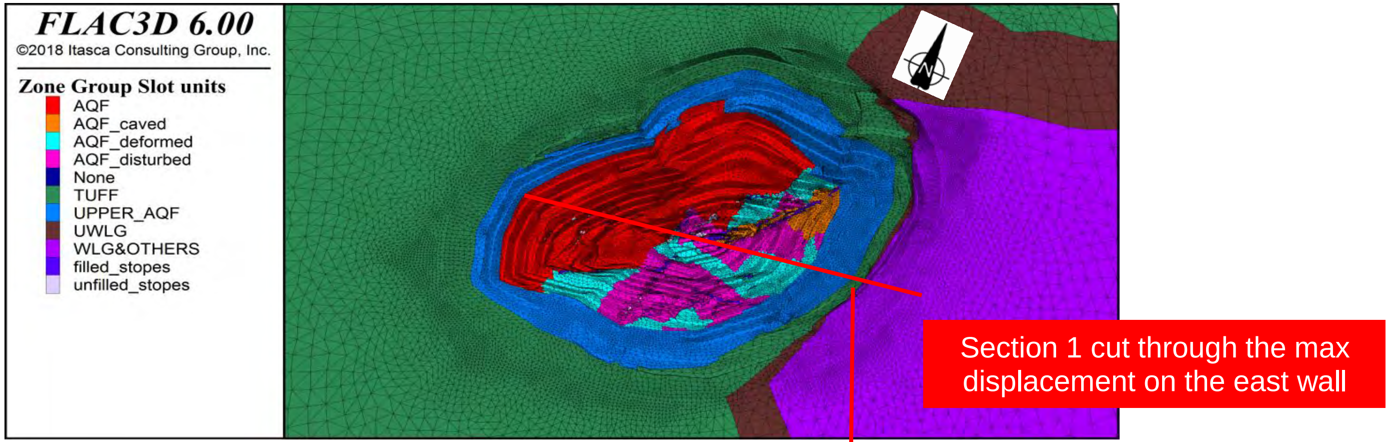

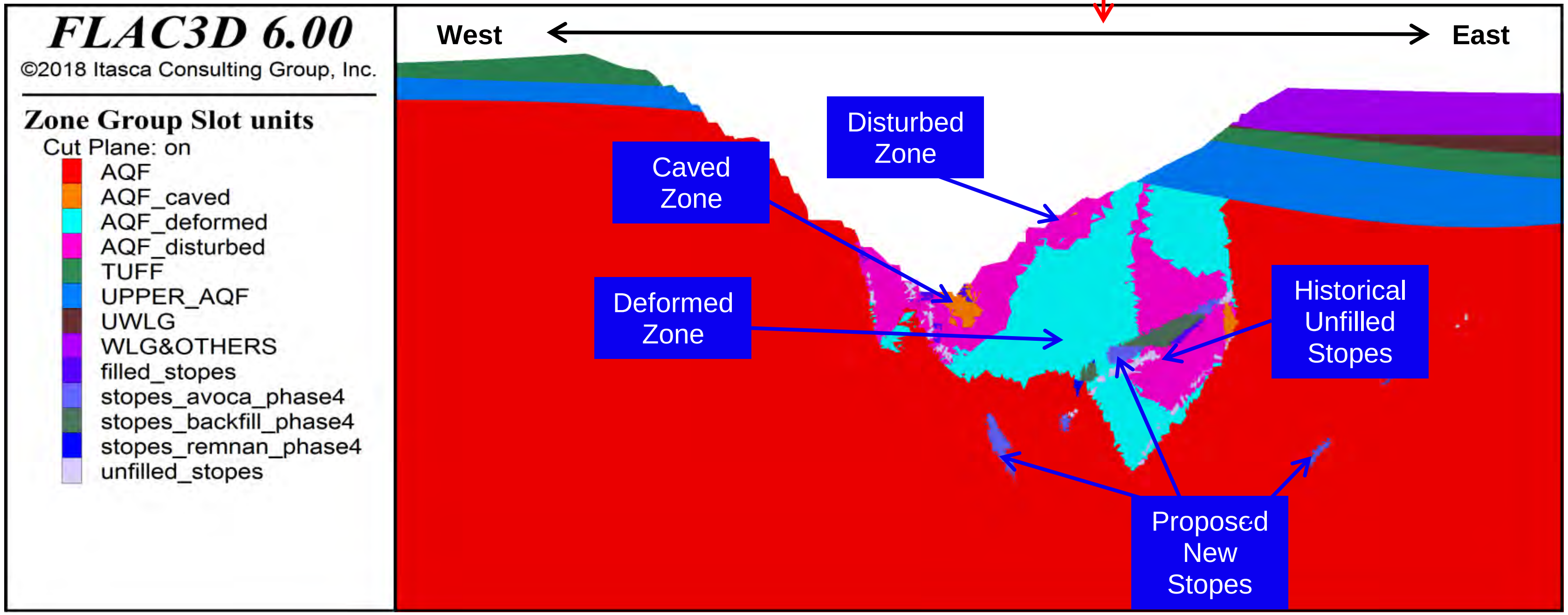

Anderson Lloyd Waihi, New Zealand FLAC3D Model GEOLOGY CONDITION OF SECTION 1	
PSM125-283R	Figure 21

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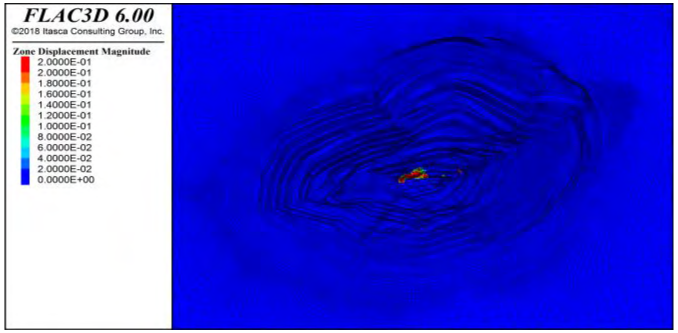
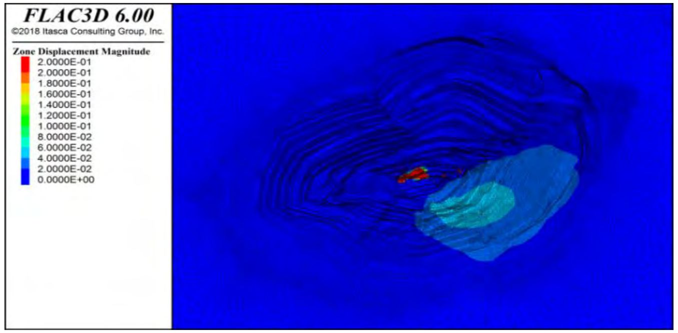
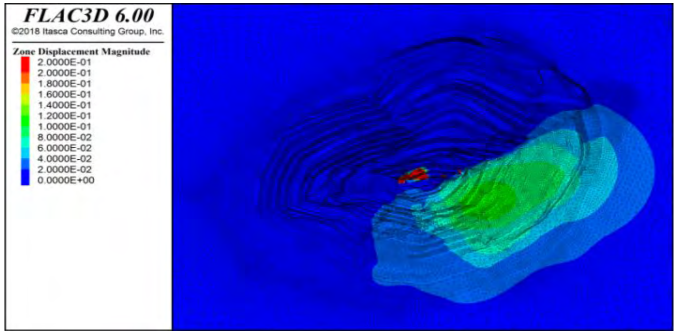


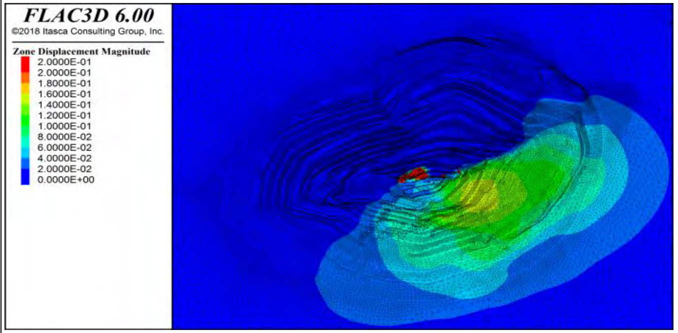
After Year 2 underground working



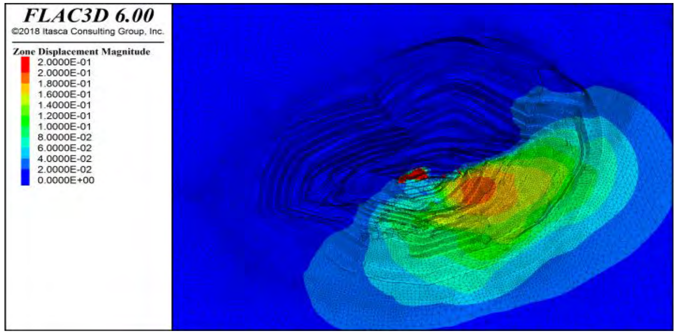
After Year 3 underground working



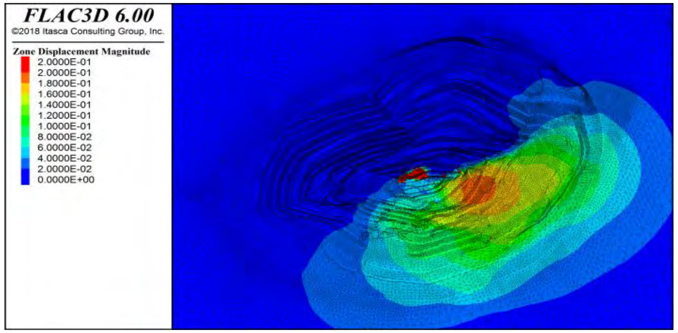
After Year 4 underground working



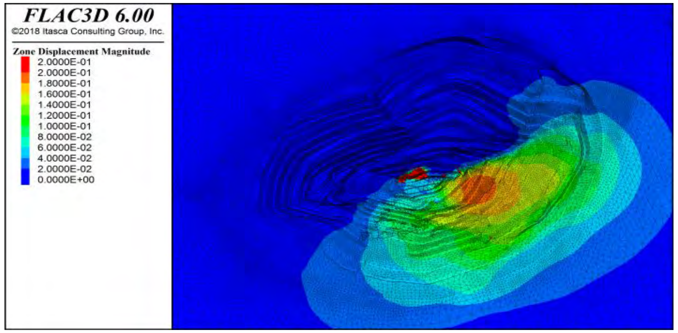
After Year 5 underground working



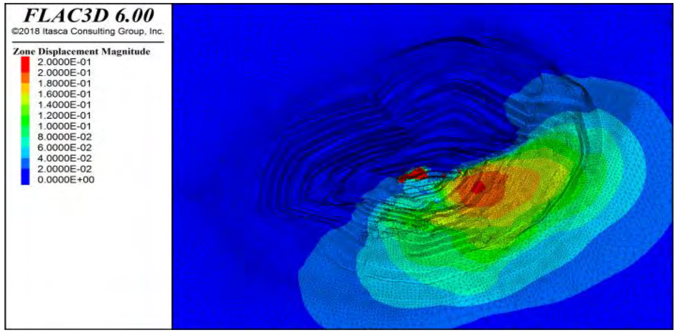
After Year 6 underground working



After Year 7 underground working



After Year 8 underground working



After Year 9 underground working

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Numerical Model - Run 1
PREDICTED TOTAL DISPLACEMENT FOR YEARLY SEQUENCE

PSM125-283R	**Figure 22**

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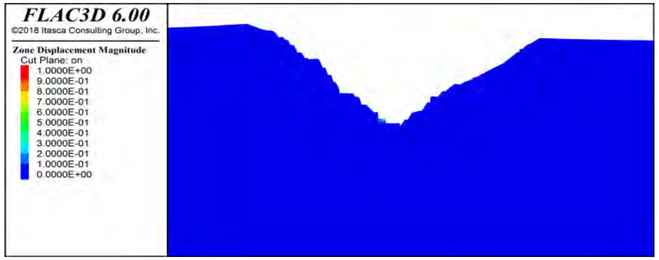
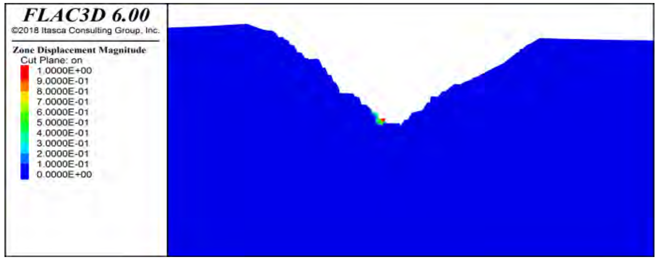
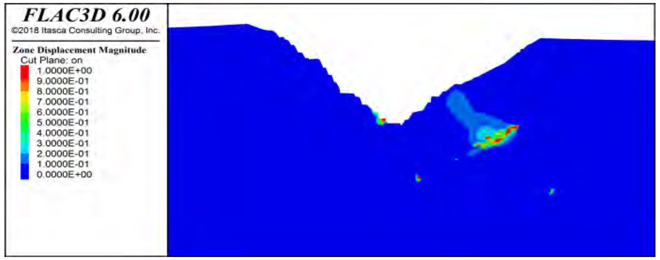


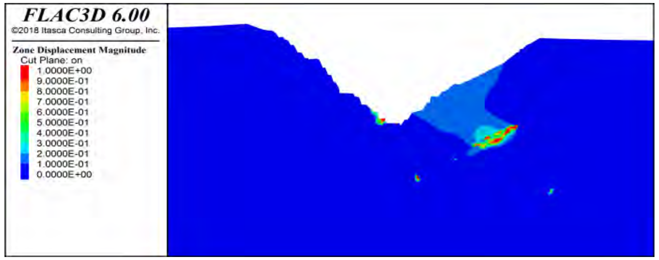
After Year 2 underground working



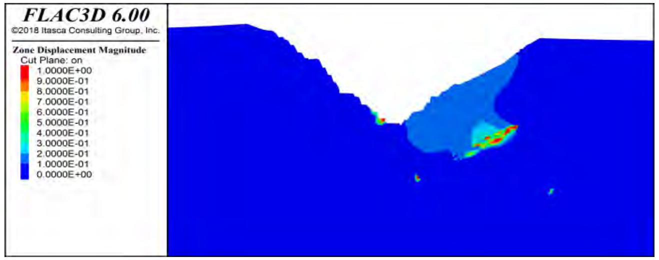
After Year 3 underground working



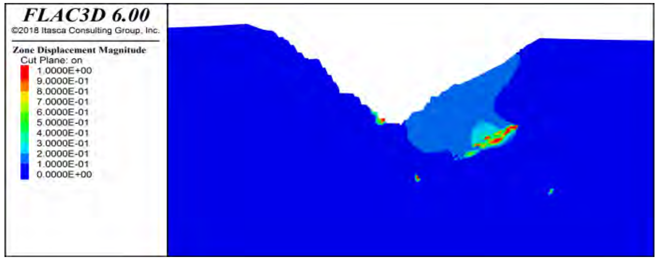
After Year 4 underground working



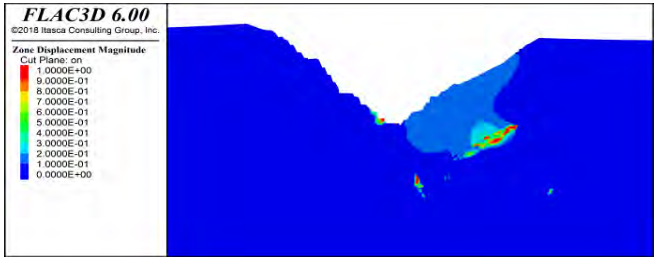
After Year 5 underground working



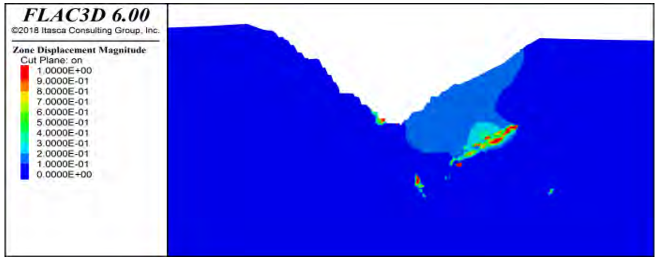
After Year 6 underground working



After Year 7 underground working



After Year 8 underground working



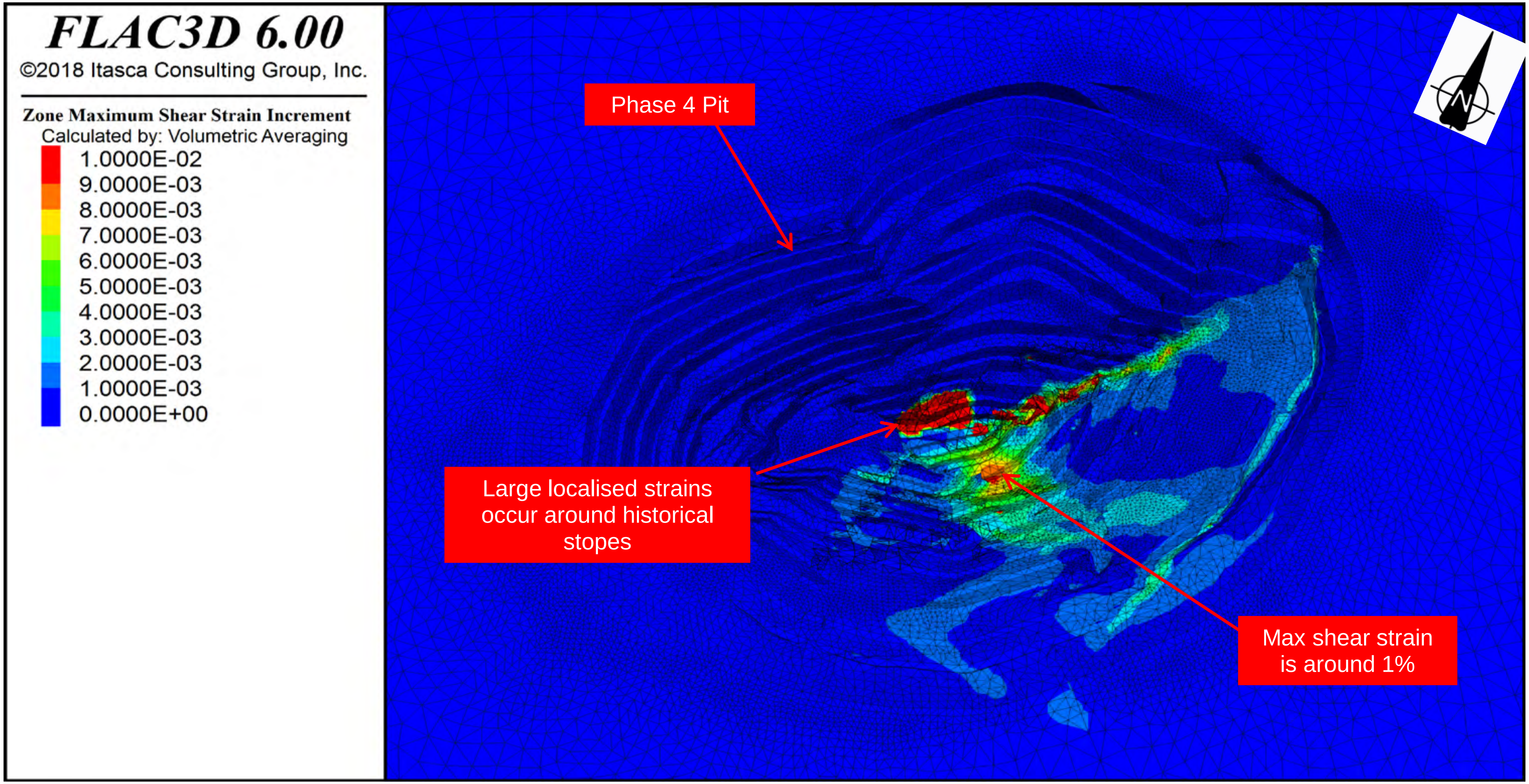
After Year 9 underground working

PSM

Pells Sullivan Meynink

Anderson Lloyd
Waihi, New Zealand
Numerical Model - Run 1
PREDICTED TOTAL DISPLACEMENT OF SECTION 1 FOR YEARLY SEQUENCE

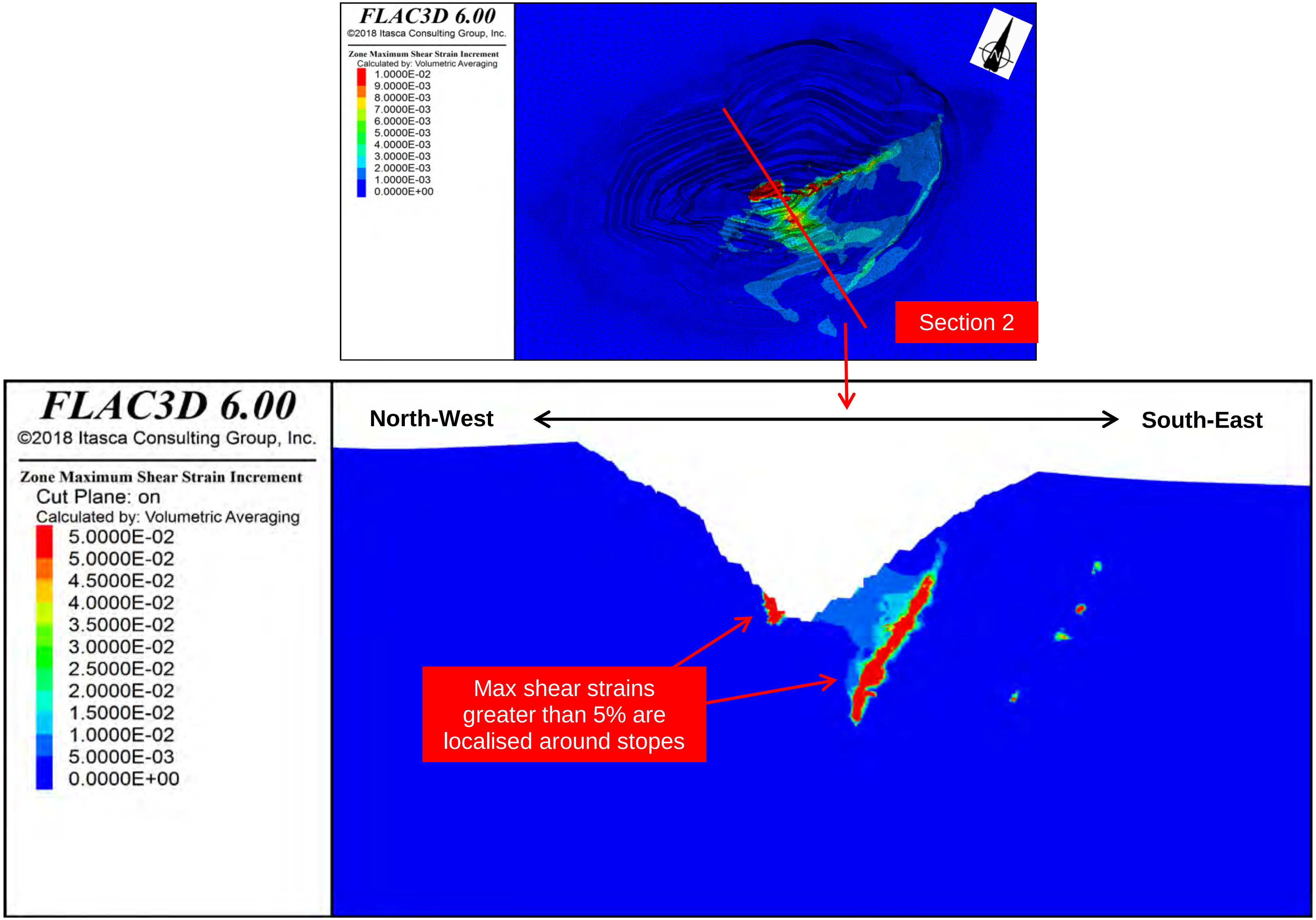
PSM125-283R	**Figure 23**



Anderson Lloyd
Waihi, New Zealand
Numerical Model - Run 1
PREDICTED MAX SHEAR STRAIN
AFTER YEAR 9

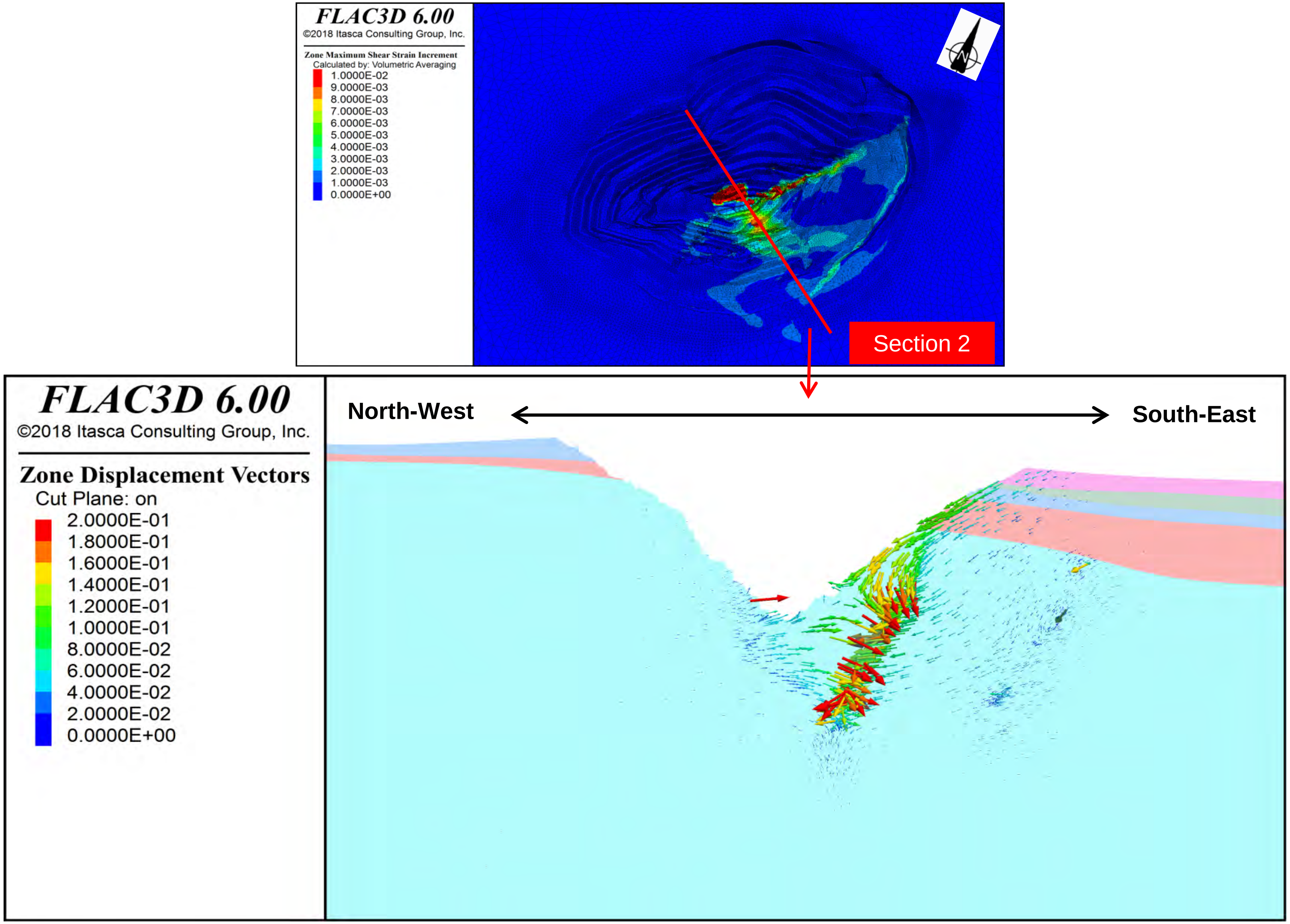
PSM125-283R	Figure 24

PSM
Pells Sullivan Meynink



Pells Sullivan Meynink

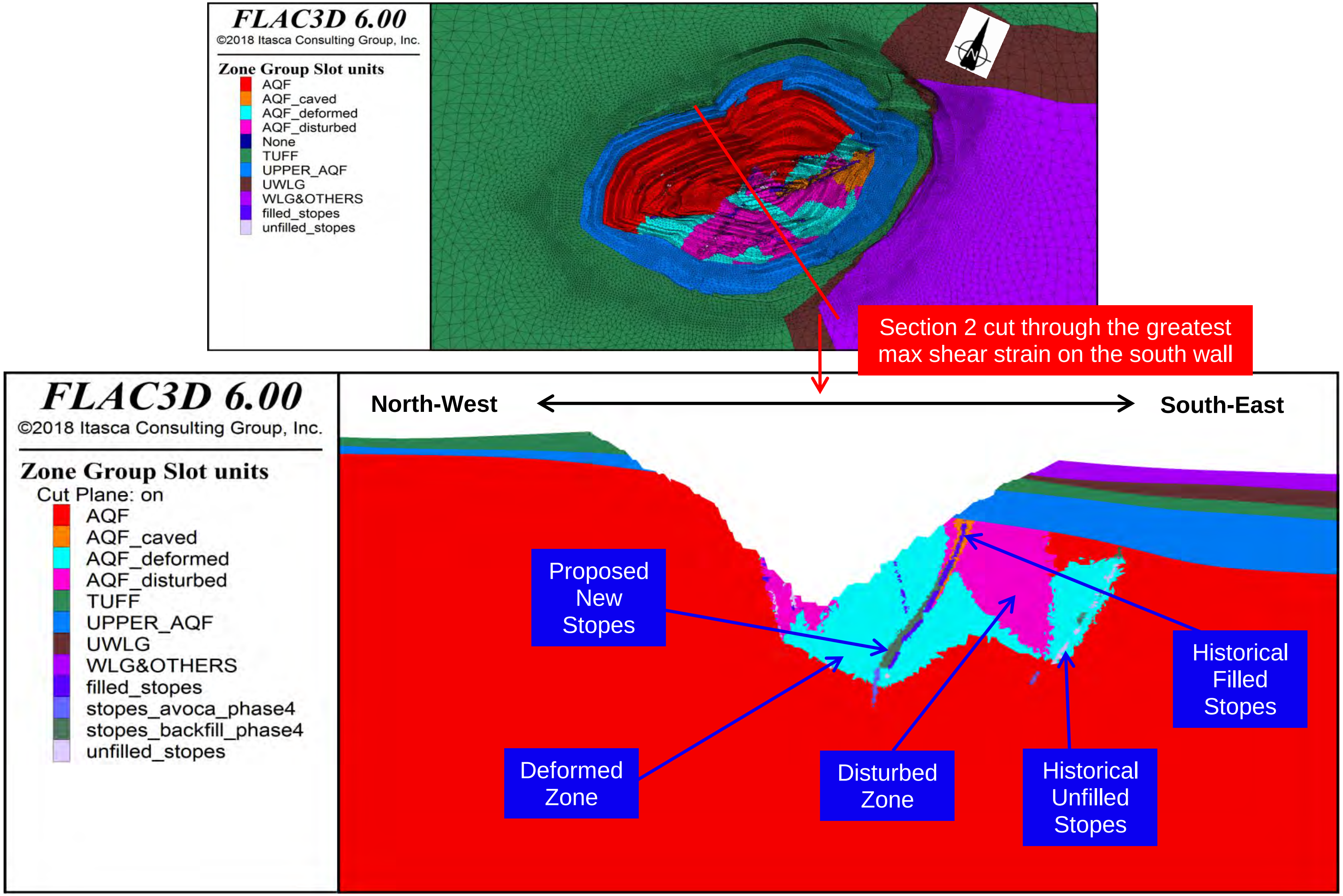
Anderson Lloyd Waihi, New Zealand Numerical Model - Run 1 PREDICTED MAX SHEAR STRAIN OF SECTION 2 AFTER YEAR 9	
PSM125-283R	Figure 25



Anderson Lloyd
Waihi, New Zealand
Numerical Model - Run 1
PREDICTED DISPLACEMENT VECTOR OF SECTION 2 AFTER YEAR 9

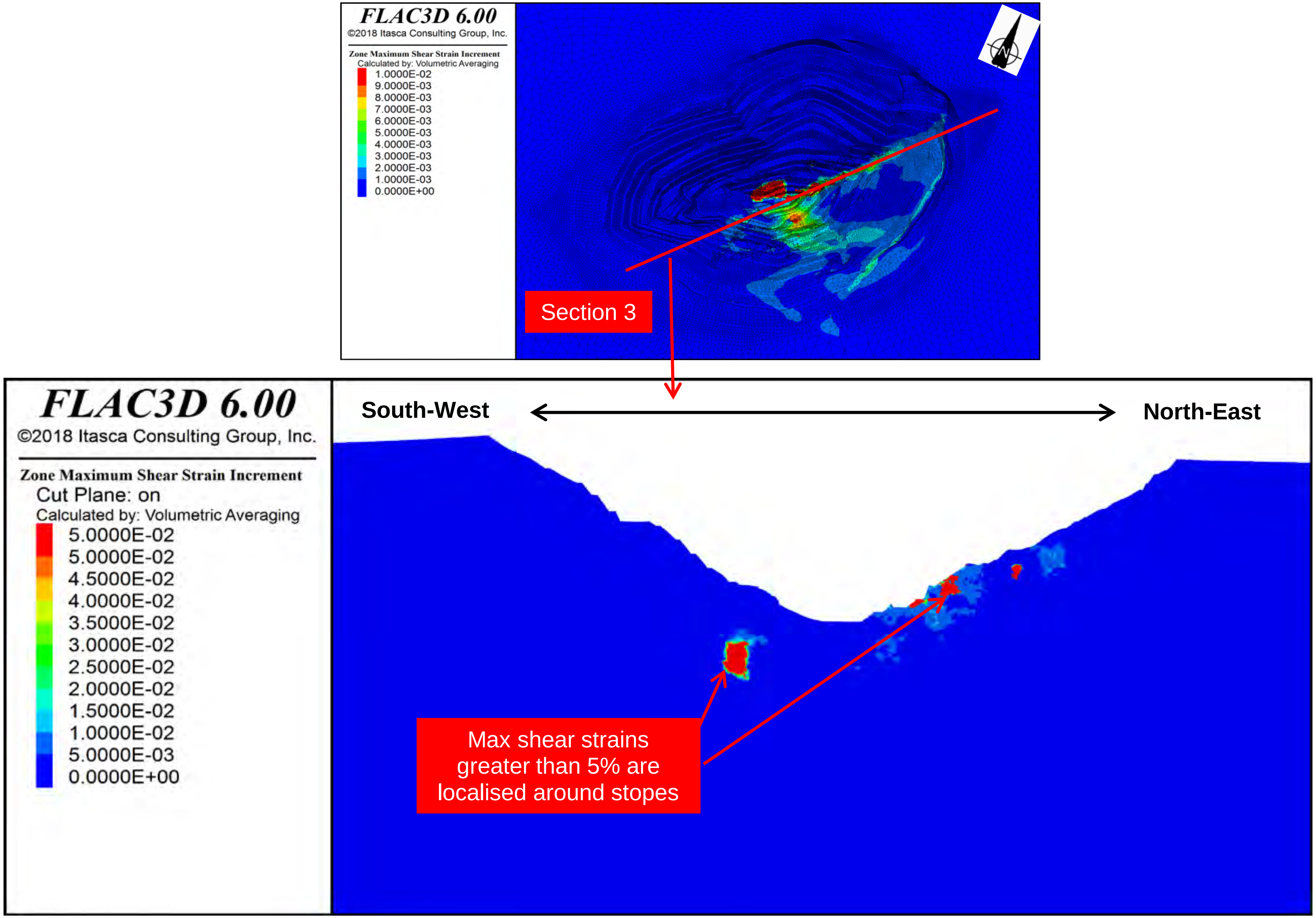
PSM125-283R	Figure 26

Pells Sullivan Meynink



Anderson Lloyd **Waihi, New Zealand** **FLAC3D Model** **GEOLOGY CONDITION OF SECTION 2**	
PSM125-283R	**Figure 27**

Pells Sullivan Meynink

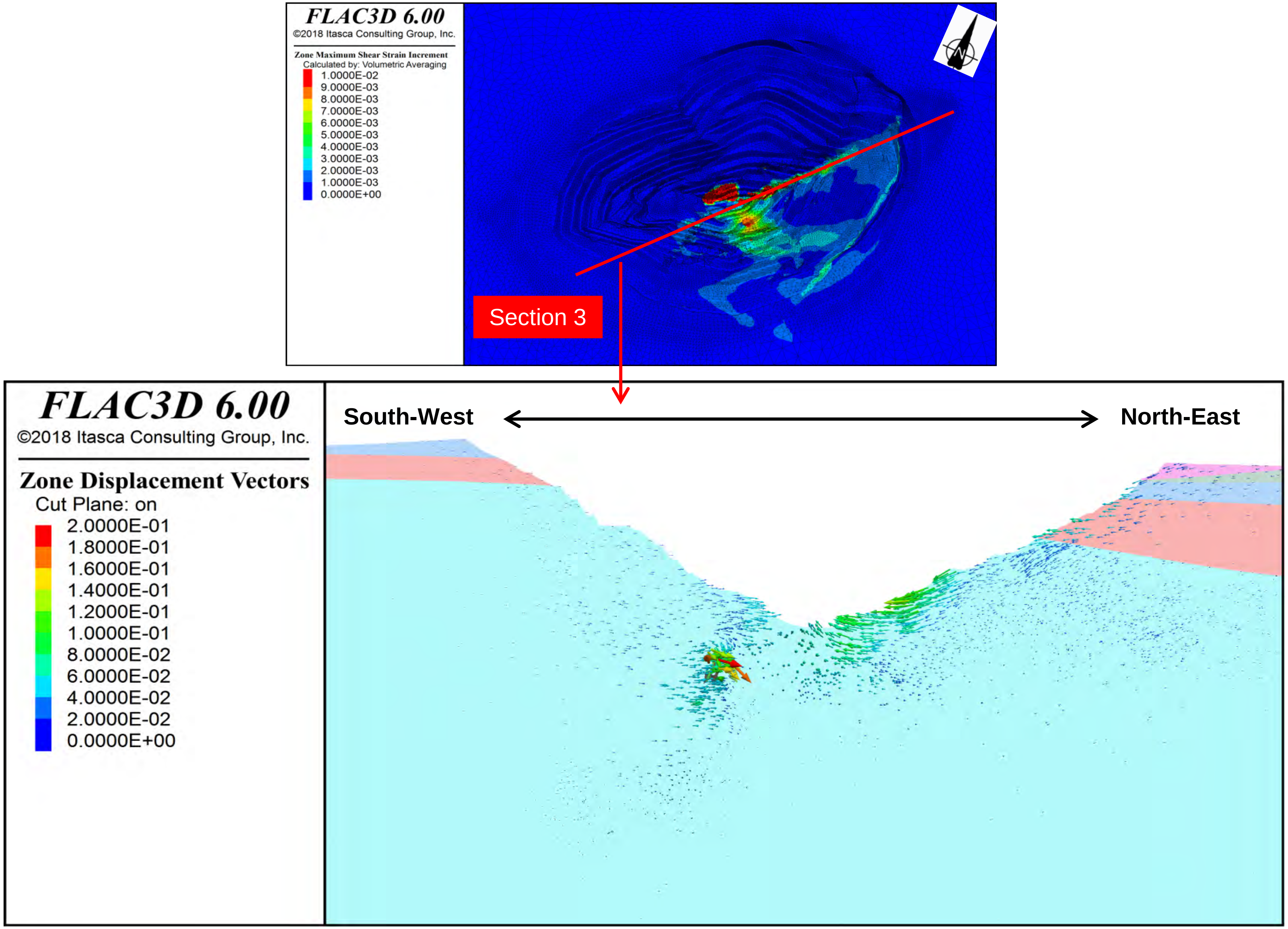


PSM

Pells Sullivan Meynink

Anderson Lloyd
Waihi, New Zealand
Numerical Model - Run 1
PREDICTED MAX SHEAR STRAIN OF SECTION 3 AFTER YEAR 9

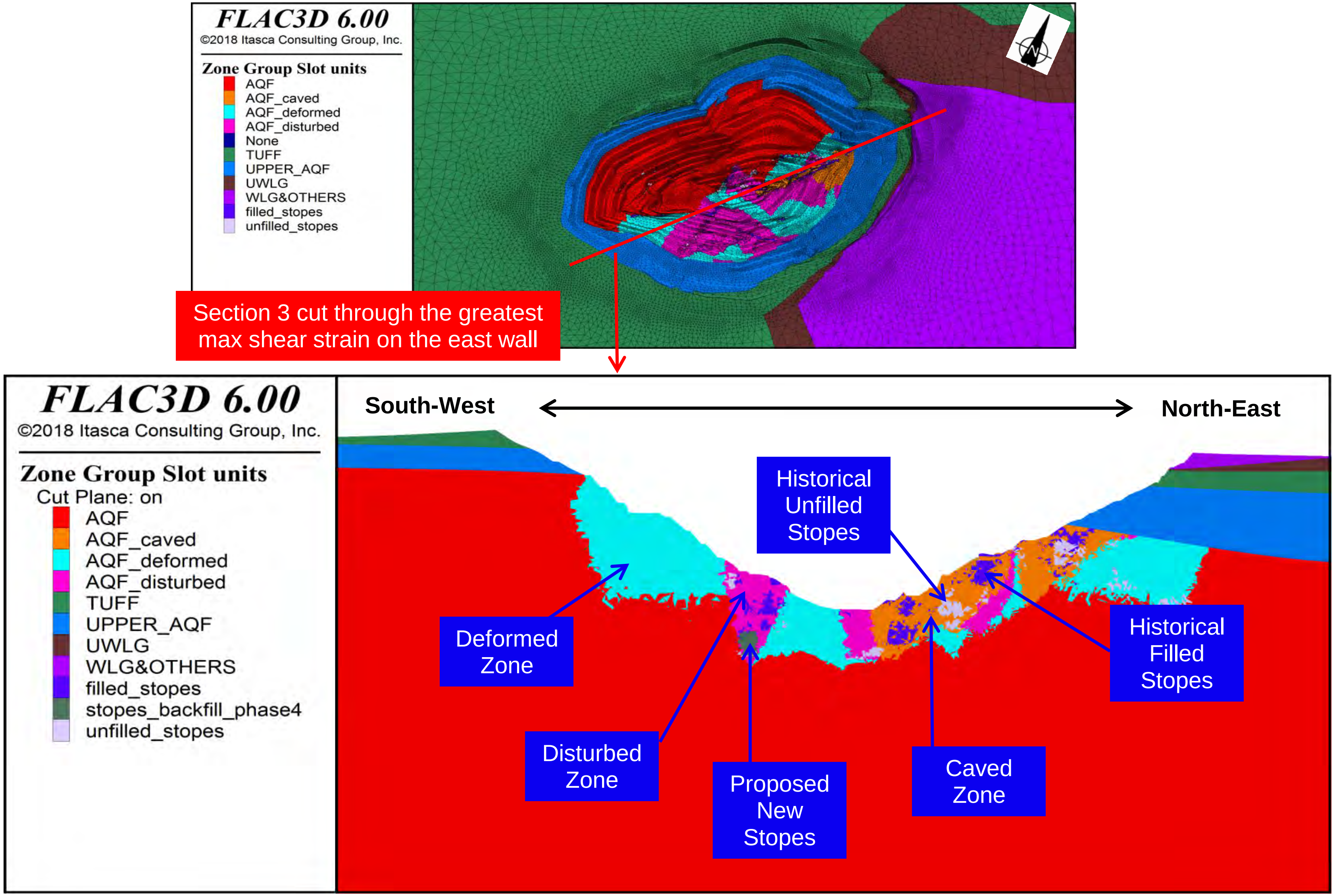
PSM125-283R	**Figure 28**



Anderson Lloyd
Waihi, New Zealand
Numerical Model - Run 1
PREDICTED DISPLACEMENT VECTOR OF SECTION 3 AFTER YEAR 9

PSM125-283R	Figure 29

PSM
Pells Sullivan Meynink

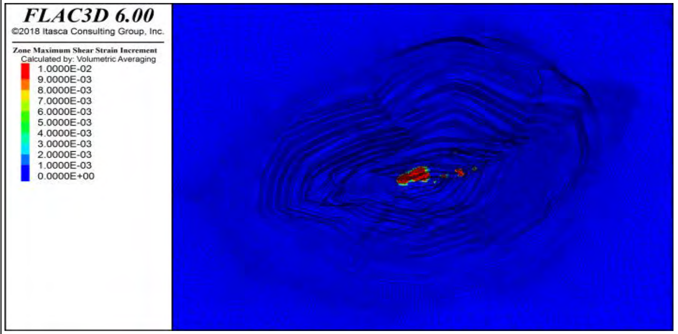


Anderson Lloyd
Waihi, New Zealand
FLAC3D Model

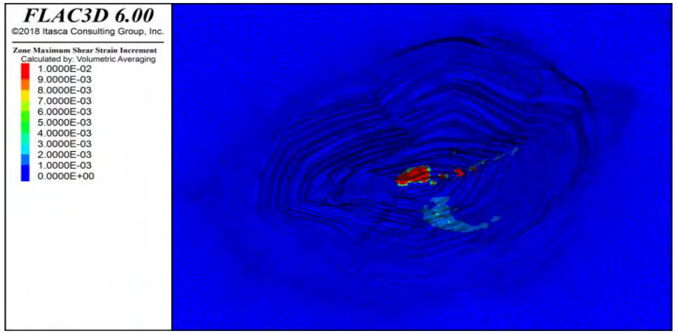
GEOLOGY CONDITION OF SECTION 3

PSM125-283R	Figure 30

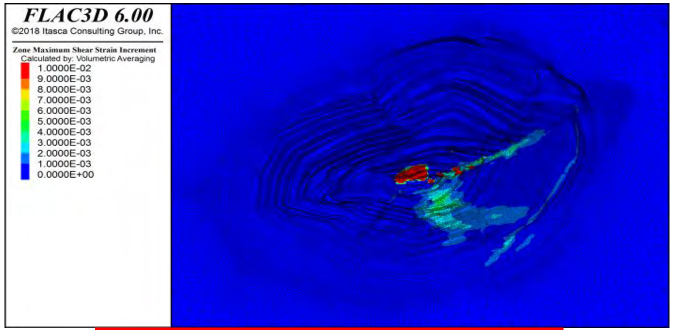
Pells Sullivan Meynink



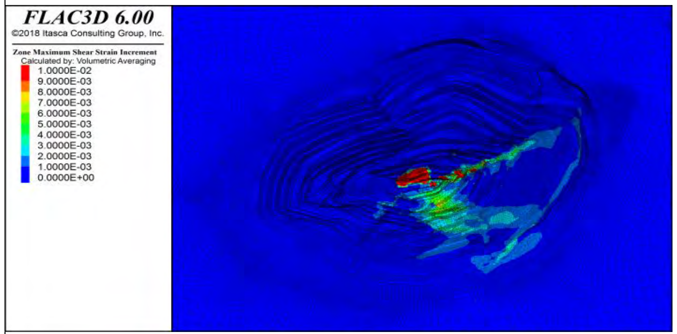
After Year 2 underground working



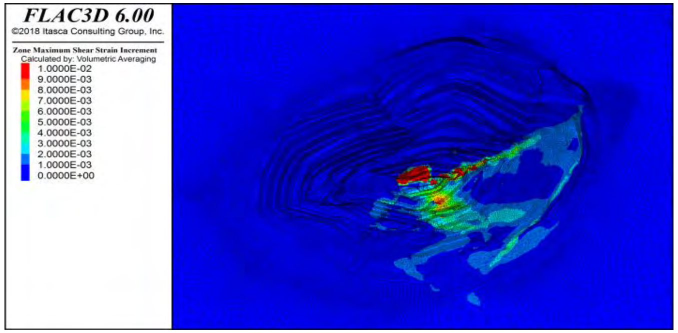
After Year 3 underground working



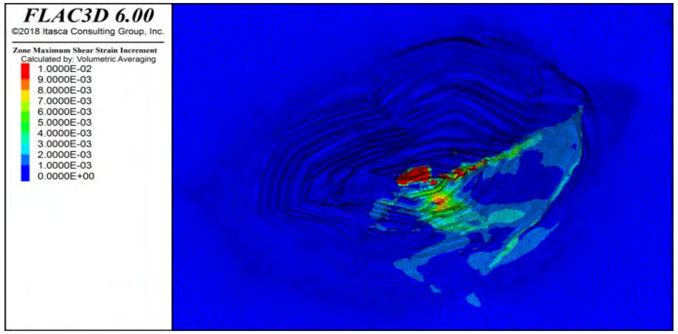
After Year 4 underground working



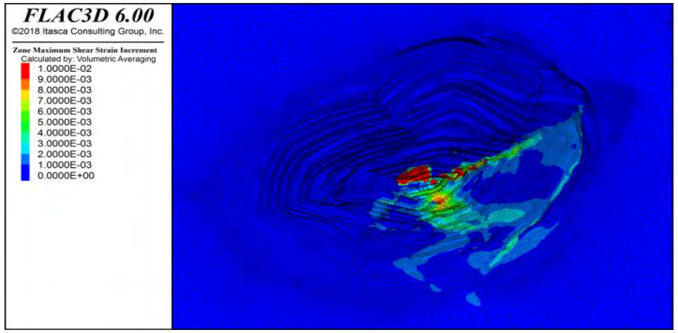
After Year 5 underground working



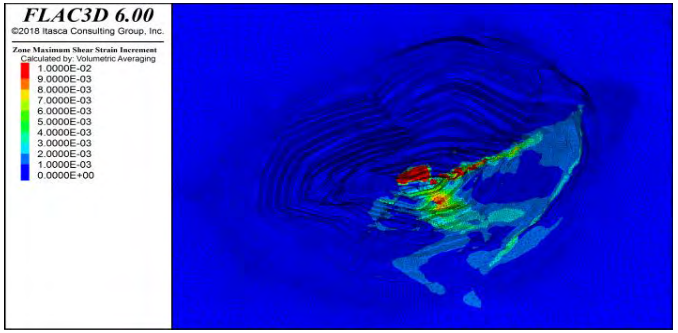
After Year 6 underground working



After Year 7 underground working



After Year 8 underground working



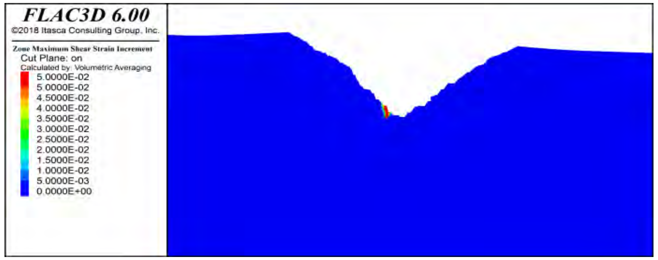
After Year 9 underground working

PSM

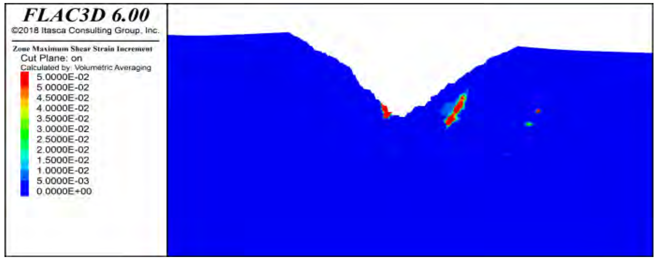
Pells Sullivan Meynink

Anderson Lloyd
Waihi, New Zealand
Numerical Model - Run 1
PREDICTED MAX SHEAR STRAIN FOR YEARLY SEQUENCE

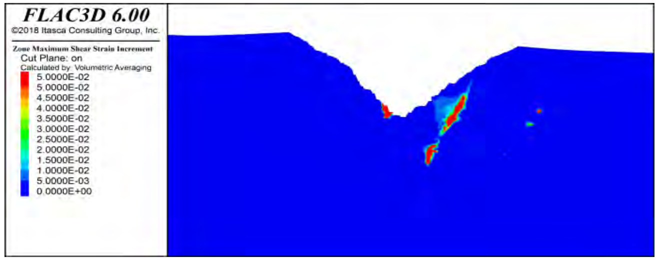
PSM125-283R	**Figure 31**



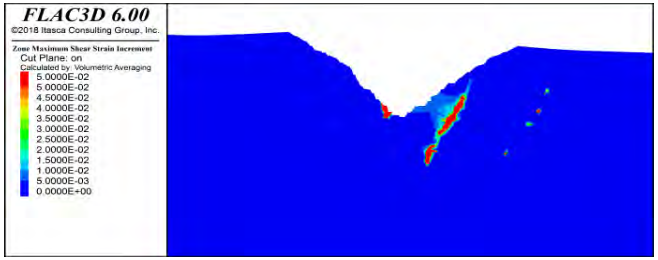
After Year 2 underground working



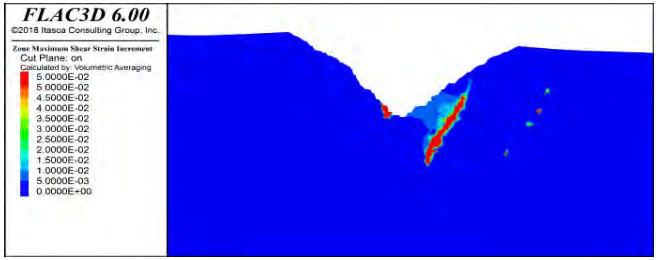
After Year 3 underground working



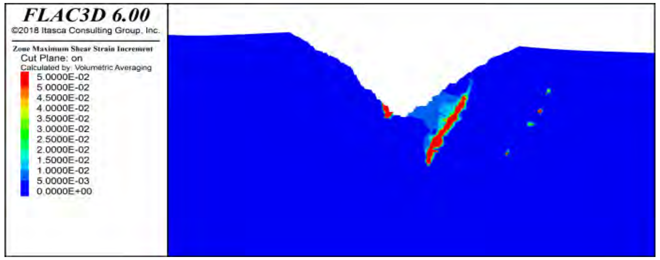
After Year 4 underground working



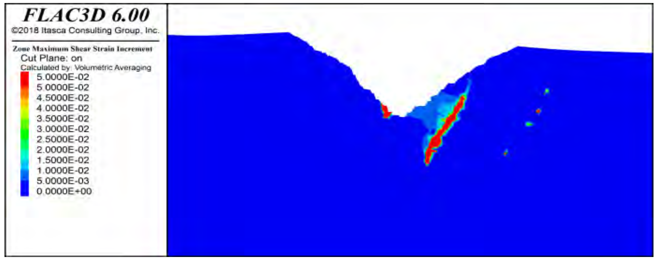
After Year 5 underground working



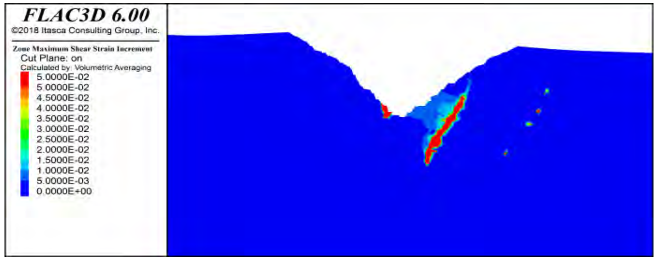
After Year 6 underground working



After Year 7 underground working



After Year 8 underground working

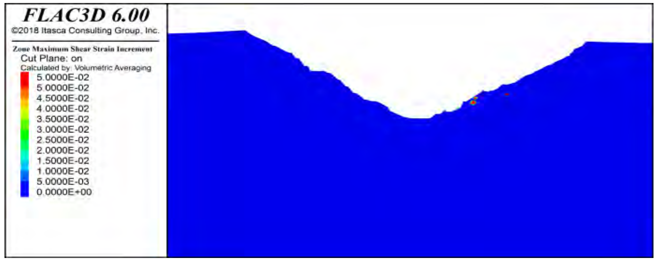


After Year 9 underground working

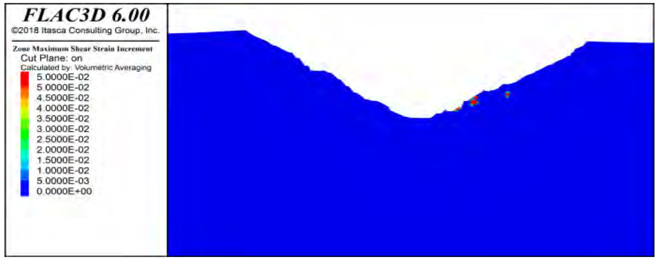
PSM
Pells Sullivan Meynink

Anderson Lloyd
Waihi, New Zealand
Numerical Model - Run 1
PREDICTED MAX SHEAR STRAIN OF SECTION 2 FOR YEARLY SEQUENCE

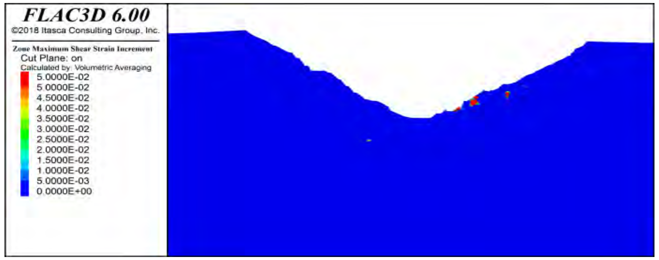
PSM125-283R	**Figure 32**



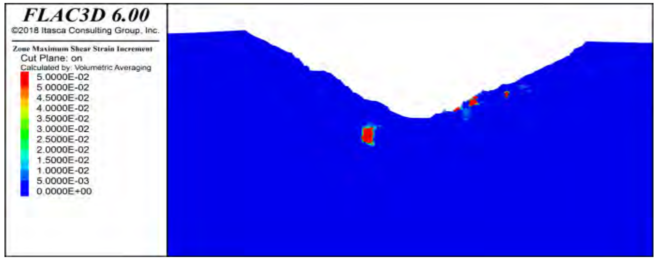
After Year 2 underground working



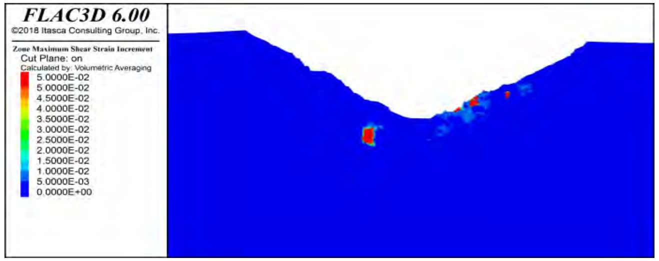
After Year 3 underground working



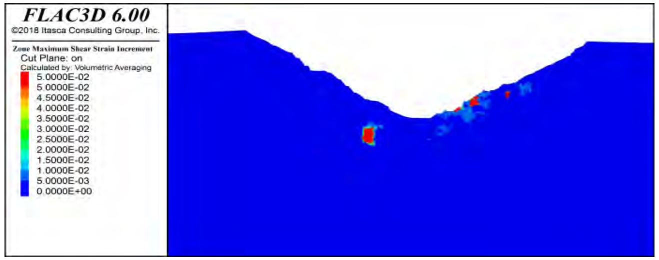
After Year 4 underground working



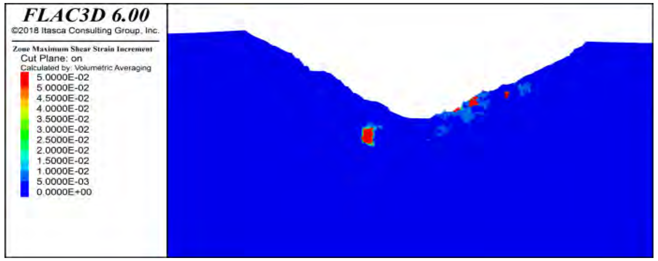
After Year 5 underground working



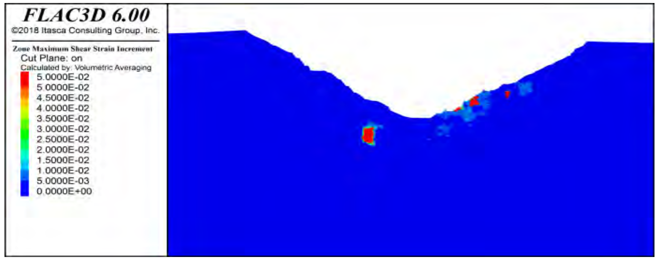
After Year 6 underground working



After Year 7 underground working



After Year 8 underground working

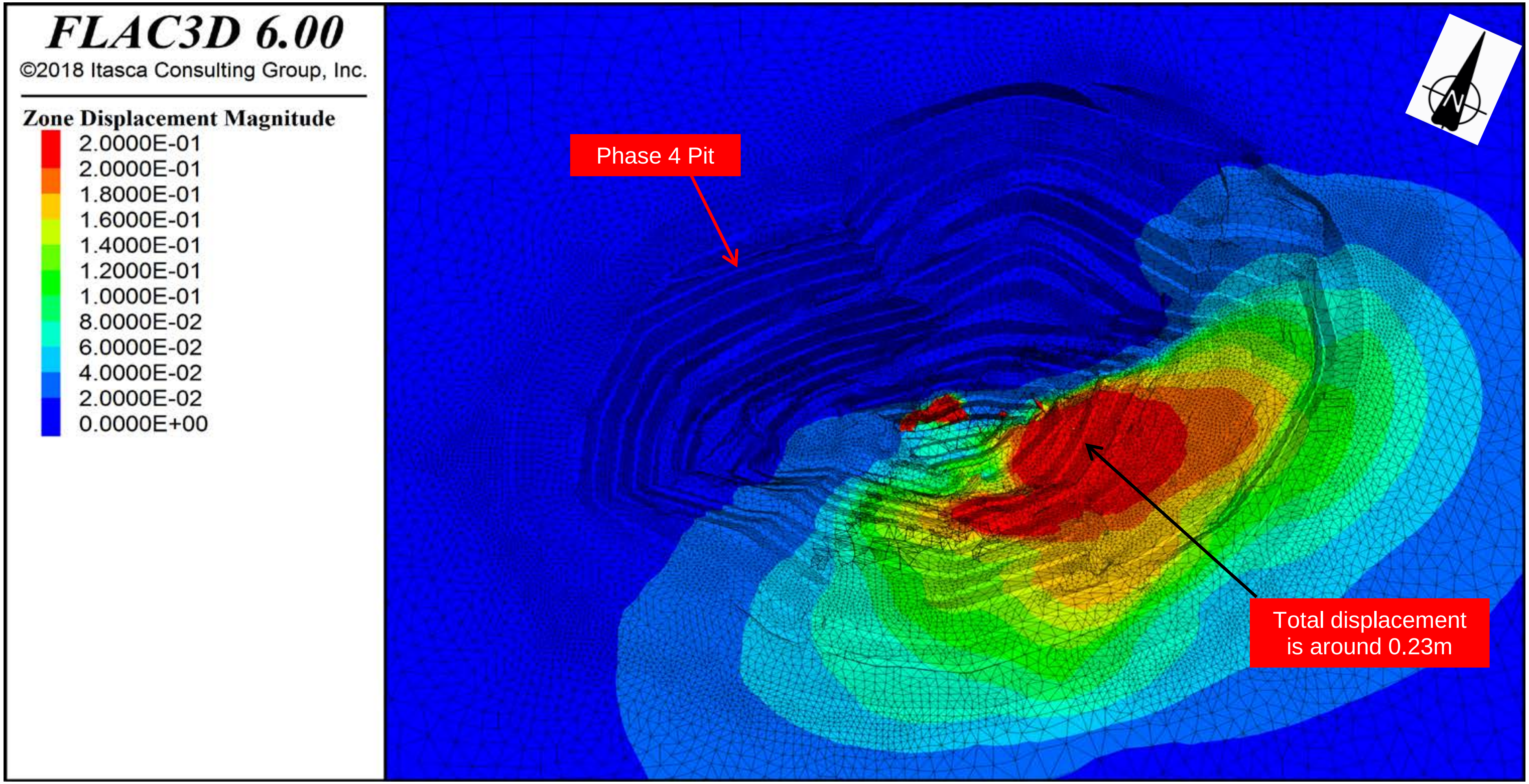


After Year 9 underground working

PSM

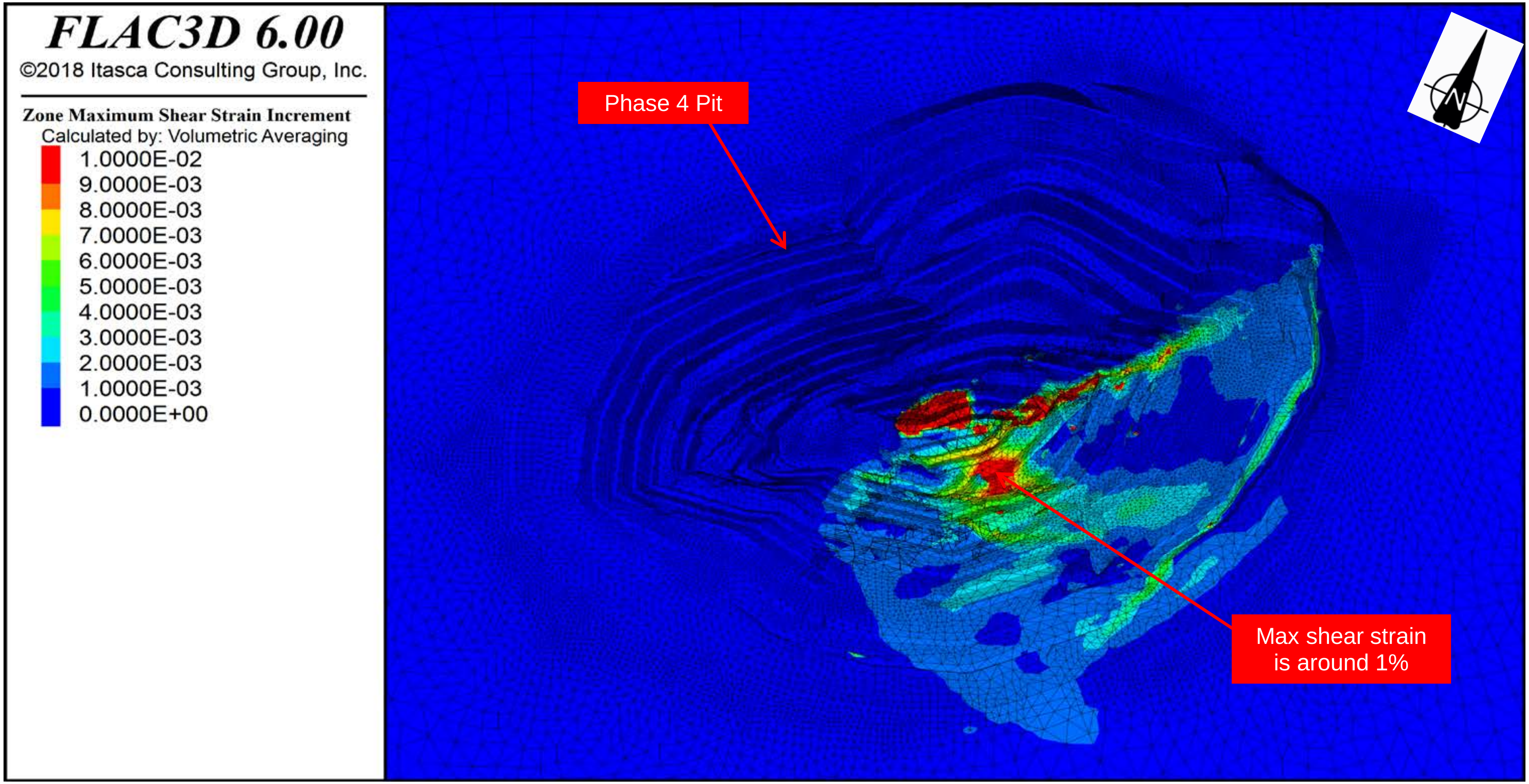
Pells Sullivan Meynink

Anderson Lloyd Waihi, New Zealand Numerical Model - Run 1 PREDICTED MAX SHEAR STRAIN OF SECTION 3 FOR YEARLY SEQUENCE	
PSM125-283R	**Figure 33**



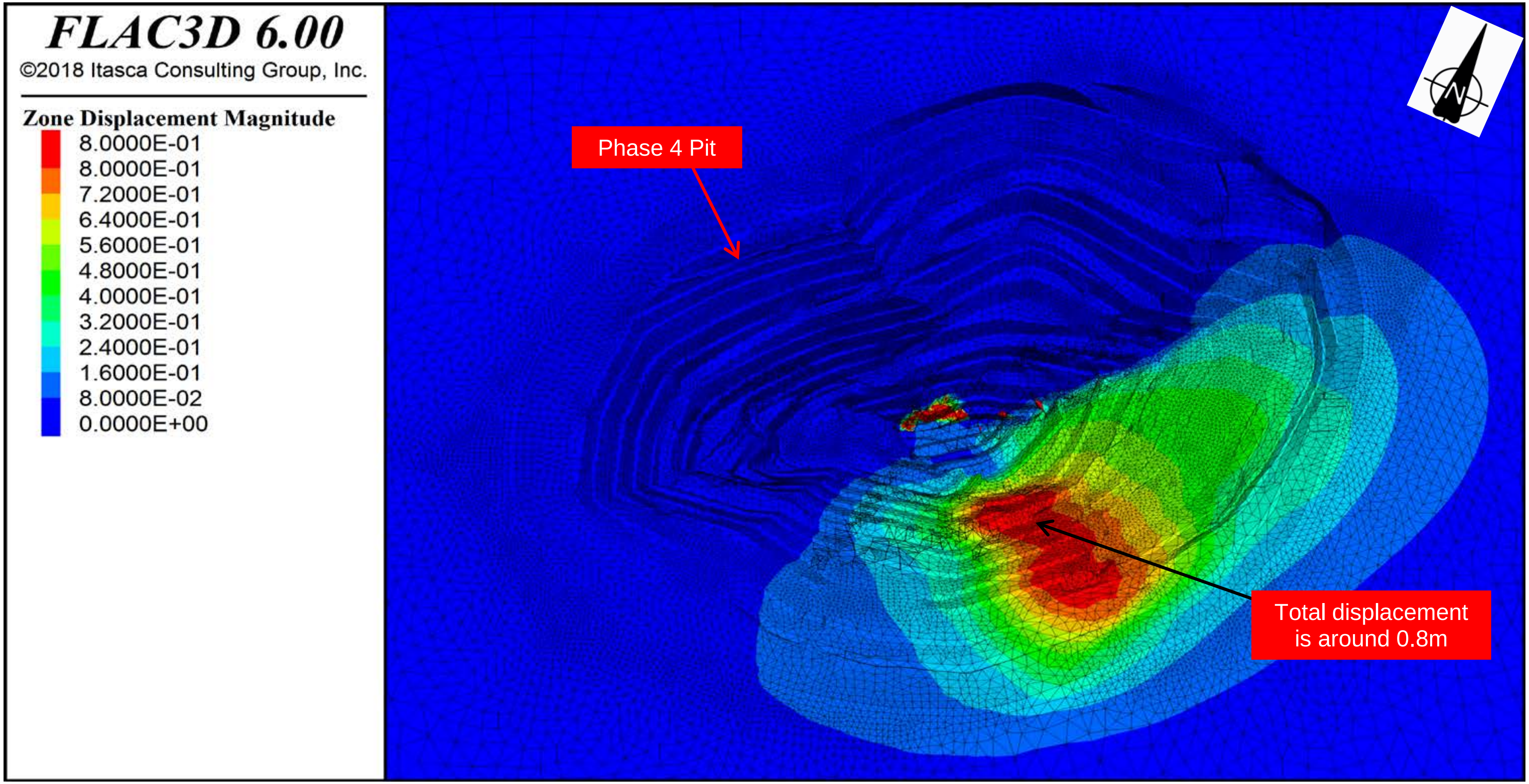
Anderson Lloyd Waihi, New Zealand Numerical Model - Run 2 PREDICTED TOTAL DISPLACEMENT AFTER YEAR 9	
PSM125-283R	Figure 34

Pells Sullivan Meynink



Anderson Lloyd Waihi, New Zealand Numerical Model - Run 2 PREDICTED MAX SHEAR STRAIN AFTER YEAR 9	
PSM125-283R	Figure 35

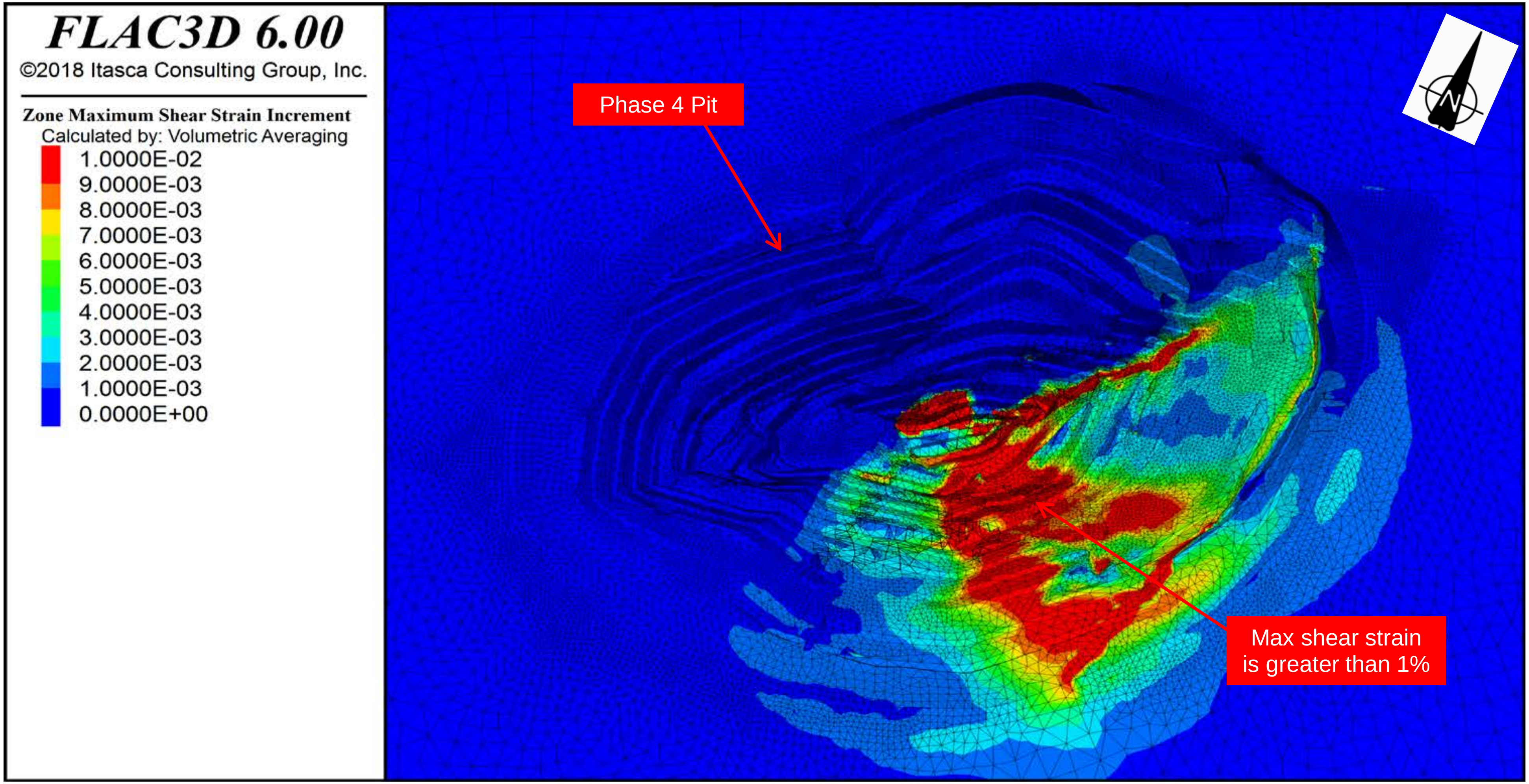
PSM Pells Sullivan Meynink



Note: The maximum contour limit is different to Run 1

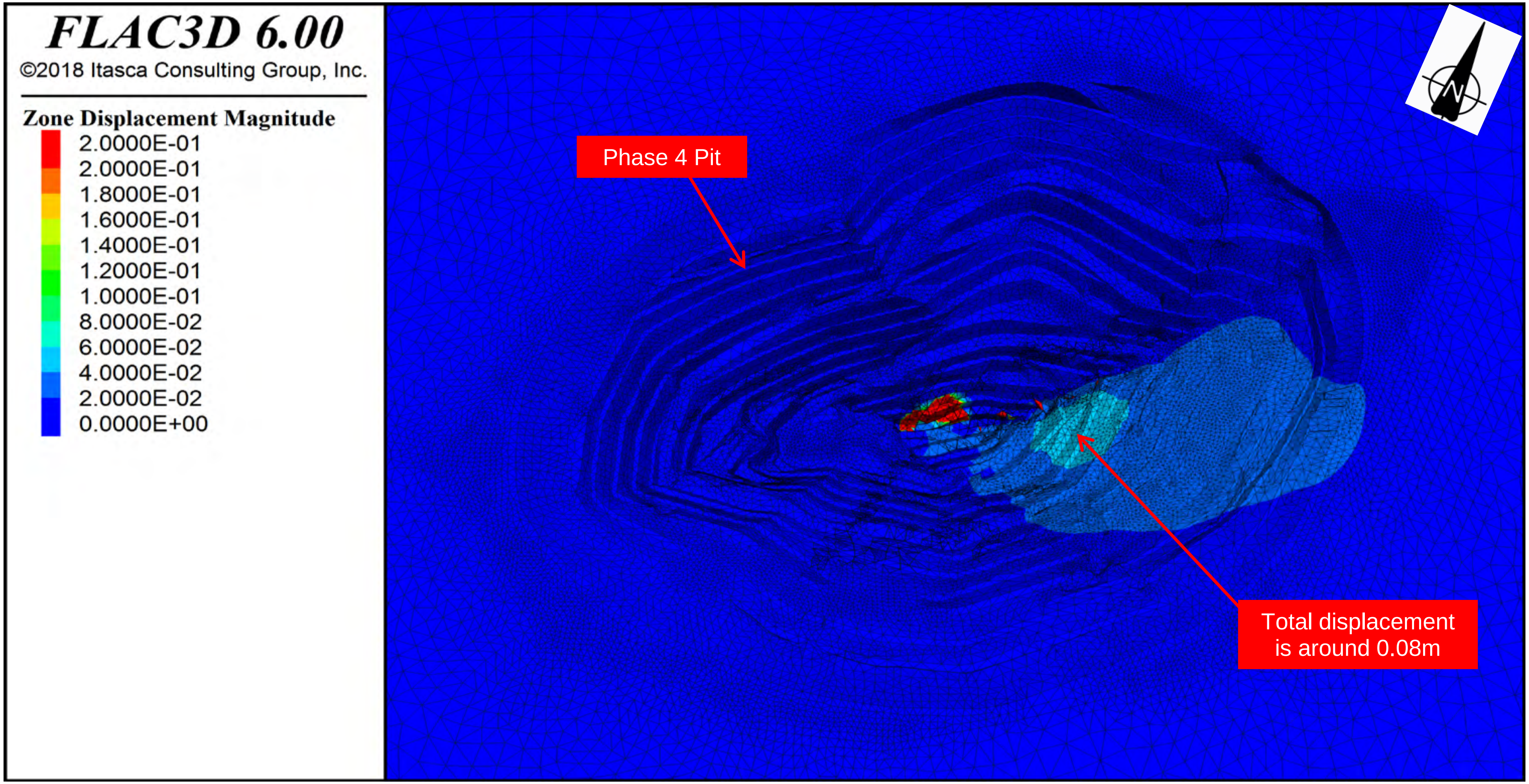
Pells Sullivan Meynink

Anderson Lloyd Waihi, New Zealand Numerical Model - Run 3 **PREDICTED TOTAL DISPLACEMENT AFTER YEAR 9**	
PSM125-283R	**Figure 36**



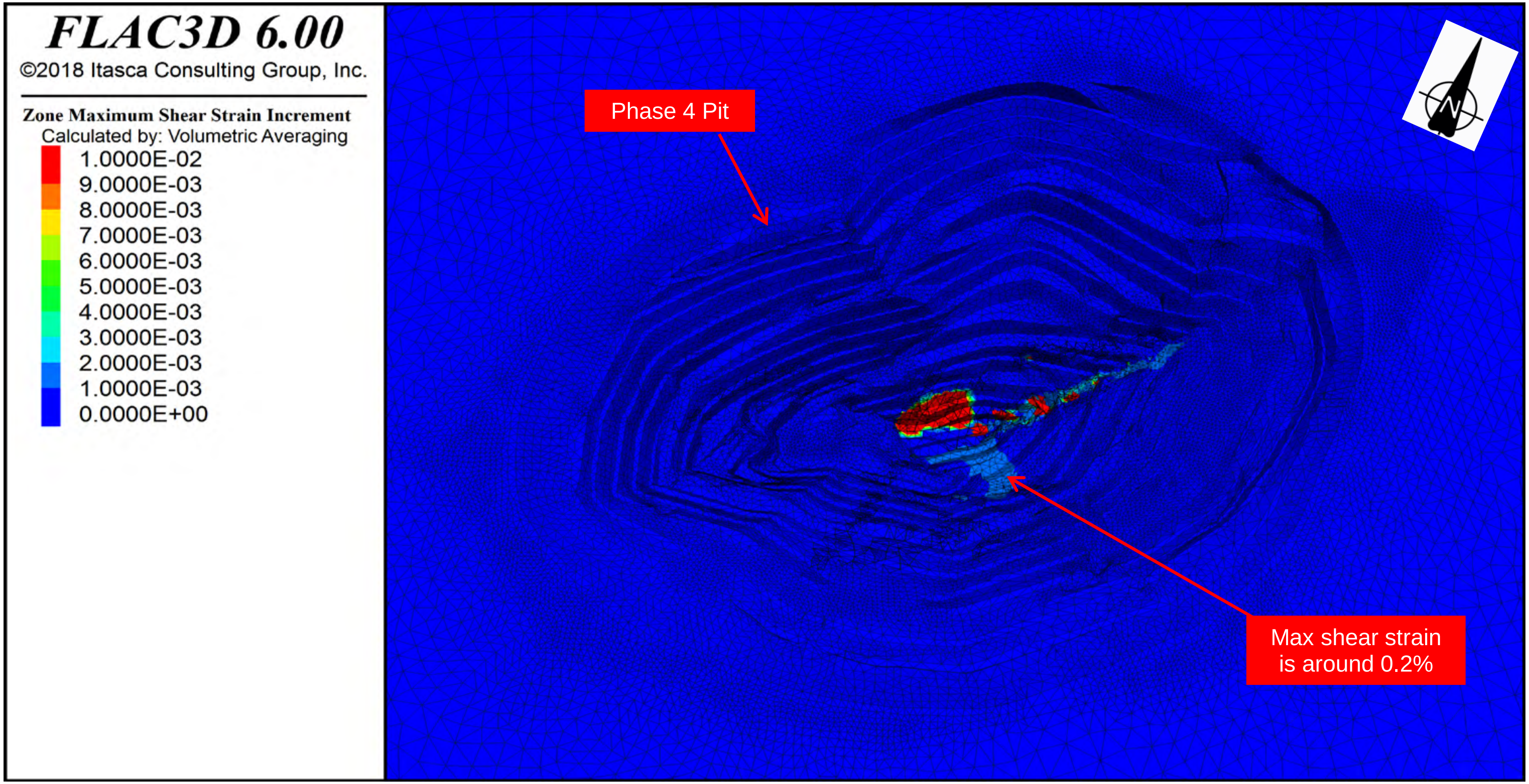
Pells Sullivan Meynink

Anderson Lloyd Waihi, New Zealand Numerical Model - Run 3 PREDICTED MAX SHEAR STRAIN AFTER YEAR 9	
PSM125-283R	**Figure 37**



Anderson Lloyd
Waihi, New Zealand
Numerical Model - Run 4
PREDICTED TOTAL DISPLACEMENT AFTER YEAR 9

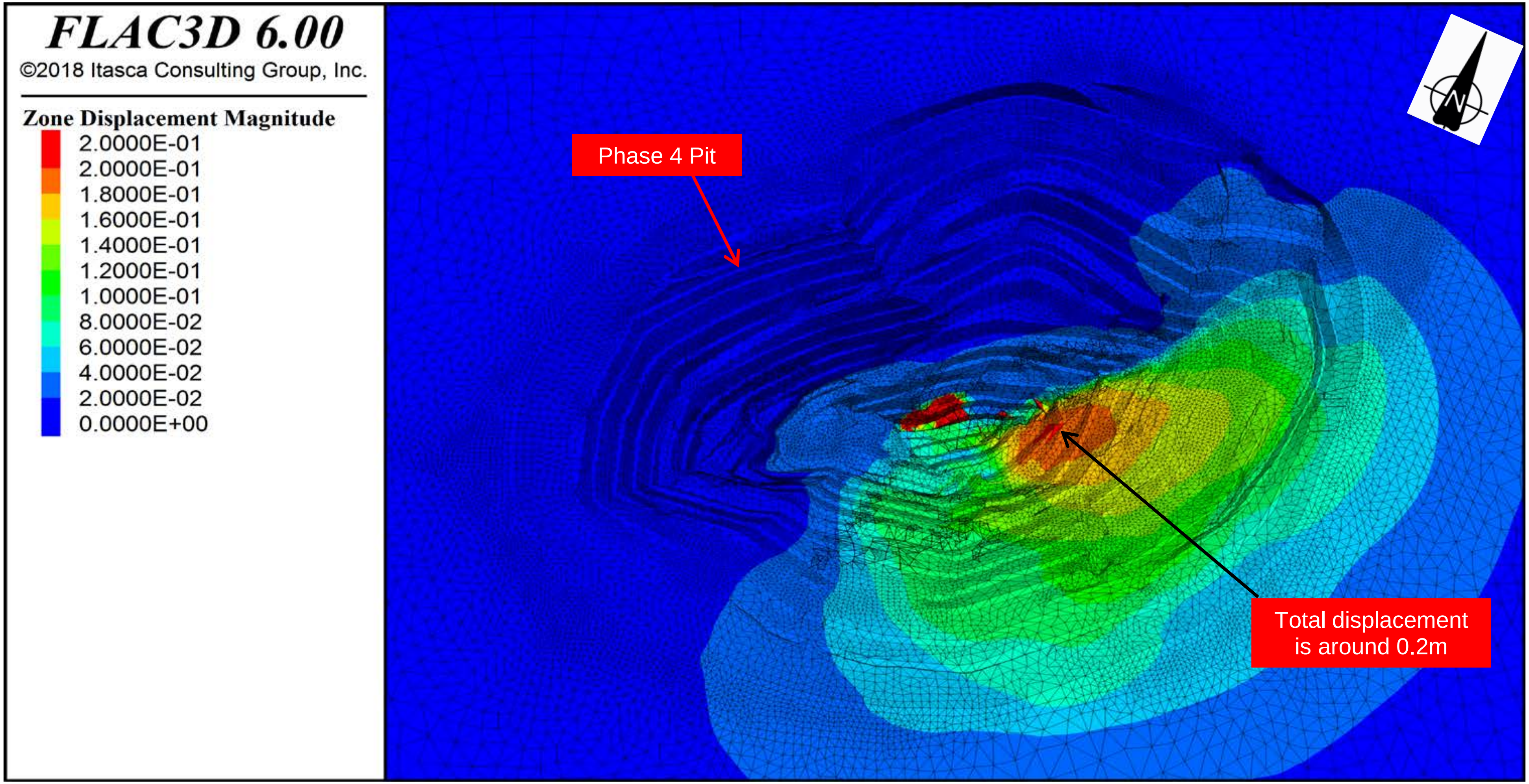
PSM125-283R	**Figure 38**



Anderson Lloyd Waihi, New Zealand Numerical Model - Run 4 PREDICTED MAX SHEAR STRAIN AFTER YEAR 9	
PSM125-283R	Figure 39

PSM

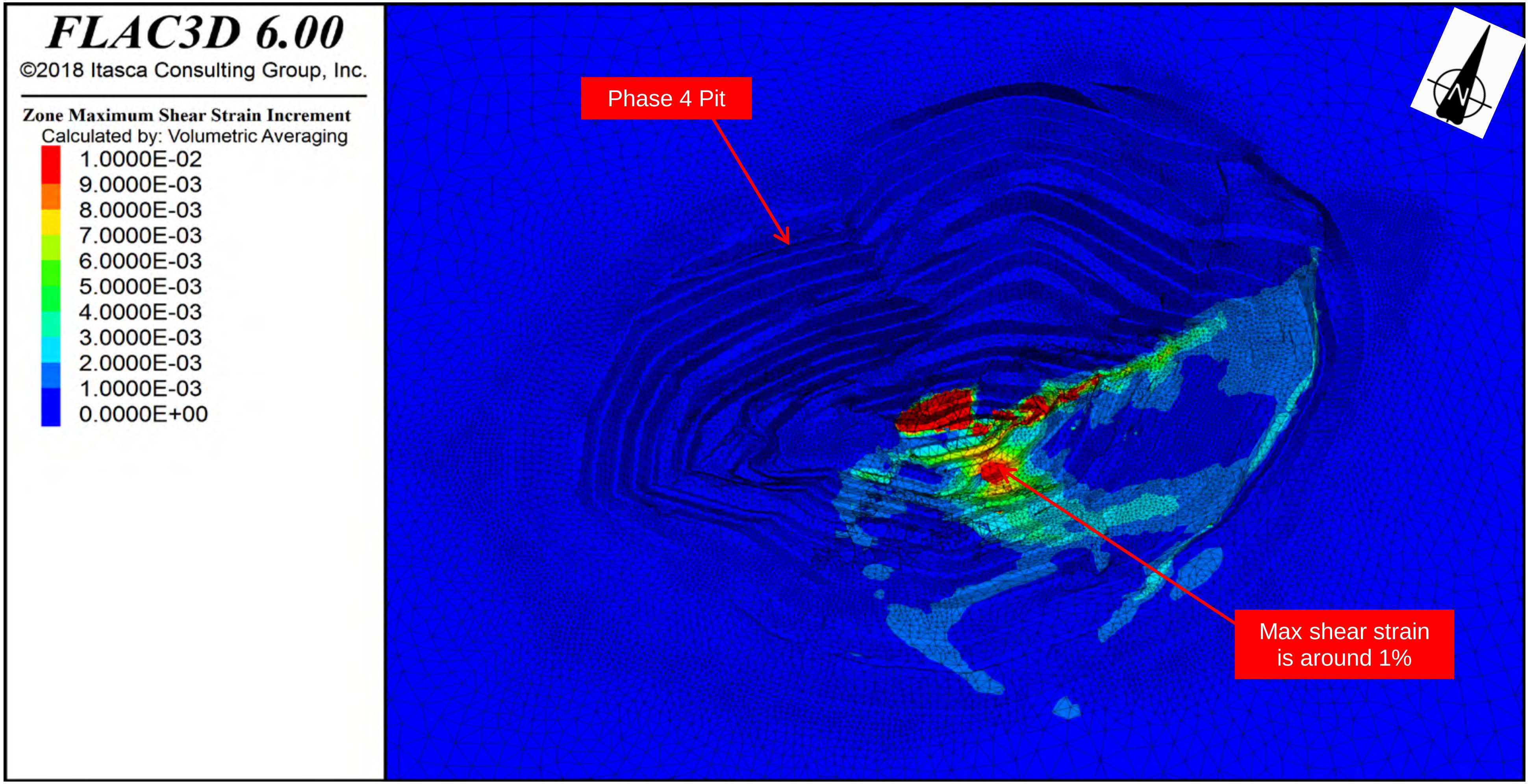
Pells Sullivan Meynink



Anderson Lloyd
Waihi, New Zealand
Numerical Model - Run 5
PREDICTED TOTAL DISPLACEMENT
AFTER YEAR 9

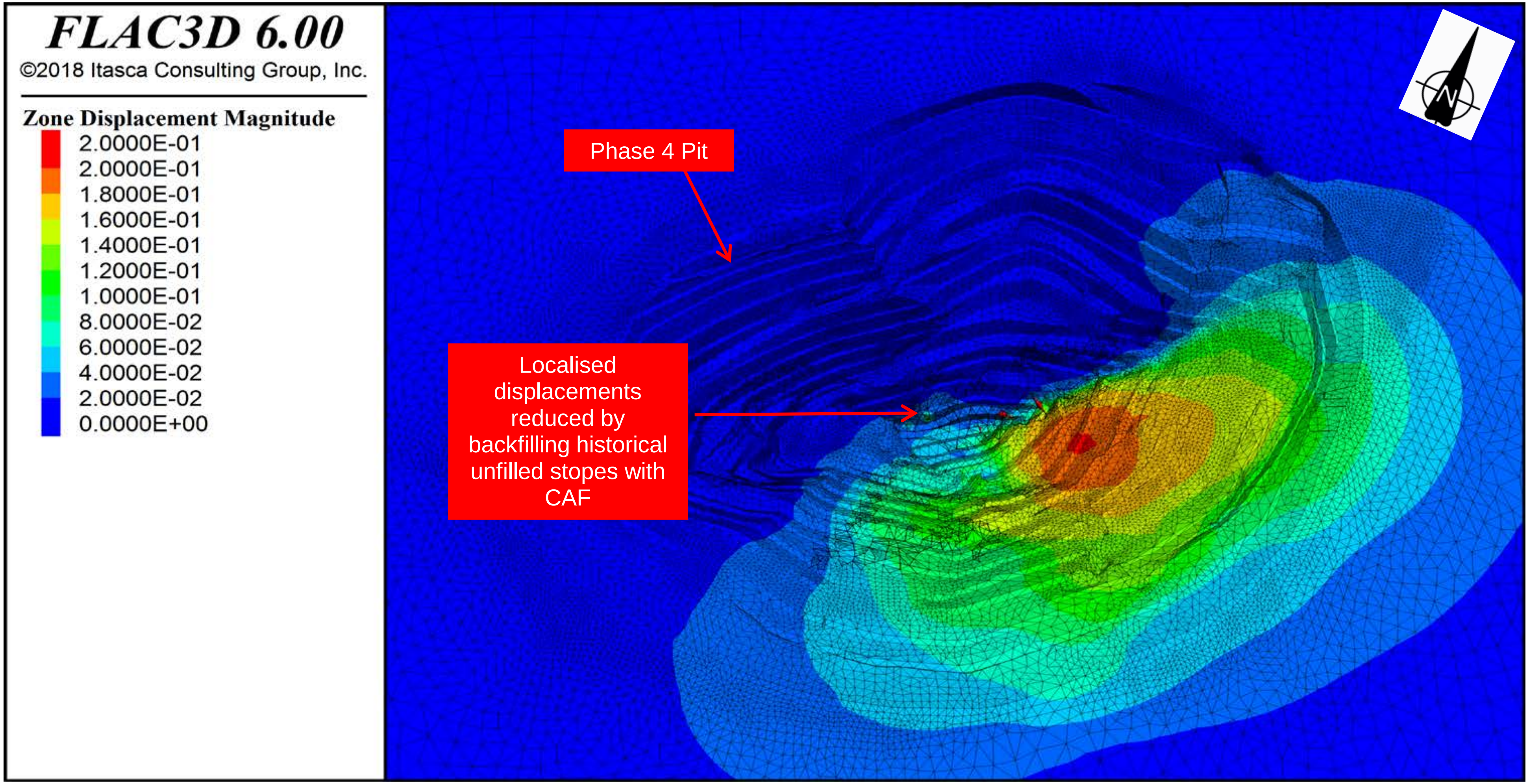
PSM125-283R	**Figure 40**

Pells Sullivan Meynink



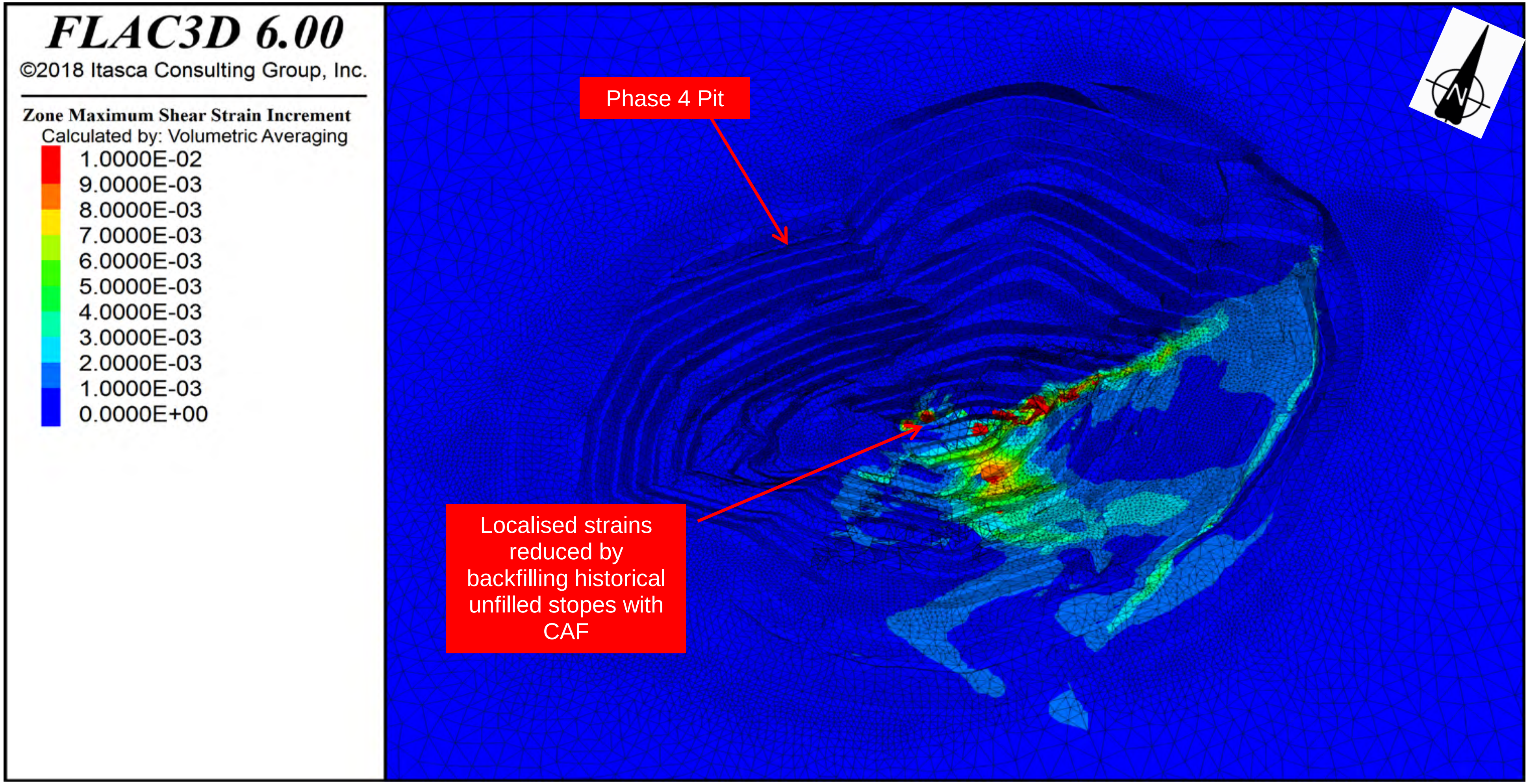
Anderson Lloyd Waihi, New Zealand Numerical Model - Run 5 PREDICTED MAX SHEAR STRAIN AFTER YEAR 9	
PSM125-283R	Figure 41

PSM Pells Sullivan Meynink



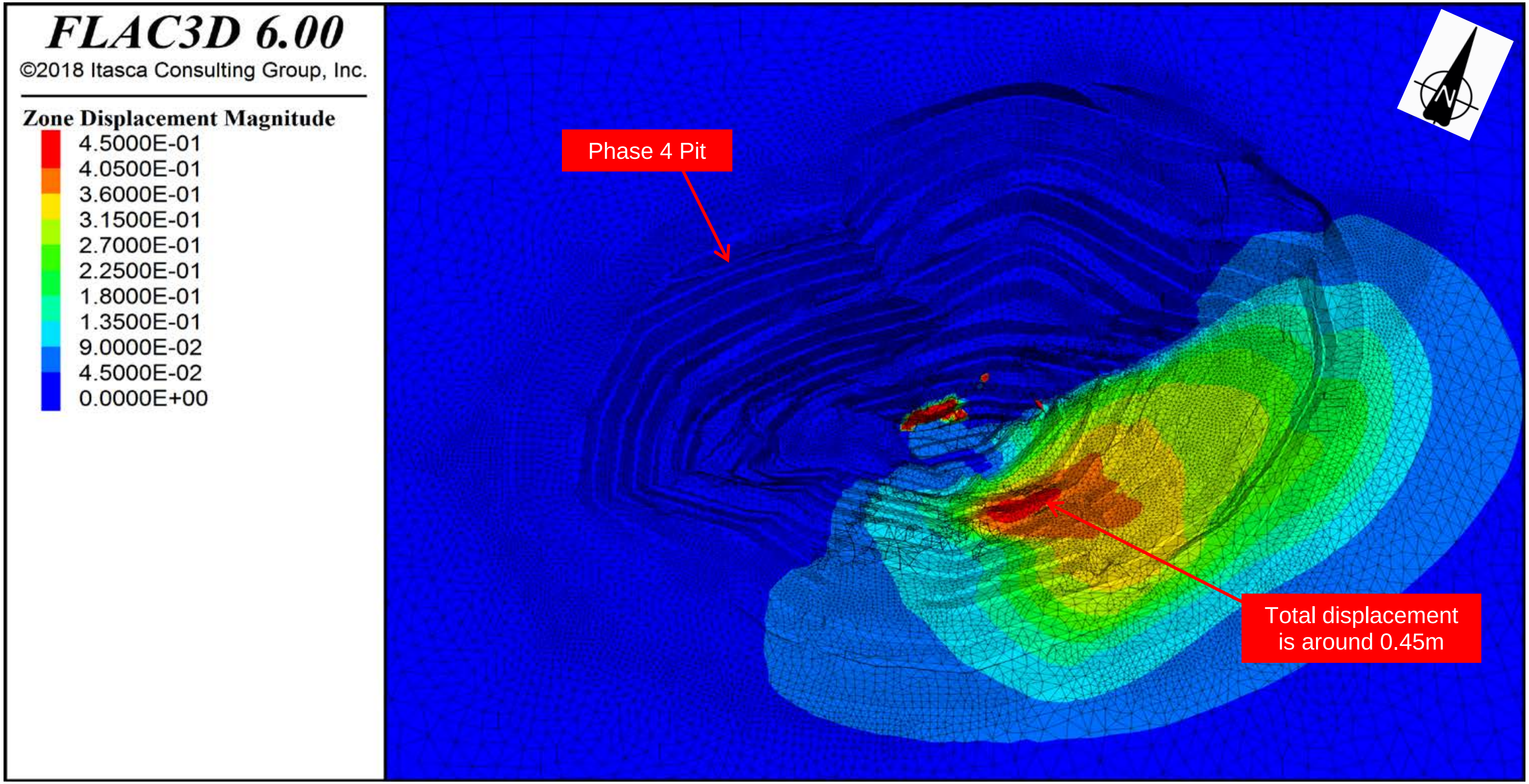
Anderson Lloyd Waihi, New Zealand Numerical Model - Run 6 PREDICTED TOTAL DISPLACEMENT AFTER YEAR 9	
PSM125-283R	Figure 42

Pells Sullivan Meynink



PSM **Pells Sullivan Meynink**

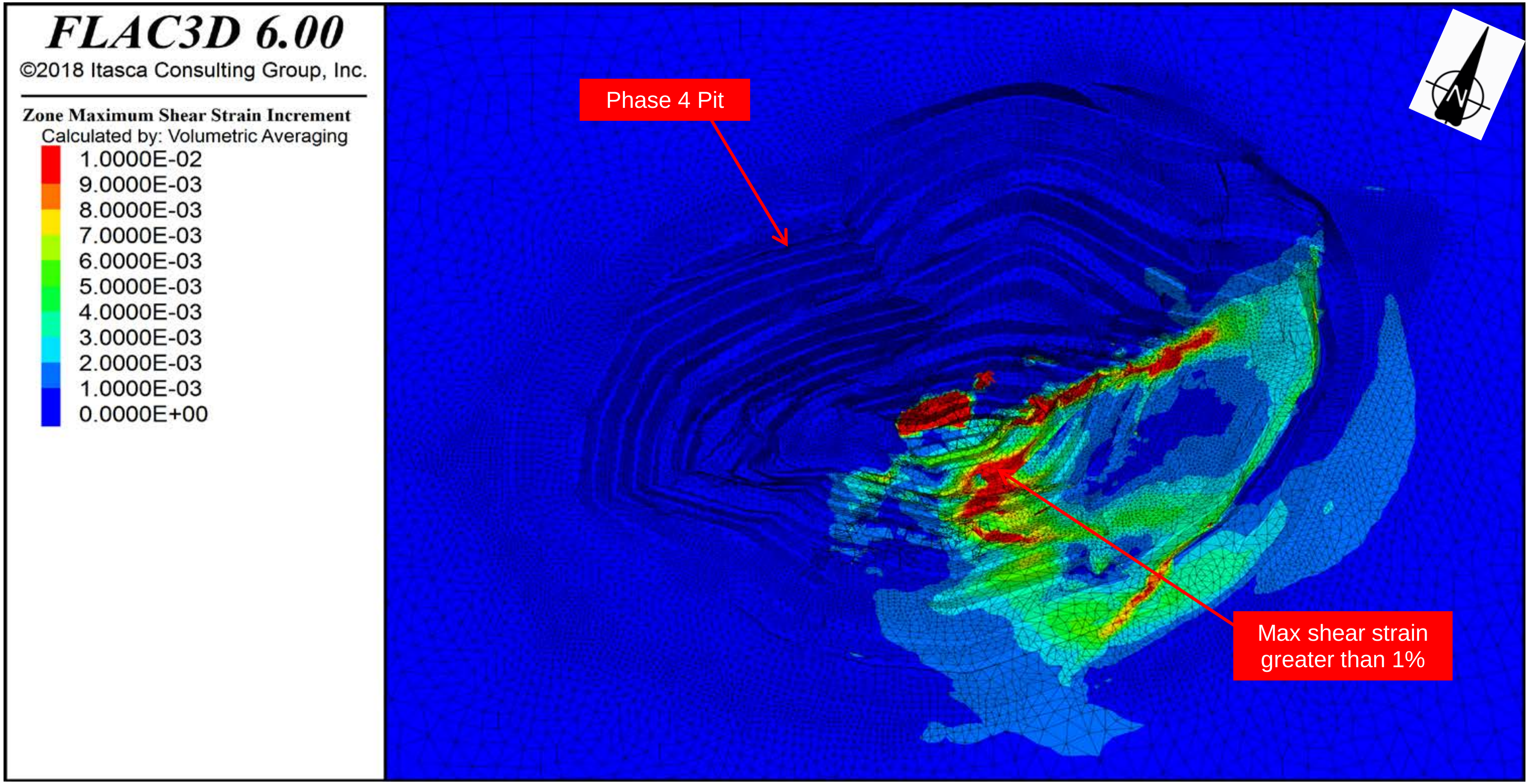
Anderson Lloyd Waihi, New Zealand Numerical Model - Run 6 PREDICTED MAX SHEAR STRAIN AFTER YEAR 9	
PSM125-283R	**Figure 43**



Note: The maximum contour limit is different to Run 1

PSM Pells Sullivan Meynink

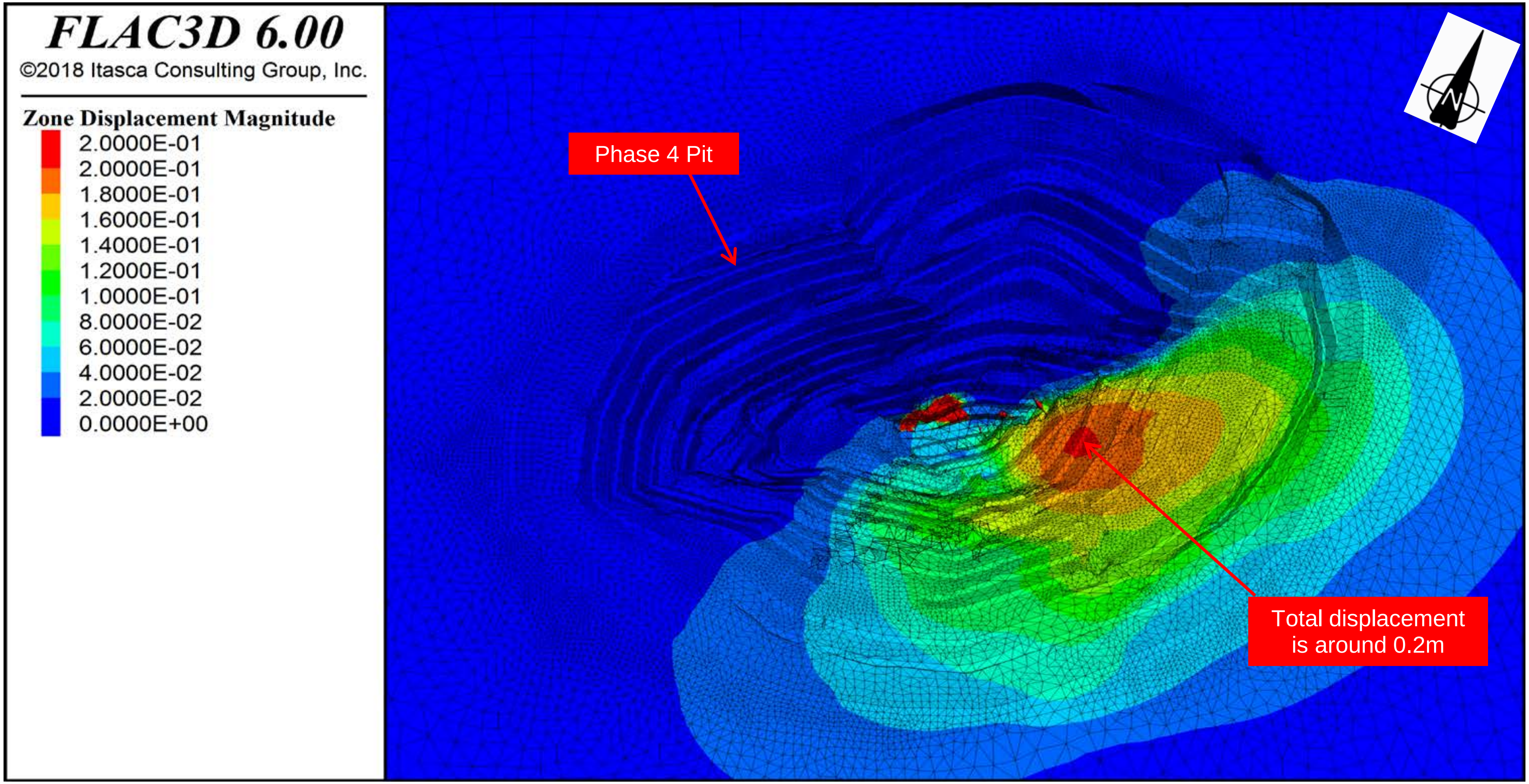
Anderson Lloyd Waihi, New Zealand Numerical Model - Run 7 PREDICTED TOTAL DISPLACEMENT AFTER YEAR 9	
PSM125-283R	Figure 44



Anderson Lloyd
Waihi, New Zealand
Numerical Model - Run 7
PREDICTED MAX SHEAR STRAIN
AFTER YEAR 9

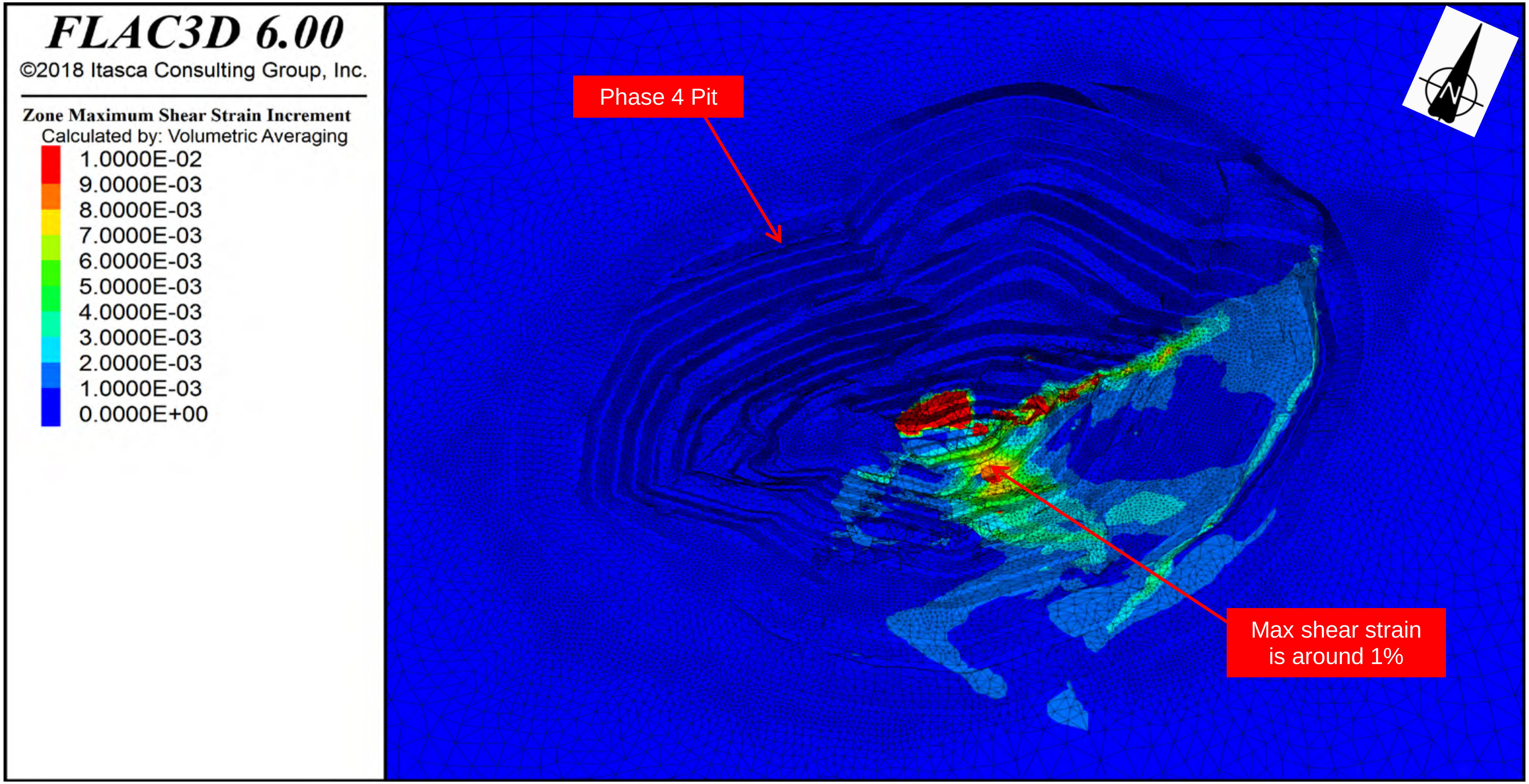
PSM125-283R	Figure 45

PSM Pells Sullivan Meynink



Anderson Lloyd Waihi, New Zealand Numerical Model - Run 8 **PREDICTED TOTAL DISPLACEMENT AFTER YEAR 9**	
PSM125-283R	Figure 46

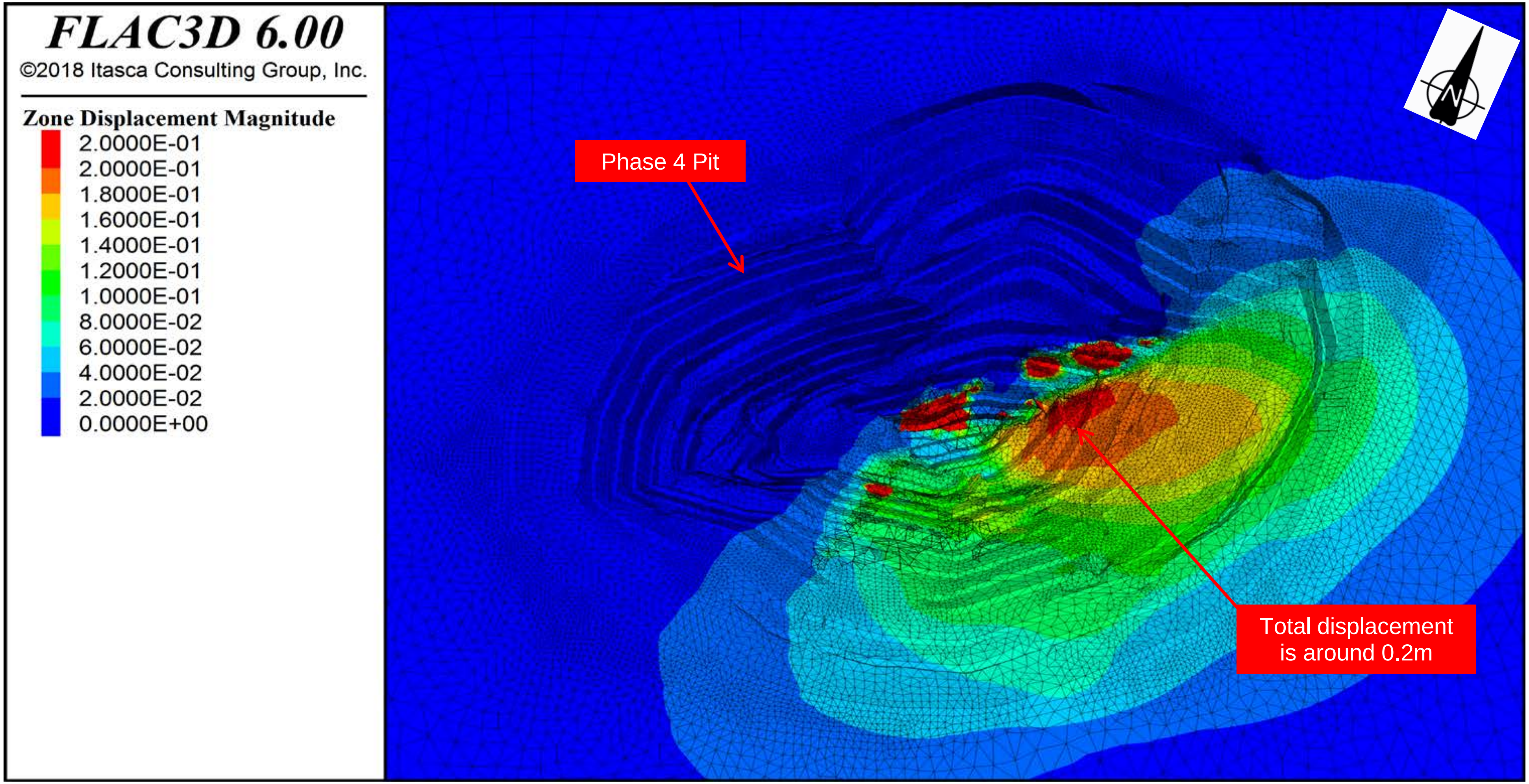
Pells Sullivan Meynink



PSM

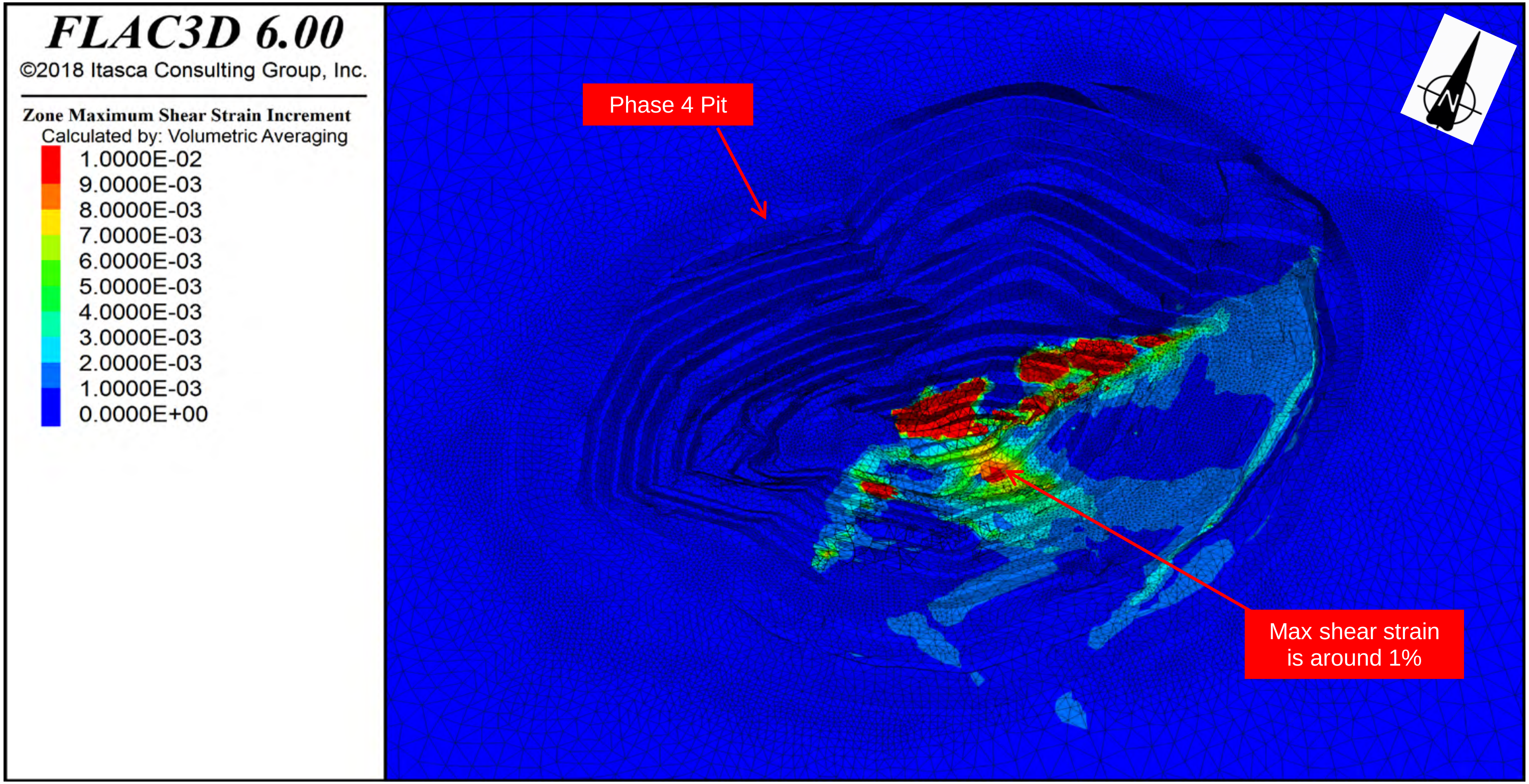
Pells Sullivan Meynink

Anderson Lloyd Waihi, New Zealand Numerical Model - Run 8 PREDICTED MAX SHEAR STRAIN AFTER YEAR 9	
PSM125-283R	Figure 47



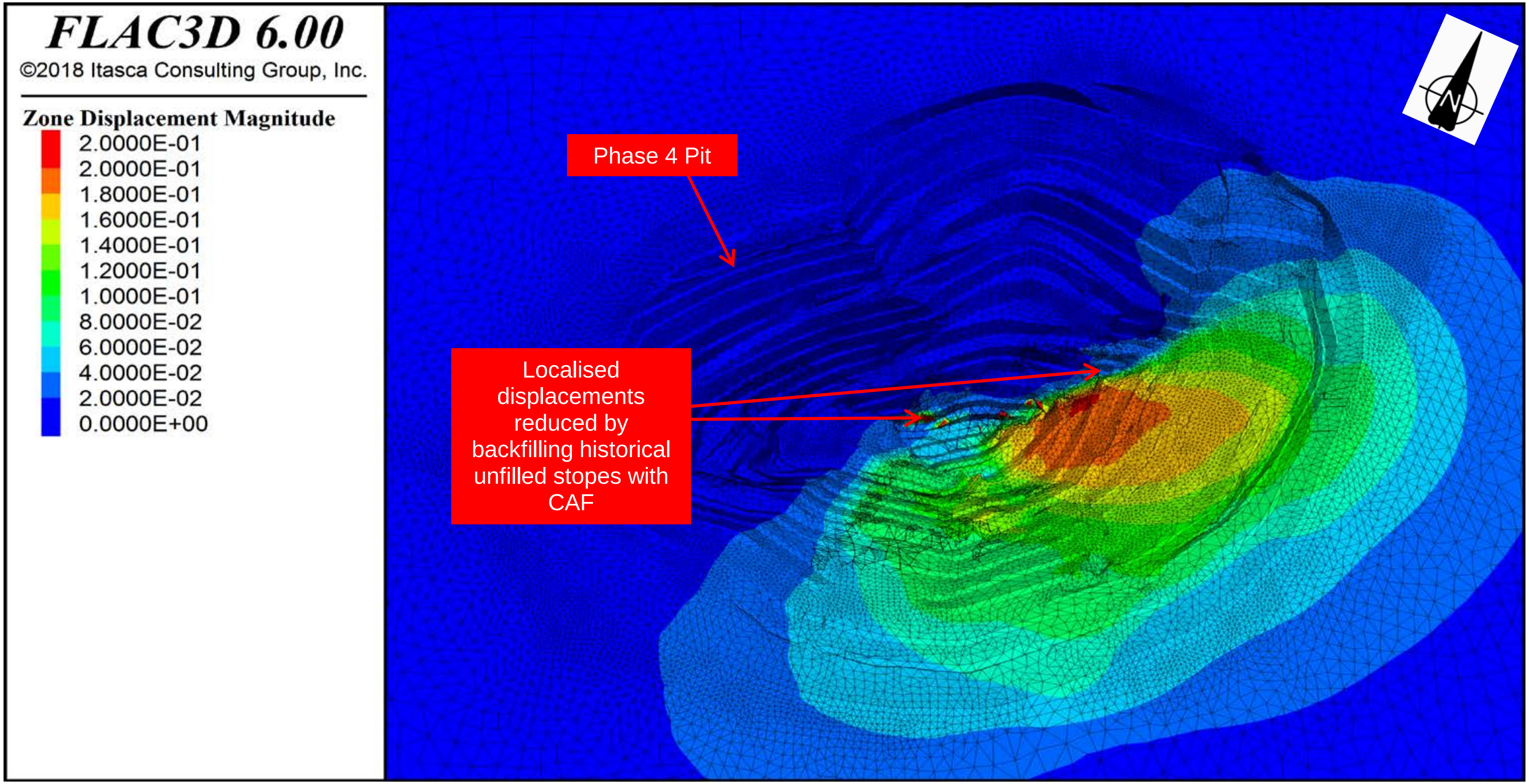
Pells Sullivan Meynink

Anderson Lloyd Waihi, New Zealand Numerical Model - Run 9 PREDICTED TOTAL DISPLACEMENT AFTER YEAR 9	
PSM125-283R	Figure 48



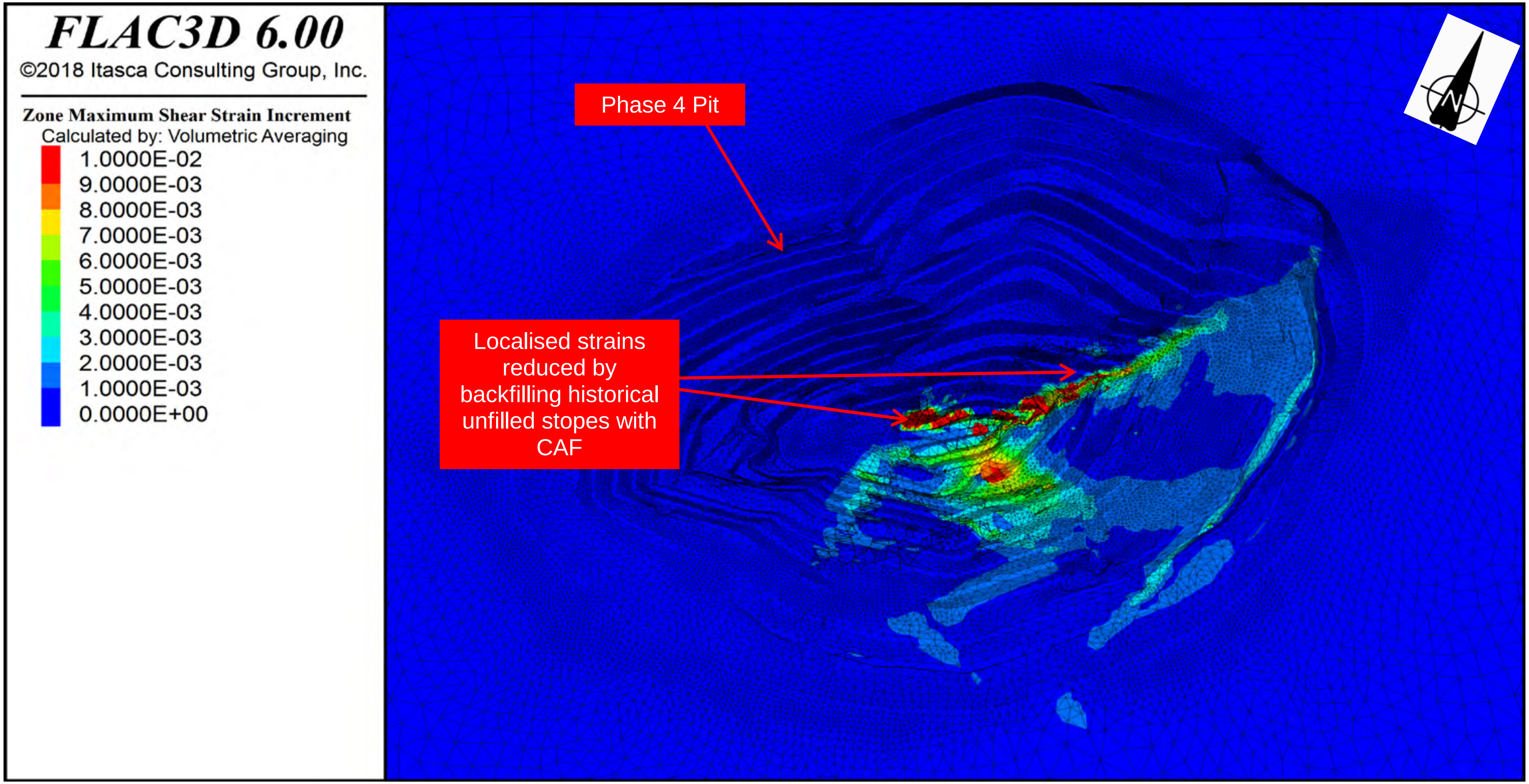
Anderson Lloyd Waihi, New Zealand Numerical Model - Run 9 PREDICTED MAX SHEAR STRAIN AFTER YEAR 9	
PSM125-283R	**Figure 49**

Pells Sullivan Meynink



Anderson Lloyd Waihi, New Zealand Numerical Model - Run 10 PREDICTED TOTAL DISPLACEMENT AFTER YEAR 9	
PSM125-283R	Figure 50

Pells Sullivan Meynink

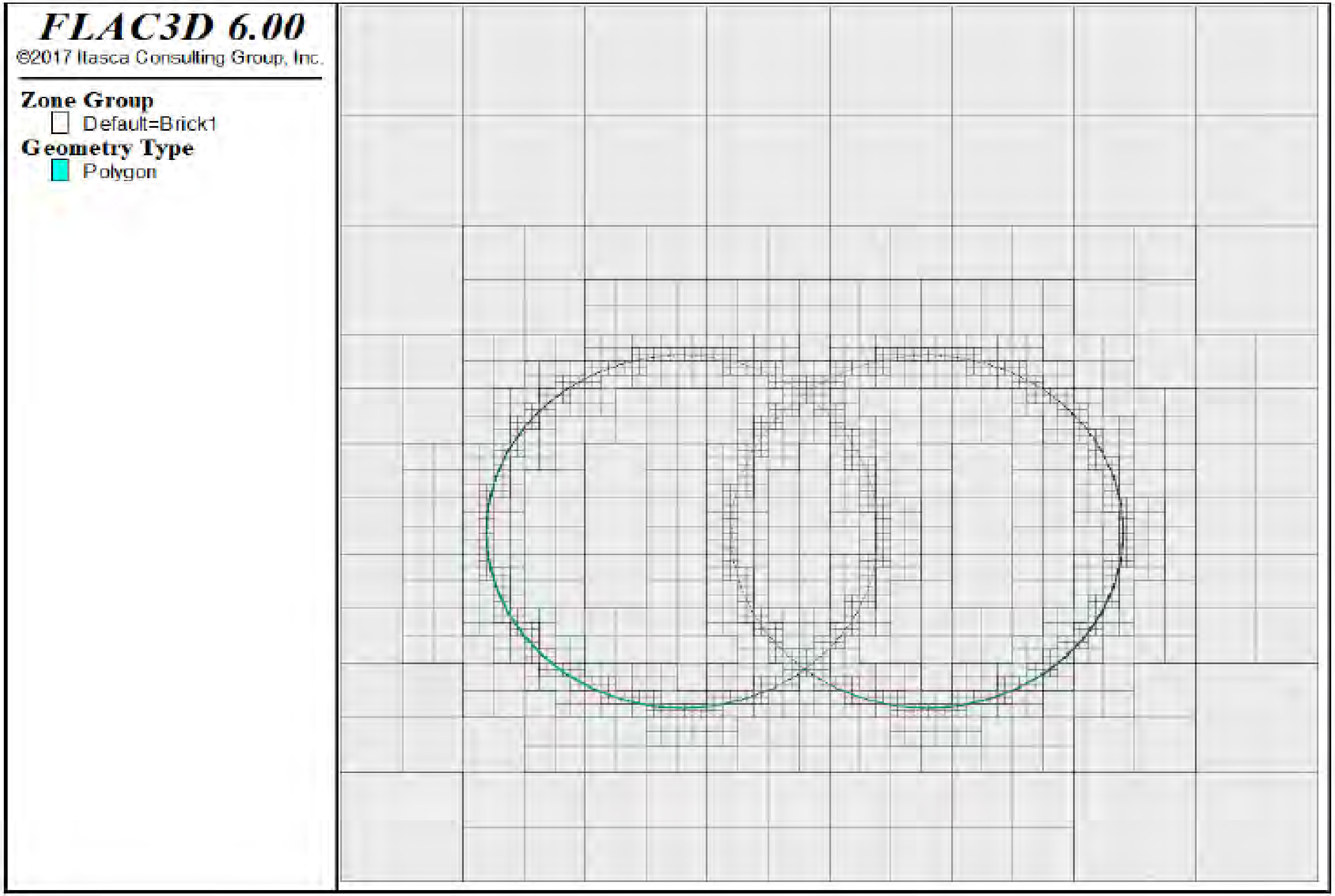


Pells Sullivan Meynink

Anderson Lloyd Waihi, New Zealand Numerical Model - Run 10 PREDICTED MAX SHEAR STRAIN AFTER YEAR 9	
PSM125-283R	Figure 51

APPENDIX A

LOCAL ELEMENT DENSIFICATION PROXIMITY TO A CYLINDER GEOMETRY



Anderson Lloyd

Waihi, New Zealand

Numerical Model

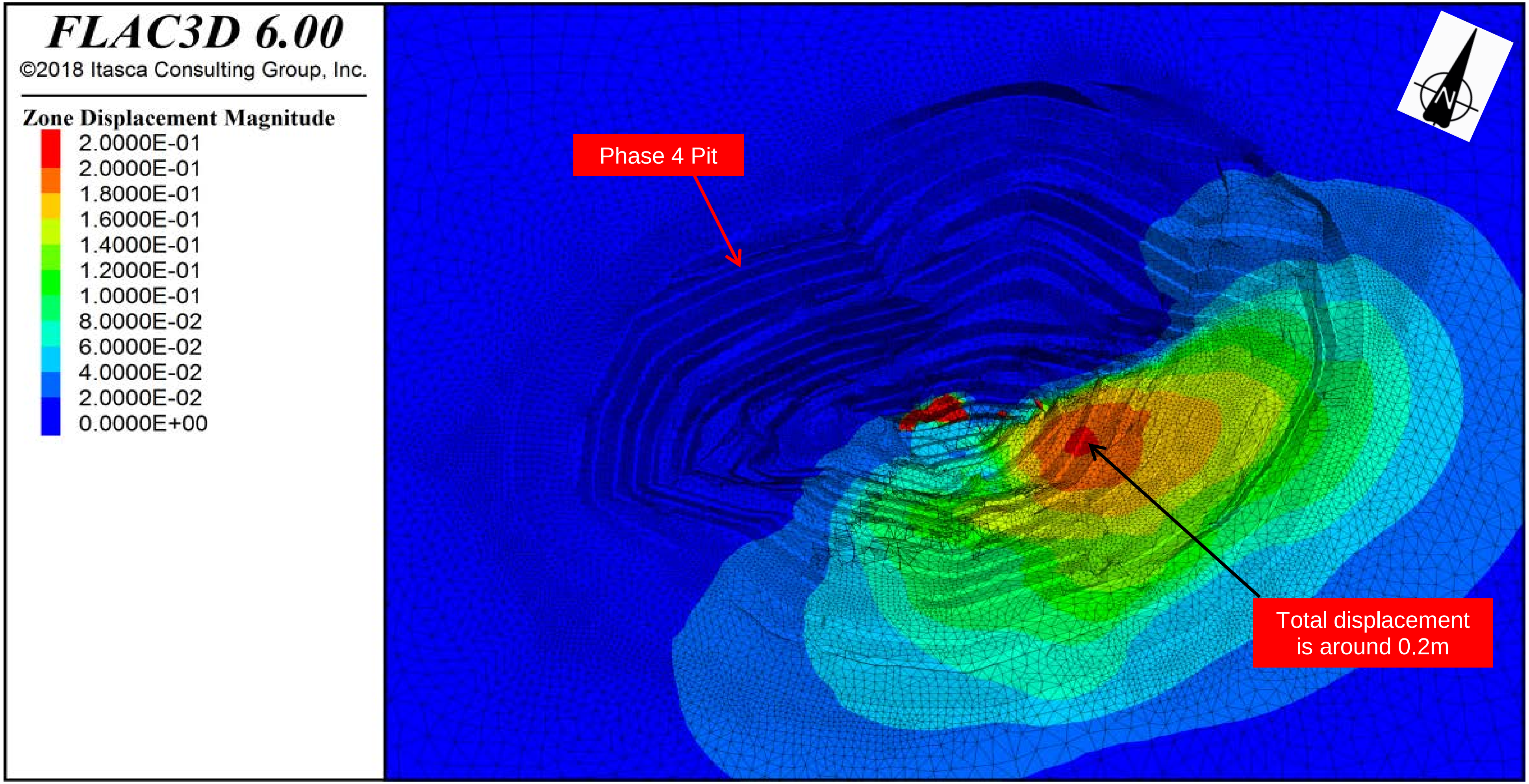
LOCAL ELEMENT DENSIFICATION PROXIMITY TO A CYLINDER GEOMETRY

PSM125-283R	Appendix A

Pells Sullivan Meynink

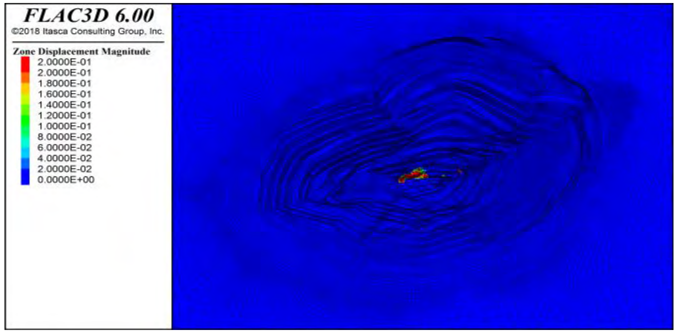
APPENDIX B

FLAC3D OUTPUTS – RUN 1

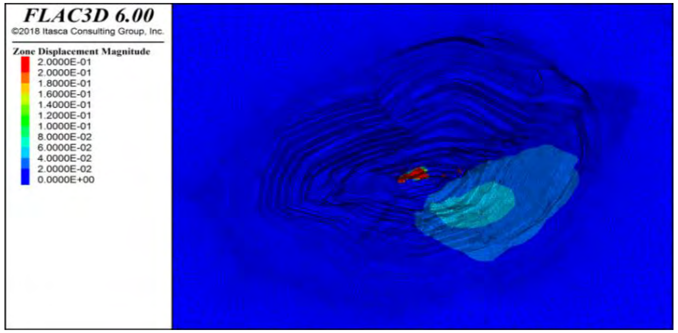


Pells Sullivan Meynink

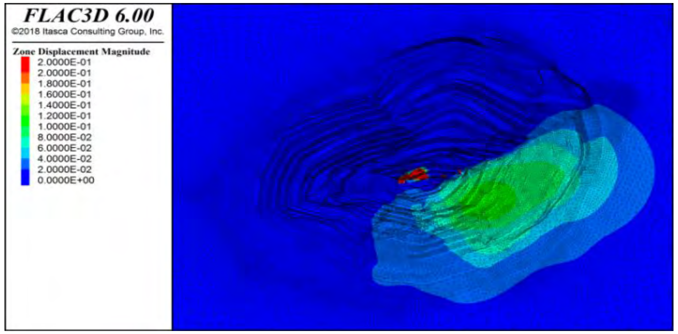
Anderson Lloyd Waihi, New Zealand Numerical Model - Run 1 PREDICTED TOTAL DISPLACEMENT AFTER YEAR 9	
PSM125-283R	**Appendix B1**



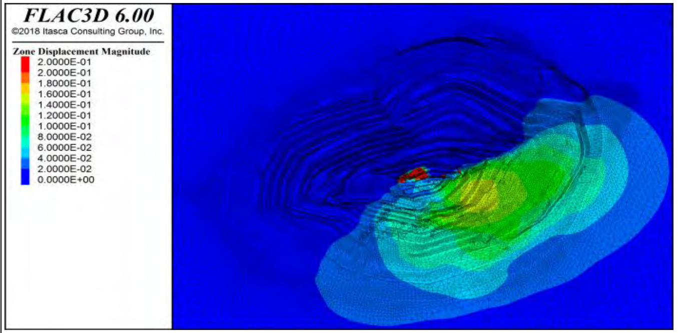
After Year 2 underground working



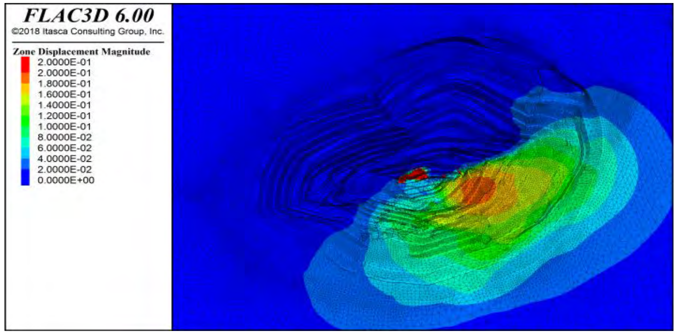
After Year 3 underground working



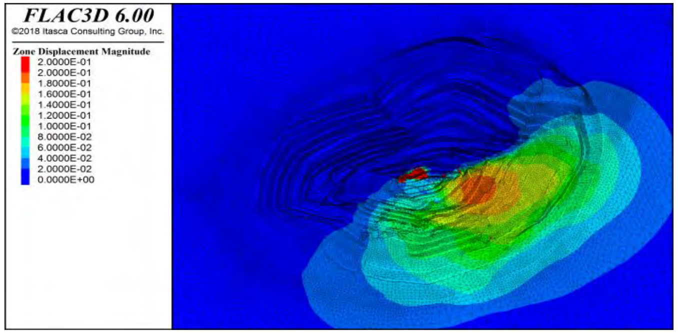
After Year 4 underground working



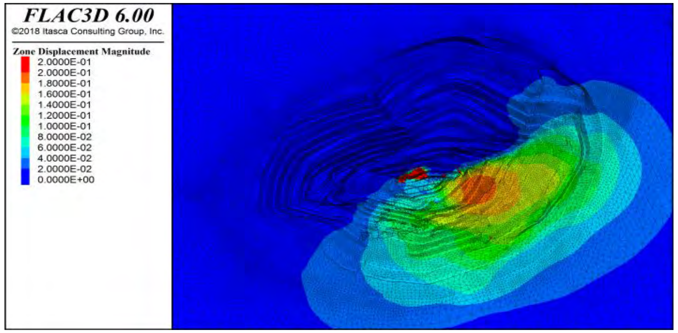
After Year 5 underground working



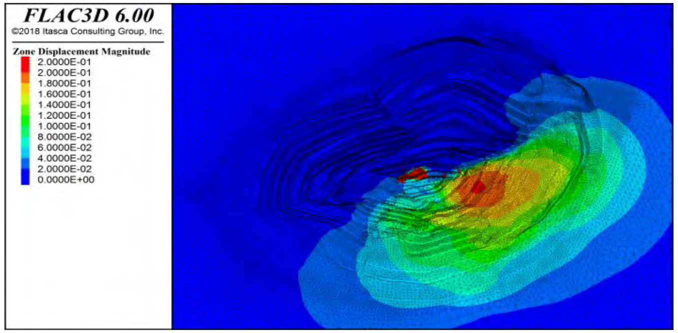
After Year 6 underground working



After Year 7 underground working



After Year 8 underground working



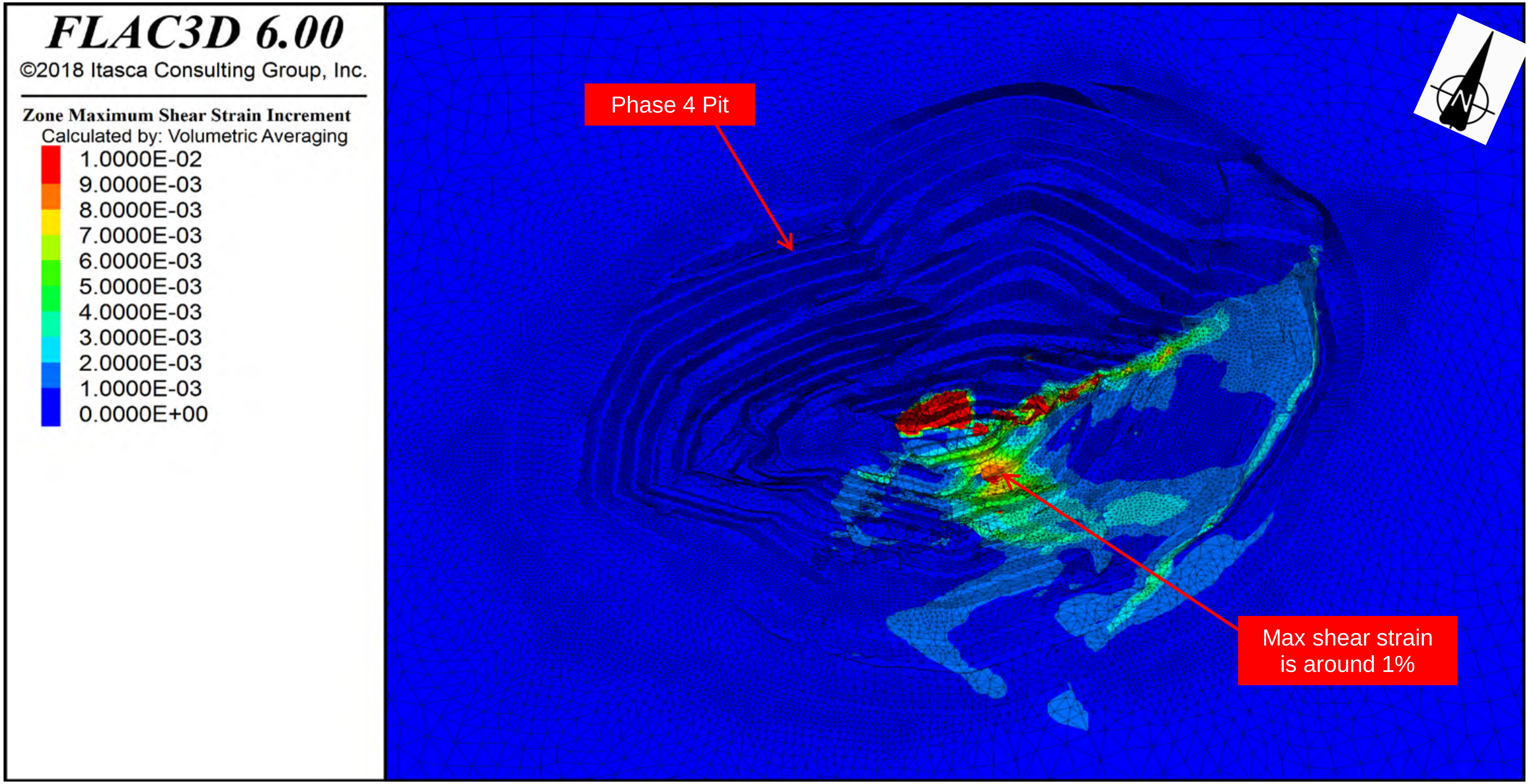
After Year 9 underground working

PSM

Pells Sullivan Meynink

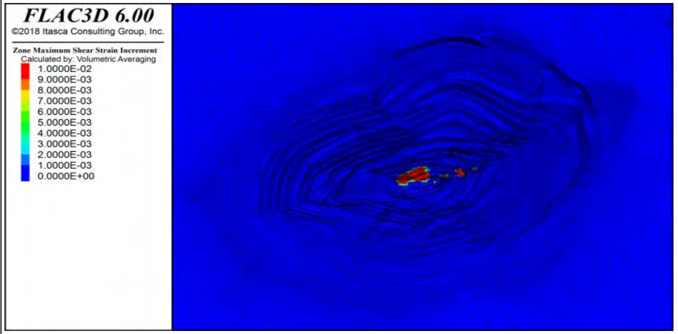
Anderson Lloyd
Waihi, New Zealand
Numerical Model - Run 1
PREDICTED TOTAL DISPLACEMENT FOR YEARLY SEQUENCE

PSM125-283R	**Appendix B2**

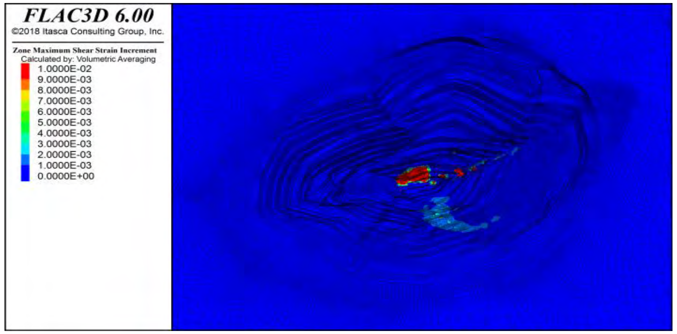


Anderson Lloyd Waihi, New Zealand Numerical Model - Run 1 PREDICTED MAX SHEAR STRAIN AFTER YEAR 9	
PSM125-283R	Appendix B3

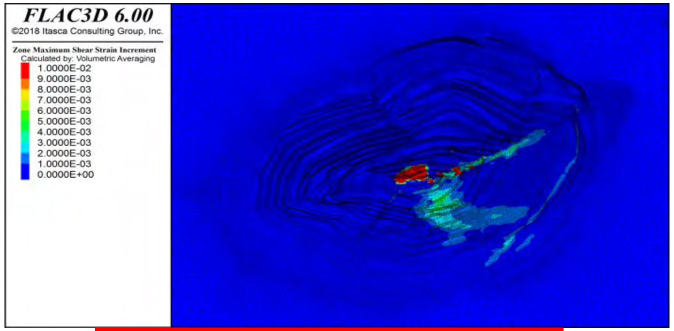
Pells Sullivan Meynink



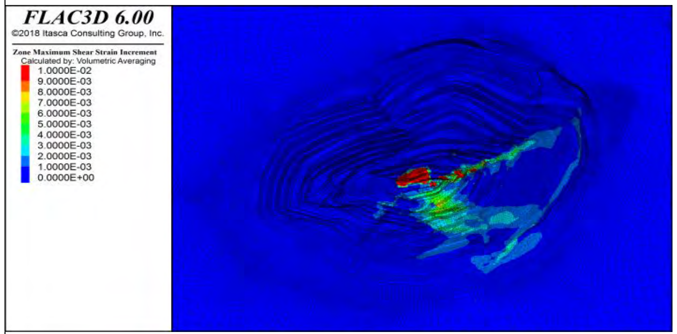
After Year 2 underground working



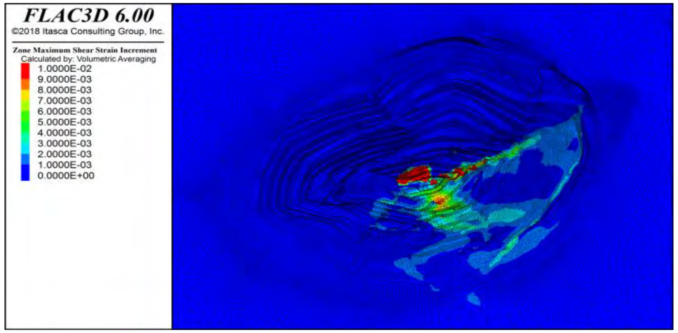
After Year 3 underground working



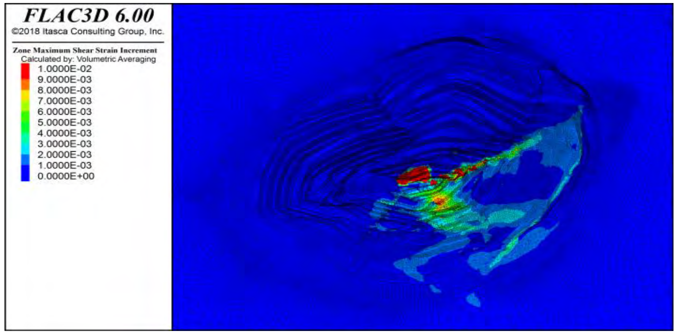
After Year 4 underground working



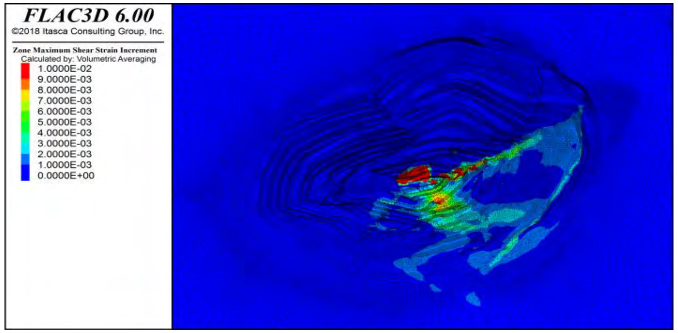
After Year 5 underground working



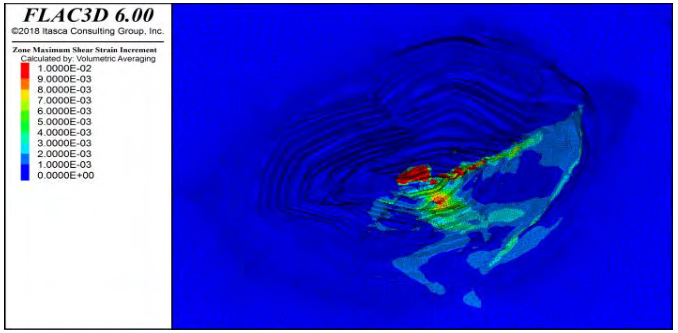
After Year 6 underground working



After Year 7 underground working



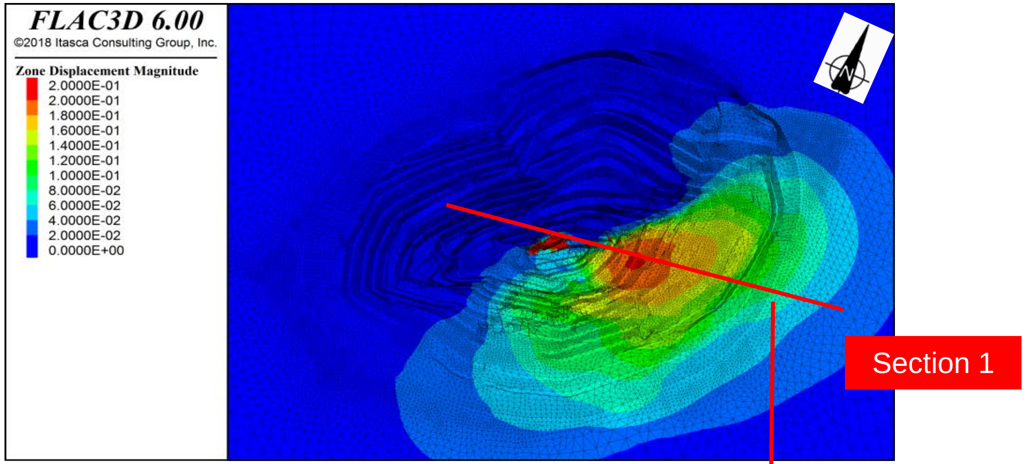
After Year 8 underground working

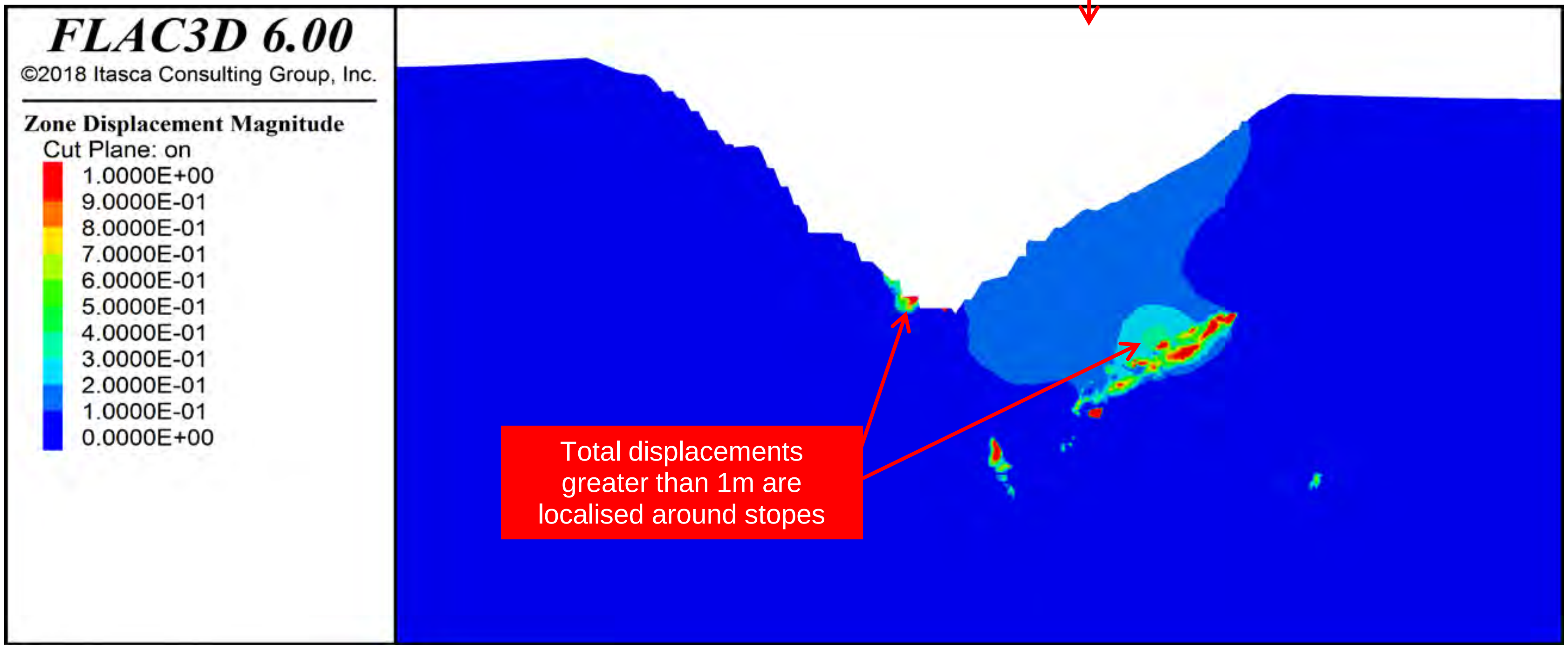


After Year 29 underground workin

PSM Pells Sullivan Meynink

Anderson Lloyd Waihi, New Zealand Numerical Model - Run 1 PREDICTED MAX SHEAR STRAIN FOR YEARLY SEQUENCE	
PSM125-283R	Appendix B4

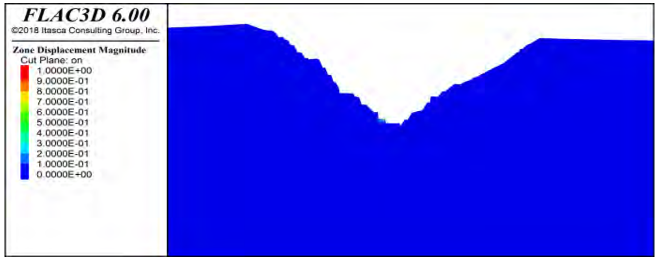




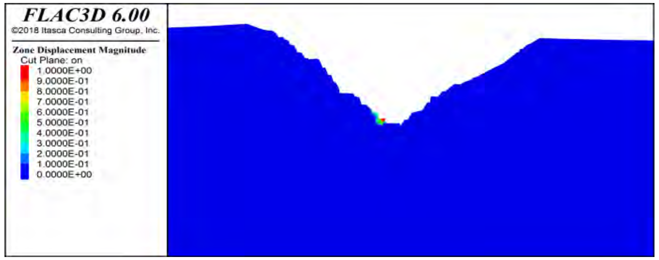
Anderson Lloyd
Waihi, New Zealand
Numerical Model - Run 1
PREDICTED TOTAL DISPLACEMENT OF SECTION 1 AFTER YEAR 9

PSM125-283R	**Appendix B5**

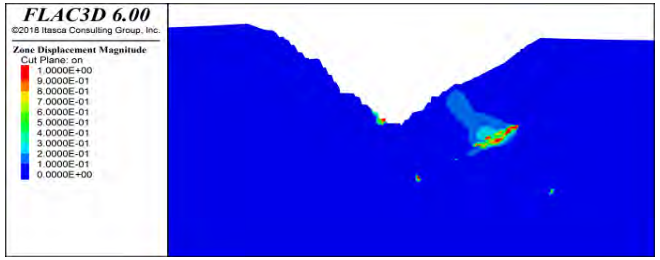
Pells Sullivan Meynink



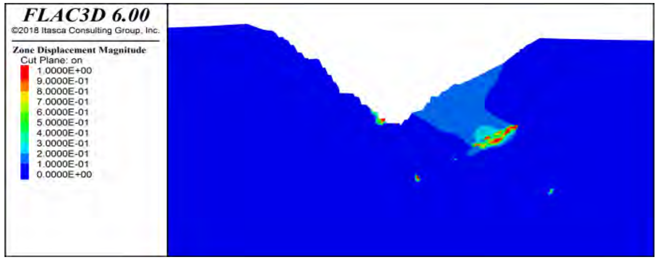
After Year 2 underground working



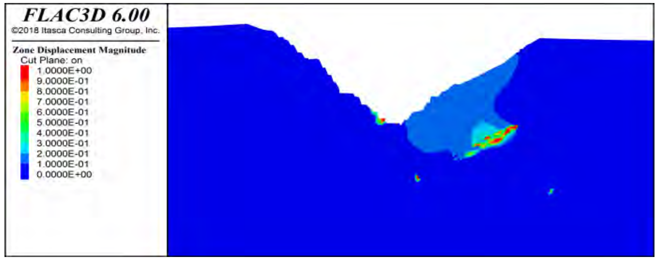
After Year 3 underground working



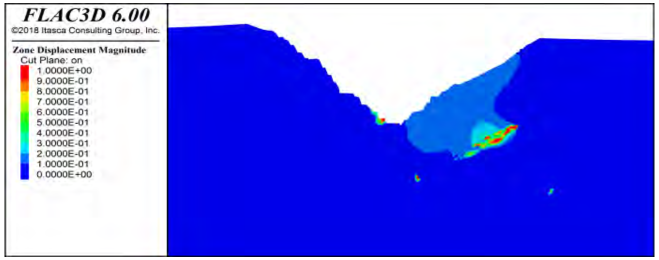
After Year 4 underground working



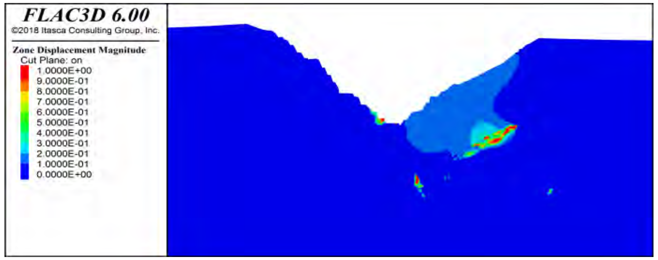
After Year 5 underground working



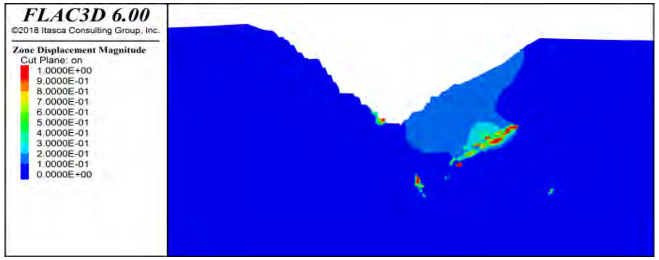
After Year 6 underground working



After Year 7 underground working



After Year 8 underground working



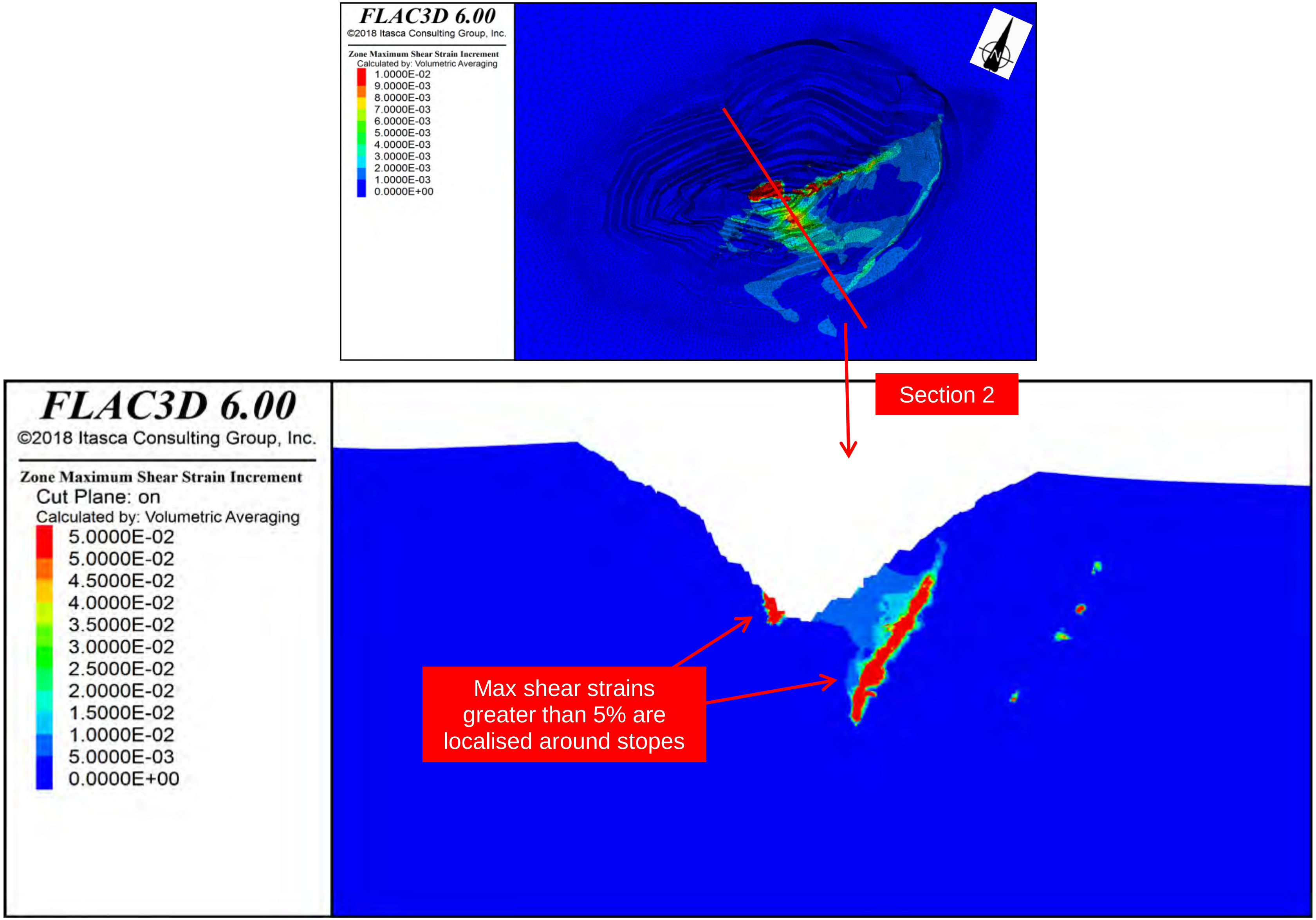
After Year 9 underground working

Anderson Lloyd
Waihi, New Zealand
Numerical Model - Run 1
PREDICTED TOTAL DISPLACEMENT OF SECTION 1 FOR YEARLY SEQUENCE

PSM125-283R	**Appendix B6**

PSM

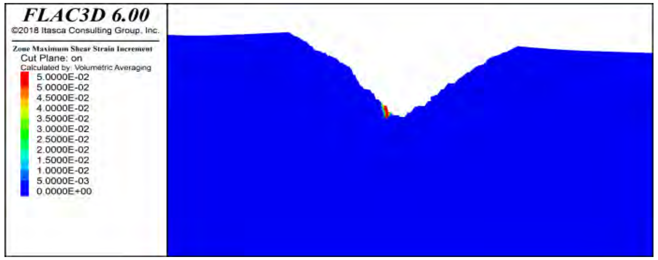
Pells Sullivan Meynink



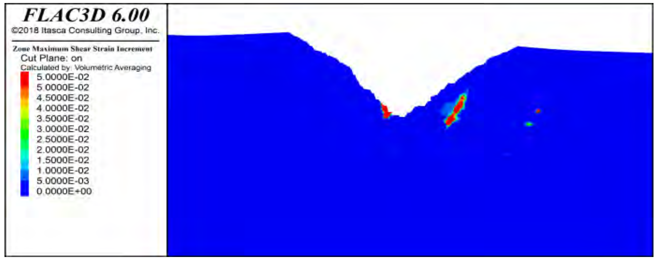
Anderson Lloyd
Waihi, New Zealand
Numerical Model - Run 1
PREDICTED MAX SHEAR STRAIN OF SECTION 2 AFTER YEAR 9

Pells Sullivan Meynink

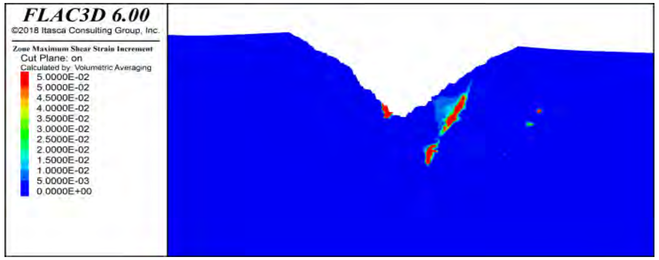
PSM125-283R	Appendix B7



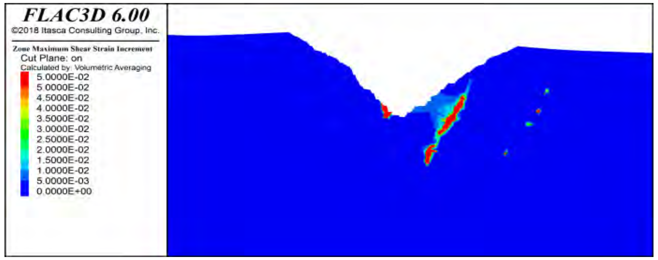
After Year 2 underground working



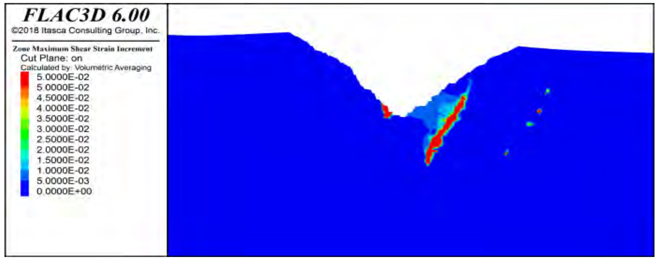
After Year 3 underground working



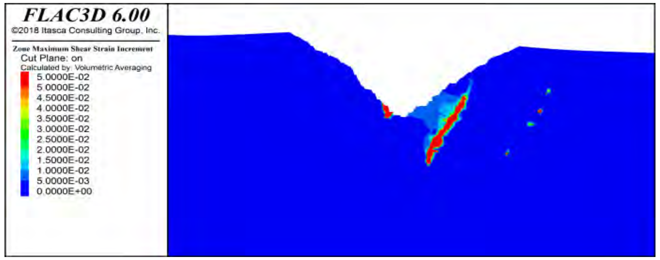
After Year 4 underground working



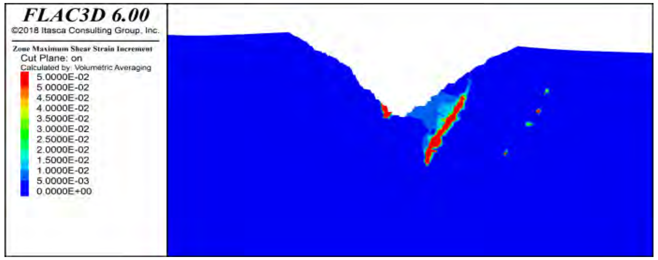
After Year 5 underground working



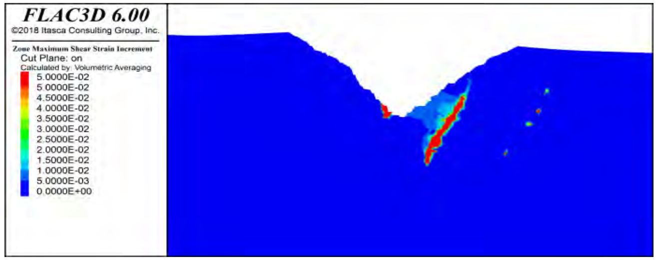
After Year 6 underground working



After Year 7 underground working



After Year 8 underground working



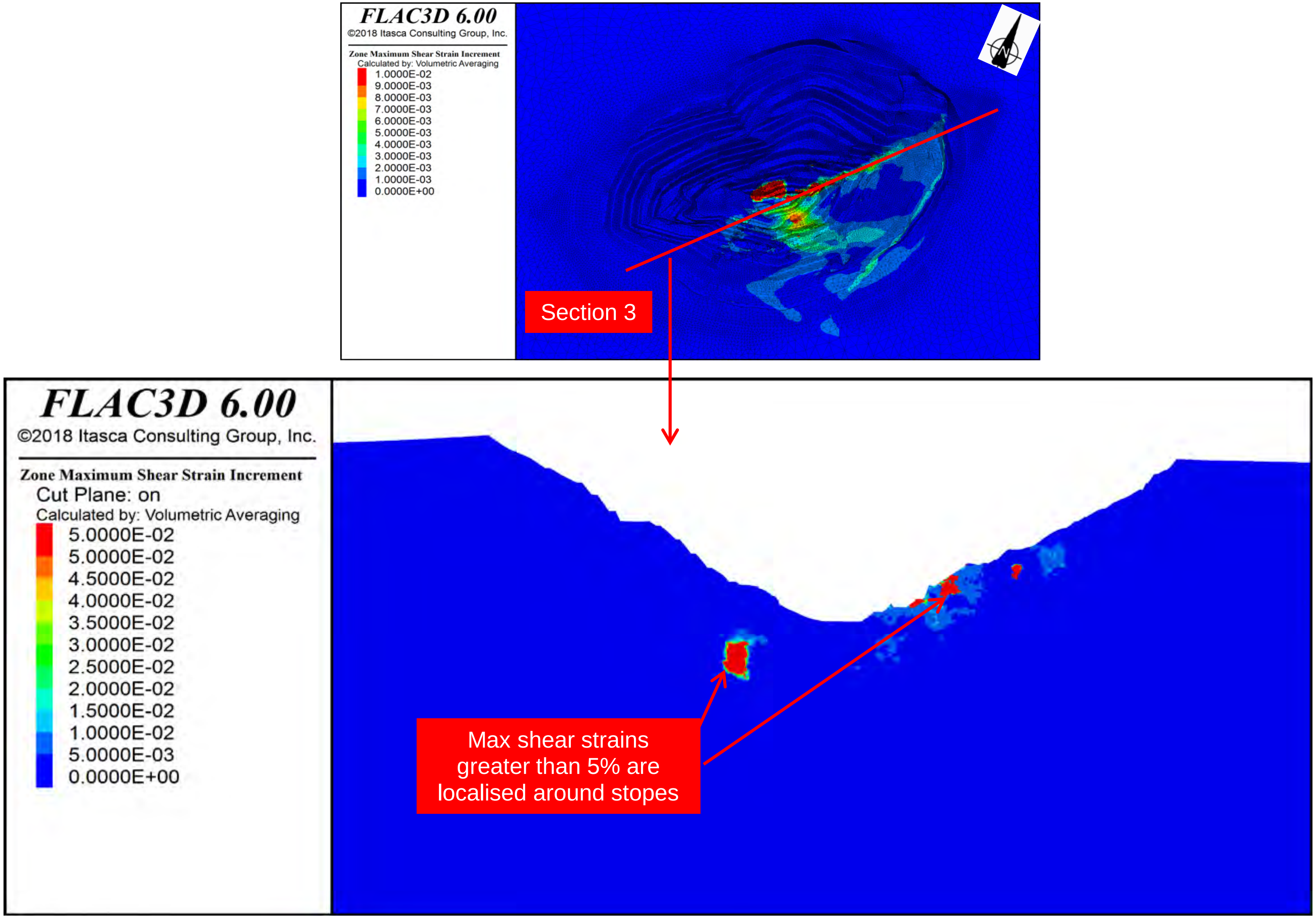
After Year 9 underground working

PSM

Pells Sullivan Meynink

Anderson Lloyd
Waihi, New Zealand
Numerical Model - Run 1
PREDICTED MAX SHEAR STRAIN OF SECTION 2 FOR YEARLY SEQUENCE

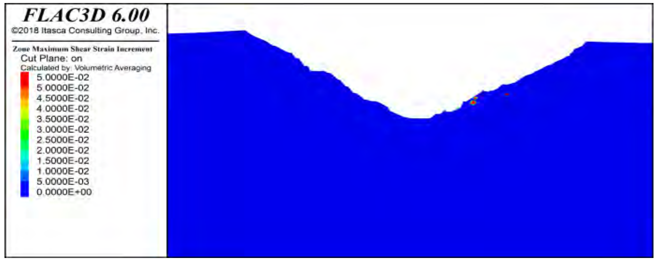
PSM125-283R	**Appendix B8**



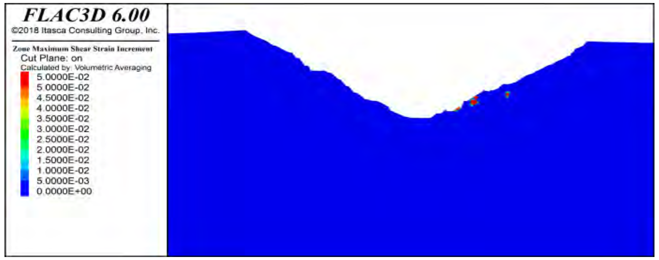
PSM

Pells Sullivan Meynink

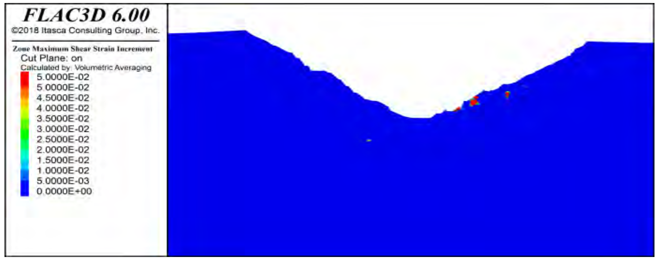
Anderson Lloyd **Waihi, New Zealand** **Numerical Model - Run 1** **PREDICTED MAX SHEAR STRAIN OF SECTION 3 AFTER YEAR 9**	
PSM125-283R	**Appendix B9**



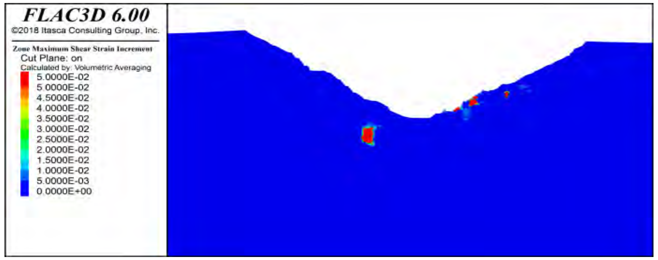
After Year 2 underground working



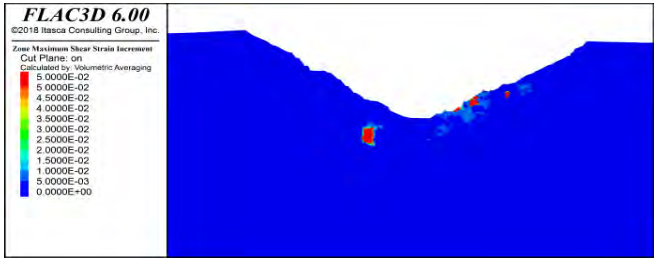
After Year 3 underground working



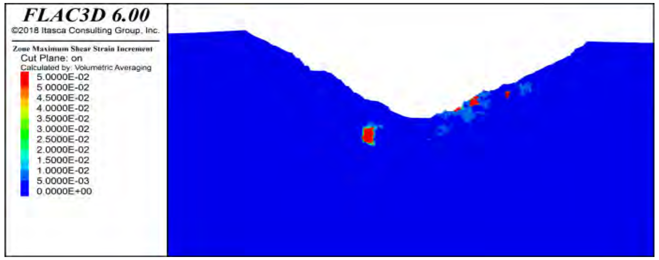
After Year 4 underground working



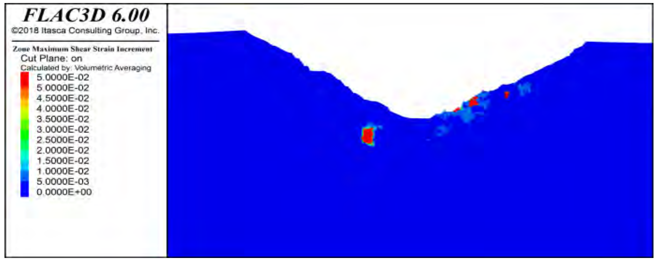
After Year 5 underground working



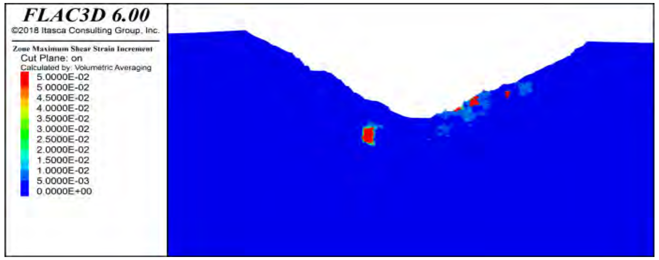
After Year 6 underground working



After Year 7 underground working



After Year 8 underground working



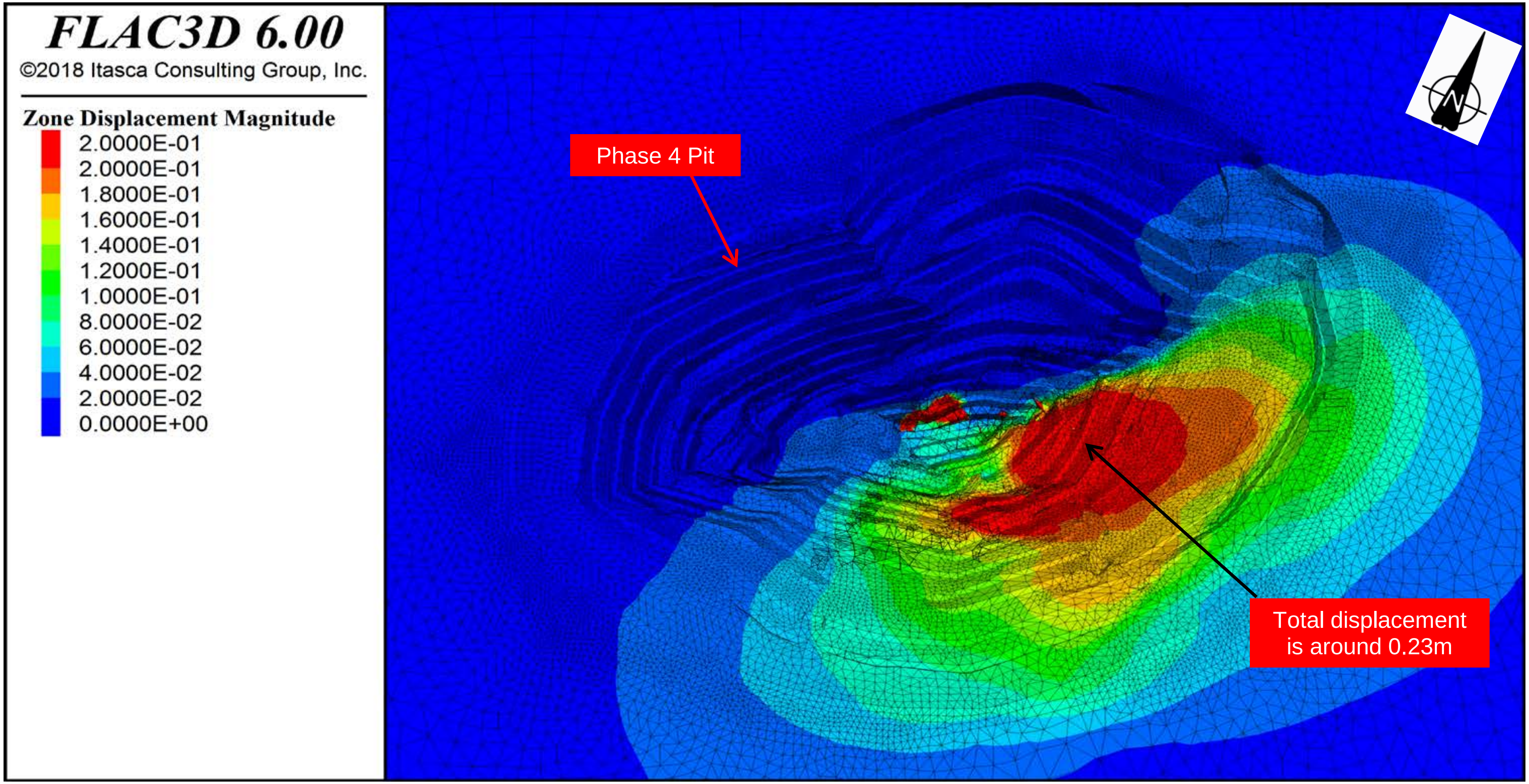
After Year 9 underground working

PSM Pells Sullivan Meynink

Anderson Lloyd Waihi, New Zealand Numerical Model - Run 1 PREDICTED MAX SHEAR STRAIN OF SECTION 3 FOR YEARLY SEQUENCE	
PSM125-283R	**Appendix B10**

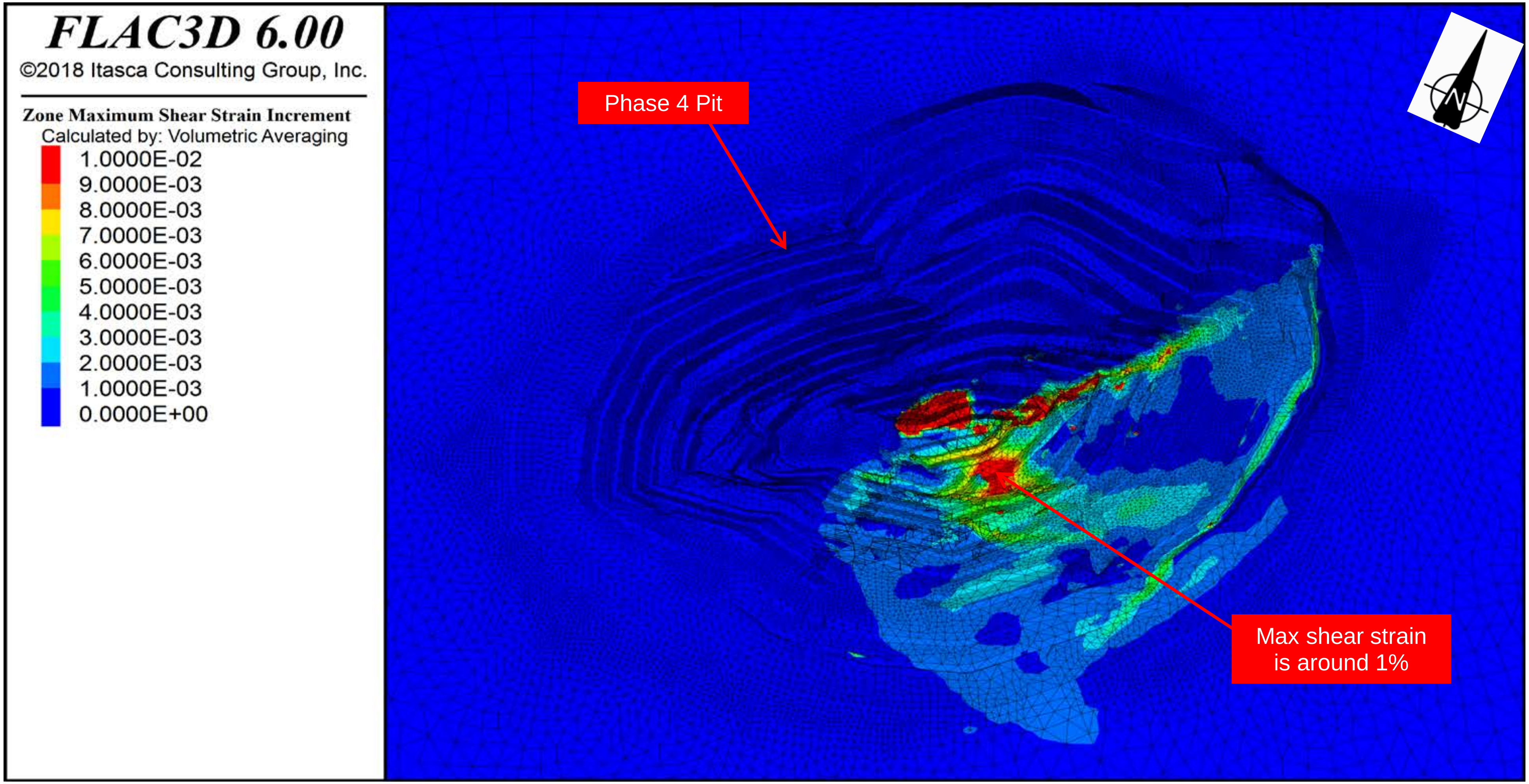
APPENDIX C

***FLAC3D* OUTPUTS – RUN 2**



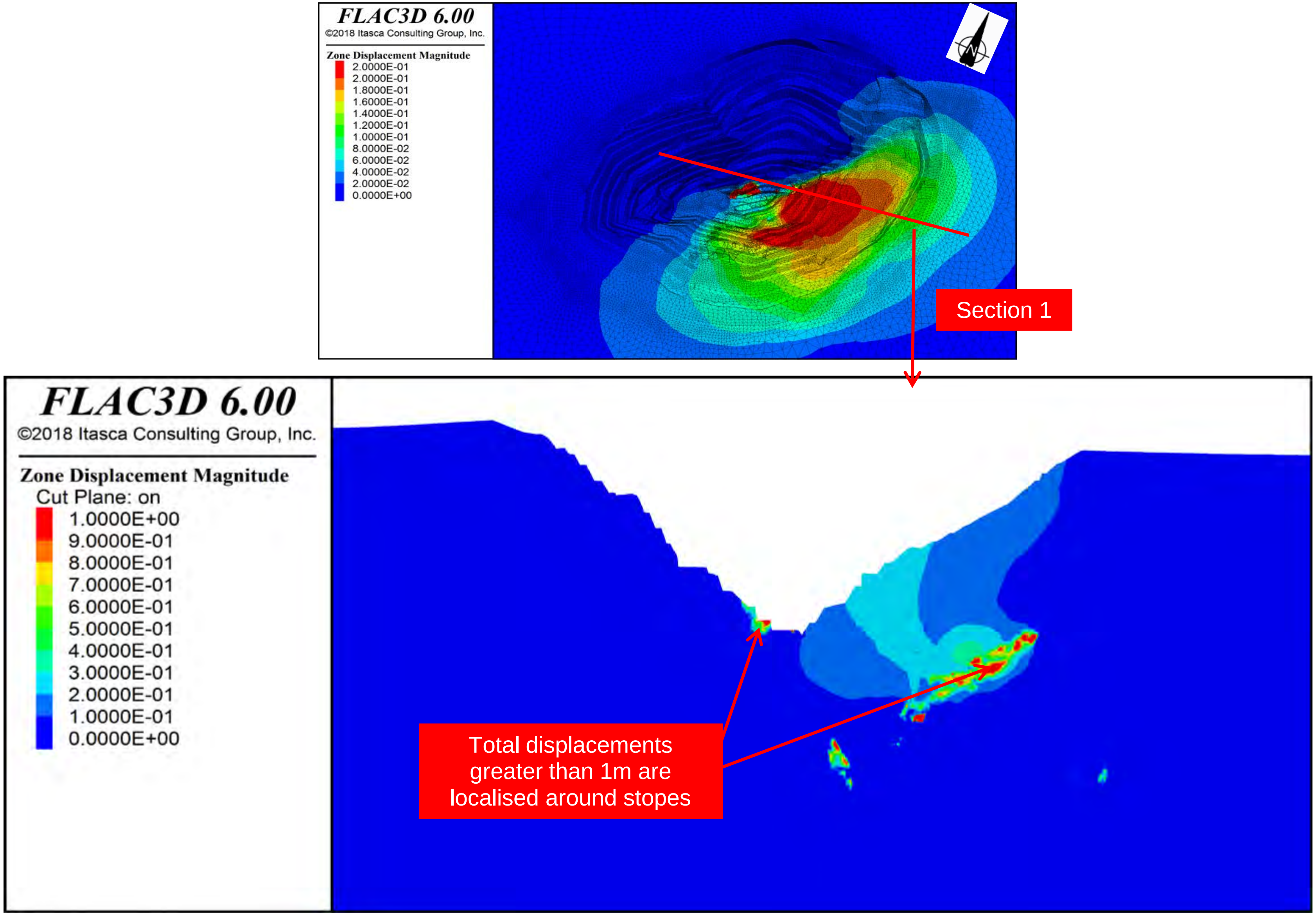
Anderson Lloyd Waihi, New Zealand Numerical Model - Run 2 PREDICTED TOTAL DISPLACEMENT AFTER YEAR 9	
PSM125-283R	Appendix C1

PSM Pells Sullivan Meynink



Anderson Lloyd Waihi, New Zealand Numerical Model - Run 2 PREDICTED MAX SHEAR STRAIN AFTER YEAR 9	
PSM125-283R	Appendix C2

Pells Sullivan Meynink

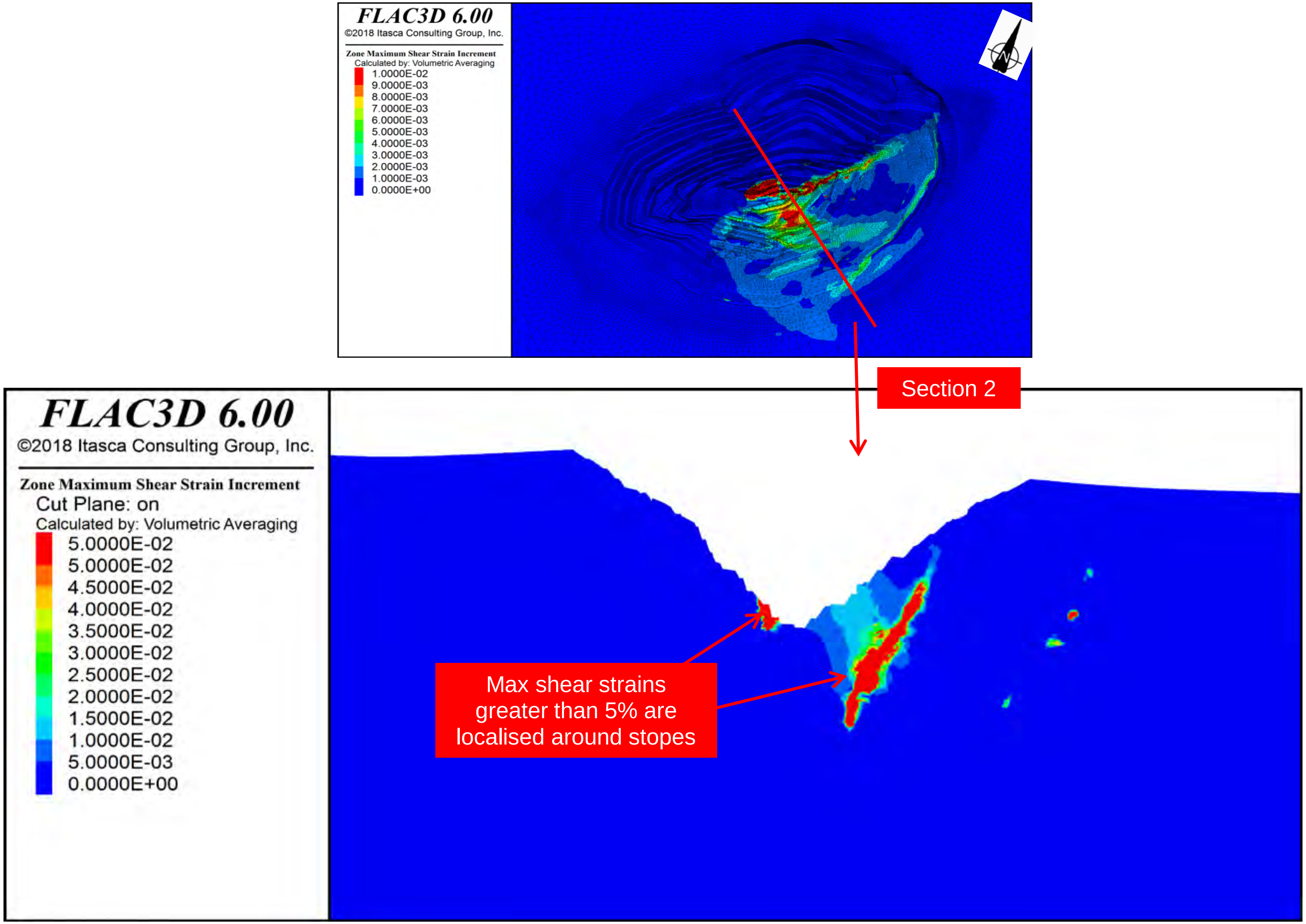


Anderson Lloyd
Waihi, New Zealand
Numerical Model - Run 2
PREDICTED TOTAL DISPLACEMENT
OF SECTION 1 AFTER YEAR 9

PSM125-283R	**Appendix C3**

PSM

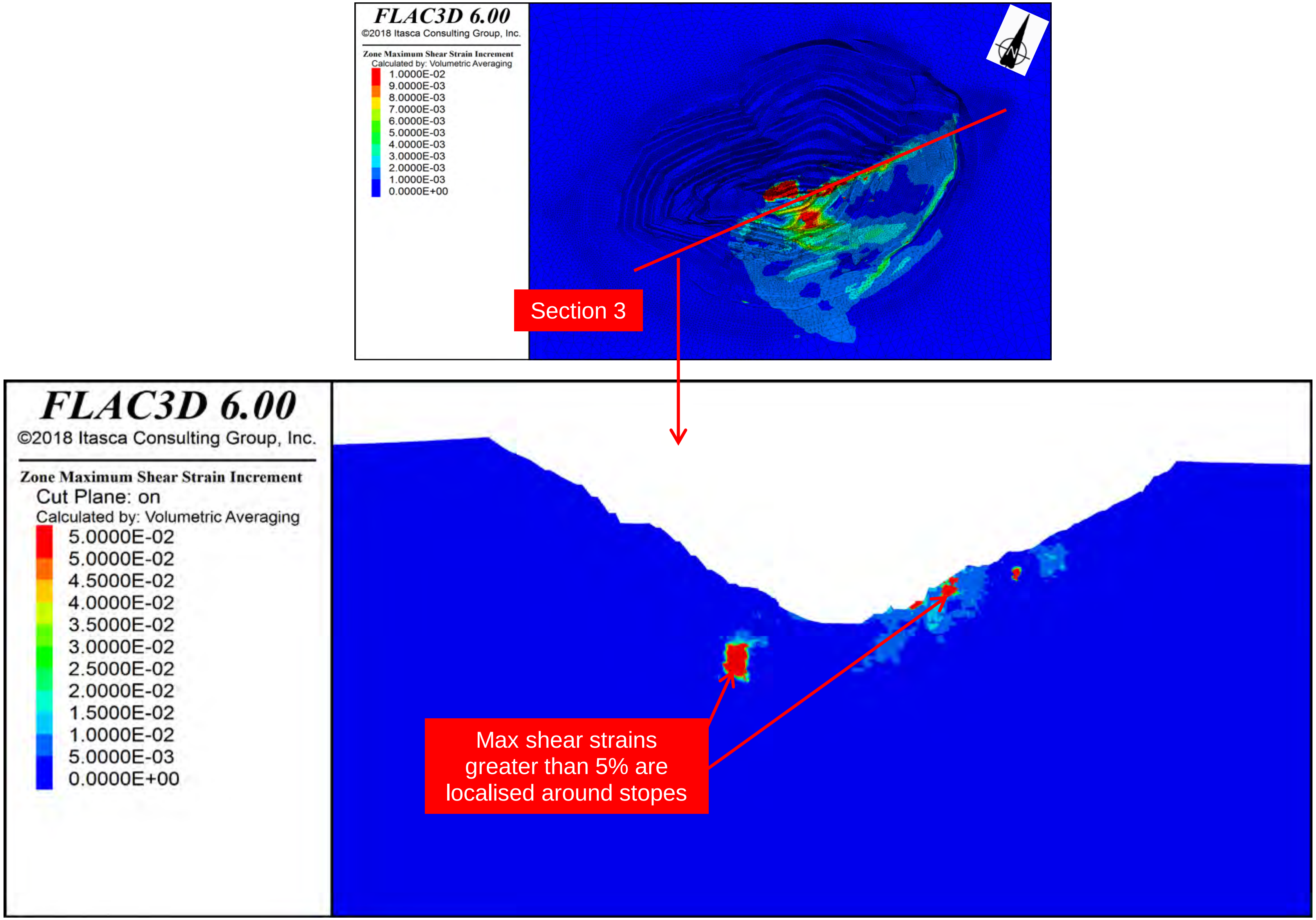
Pells Sullivan Meynink



Anderson Lloyd
Waihi, New Zealand
Numerical Model - Run 2
PREDICTED MAX SHEAR STRAIN OF SECTION 2 AFTER YEAR 9

PSM125-283R	**Appendix C4**

Pells Sullivan Meynink



Anderson Lloyd
Waihi, New Zealand
Numerical Model - Run 2
PREDICTED MAX SHEAR STRAIN OF SECTION 3 AFTER YEAR 9

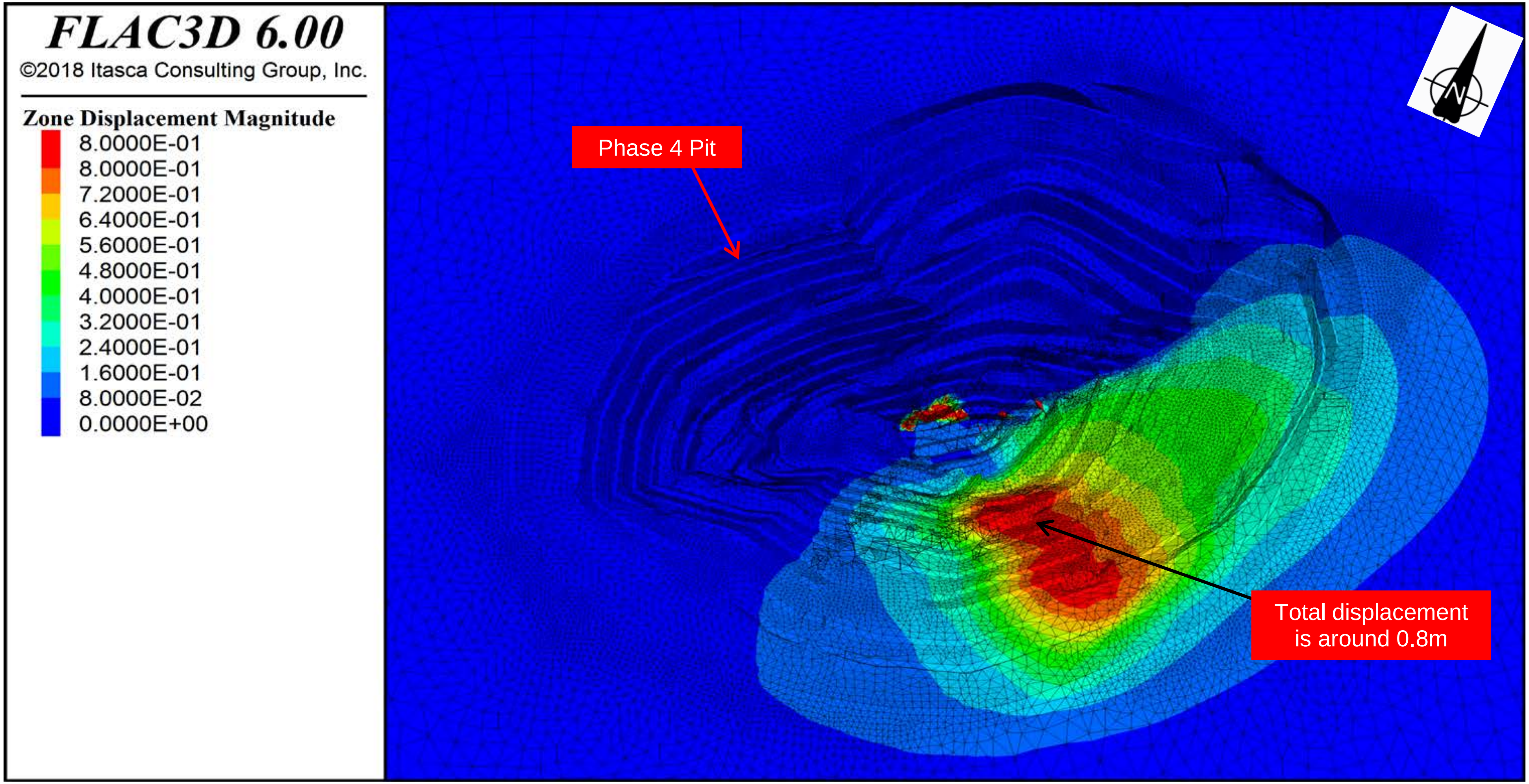
PSM125-283R	**Appendix C5**

PSM

Pells Sullivan Meynink

APPENDIX D

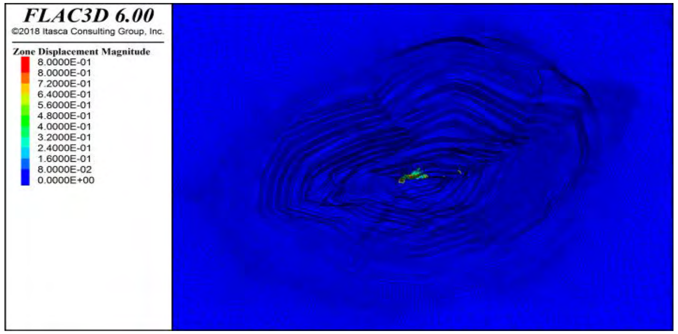
***FLAC3D* OUTPUTS – RUN 3**



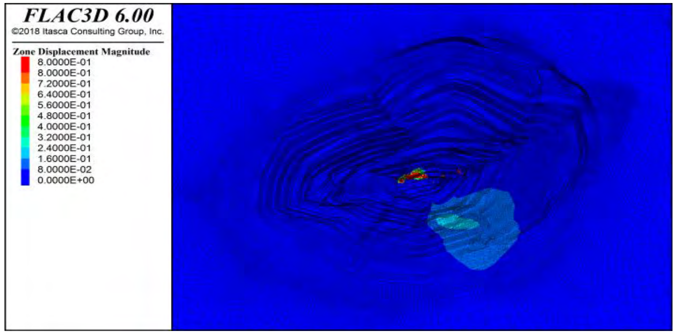
Note: The maximum contour limit is different to Run 1

Anderson Lloyd **Waihi, New Zealand** **Numerical Model - Run 3** **PREDICTED TOTAL DISPLACEMENT** **AFTER YEAR 9**	
PSM125-283R	**Appendix D1**

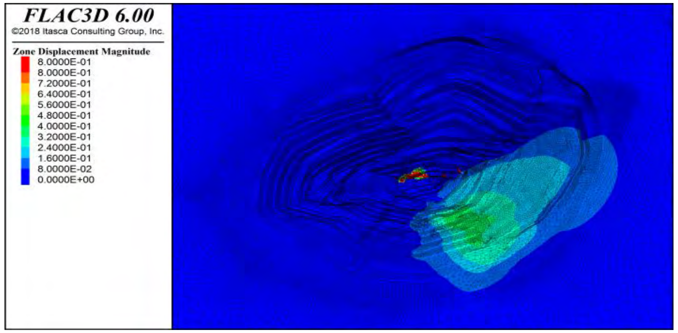
Pells Sullivan Meynink



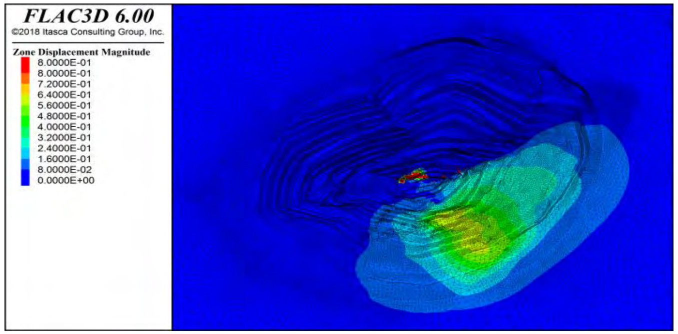
After Year 2 underground working



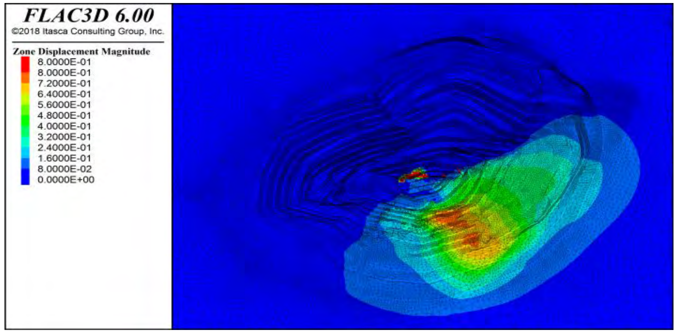
After Year 3 underground working



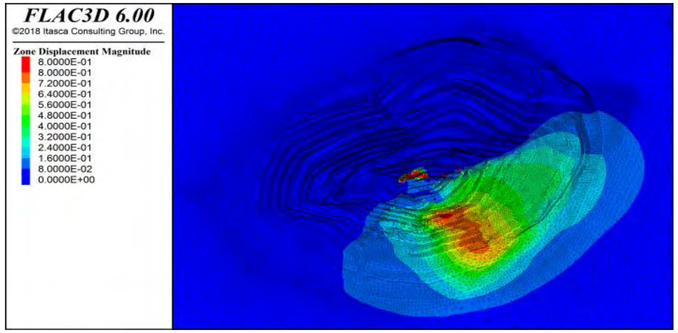
After Year 4 underground working



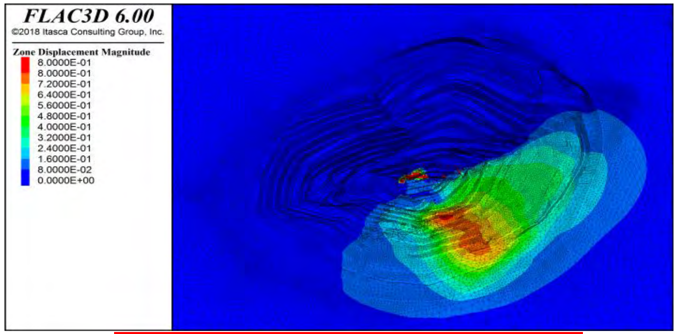
After Year 5 underground working



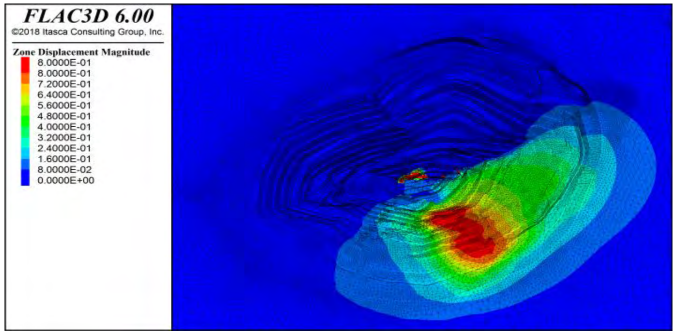
After Year 6 underground working



After Year 7 underground working



After Year 8 underground working



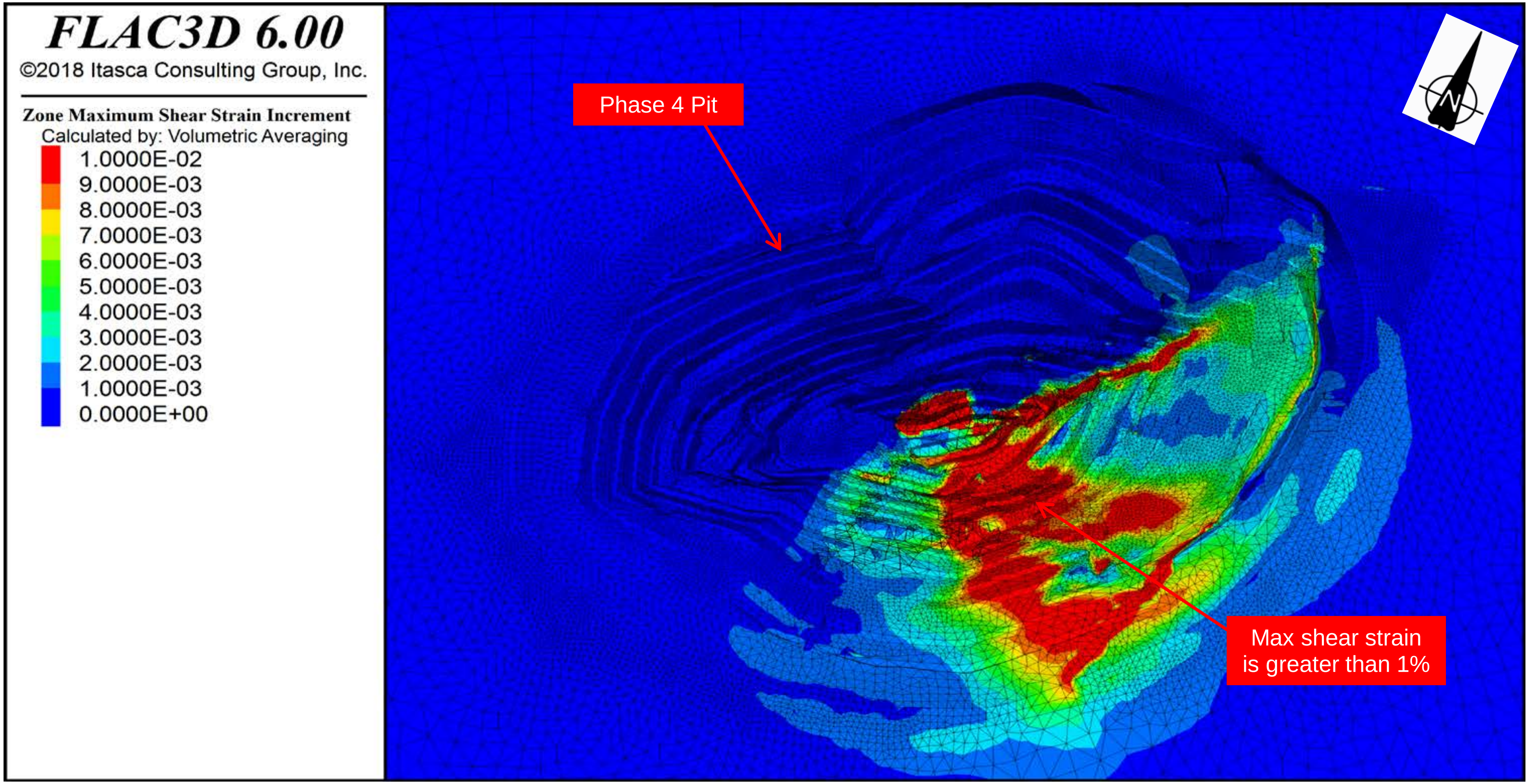
After Year 9 underground working

Note: The maximum contour limit is different to Run 1

PSM

Pells Sullivan Meynink

Anderson Lloyd Waihi, New Zealand Numerical Model - Run 3 PREDICTED TOTAL DISPLACEMENT FOR YEARLY SEQUENCE	
PSM125-283R	**Appendix D2**

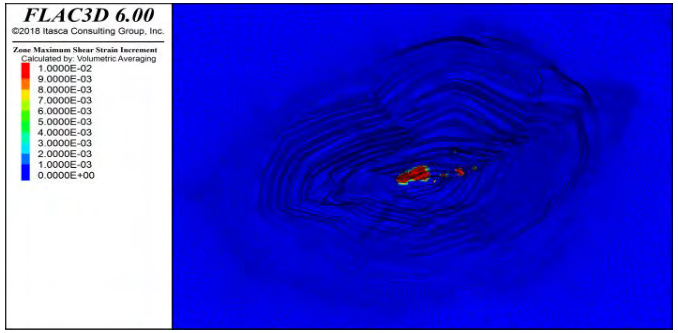


Anderson Lloyd
Waihi, New Zealand
Numerical Model - Run 3
PREDICTED MAX SHEAR STRAIN
AFTER YEAR 9

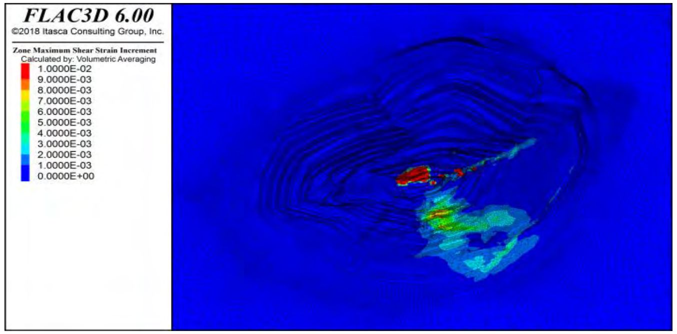
PSM125-283R	**Appendix D3**

PSM

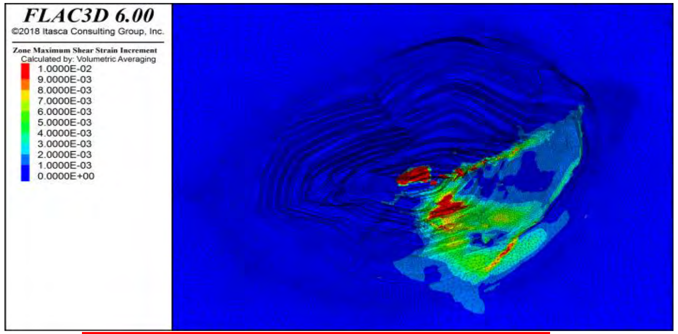
Pells Sullivan Meynink



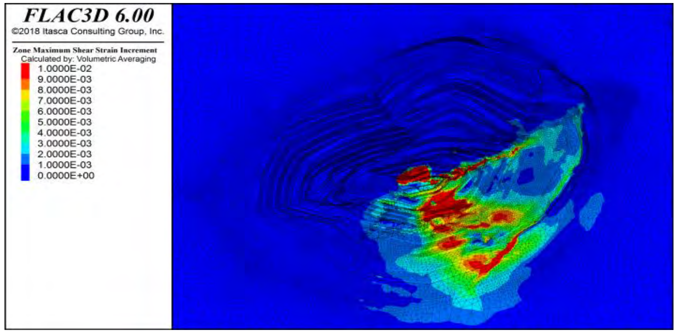
After Year 2 underground working



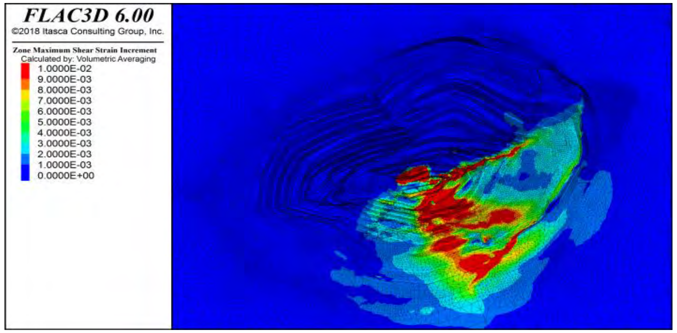
After Year 3 underground working



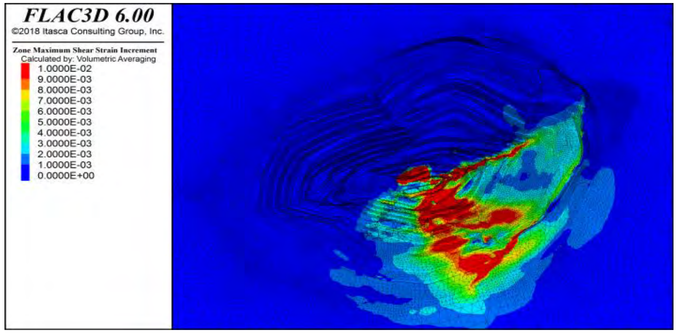
After Year 4 underground working



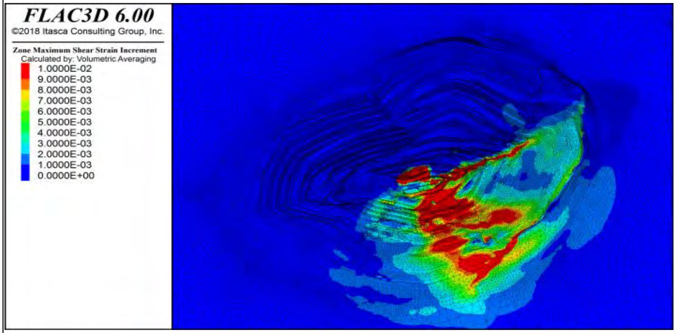
After Year 5 underground working



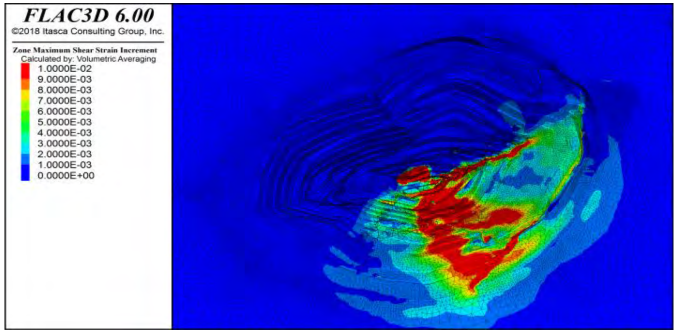
After Year 6 underground working



After Year 7 underground working



After Year 8 underground working



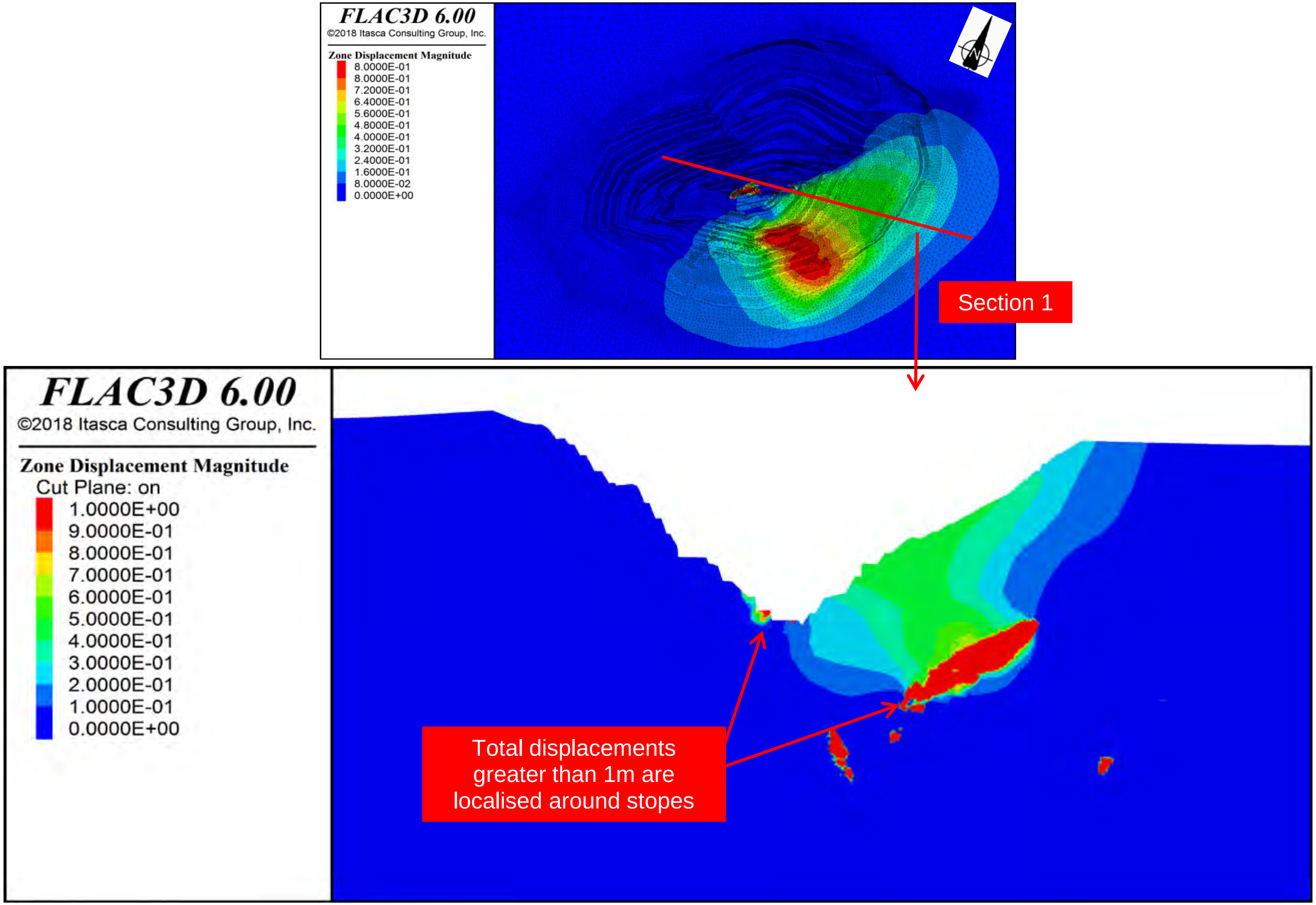
After Year 9 underground working

PSM

Pells Sullivan Meynink

Anderson Lloyd
Waihi, New Zealand
Numerical Model - Run 3
PREDICTED MAX SHEAR STRAIN FOR YEARLY SEQUENCE

PSM125-283R	**Appendix D4**

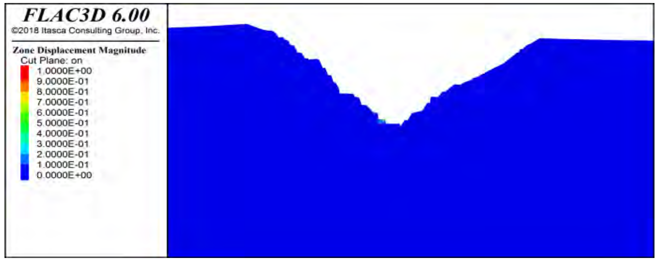


Anderson Lloyd
Waihi, New Zealand
Numerical Model - Run 3
PREDICTED TOTAL DISPLACEMENT OF SECTION 1 AFTER YEAR 9

PSM125-283R	Appendix D5

PSM

Pells Sullivan Meynink



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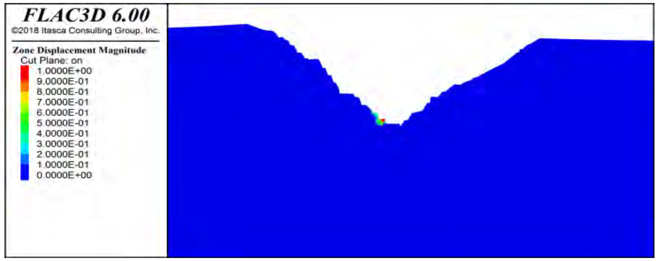
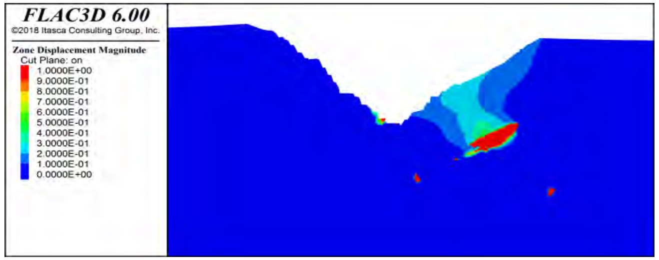


After Year 3 underground working



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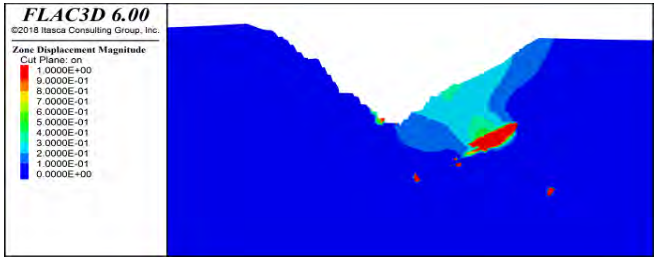
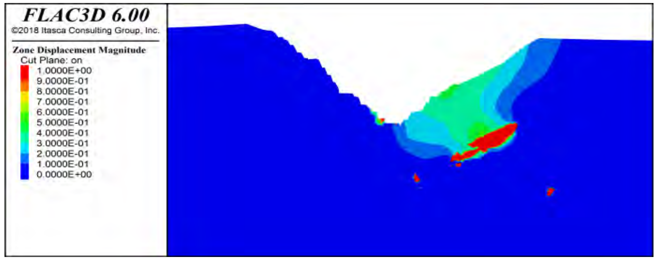


After Year 5 underground working



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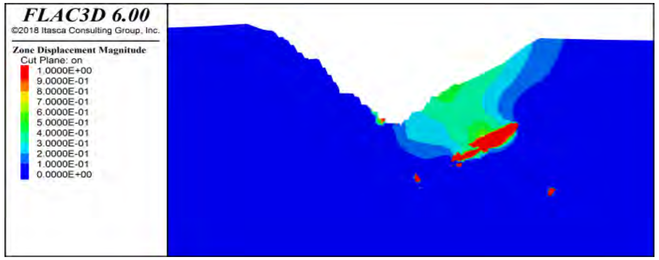
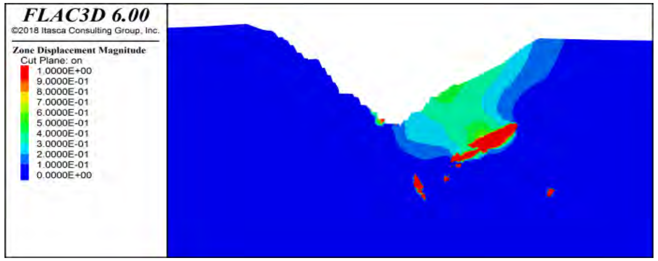
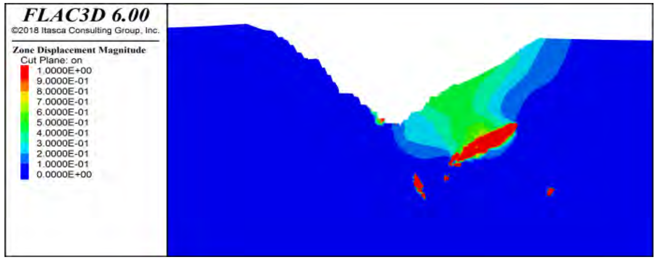


After Year 7 underground working



After Year 8 underground working

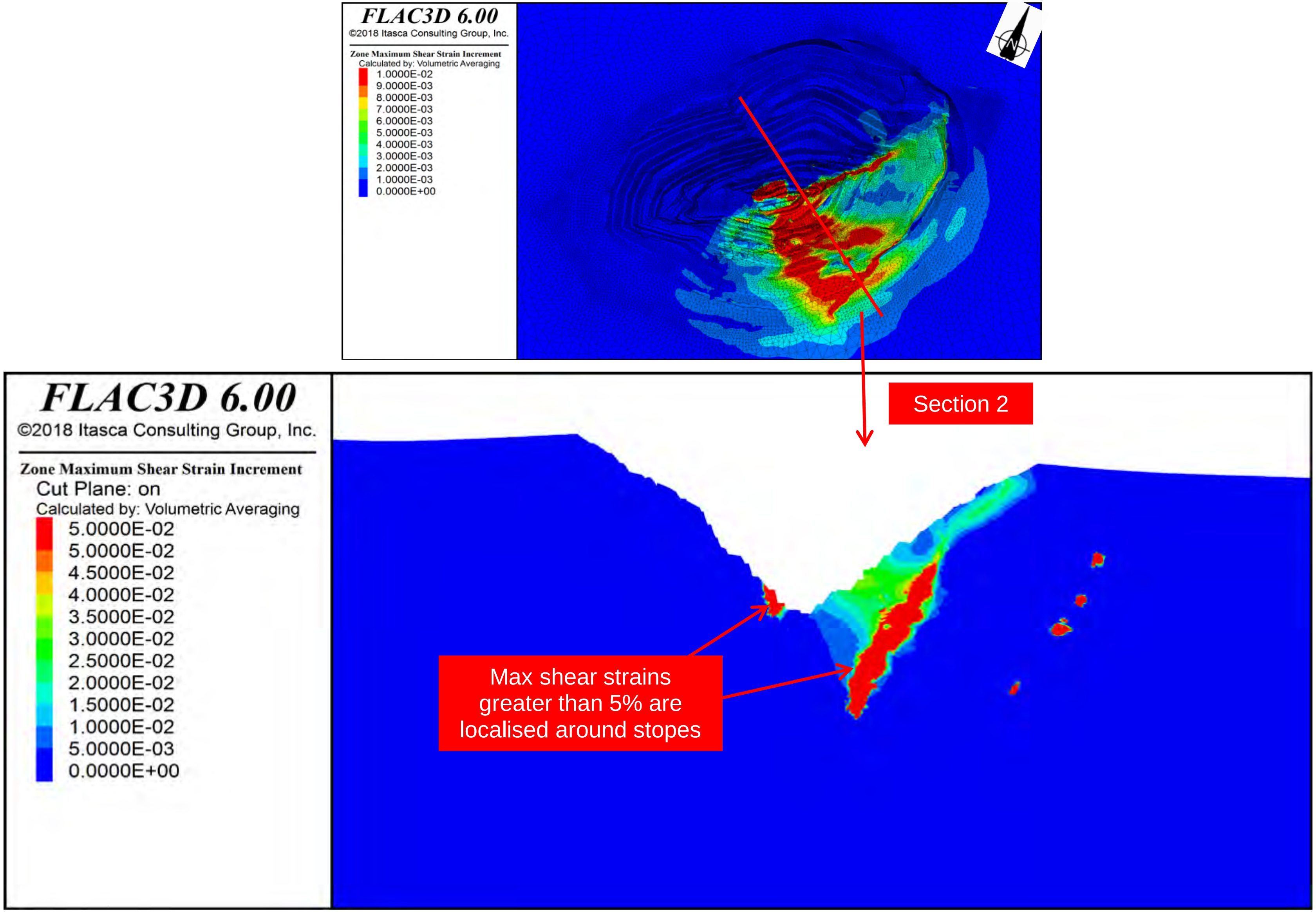


After Year 9 underground working

PSM **Pells Sullivan Meynink**

Anderson Lloyd
Waihi, New Zealand
Numerical Model - Run 3
PREDICTED TOTAL DISPLACEMENT OF SECTION 1 FOR YEARLY SEQUENCE

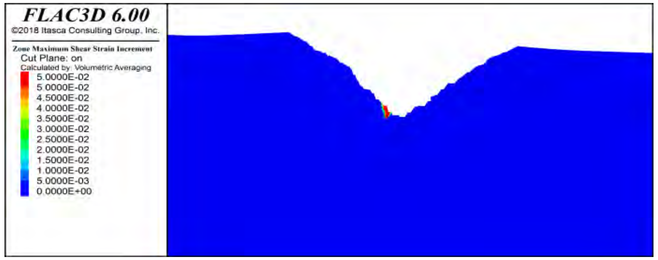
PSM125-283R	**Appendix D6**



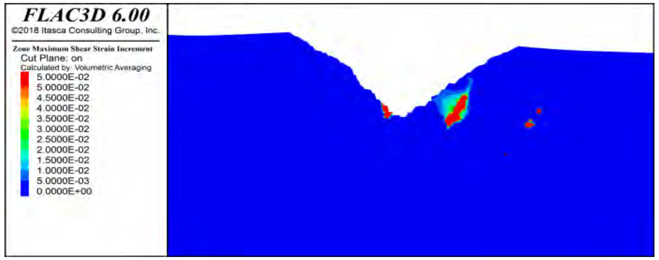
Anderson Lloyd
Waihi, New Zealand
Numerical Model - Run 3
PREDICTED MAX SHEAR STRAIN OF SECTION 2 AFTER YEAR 9

PSM125-283R	Appendix D7

Pells Sullivan Meynink



After Year 2 underground working



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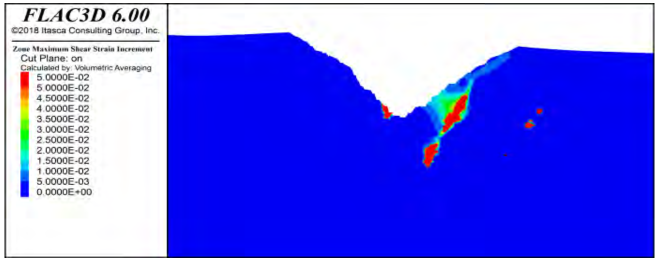
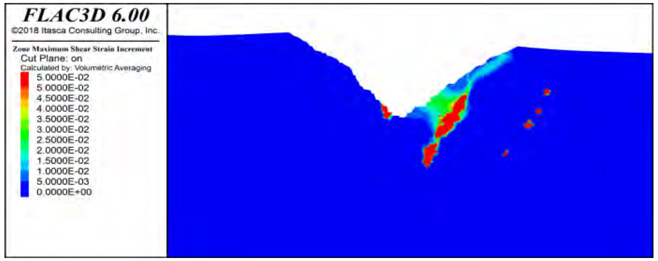
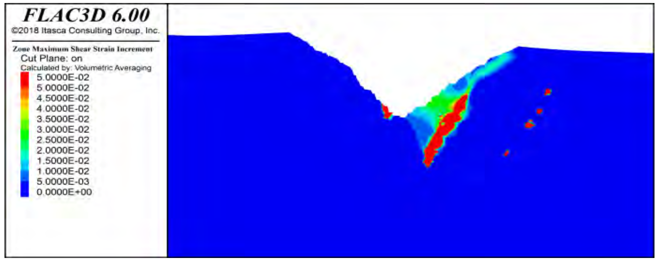


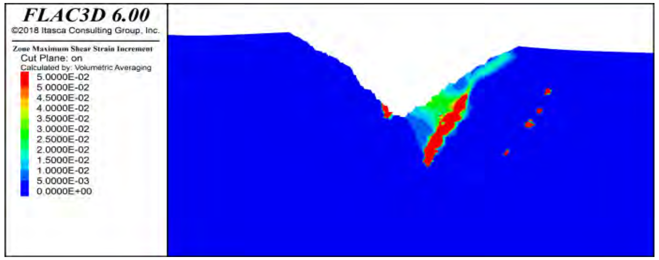
After Year 4 underground working



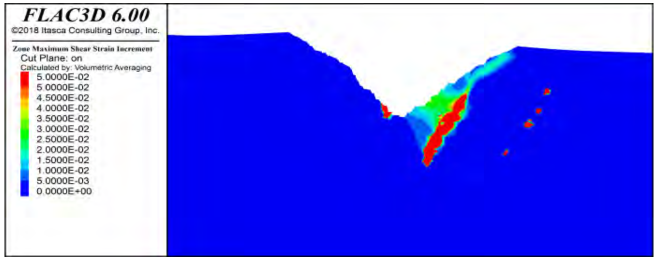
After Year 5 underground working



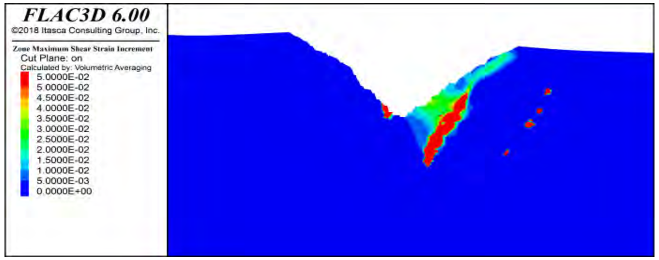
After Year 6 underground working



After Year 7 underground working



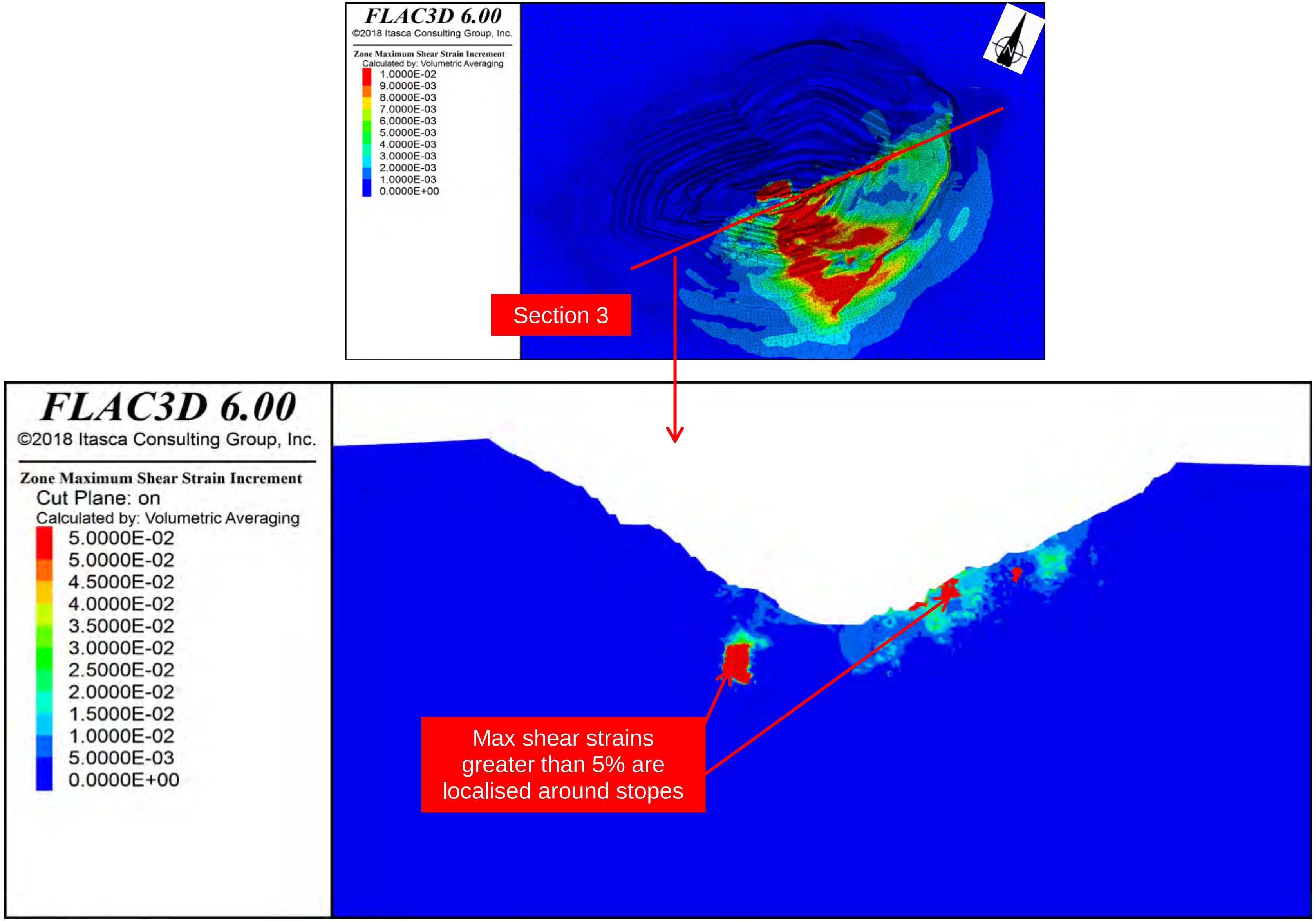
After Year 8 underground working



After Year 9 underground working

Pells Sullivan Meynink

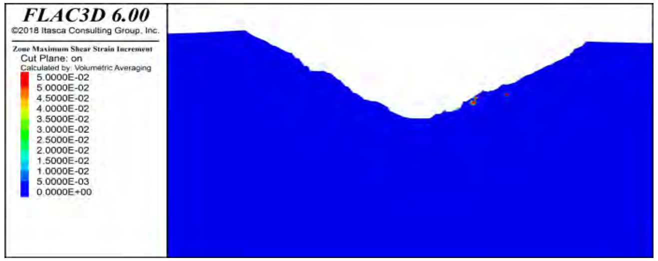
Anderson Lloyd Waihi, New Zealand Numerical Model - Run 3 PREDICTED MAX SHEAR STRAIN OF SECTION 2 FOR YEARLY SEQUENCE	
PSM125-283R	Appendix D8



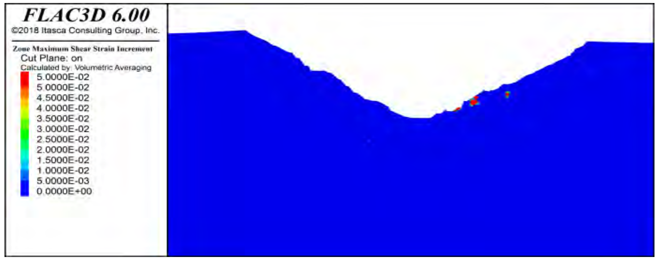
Anderson Lloyd
Waihi, New Zealand
Numerical Model - Run 3
PREDICTED MAX SHEAR STRAIN OF SECTION 3 AFTER YEAR 9

Pells Sullivan Meynink

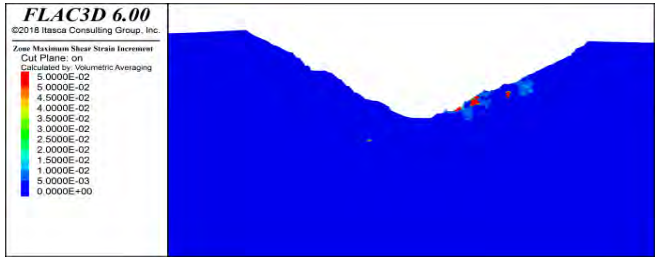
PSM125-283R	Appendix D9



After Year 2 underground working



After Year 3 underground working



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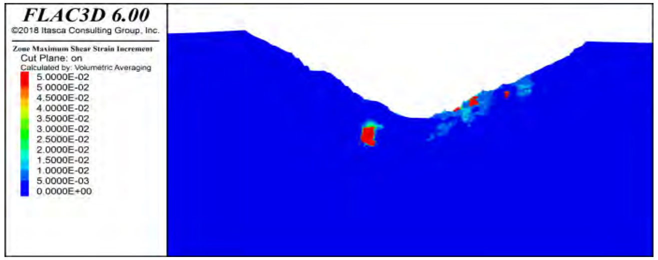
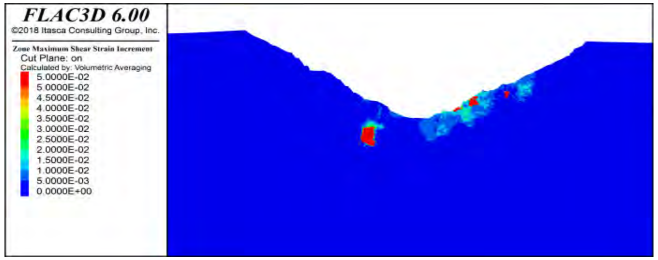
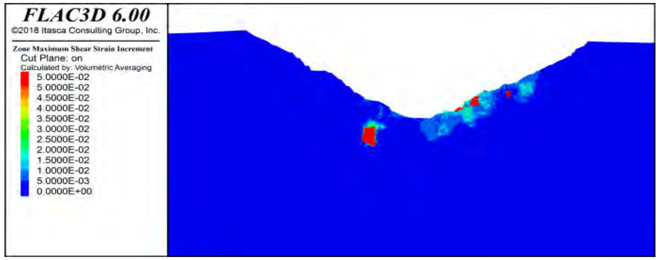


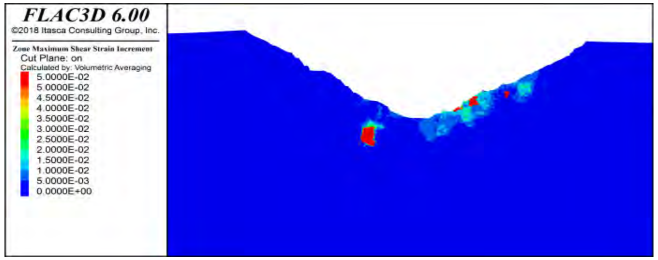
After Year 5 underground working



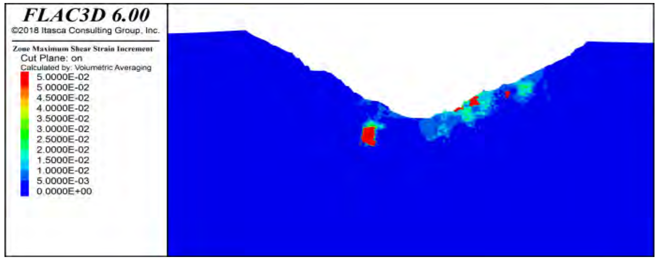
After Year 6 underground working



After Year 7 underground working



After Year 8 underground working



After Year 9 underground working

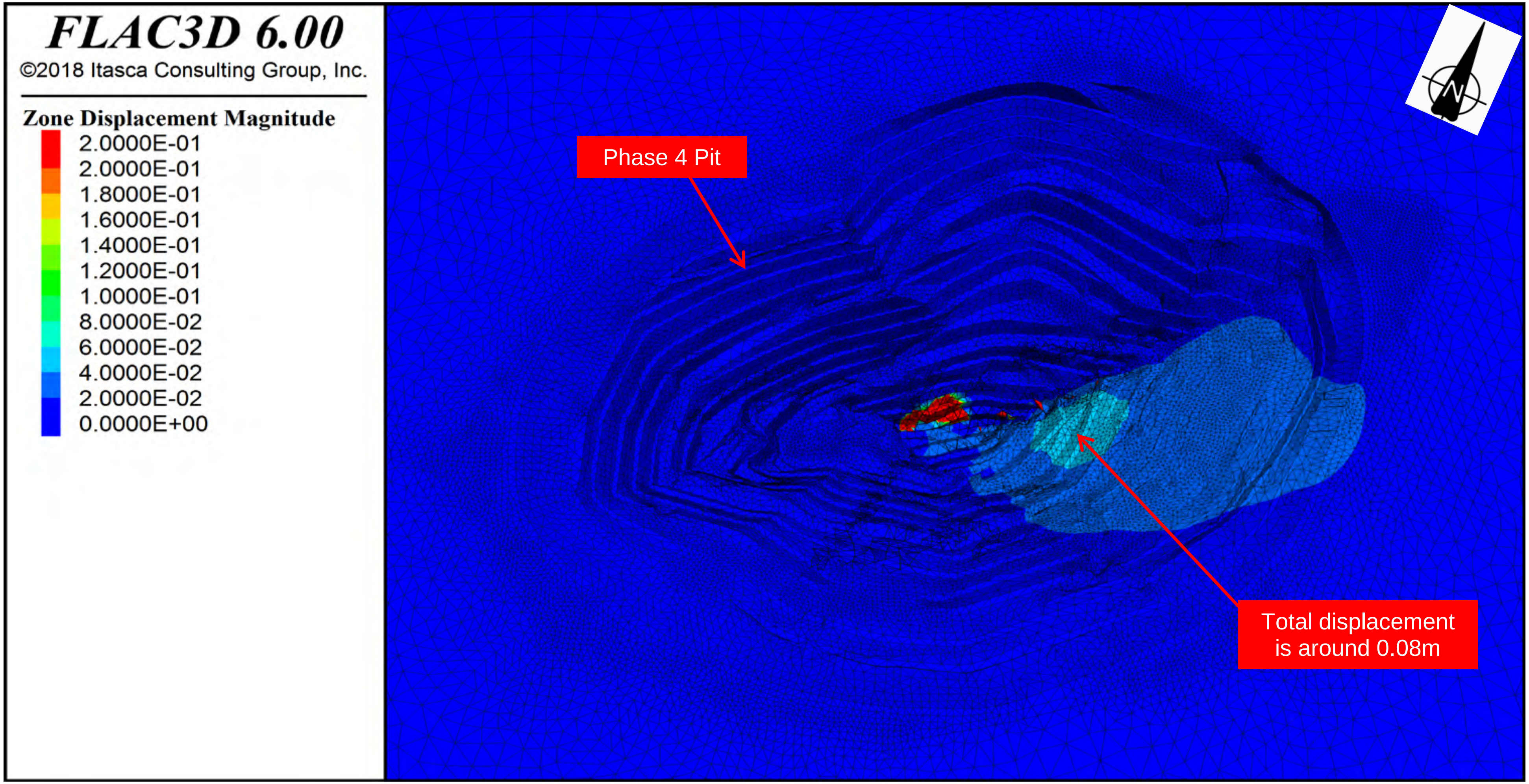
Pells Sullivan Meynink

Anderson Lloyd
Waihi, New Zealand
Numerical Model - Run 3
PREDICTED MAX SHEAR STRAIN OF SECTION 3 FOR YEARLY SEQUENCE

PSM125-283R	**Appendix D10**

APPENDIX E

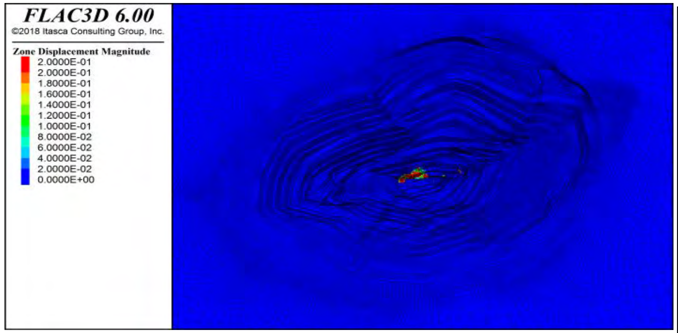
FLAC3D OUTPUTS – RUN 4



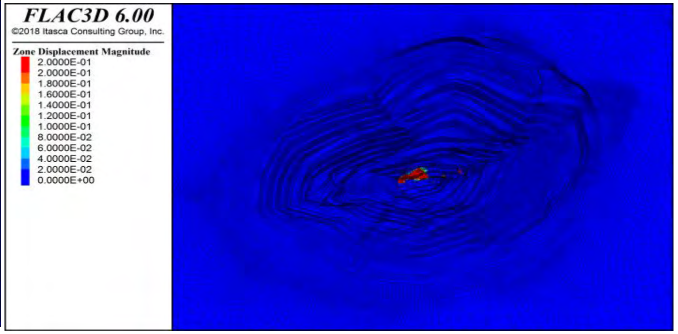
Anderson Lloyd Waihi, New Zealand Numerical Model - Run 4 **PREDICTED TOTAL DISPLACEMENT** **AFTER YEAR 9**	
PSM125-283R	Appendix E1

PSM

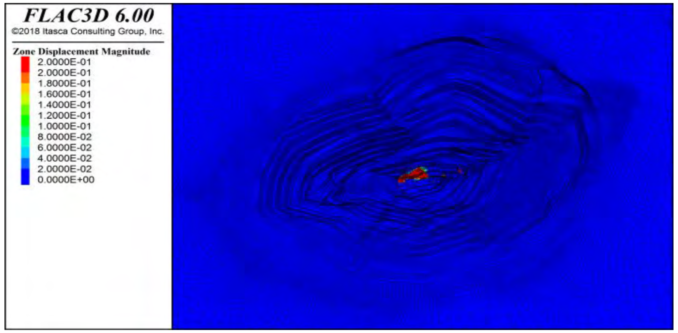
Pells Sullivan Meynink



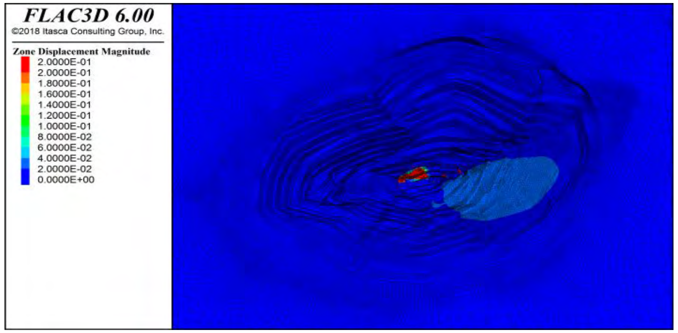
After Year 2 underground working



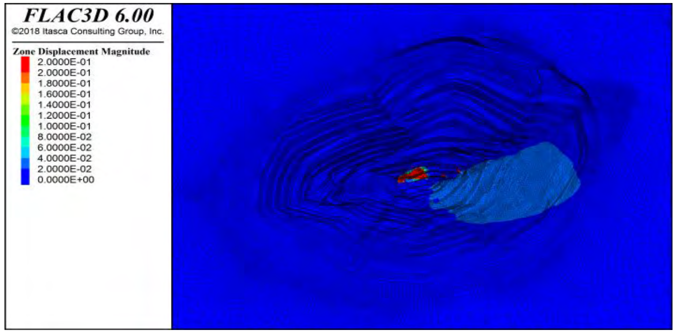
After Year 3 underground working



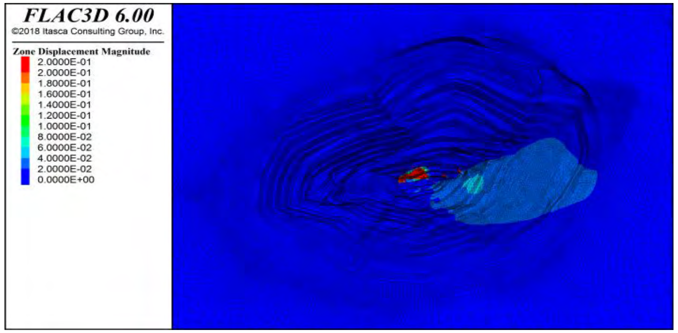
After Year 4 underground working



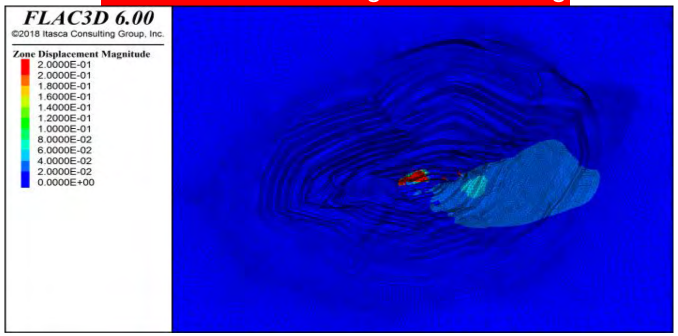
After Year 5 underground working



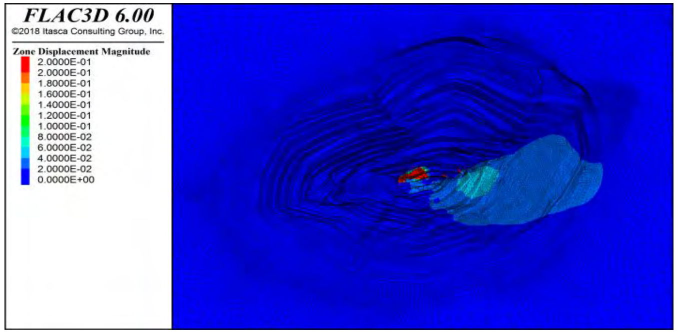
After Year 6 underground working



After Year 7 underground working



After Year 8 underground working



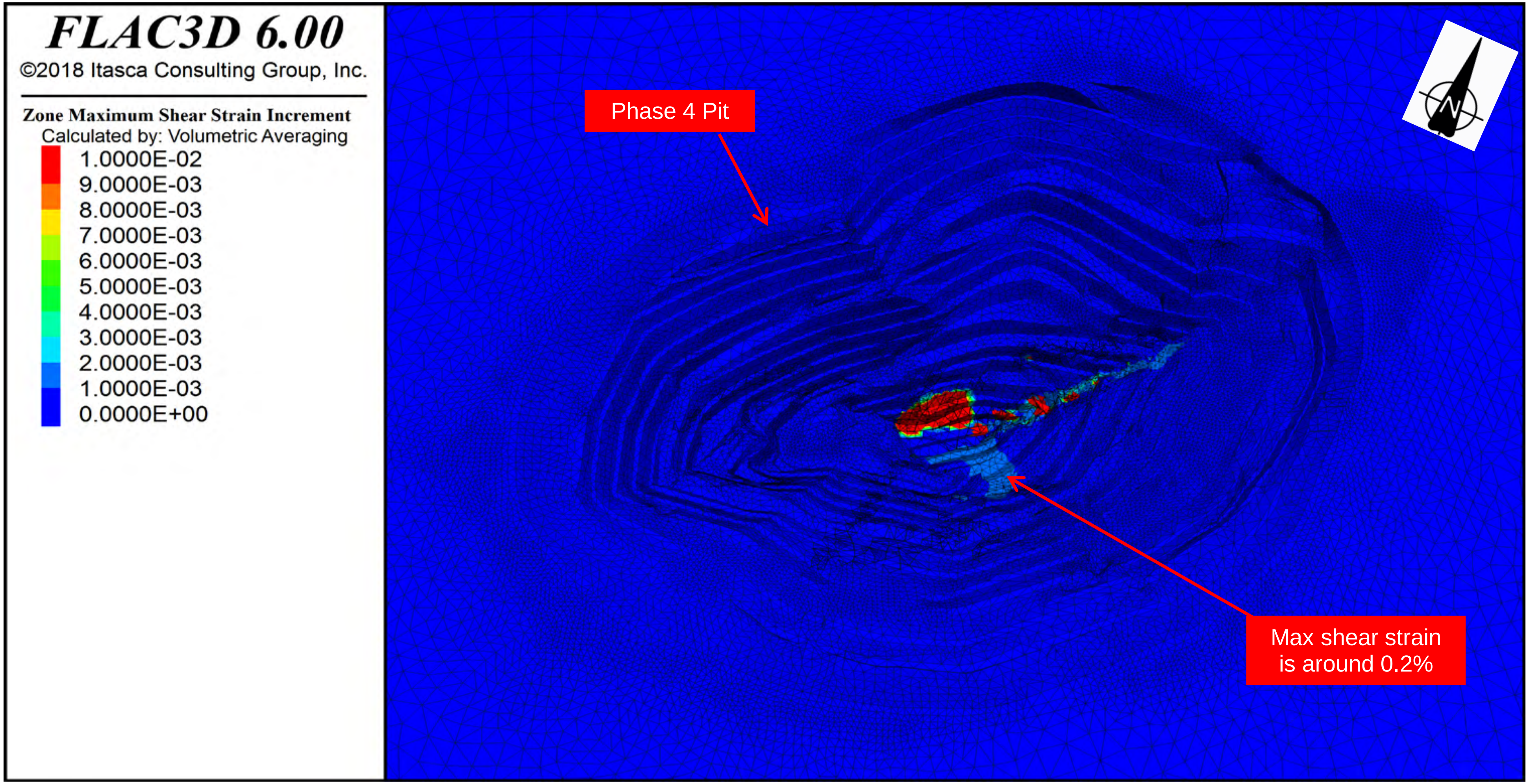
After Year 9 underground working

PSM

Pells Sullivan Meynink

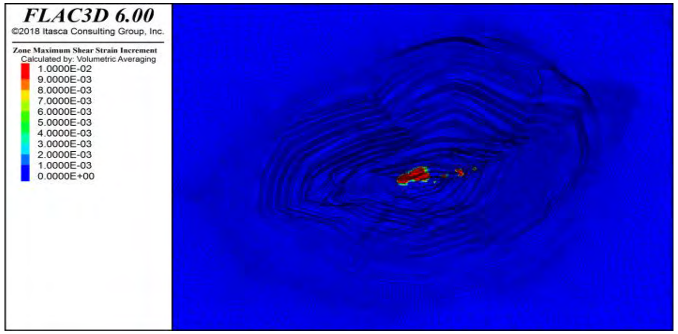
Anderson Lloyd
Waihi, New Zealand
Numerical Model - Run 4
PREDICTED TOTAL DISPLACEMENT FOR YEARLY SEQUENCE

PSM125-283R	**Appendix E2**

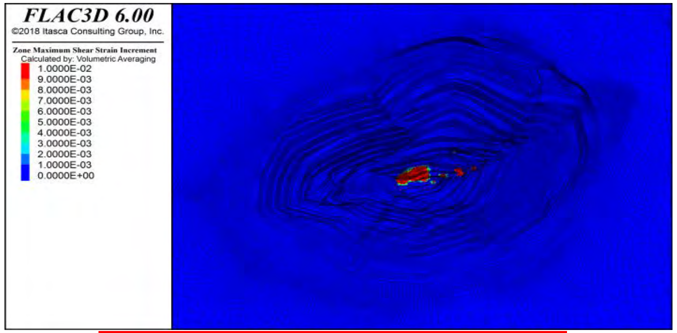


PSM Pells Sullivan Meynink

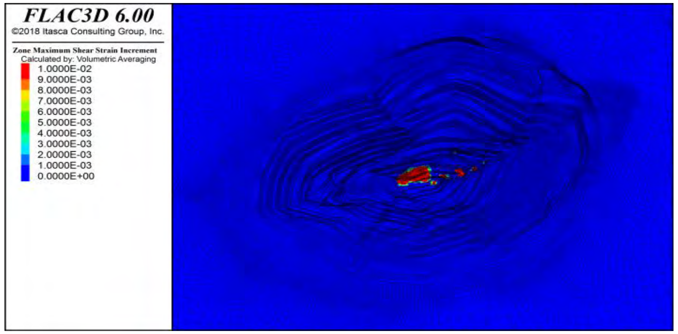
Anderson Lloyd Waihi, New Zealand Numerical Model - Run 4 PREDICTED MAX SHEAR STRAIN AFTER YEAR 9	
PSM125-283R	Appendix E3



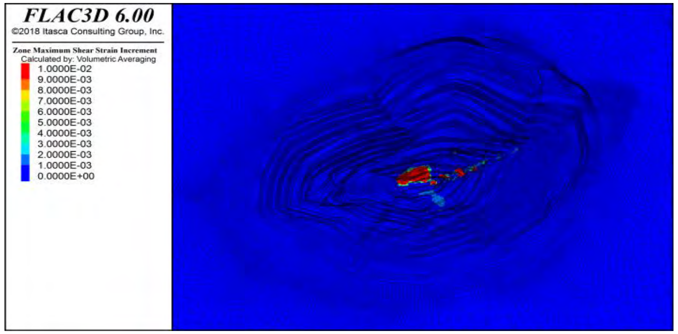
After Year 2 underground working



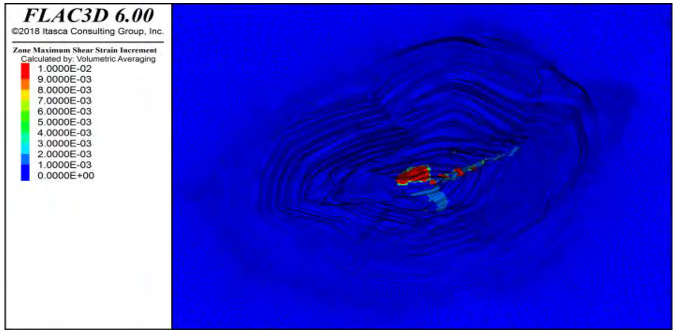
After Year 3 underground working



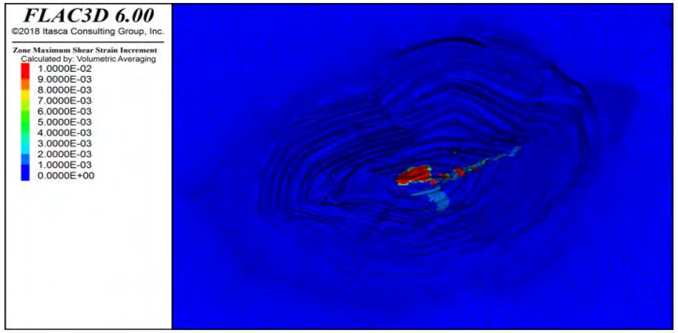
After Year 4 underground working



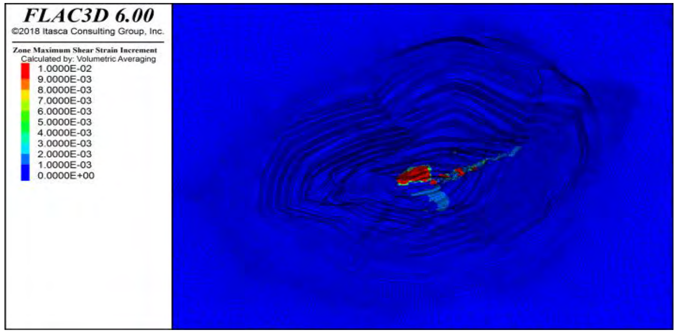
After Year 5 underground working



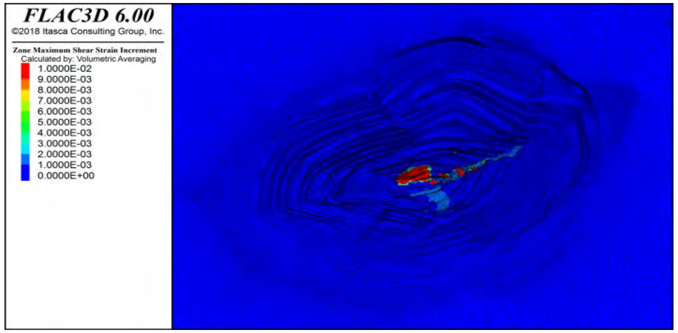
After Year 6 underground working



After Year 7 underground working



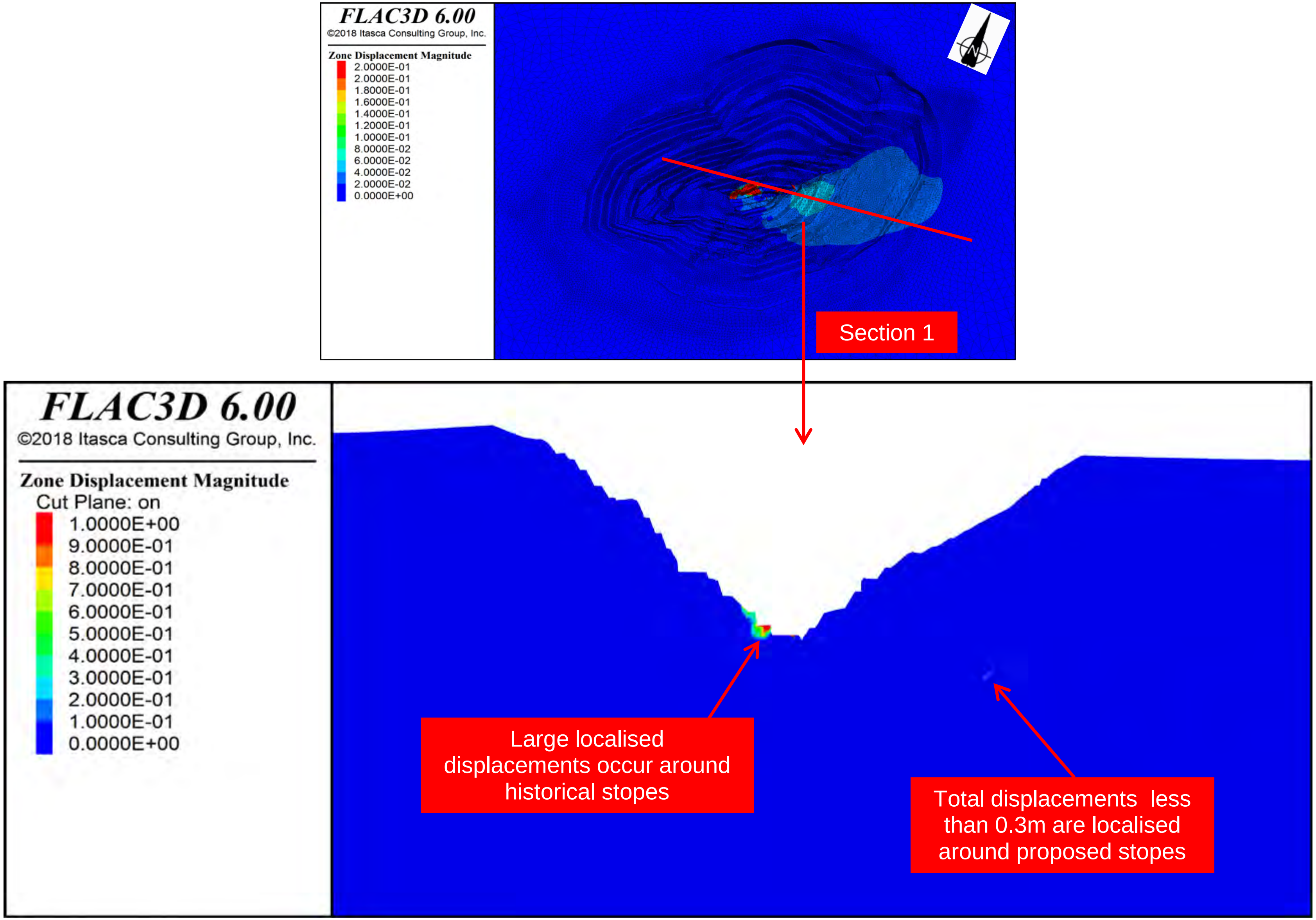
After Year 8 underground working



After Year 9 underground working

Anderson Lloyd
Waihi, New Zealand
Numerical Model - Run 4
PREDICTED MAX SHEAR STRAIN FOR YEARLY SEQUENCE

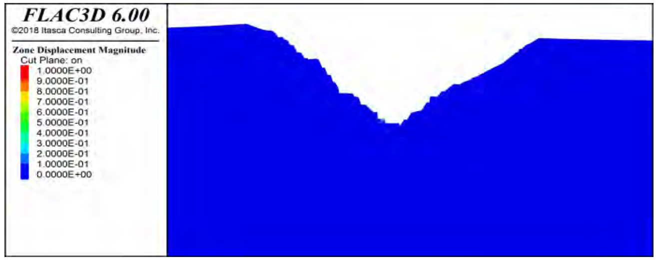
PSM125-283R	Appendix E4



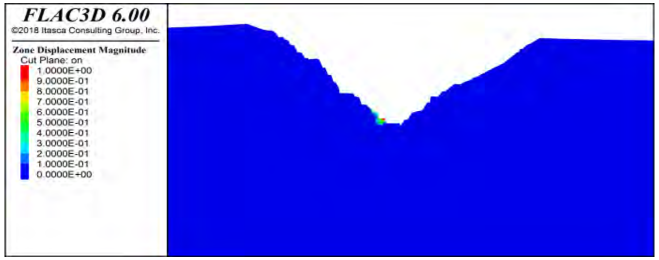
Anderson Lloyd Waihi, New Zealand Numerical Model - Run 4 PREDICTED TOTAL DISPLACEMENT OF SECTION 1 AFTER YEAR 9	
PSM125-283R	Appendix E5

PSM

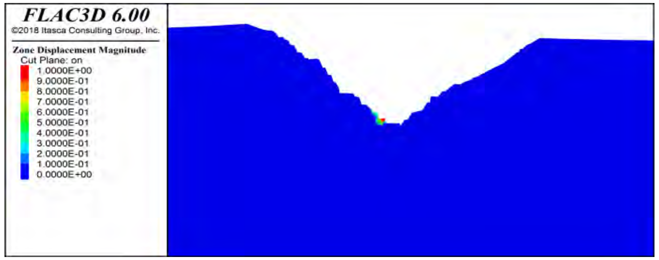
Pells Sullivan Meynink



After Year 2 underground working



After Year 3 underground working



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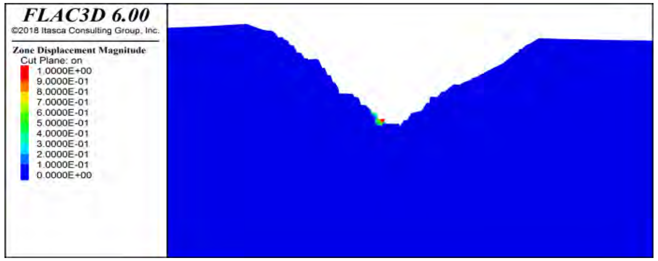
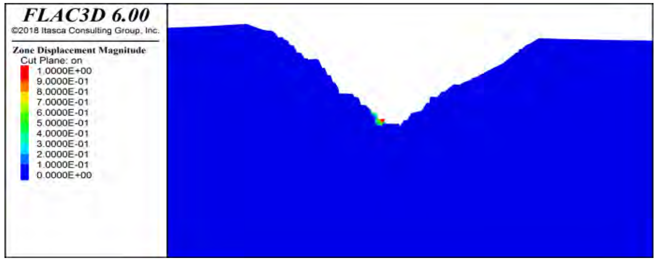
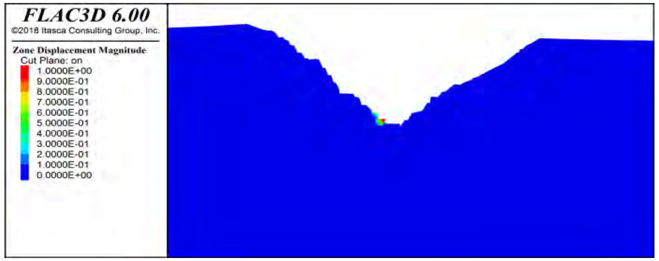


After Year 5 underground working



After Year 6 underground working



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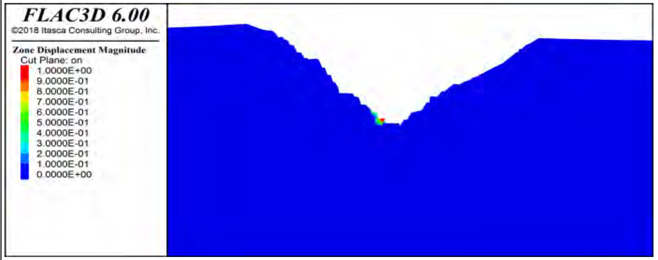
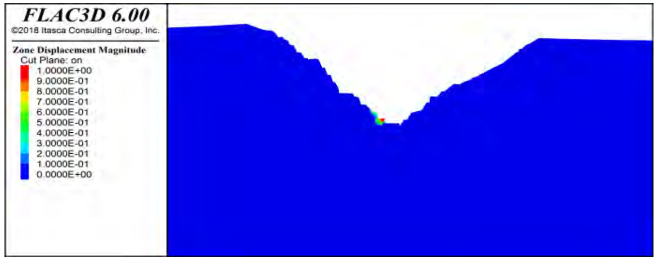


After Year 8 underground working



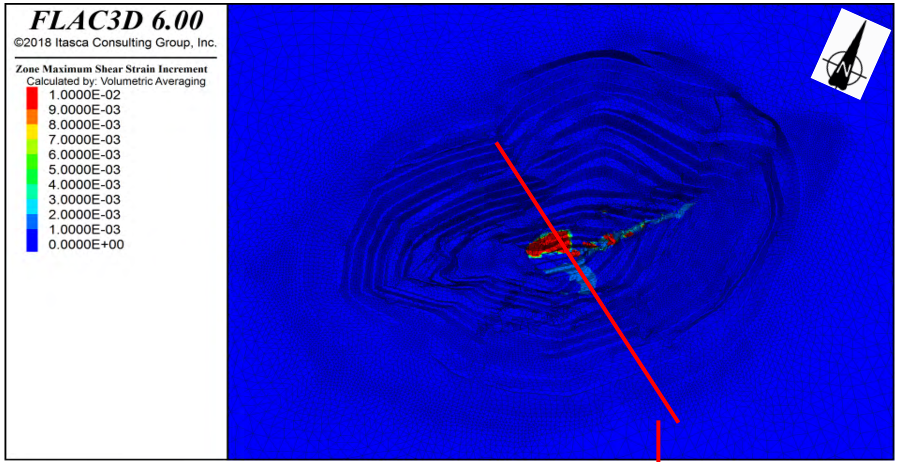
After Year 9 underground working

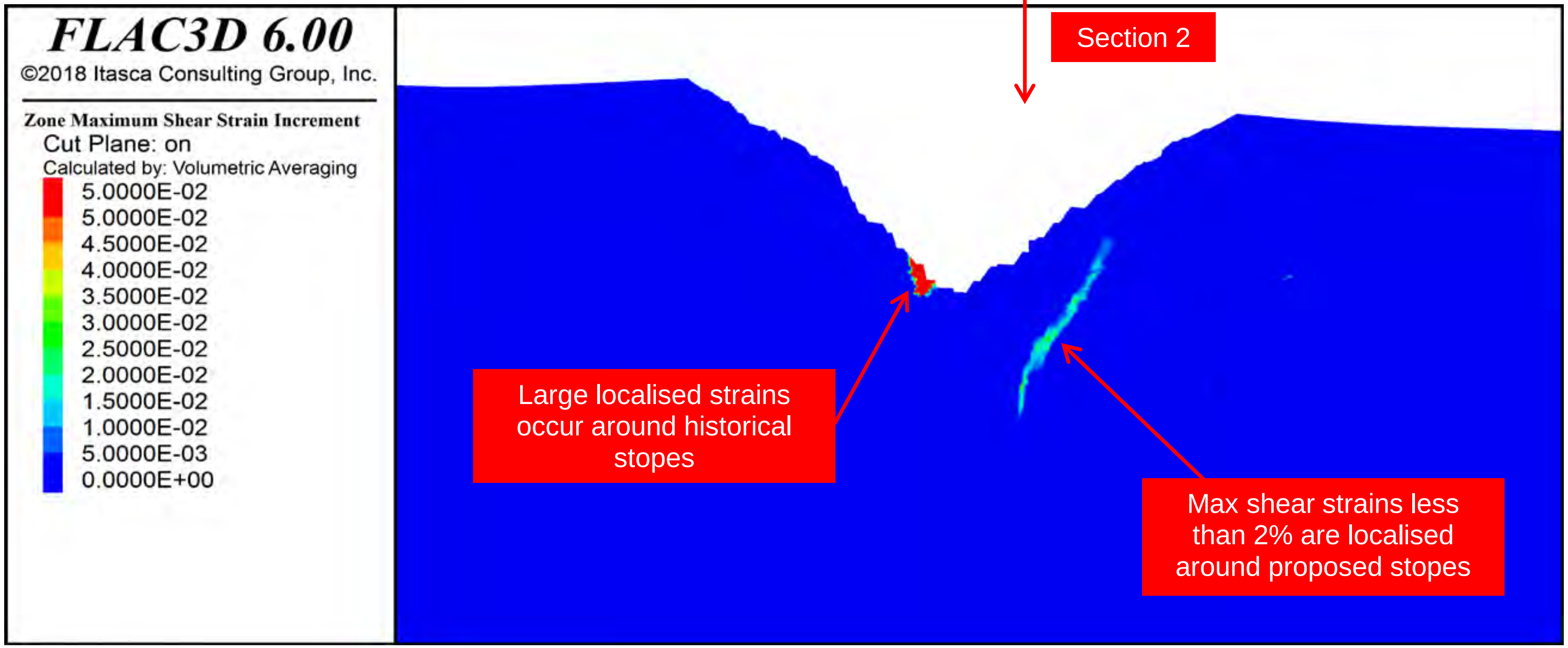
PSM

Pells Sullivan Meynink

Anderson Lloyd
Waihi, New Zealand
Numerical Model - Run 4
PREDICTED TOTAL DISPLACEMENT OF SECTION 1 FOR YEARLY SEQUENCE

PSM125-283R	**Appendix E6**



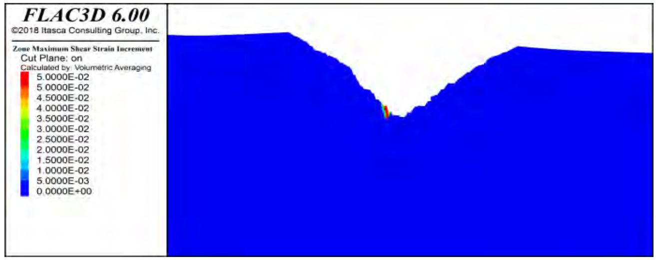


Pells Sullivan Meynink

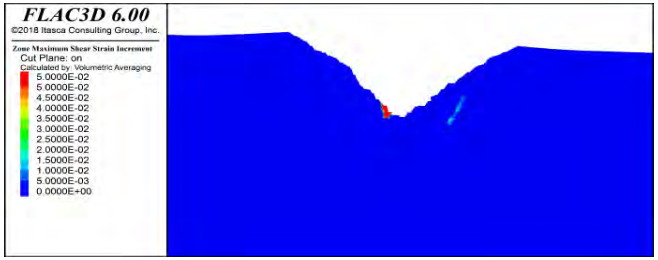
Anderson Lloyd
Waihi, New Zealand
Numerical Model - Run 4

PREDICTED MAX SHEAR STRAIN OF SECTION 2 AFTER YEAR 9

PSM125-283R	Appendix E7



After Year 2 underground working



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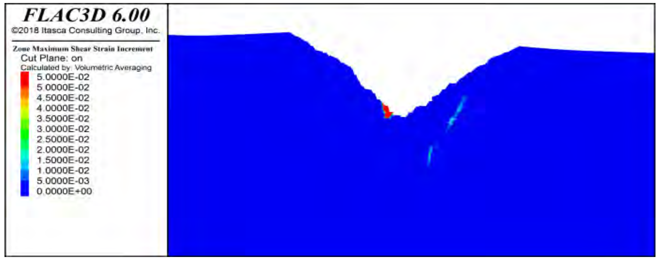
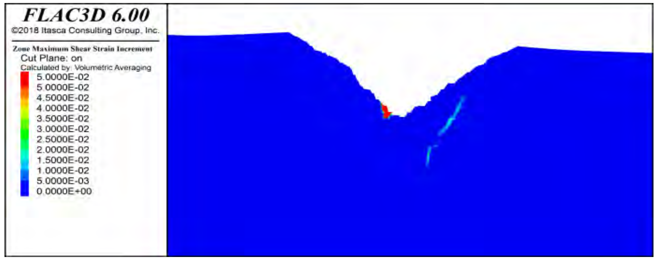
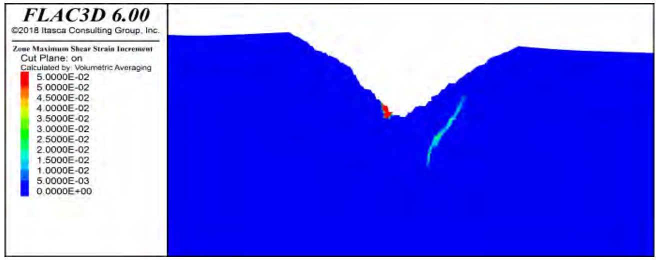


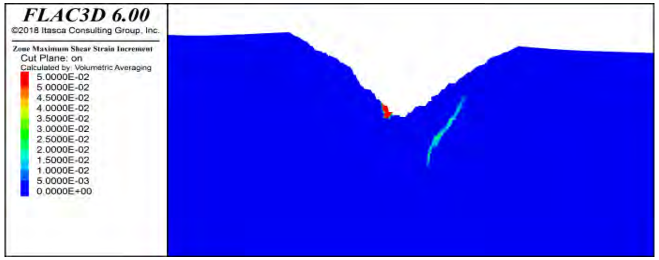
After Year 4 underground working



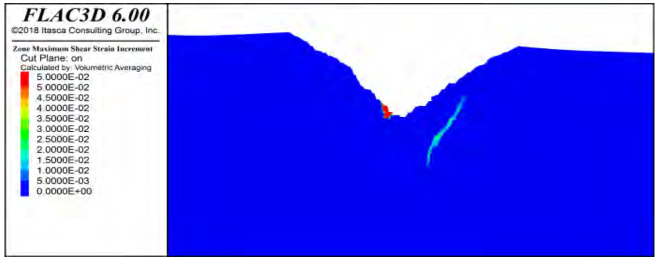
After Year 5 underground working



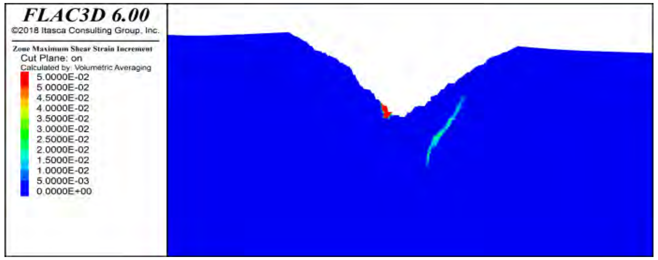
After Year 6 underground working



After Year 7 underground working



After Year 8 underground working

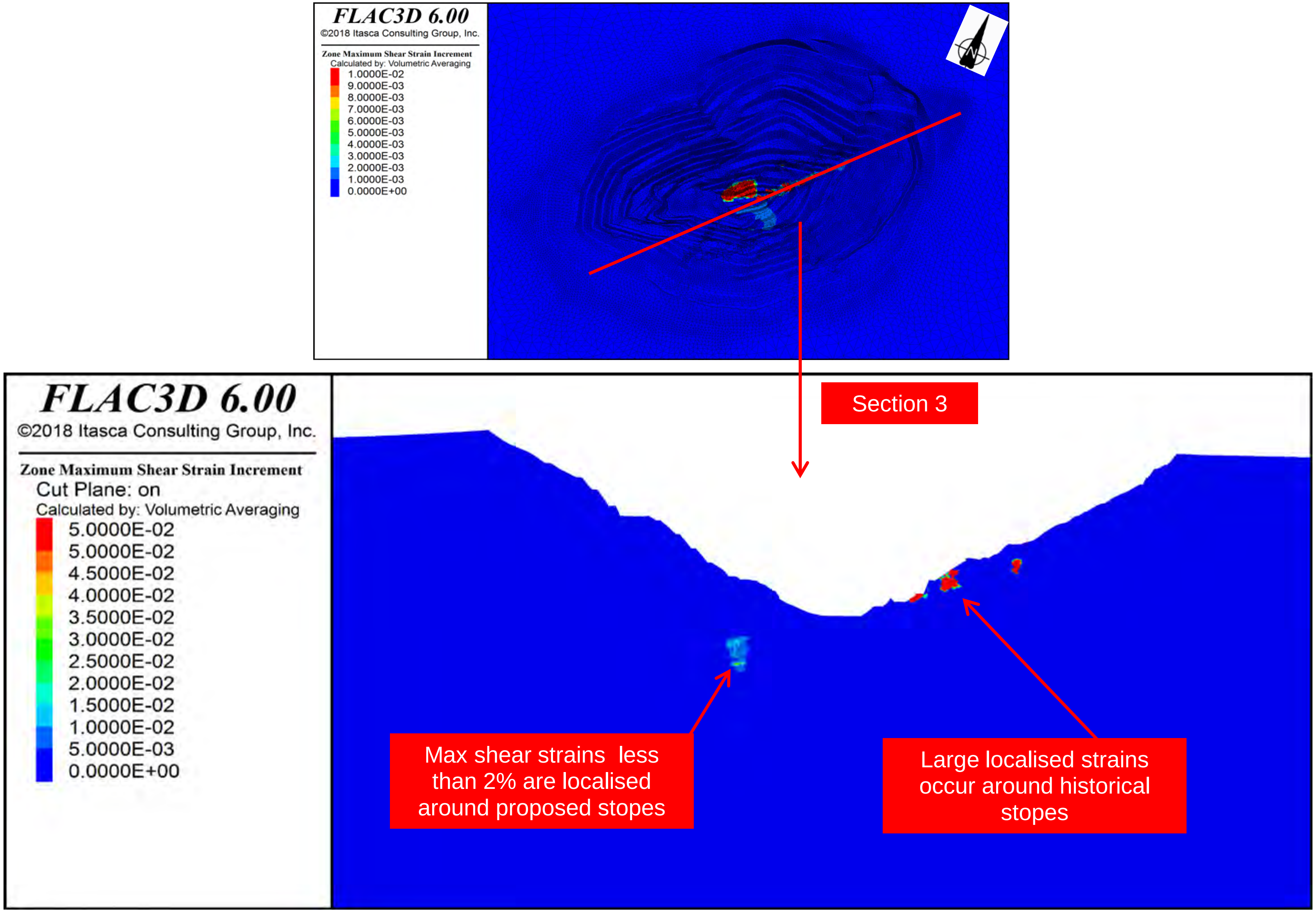


After Year 9 underground working

PSM

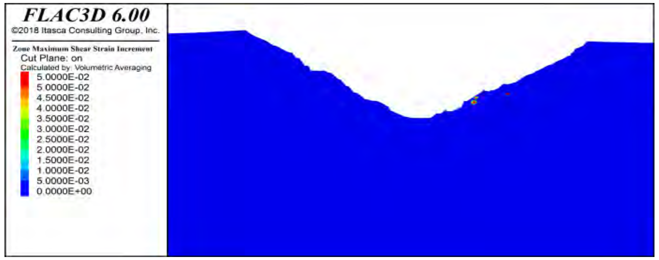
Pells Sullivan Meynink

Anderson Lloyd Waihi, New Zealand Numerical Model - Run 4 PREDICTED MAX SHEAR STRAIN OF SECTION 2 FOR YEARLY SEQUENCE	
PSM125-283R	**Appendix E8**

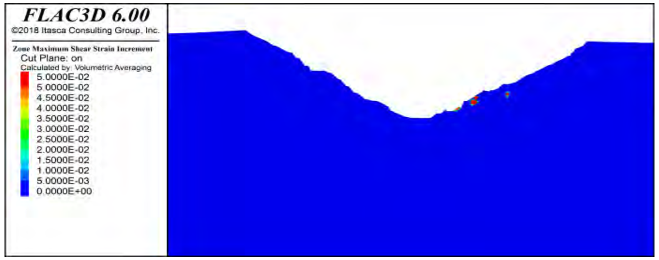


Pells Sullivan Meynink

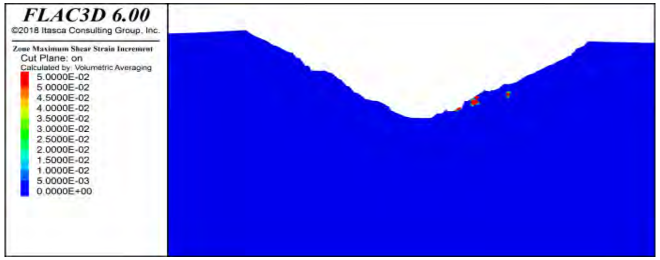
Anderson Lloyd Waihi, New Zealand Numerical Model - Run 4 PREDICTED MAX SHEAR STRAIN OF SECTION 3 AFTER YEAR 9	
PSM125-283R	Appendix E9



After Year 2 underground working



After Year 3 underground working



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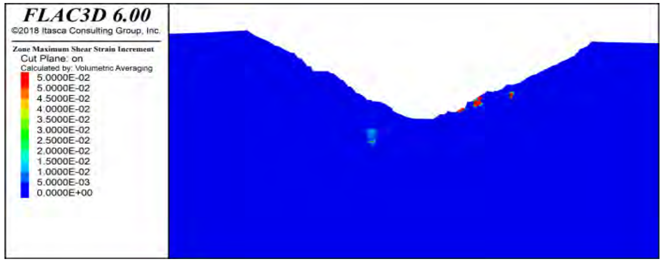
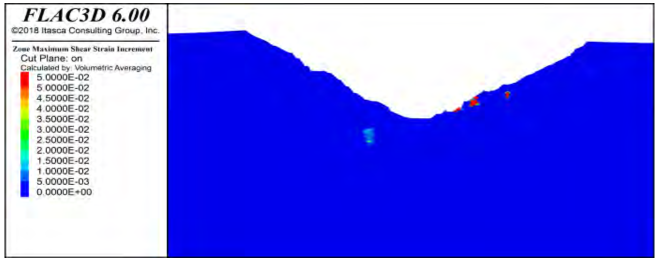
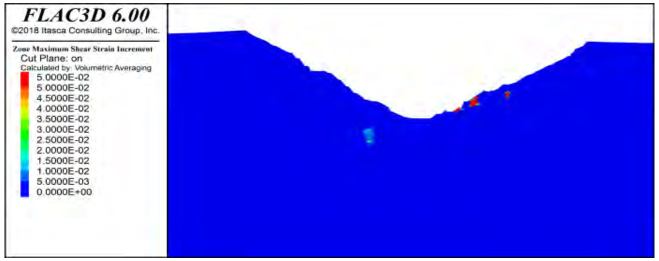


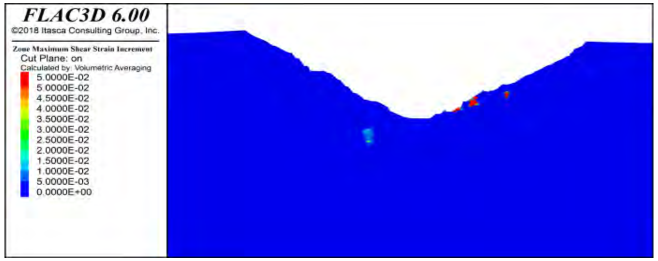
After Year 5 underground working



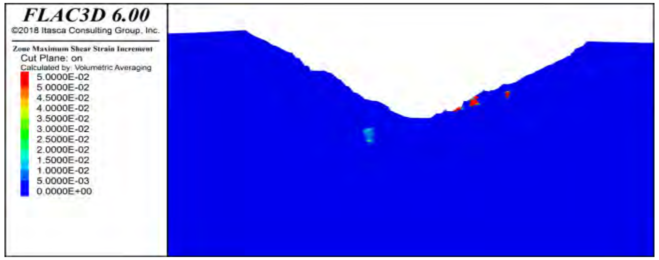
After Year 6 underground working



After Year 7 underground working



After Year 8 underground working



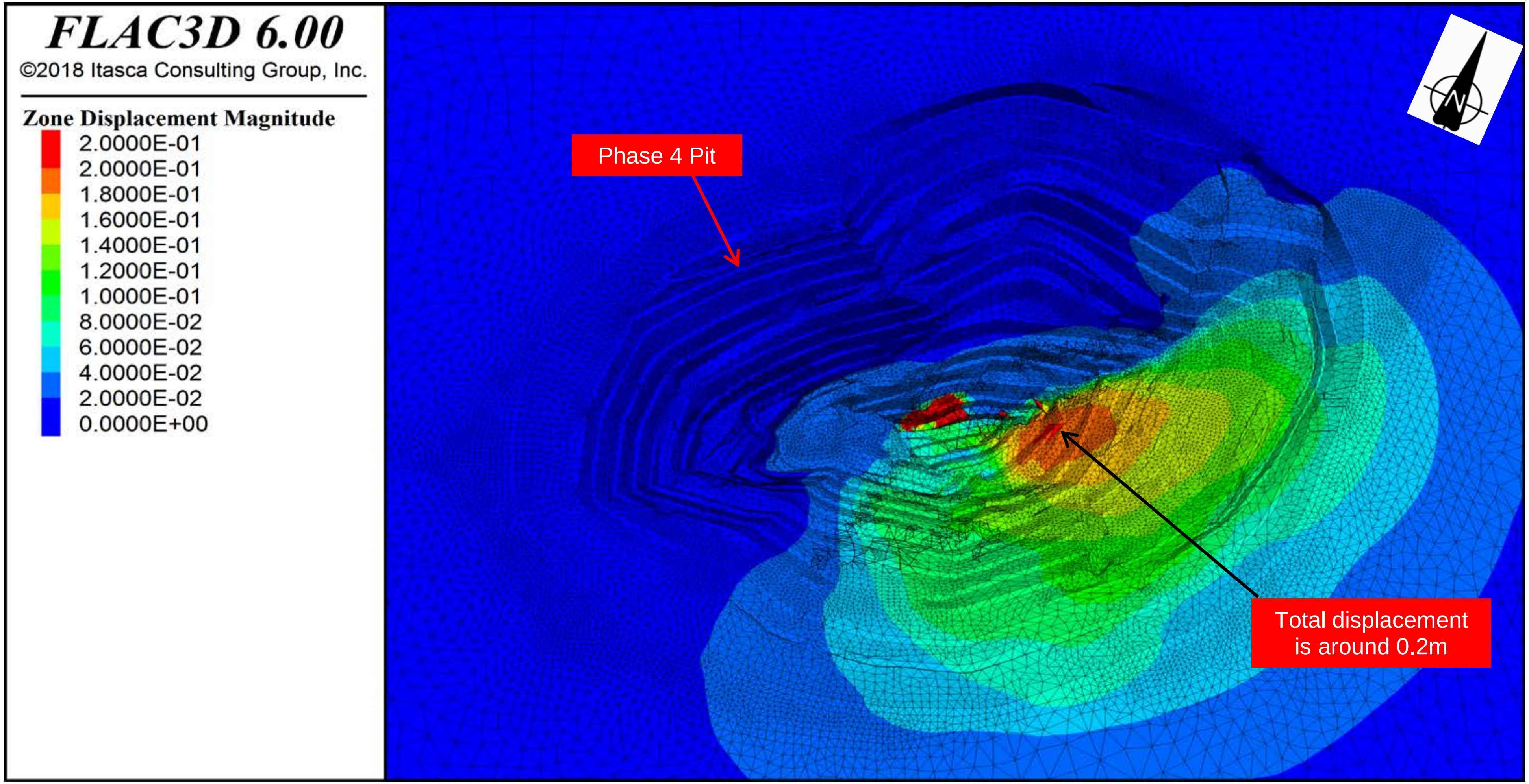
After Year 9 underground working

PSM Pells Sullivan Meynink

Anderson Lloyd Waihi, New Zealand Numerical Model - Run 4 PREDICTED MAX SHEAR STRAIN OF SECTION 3 FOR YEARLY SEQUENCE	
PSM125-283R	Appendix E10

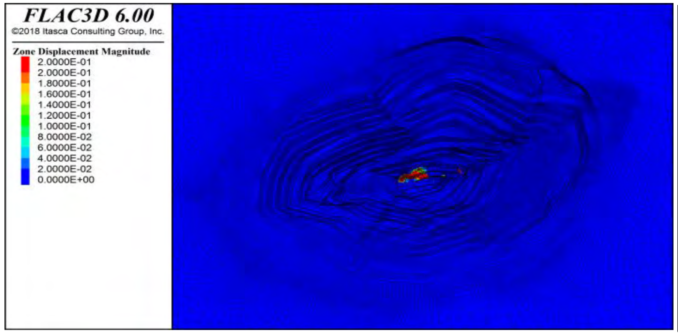
APPENDIX F

FLAC3D OUTPUTS – RUN 5



Anderson Lloyd Waihi, New Zealand Numerical Model - Run 5 PREDICTED TOTAL DISPLACEMENT AFTER YEAR 9	
PSM125-283R	Appendix F1

Pells Sullivan Meynink



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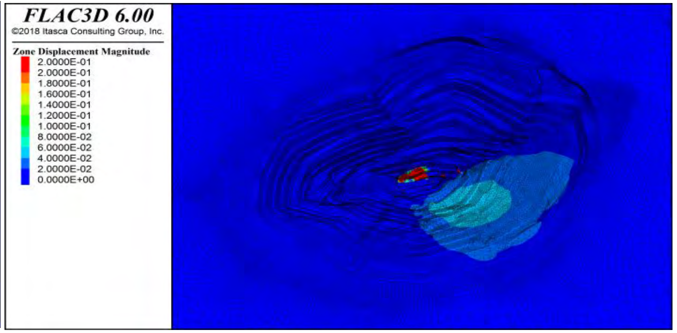

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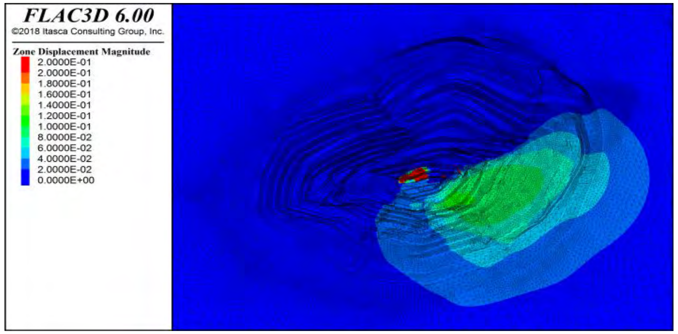
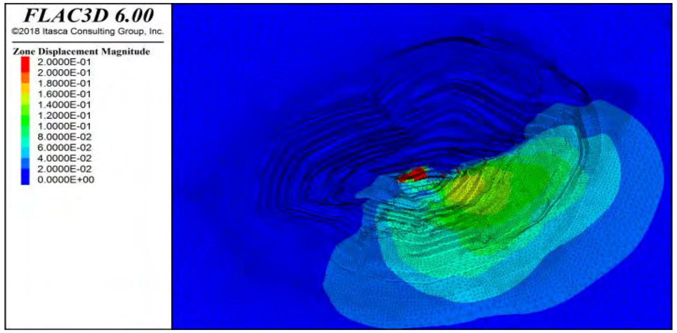
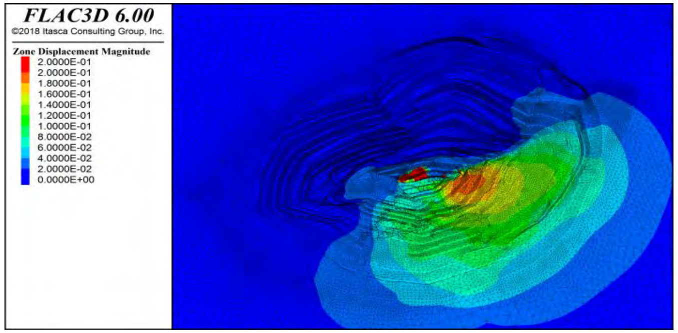


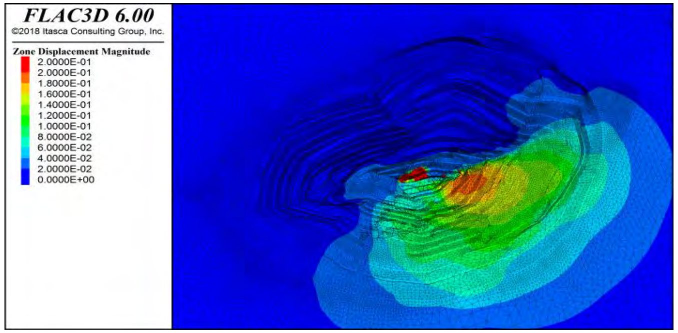
After Year 4 underground working



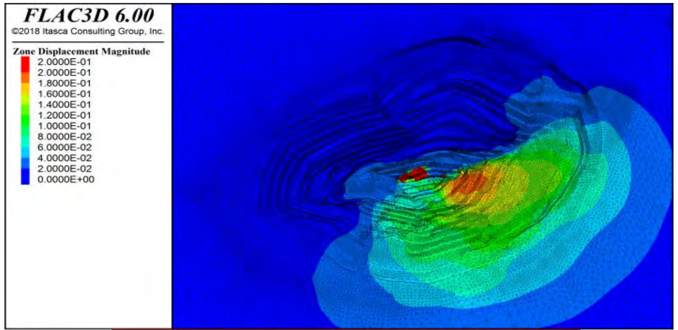
After Year 5 underground working



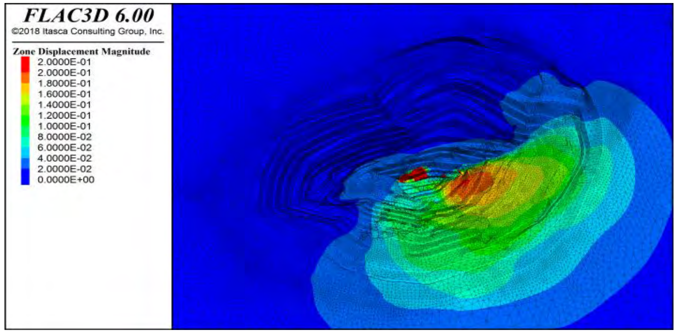
After Year 6 underground working



After Year 7 underground working



After Year 8 underground working

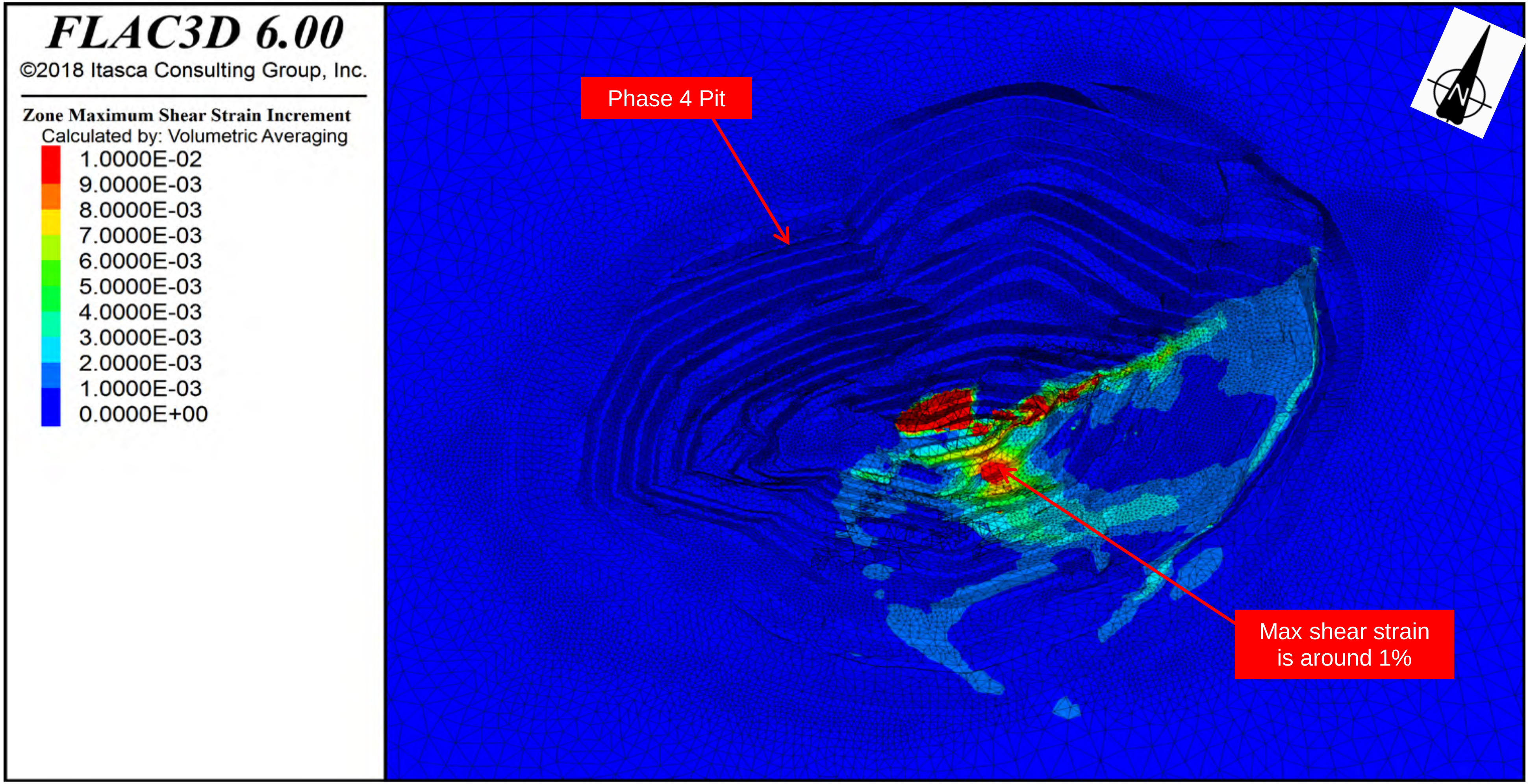


After Year 9 underground working

Pells Sullivan Meynink

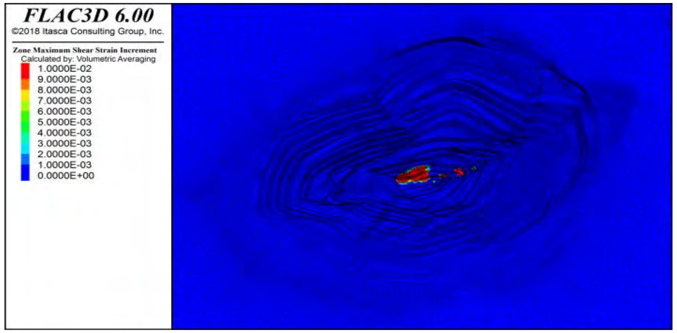
Anderson Lloyd
Waihi, New Zealand
Numerical Model - Run 5
PREDICTED TOTAL DISPLACEMENT FOR YEARLY SEQUENCE

PSM125-283R	**Appendix F2**

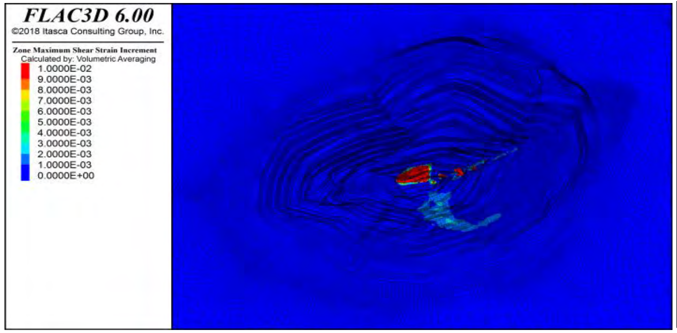


Anderson Lloyd Waihi, New Zealand Numerical Model - Run 5 PREDICTED MAX SHEAR STRAIN AFTER YEAR 9	
PSM125-283R	**Appendix F3**

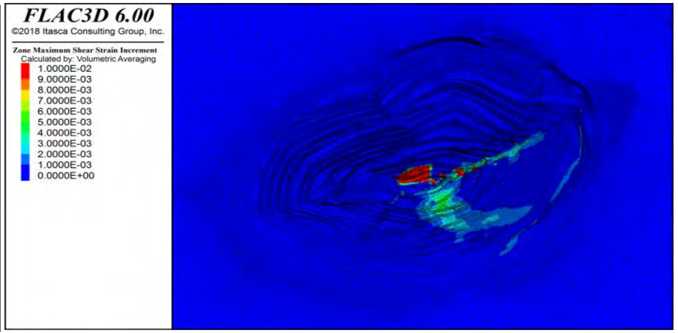
Pells Sullivan Meynink



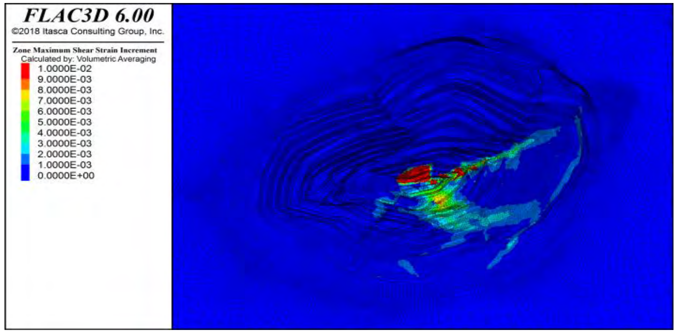
After Year 2 underground working



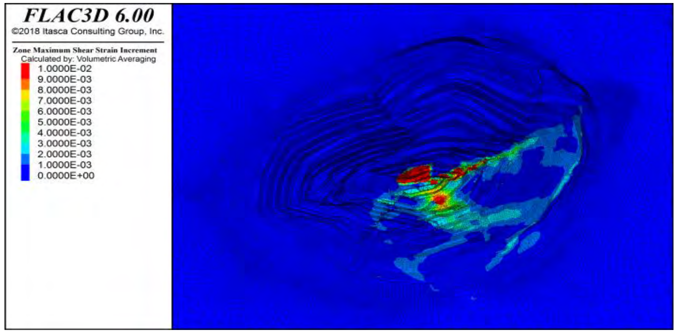
After Year 3 underground working



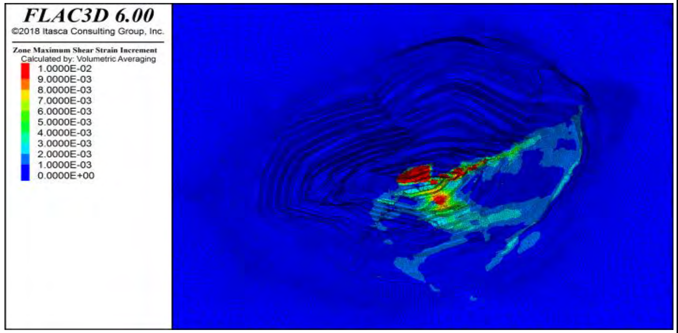
After Year 4 underground working



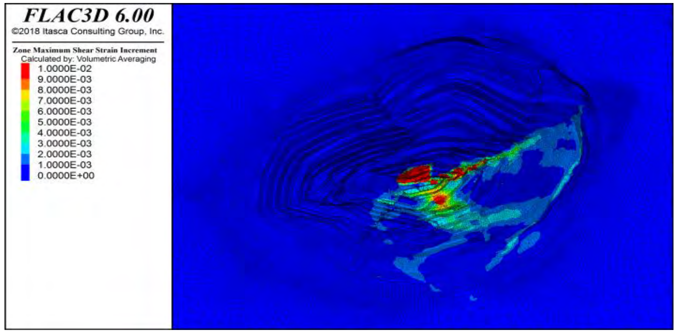
After Year 5 underground working



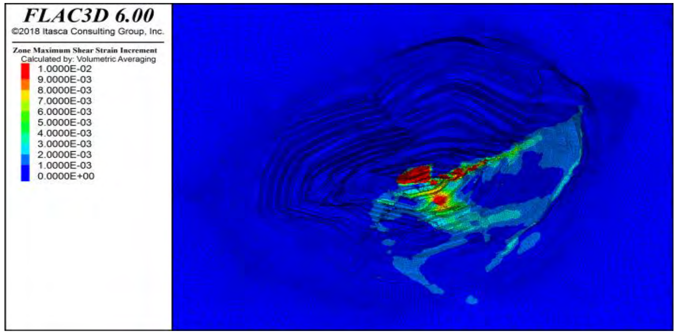
After Year 6 underground working



After Year 7 underground working



After Year 8 underground working



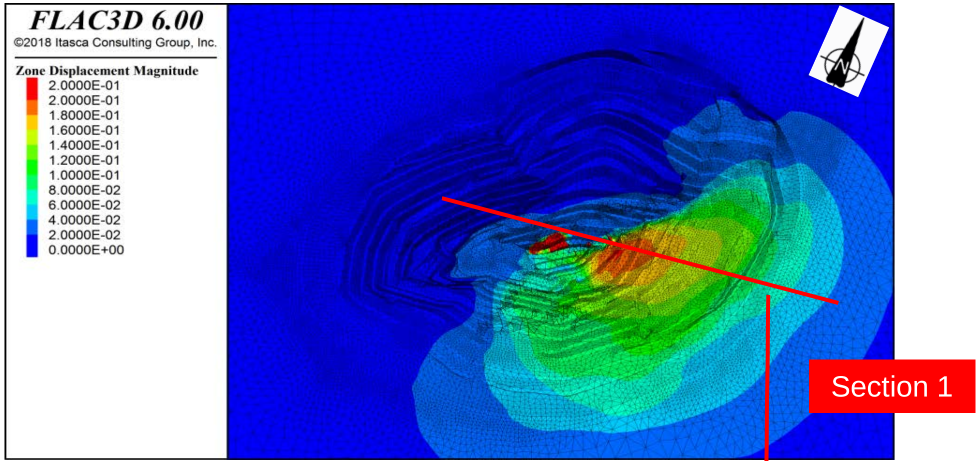
After Year 9 underground working

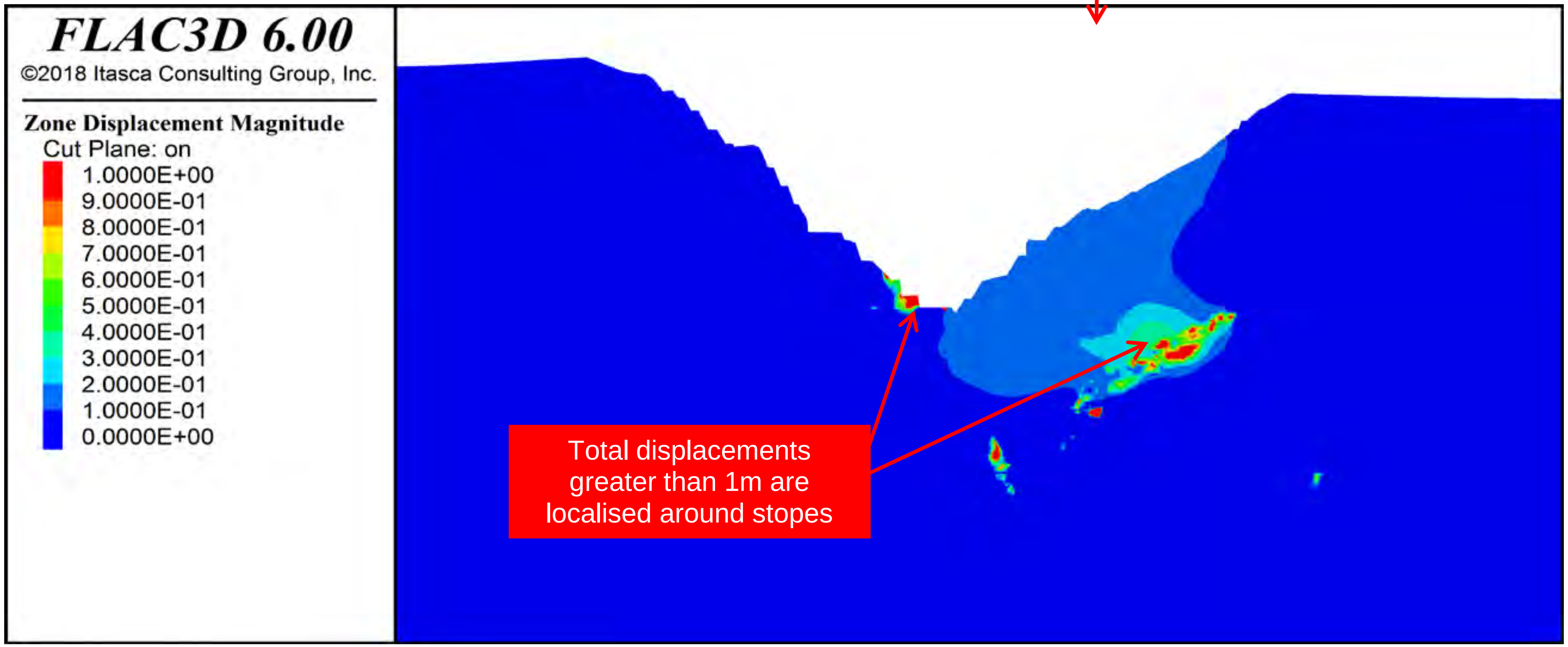
Anderson Lloyd
Waihi, New Zealand
Numerical Model - Run 5
PREDICTED MAX SHEAR STRAIN FOR YEARLY SEQUENCE

PSM125-283R	**Appendix F4**

PSM

Pells Sullivan Meynink

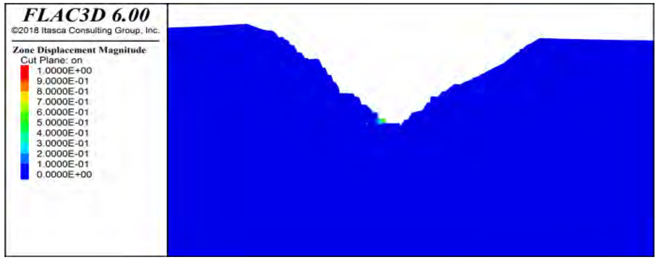




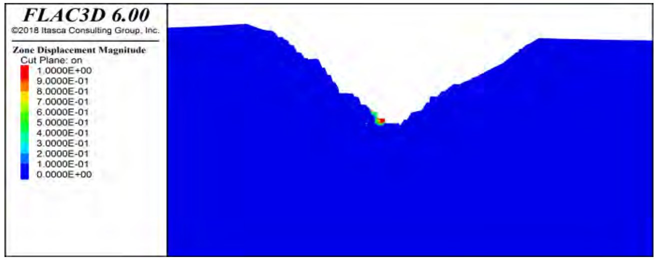
Anderson Lloyd
Waihi, New Zealand
Numerical Model - Run 5
PREDICTED TOTAL DISPLACEMENT OF SECTION 1 AFTER YEAR 9

PSM125-283R	**Appendix F5**

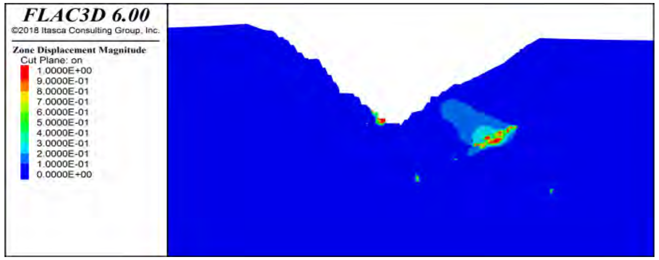
Pells Sullivan Meynink



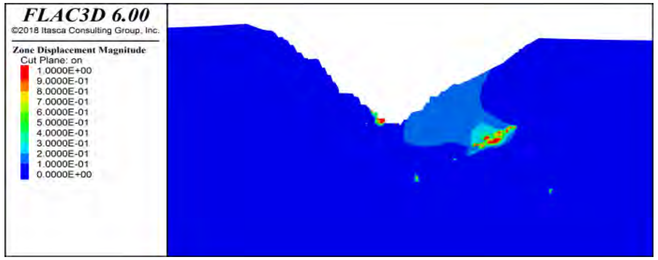
After Year 2 underground working



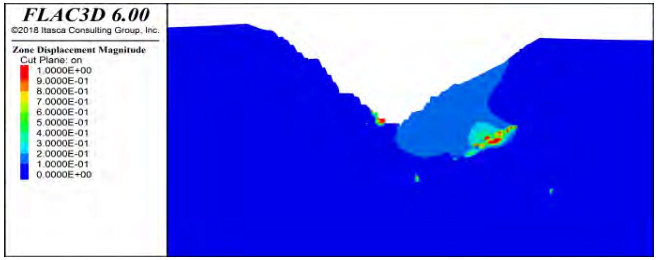
After Year 3 underground working



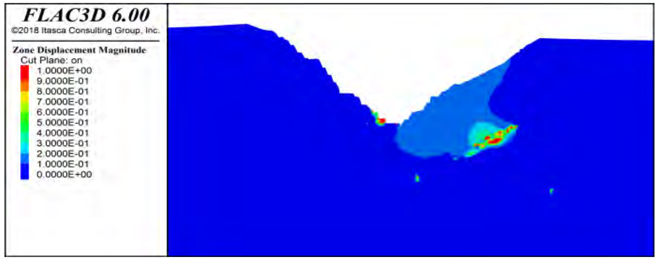
After Year 4 underground working



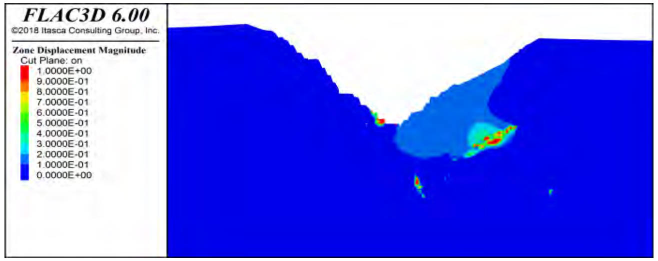
After Year 5 underground working



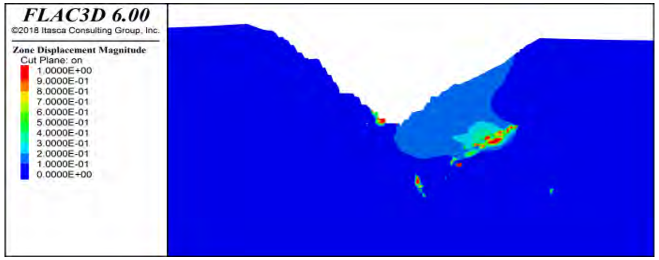
After Year 6 underground working



After Year 7 underground working



After Year 8 underground working

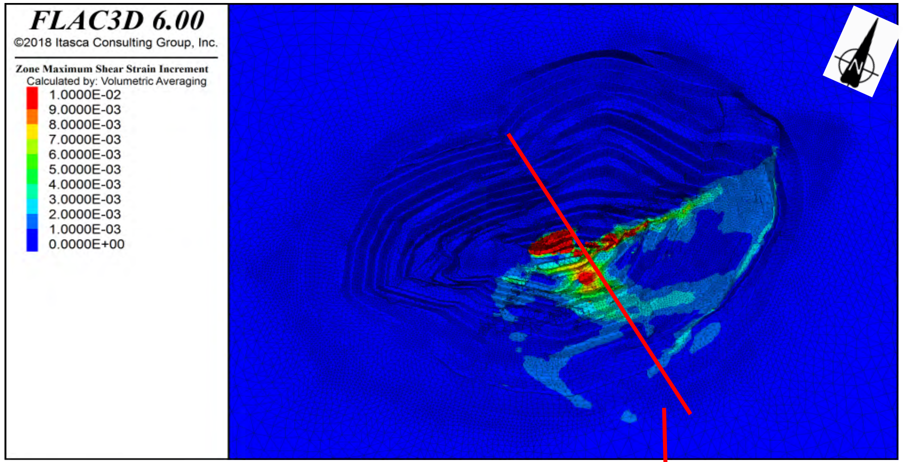


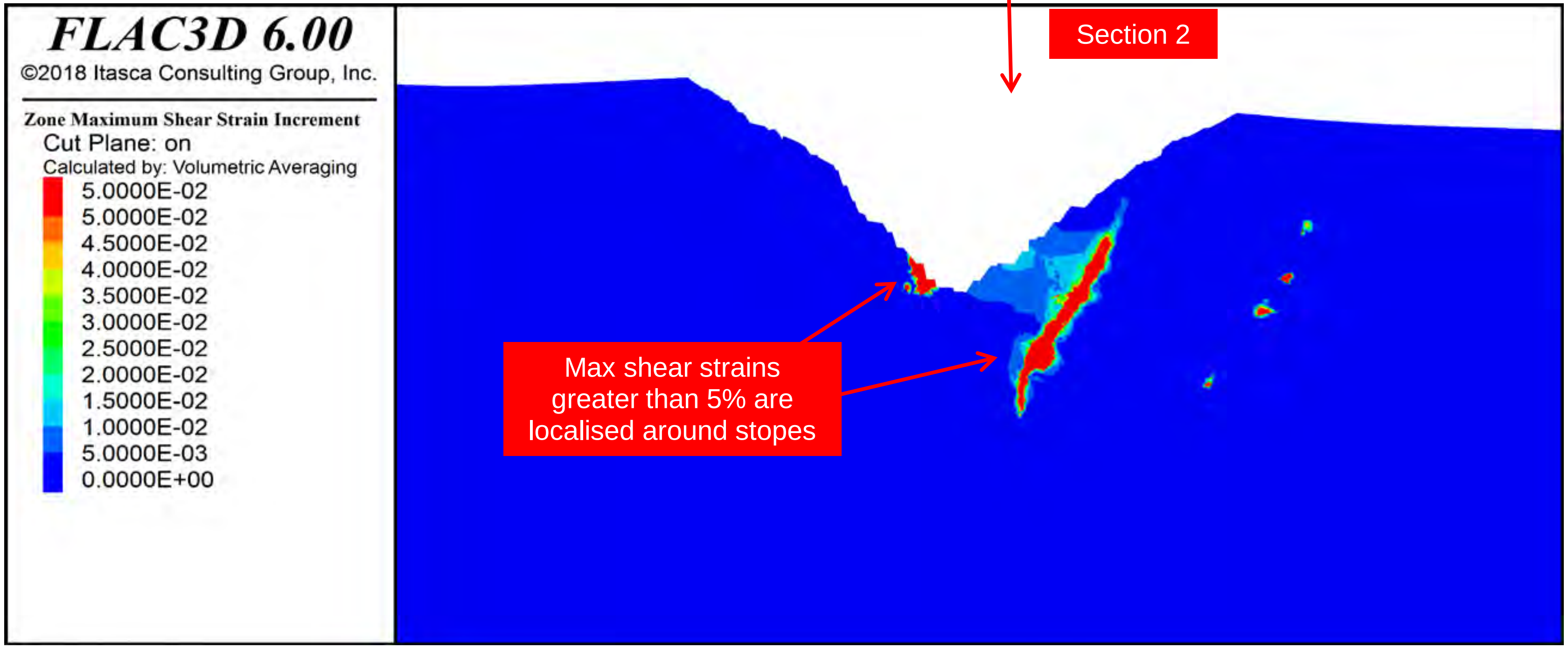
After Year 9 underground working

Anderson Lloyd
Waihi, New Zealand
Numerical Model - Run 5
PREDICTED TOTAL DISPLACEMENT OF SECTION 1 FOR YEARLY SEQUENCE

PSM125-283R	**Appendix F6**

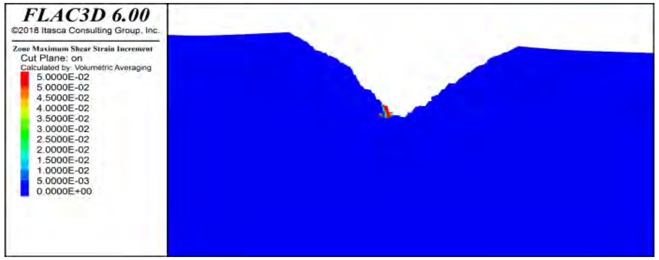
Pells Sullivan Meynink



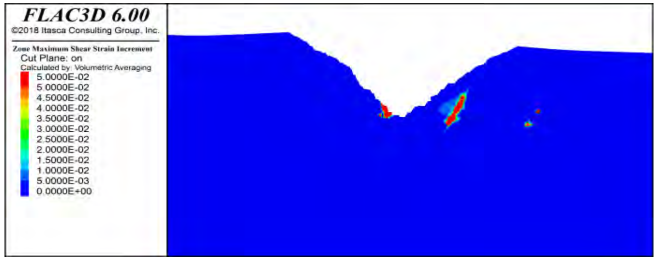


Pells Sullivan Meynink

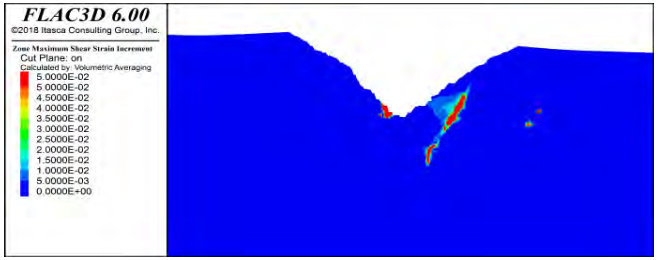
Anderson Lloyd Waihi, New Zealand Numerical Model - Run 5 **PREDICTED MAX SHEAR STRAIN OF SECTION 2 AFTER YEAR 9**	
PSM125-283R	**Appendix F7**



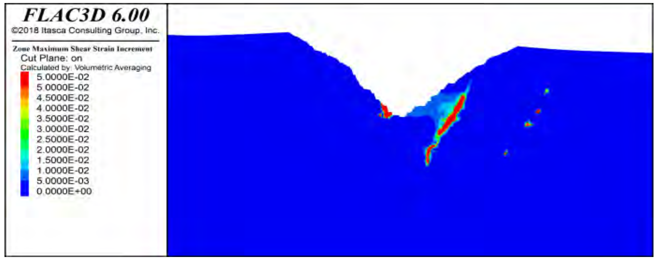
After Year 2 underground working



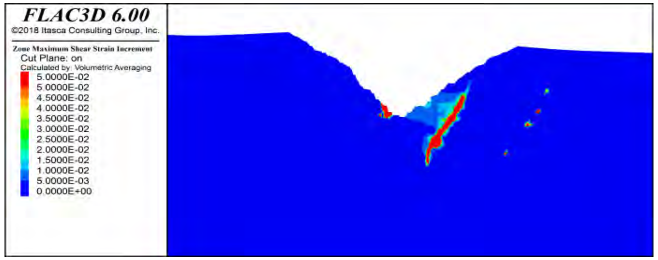
After Year 3 underground working



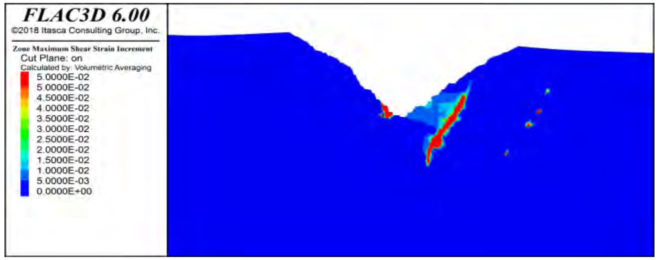
After Year 4 underground working



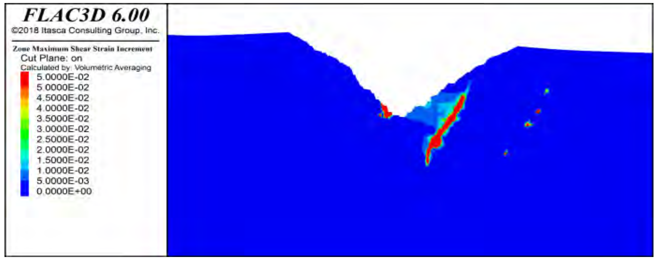
After Year 5 underground working



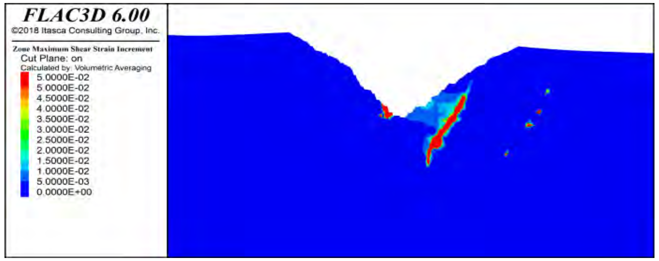
After Year 6 underground working



After Year 7 underground working



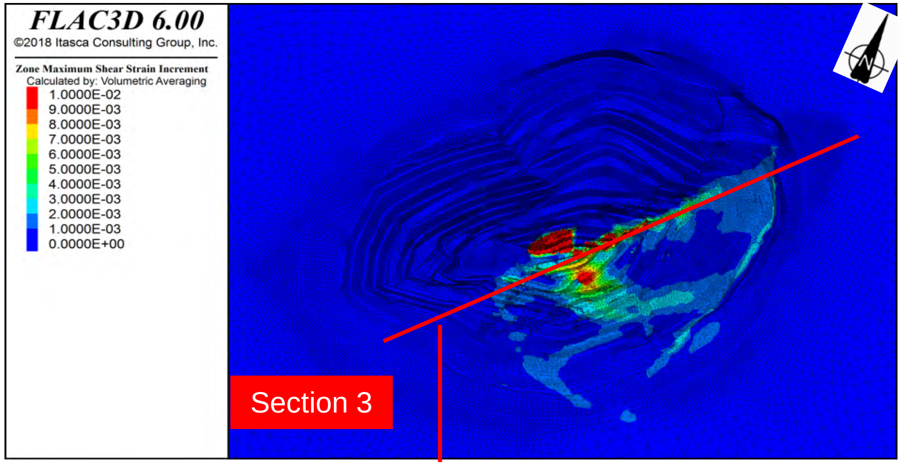
After Year 8 underground working

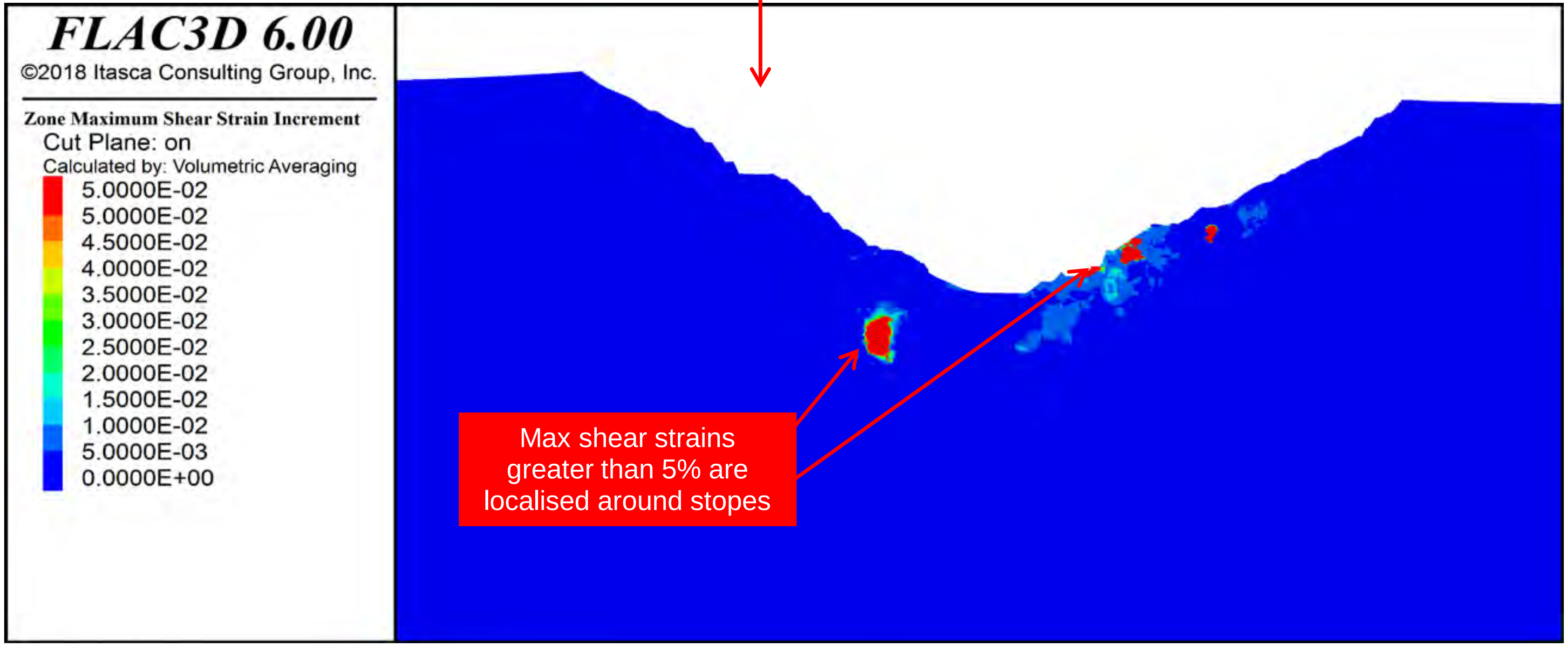


After Year 9 underground working

Anderson Lloyd Waihi, New Zealand Numerical Model - Run 5 PREDICTED MAX SHEAR STRAIN OF SECTION 2 FOR YEARLY SEQUENCE	
PSM125-283R	Appendix F8

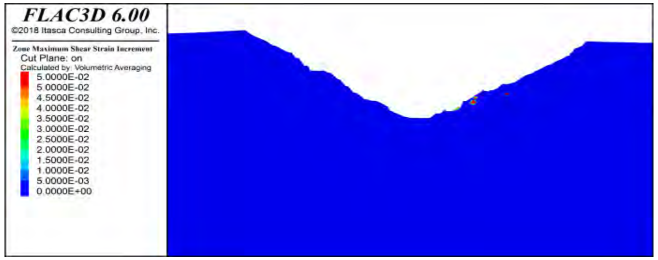
PSM Pells Sullivan Meynink



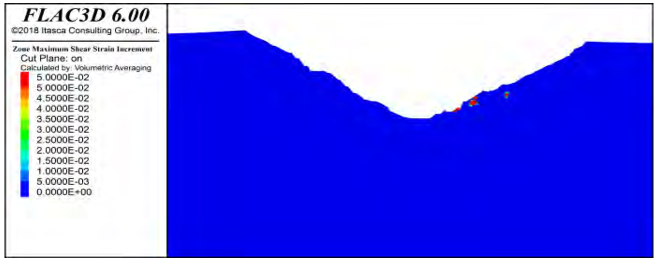


Pells Sullivan Meynink

Anderson Lloyd Waihi, New Zealand Numerical Model - Run 5 PREDICTED MAX SHEAR STRAIN OF SECTION 3 AFTER YEAR 9	
PSM125-283R	Appendix F9



After Year 2 underground working



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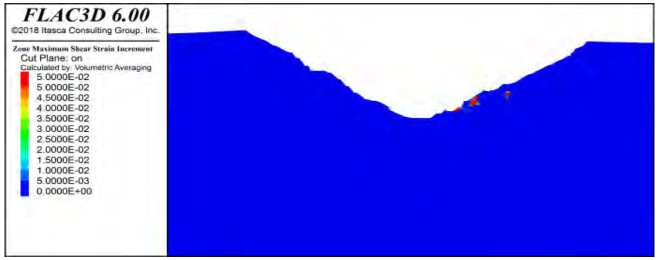
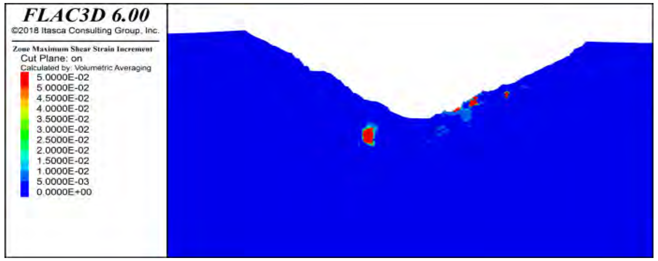
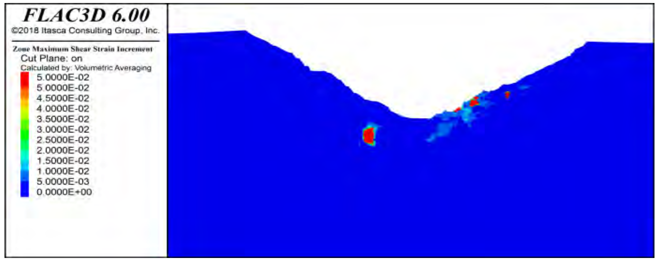


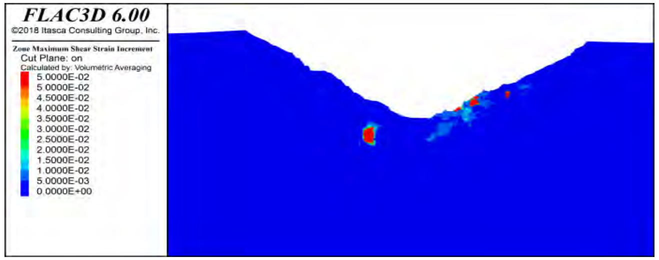
After Year 4 underground working



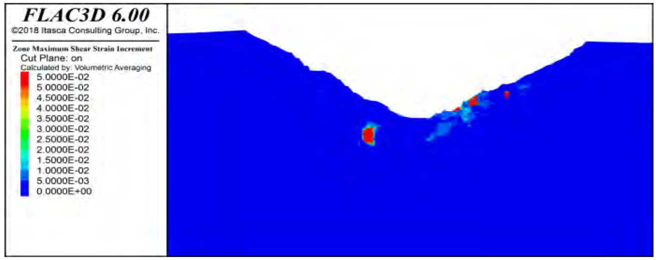
After Year 5 underground working



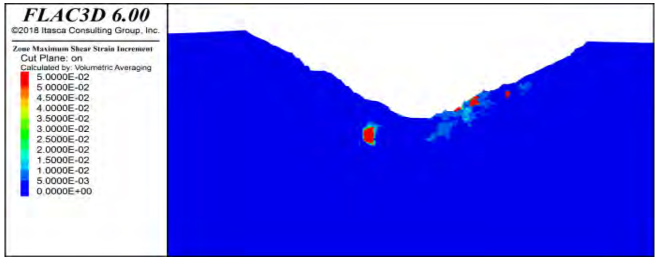
After Year 6 underground working



After Year 7 underground working



After Year 8 underground working



After Year 9 underground working

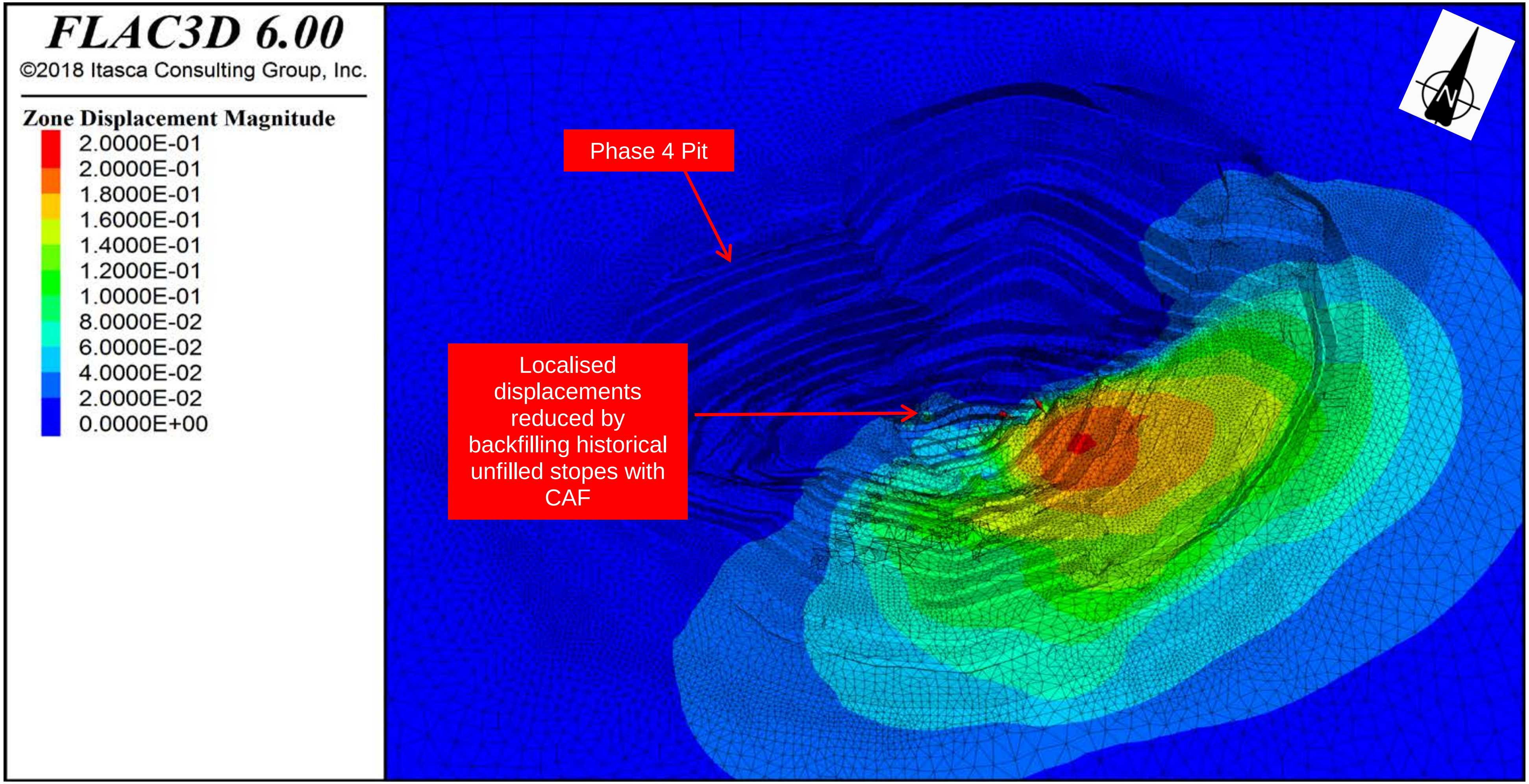
PSM

Pells Sullivan Meynink

Anderson Lloyd Waihi, New Zealand Numerical Model - Run 5 PREDICTED MAX SHEAR STRAIN OF SECTION 3 FOR YEARLY SEQUENCE	
PSM125-283R	Appendix F10

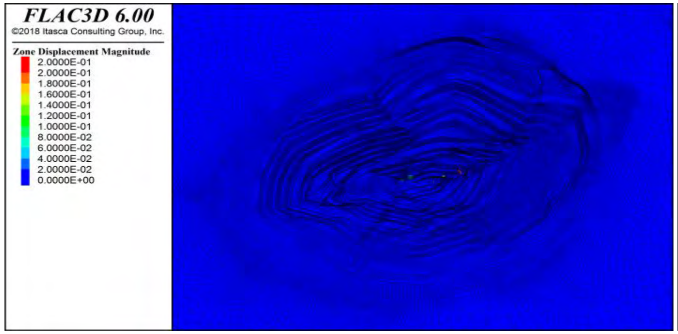
APPENDIX G

FLAC3D OUTPUTS – RUN 6

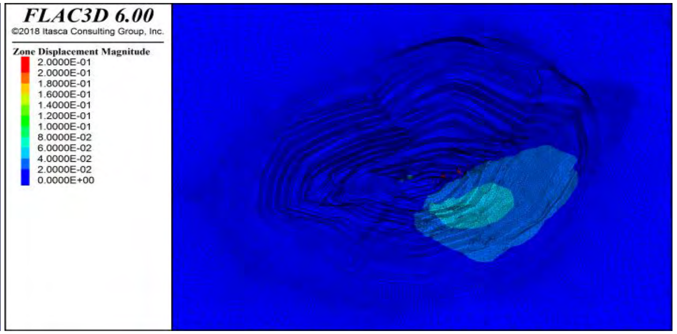


Anderson Lloyd Waihi, New Zealand Numerical Model - Run 6 PREDICTED TOTAL DISPLACEMENT AFTER YEAR 9	
PSM125-283R	Appendix G1

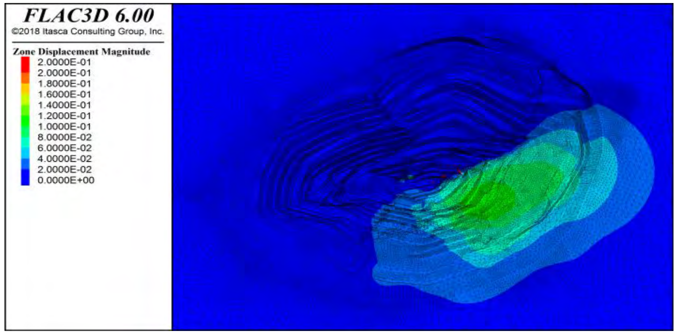
Pells Sullivan Meynink



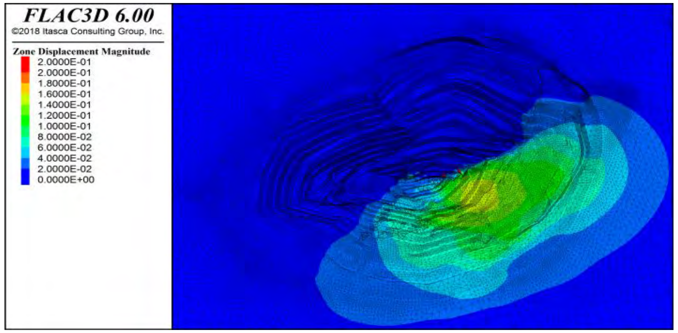
After Year 2 underground working



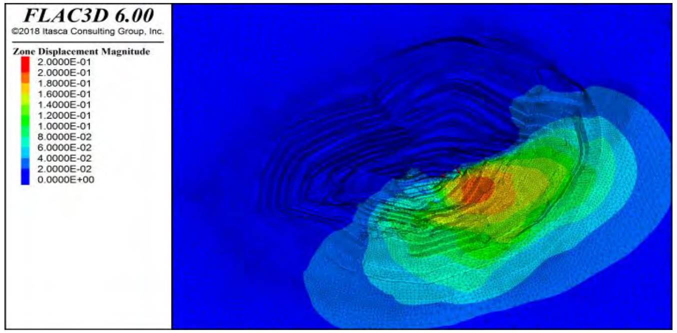
After Year 3 underground working



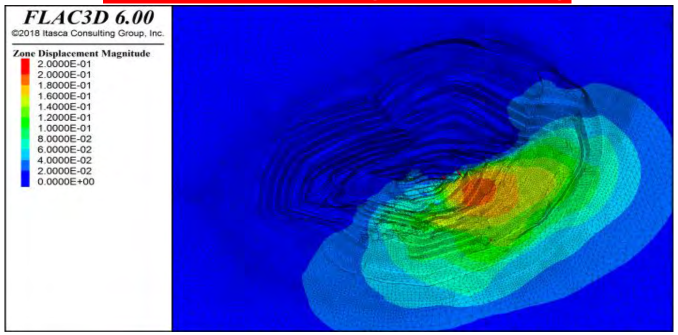
After Year 4 underground working



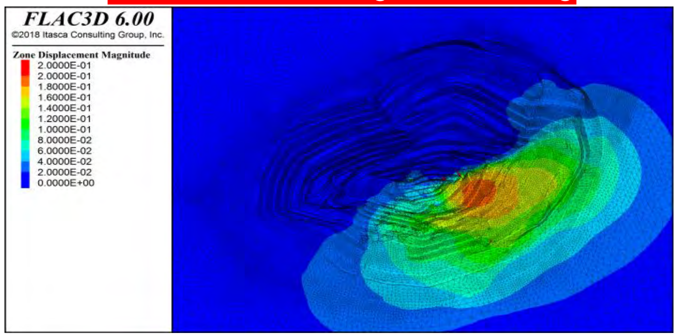
After Year 5 underground working



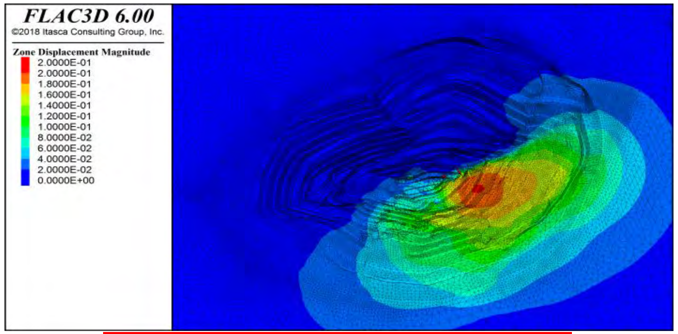
After Year 6 underground working



After Year 7 underground working



After Year 8 underground working



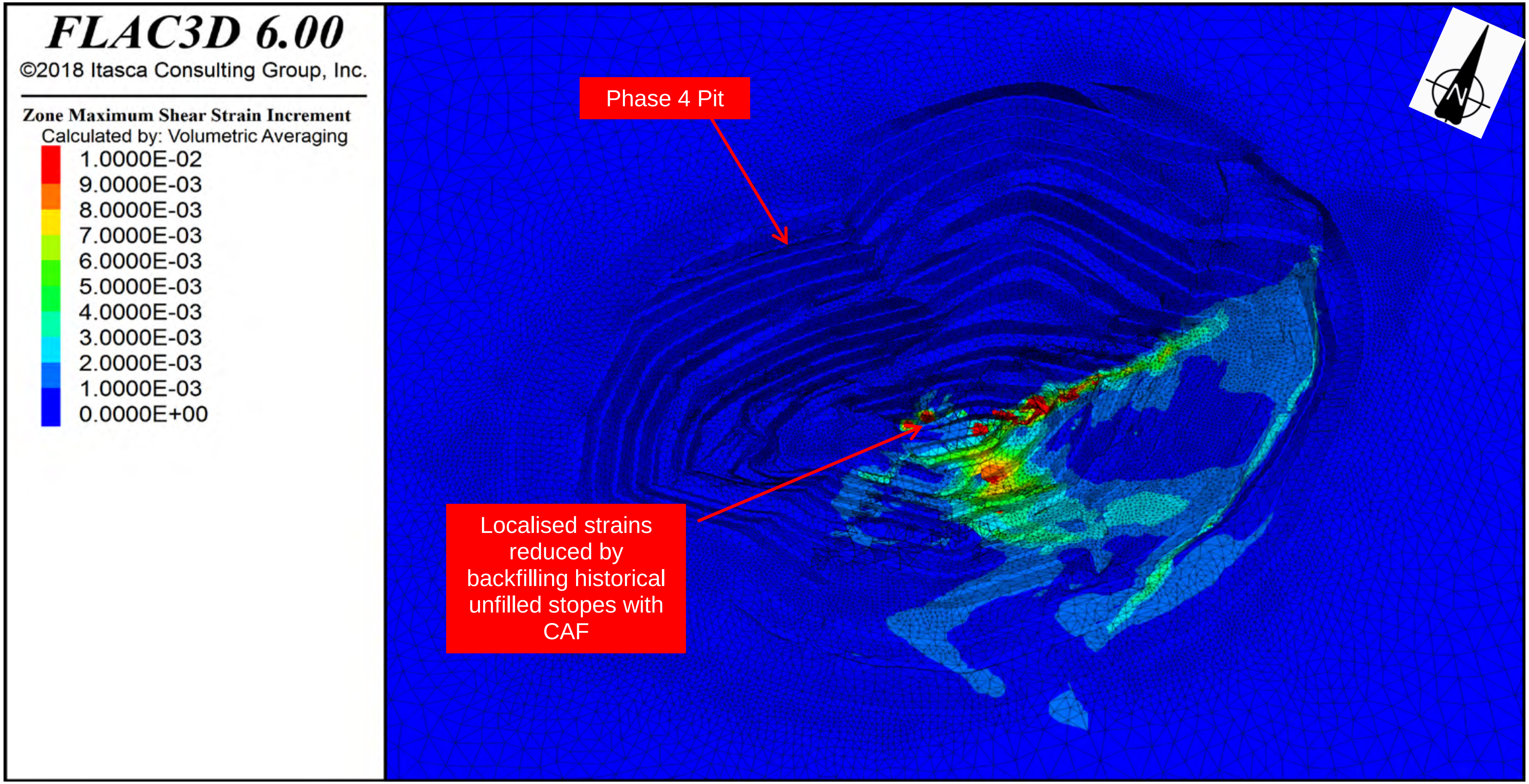
After Year 9 underground working

Anderson Lloyd
Waihi, New Zealand
Numerical Model - Run 6
PREDICTED TOTAL DISPLACEMENT FOR YEARLY SEQUENCE

PSM125-283R	**Appendix G2**

PSM

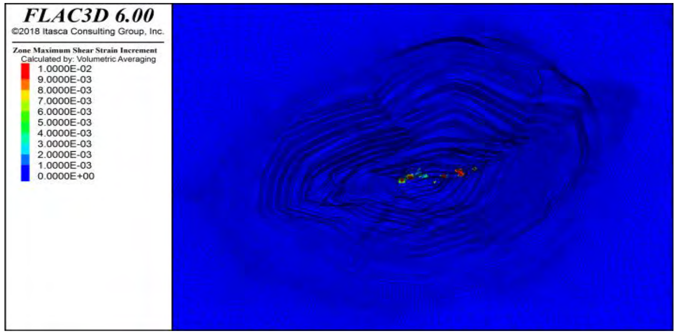
Pells Sullivan Meynink



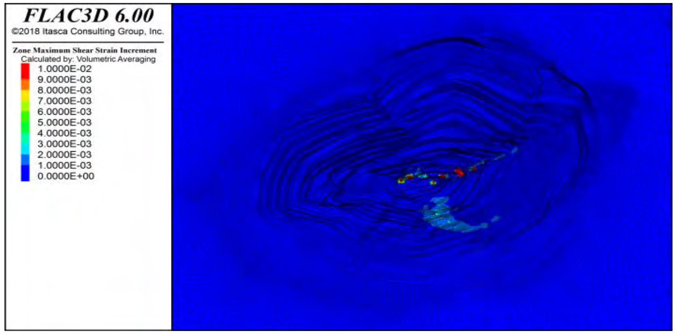
Anderson Lloyd
Waihi, New Zealand
Numerical Model - Run 6
PREDICTED MAX SHEAR STRAIN
AFTER YEAR 9

PSM125-283R	Appendix G3

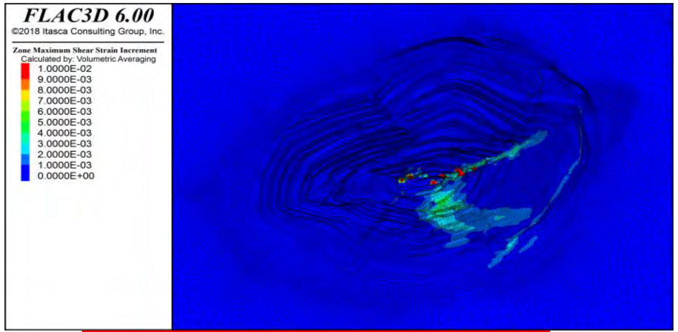
Pells Sullivan Meynink



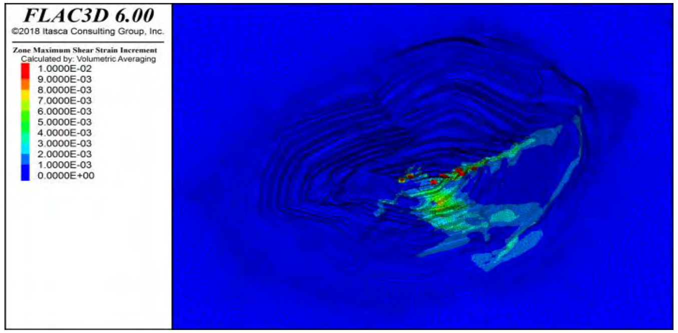
After Year 2 underground working



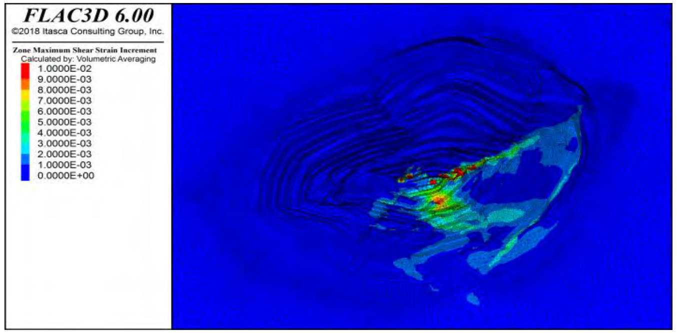
After Year 3 underground working



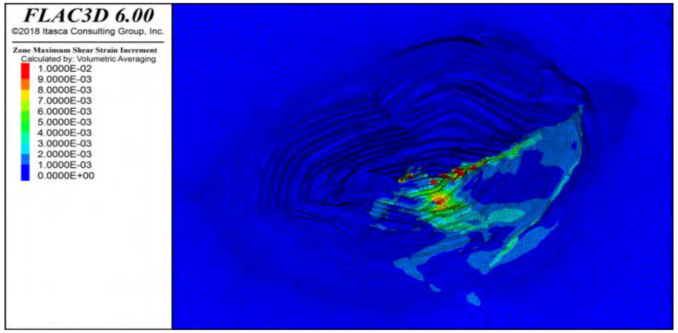
After Year 4 underground working



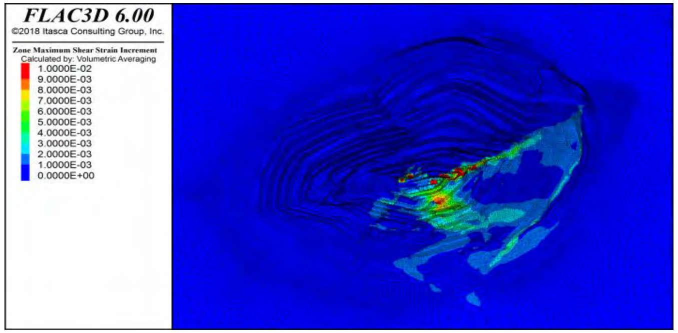
After Year 5 underground working



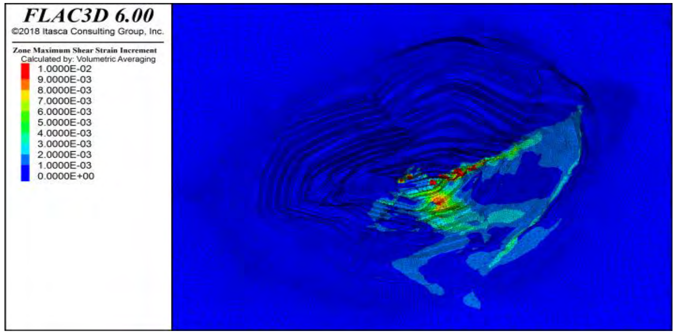
After Year 6 underground working



After Year 7 underground working



After Year 8 underground working



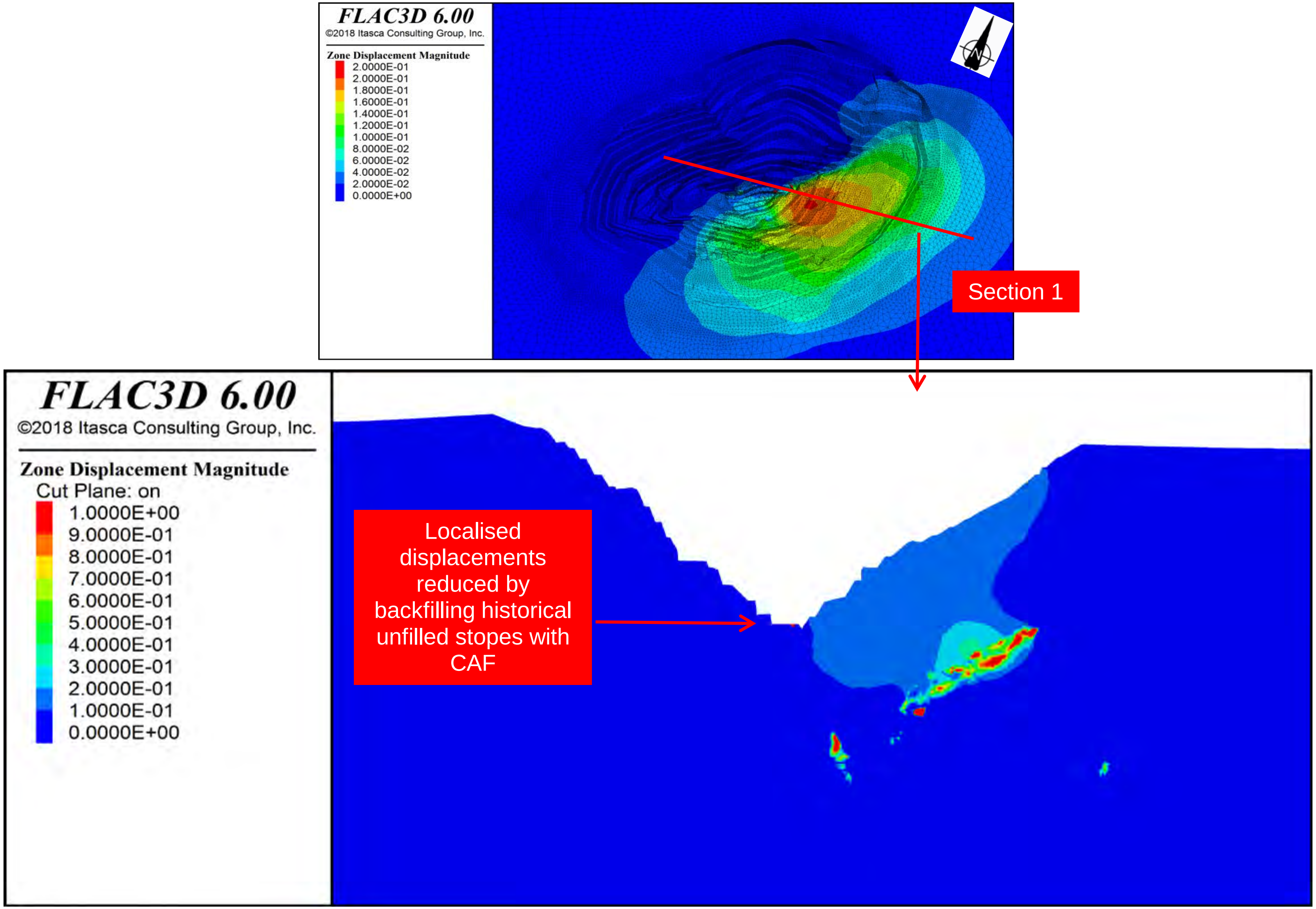
After Year 9 underground working

Anderson Lloyd
Waihi, New Zealand
Numerical Model - Run 6
PREDICTED MAX SHEAR STRAIN FOR YEARLY SEQUENCE

PSM125-283R	Appendix G4

PSM

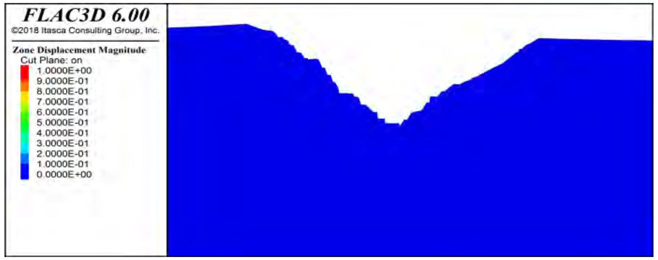
Pells Sullivan Meynink



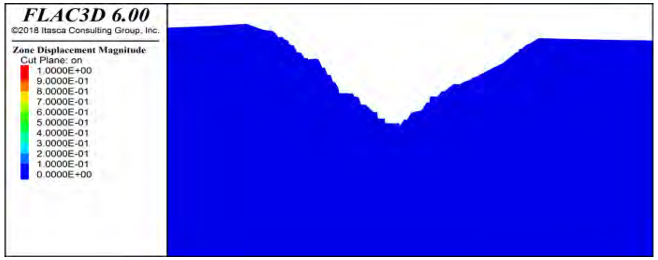
Anderson Lloyd
Waihi, New Zealand
Numerical Model - Run 6
PREDICTED TOTAL DISPLACEMENT OF SECTION 1 AFTER YEAR 9

PSM125-283R	**Appendix G5**

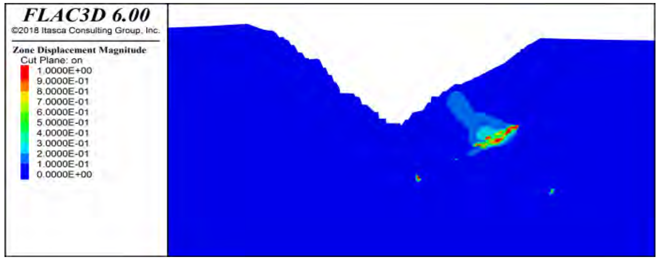
Pells Sullivan Meynink



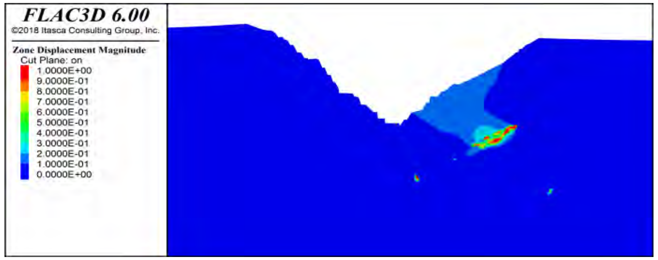
After Year 2 underground working



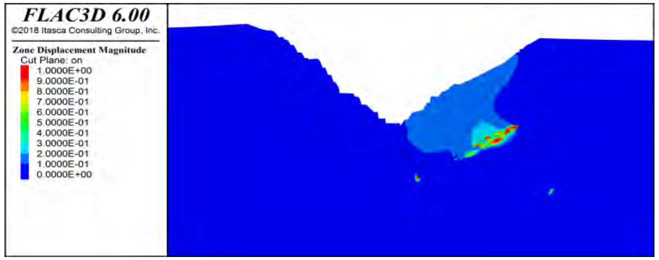
After Year 3 underground working



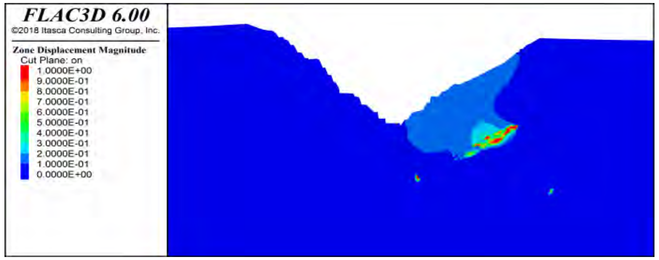
After Year 4 underground working



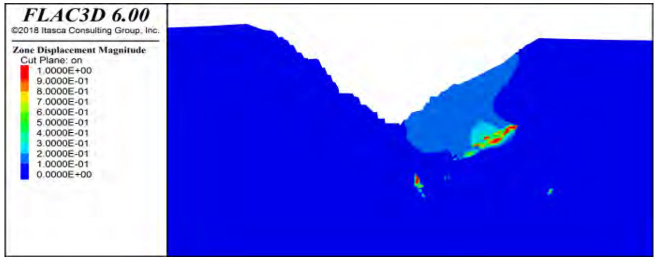
After Year 5 underground working



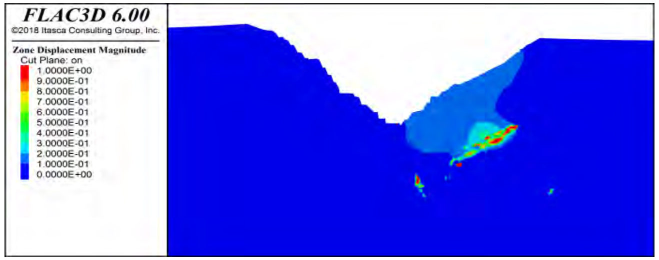
After Year 6 underground working



After Year 7 underground working



After Year 8 underground working

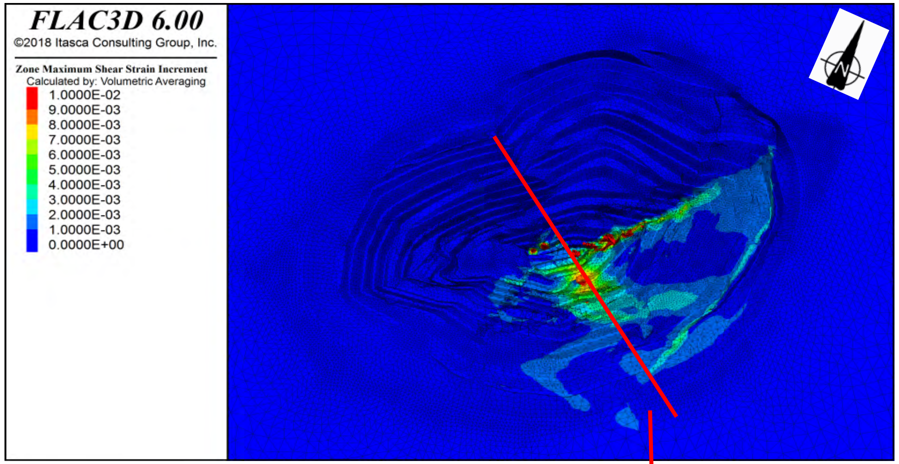


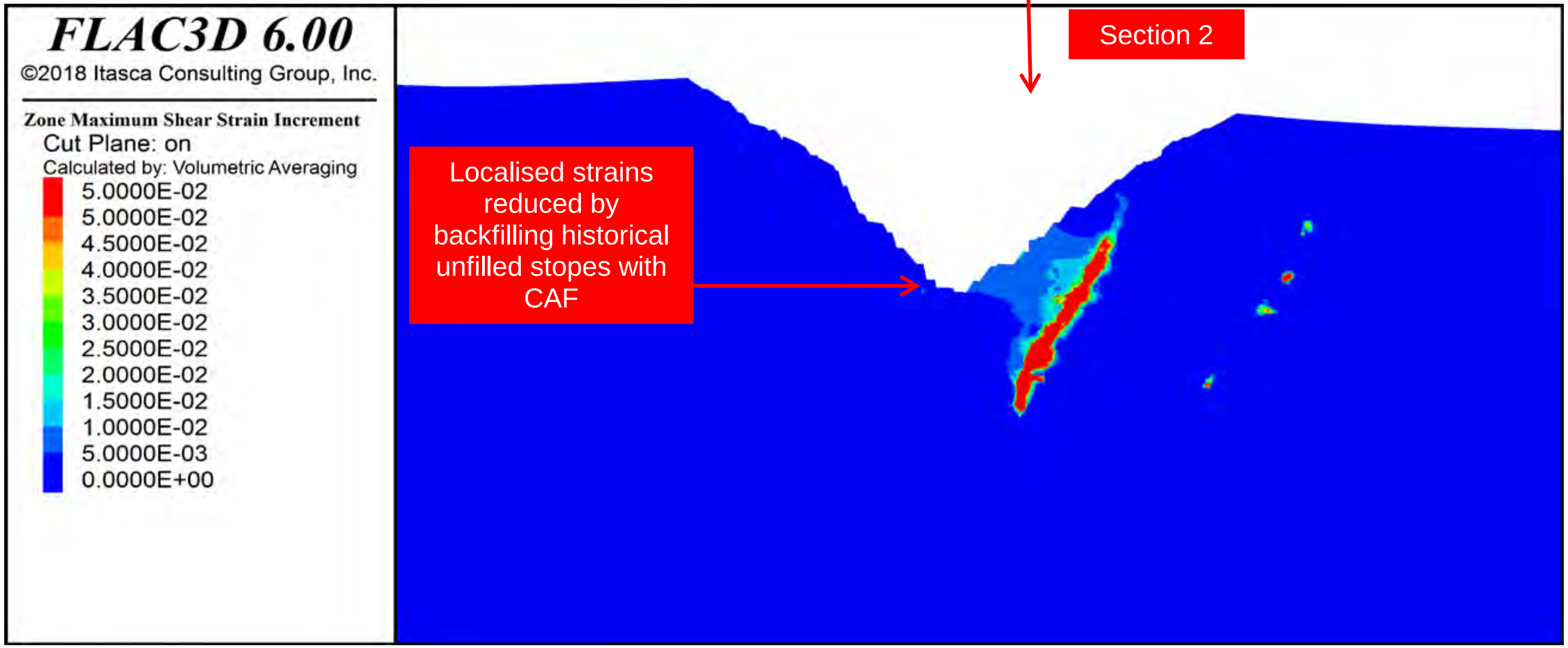
After Year 9 underground working

Pells Sullivan Meynink

Anderson Lloyd
Waihi, New Zealand
Numerical Model - Run 6
PREDICTED TOTAL DISPLACEMENT OF SECTION 1 FOR YEARLY SEQUENCE

PSM125-283R	Appendix G6

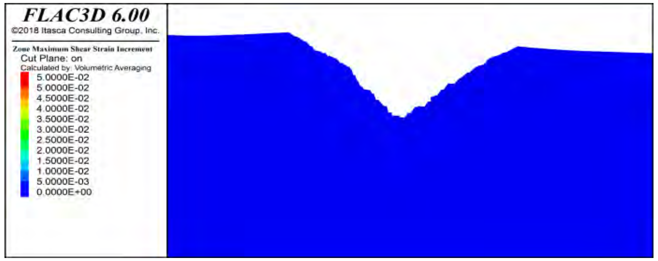




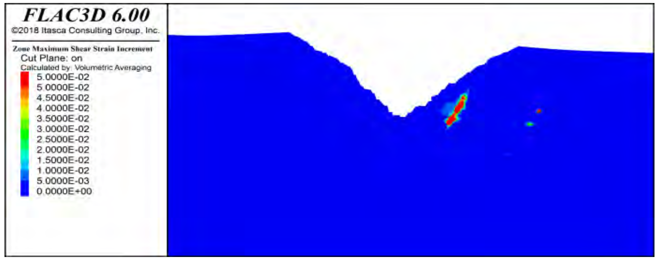
Anderson Lloyd
Waihi, New Zealand
Numerical Model - Run 6
PREDICTED MAX SHEAR STRAIN OF SECTION 2 AFTER YEAR 9

PSM125-283R | **Appendix G7**

Pells Sullivan Meynink



After Year 2 underground working



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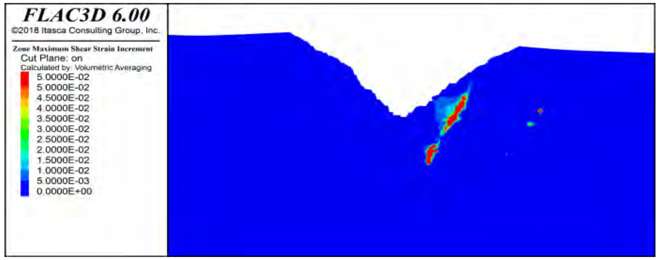
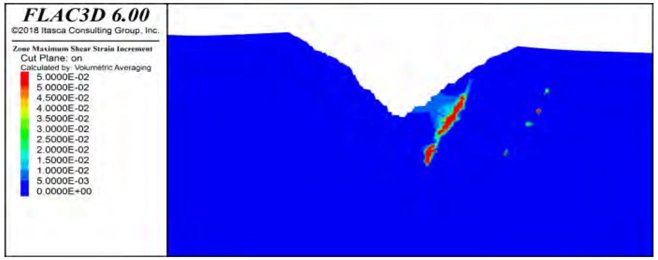
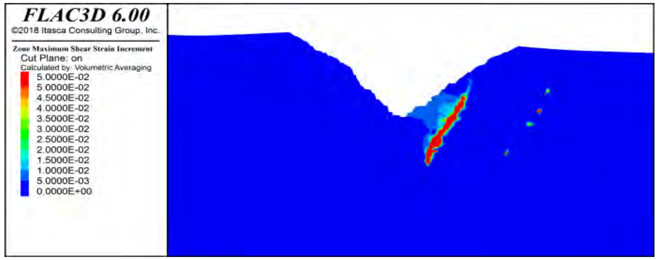


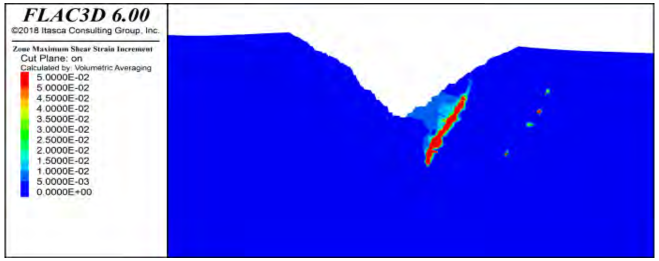
After Year 4 underground working



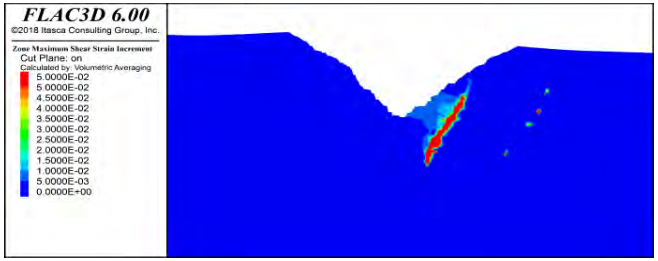
After Year 5 underground working



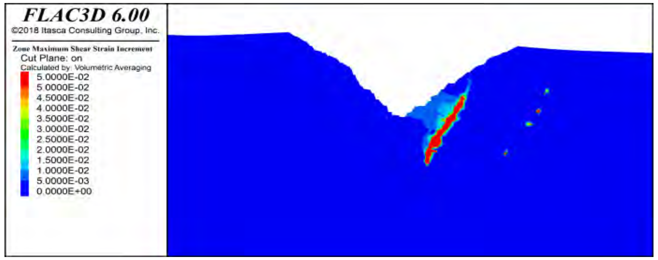
After Year 6 underground working



After Year 7 underground working



After Year 8 underground working

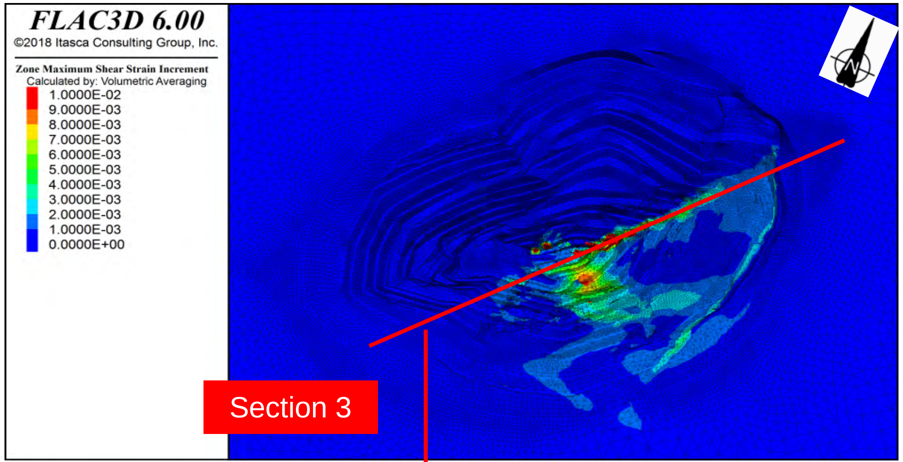


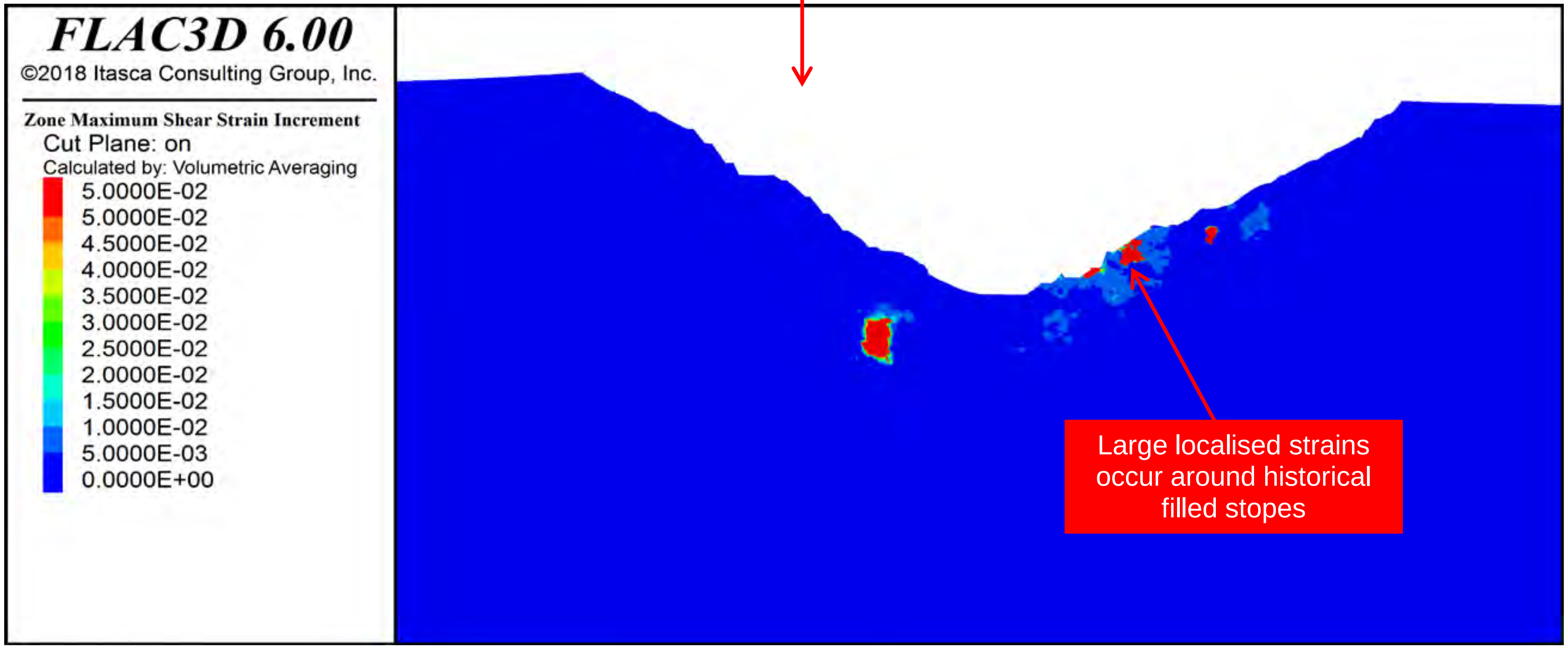
After Year 9 underground working

PSM

Pells Sullivan Meynink

Anderson Lloyd Waihi, New Zealand Numerical Model - Run 6 PREDICTED MAX SHEAR STRAIN OF SECTION 2 FOR YEARLY SEQUENCE	
PSM125-283R	**Appendix G8**

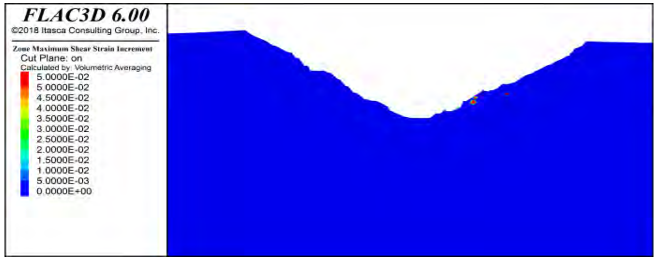




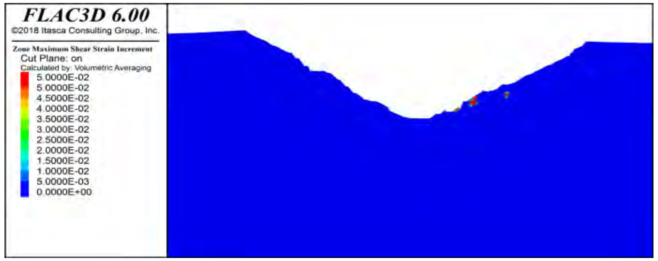
Anderson Lloyd
Waihi, New Zealand
Numerical Model - Run 6
PREDICTED MAX SHEAR STRAIN OF SECTION 3 AFTER YEAR 9

Pells Sullivan Meynink

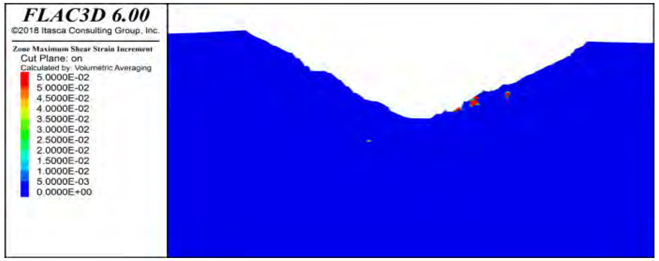
PSM125-283R	Appendix G9



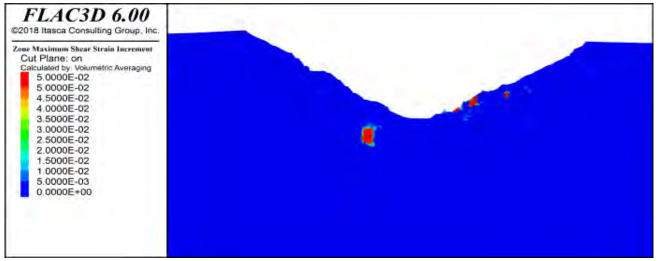
After Year 2 underground working



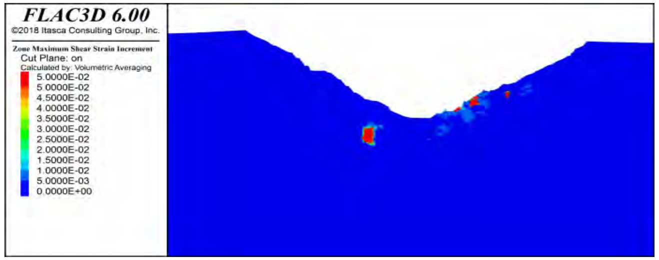
After Year 3 underground working



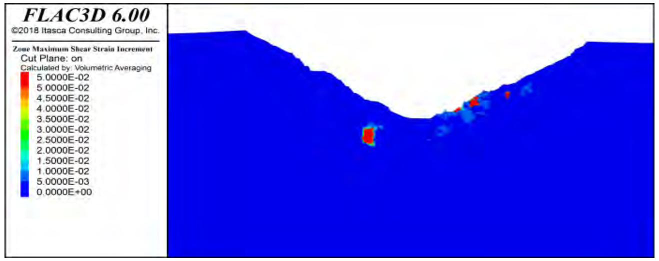
After Year 4 underground working



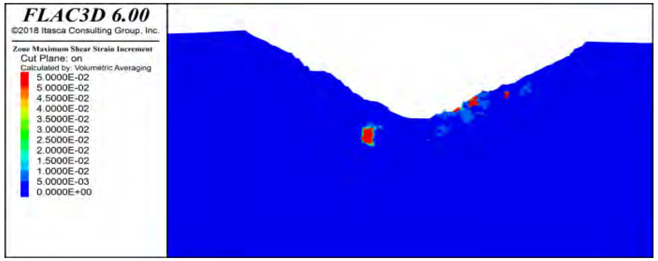
After Year 5 underground working



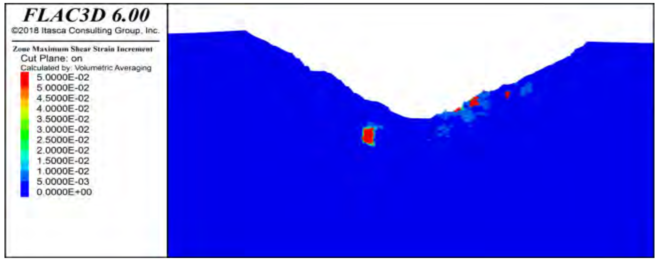
After Year 6 underground working



After Year 7 underground working



After Year 8 underground working



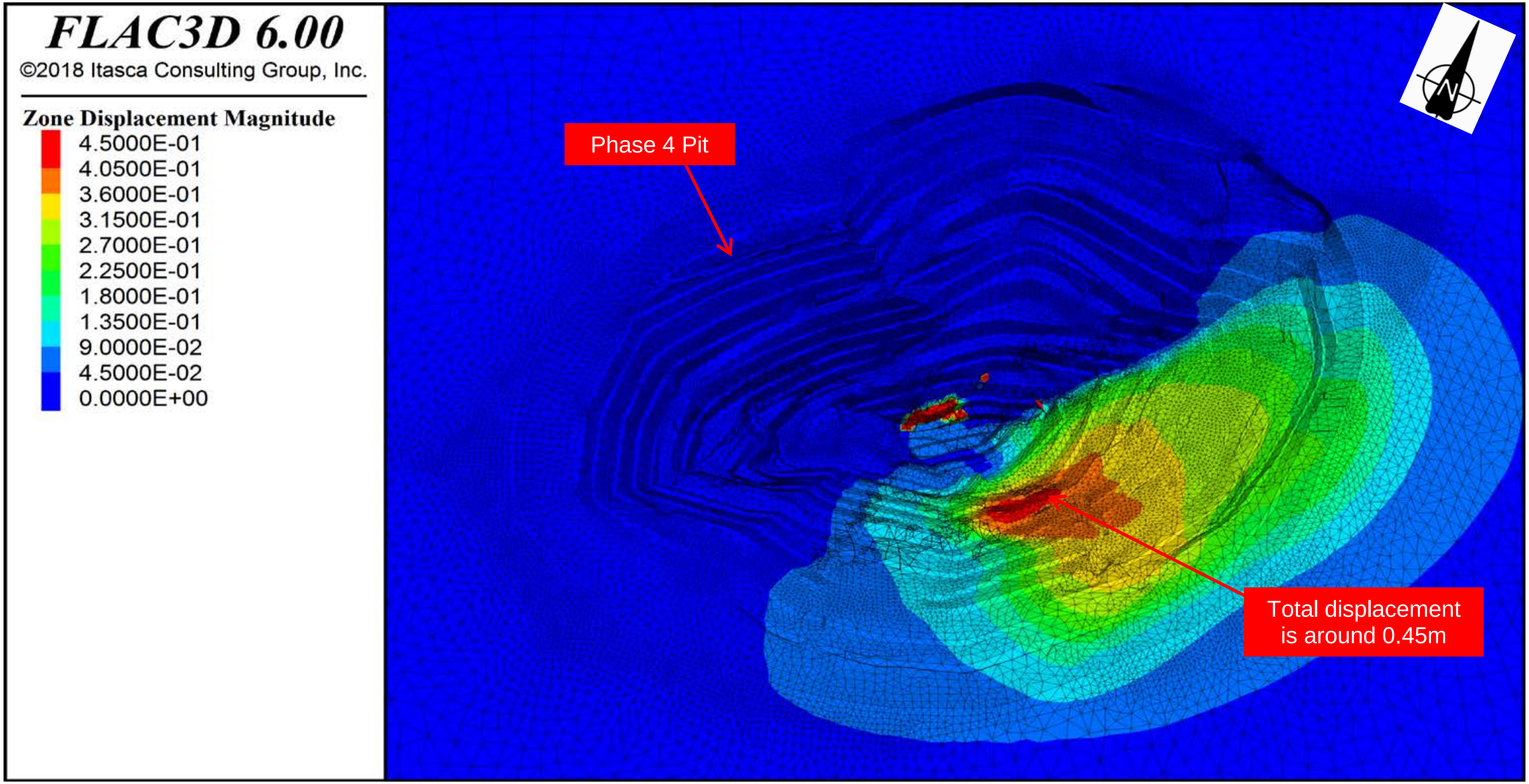
After Year 9 underground working

PSM Pells Sullivan Meynink

Anderson Lloyd Waihi, New Zealand Numerical Model - Run 6 **PREDICTED MAX SHEAR STRAIN OF SECTION 3 FOR YEARLY SEQUENCE**	
PSM125-283R	Appendix G10

APPENDIX H

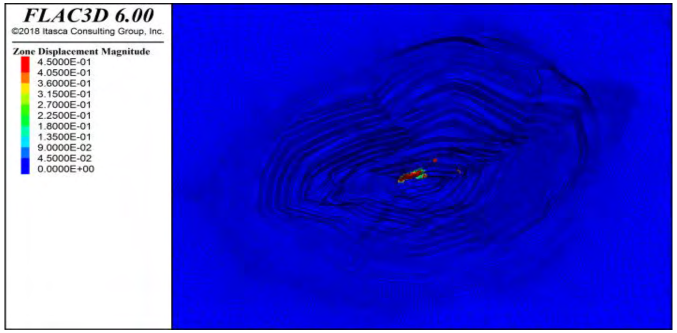
FLAC3D OUTPUTS – RUN 7



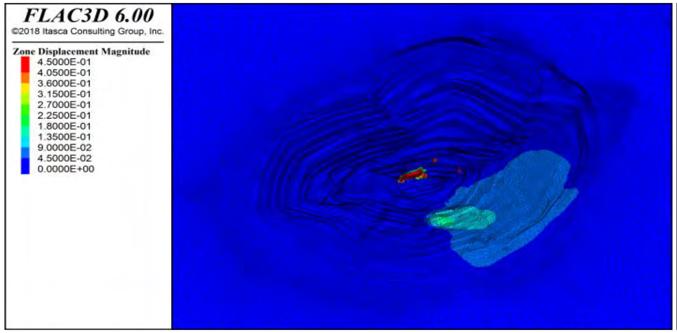
Note: The maximum contour limit is different to Run 1

Pells Sullivan Meynink

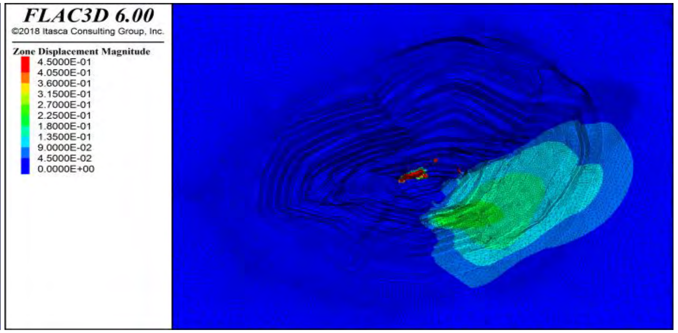
Anderson Lloyd Waihi, New Zealand Numerical Model - Run 7 PREDICTED TOTAL DISPLACEMENT AFTER YEAR 9	
PSM125-283R	Appendix H1



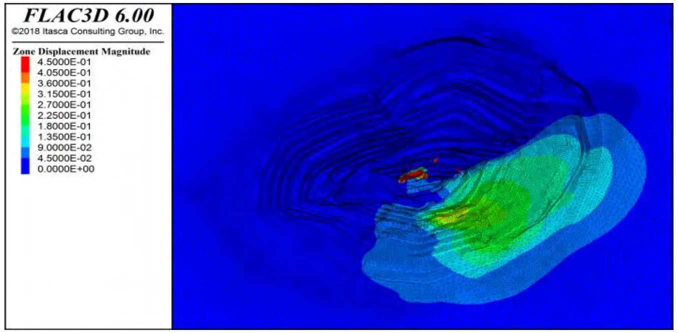
After Year 2 underground working



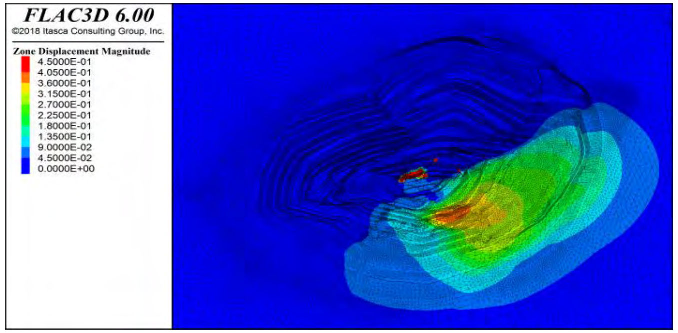
After Year 3 underground working



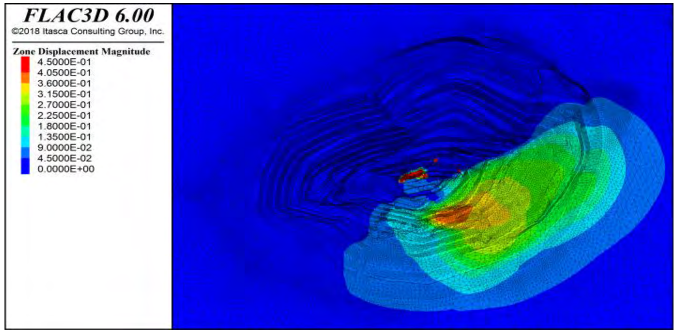
After Year 4 underground working



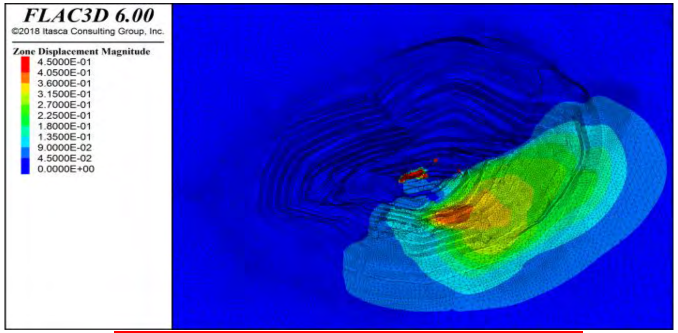
After Year 5 underground working



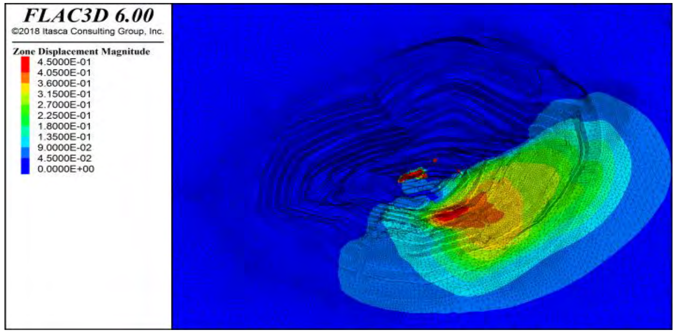
After Year 6 underground working



After Year 7 underground working



After Year 8 underground working



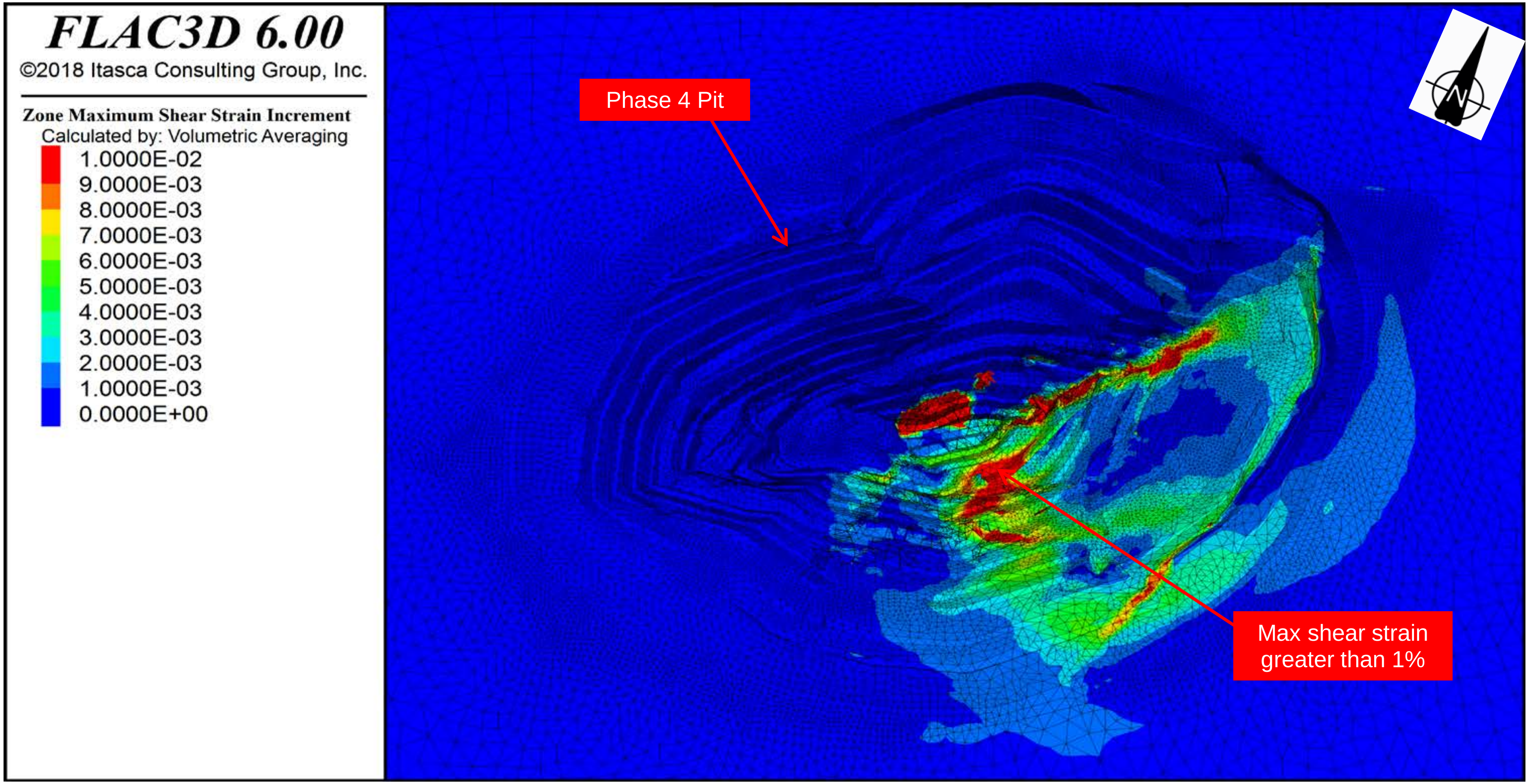
After Year 9 underground working

Note: The maximum contour limit is different to Run 1

Pells Sullivan Meynink

Anderson Lloyd
Waihi, New Zealand
Numerical Model - Run 7
PREDICTED TOTAL DISPLACEMENT FOR YEARLY SEQUENCE

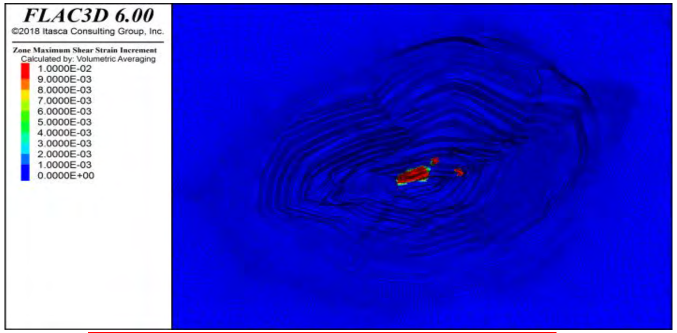
PSM125-283R	Appendix H2



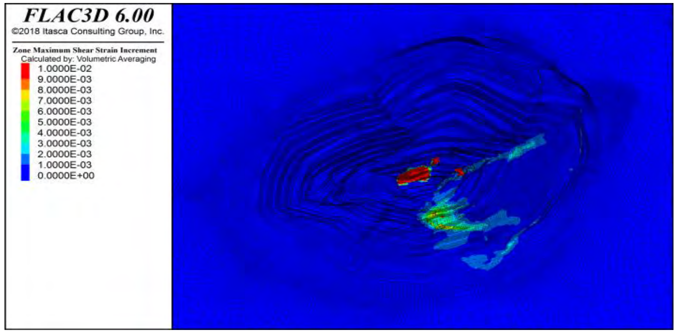
Anderson Lloyd
Waihi, New Zealand
Numerical Model - Run 7
PREDICTED MAX SHEAR STRAIN AFTER YEAR 9

PSM125-283R	Appendix H3

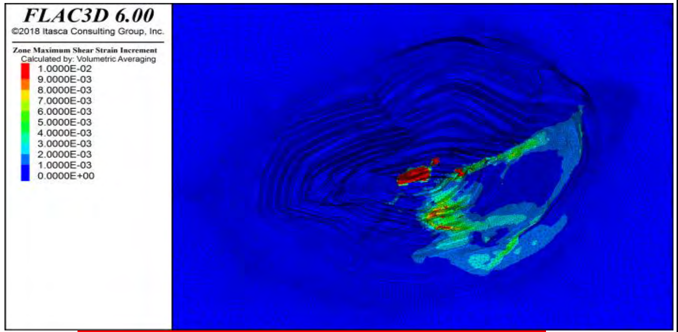
Pells Sullivan Meynink



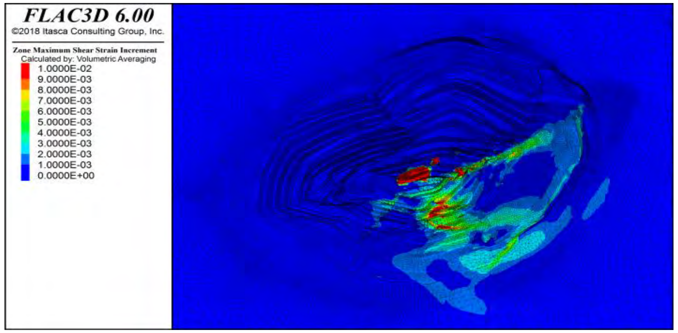
After Year 2 underground working



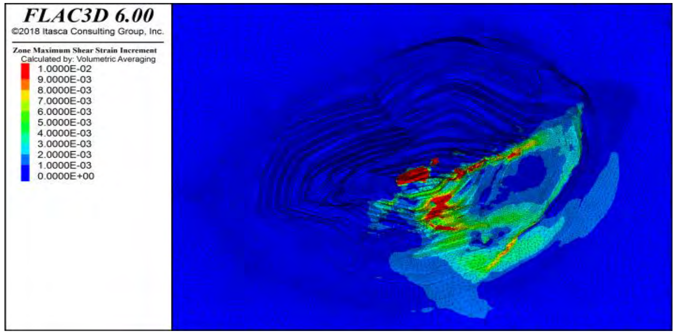
After Year 3 underground working



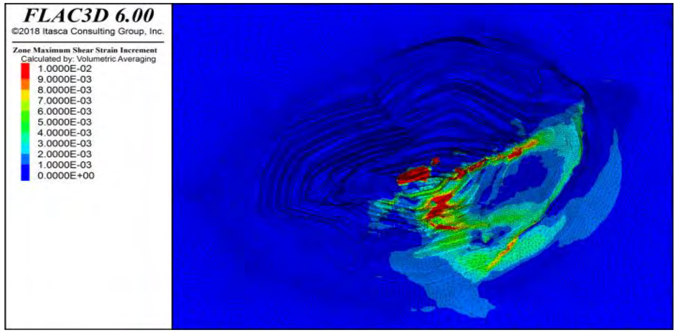
After Year 4 underground working



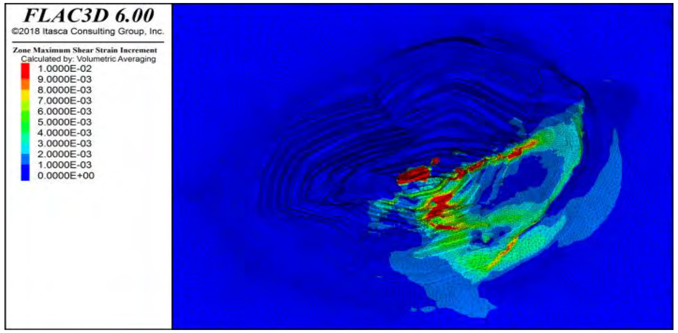
After Year 5 underground working



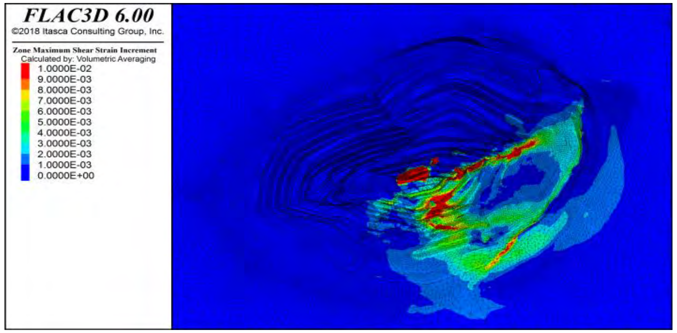
After Year 6 underground working



After Year 7 underground working



After Year 8 underground working

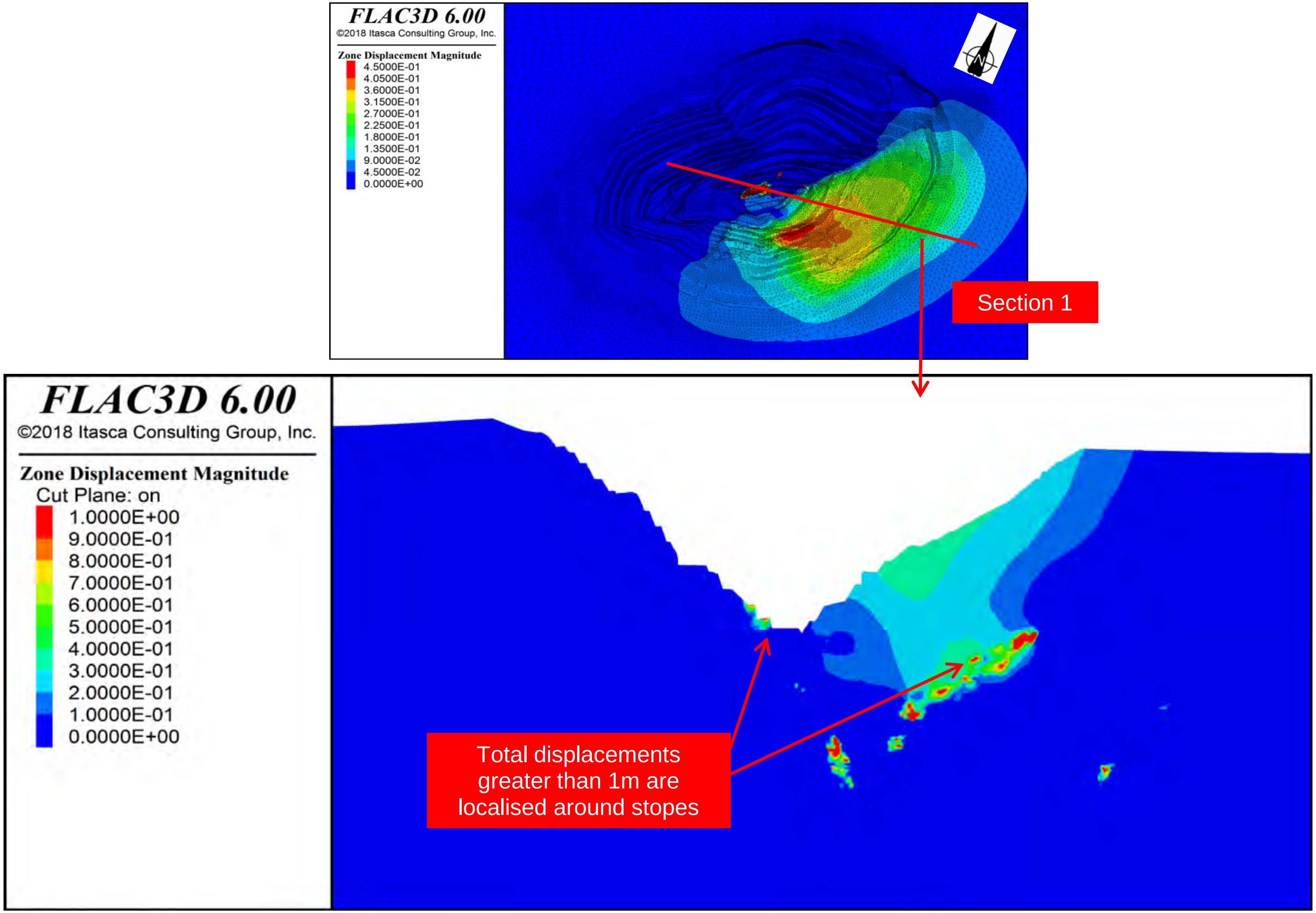


After Year 9 underground working

PSM
Pells Sullivan Meynink

Anderson Lloyd
Waihi, New Zealand
Numerical Model - Run 7
PREDICTED MAX SHEAR STRAIN FOR YEARLY SEQUENCE

PSM125-283R	**Appendix H4**

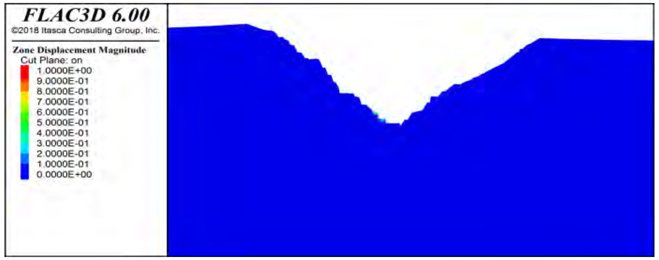


Anderson Lloyd
Waihi, New Zealand
Numerical Model - Run 7

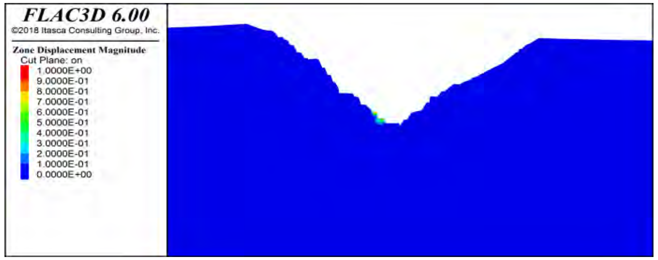
PREDICTED TOTAL DISPLACEMENT OF SECTION 1 AFTER YEAR 9

PSM125-283R	**Appendix H5**

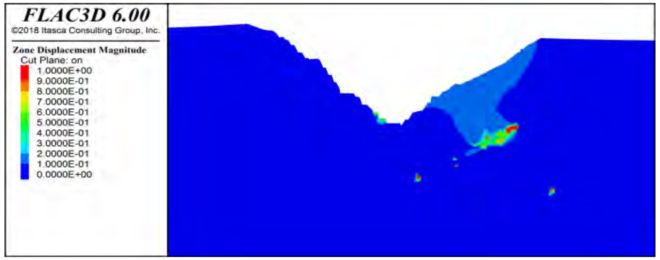
Pells Sullivan Meynink



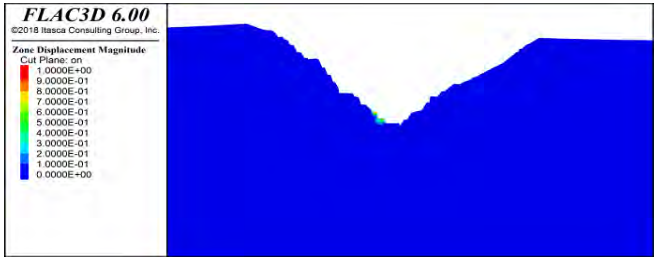
After Year 2 underground working



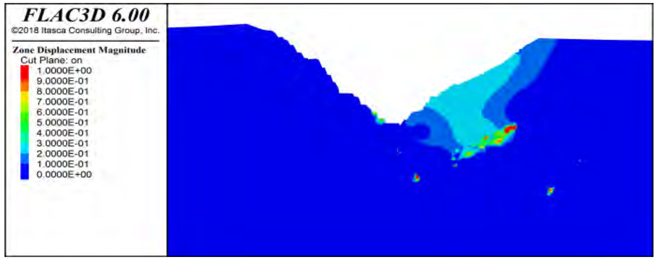
After Year 3 underground working



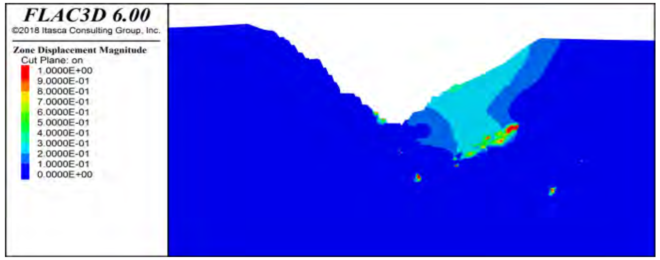
After Year 4 underground working



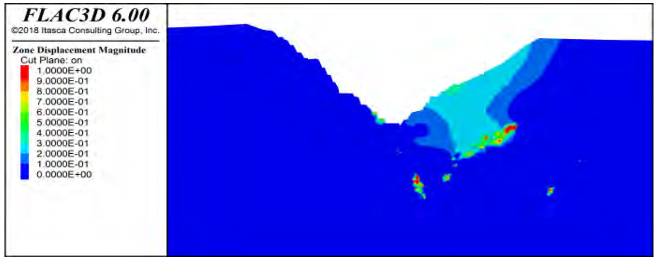
After Year 5 underground working



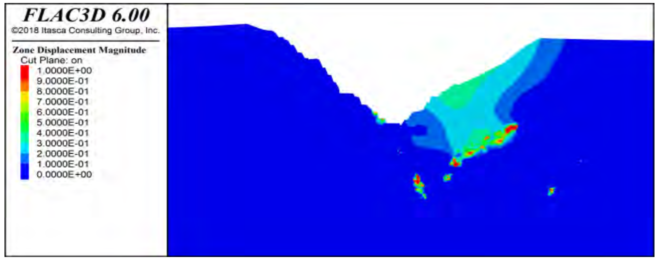
After Year 6 underground working



After Year 7 underground working



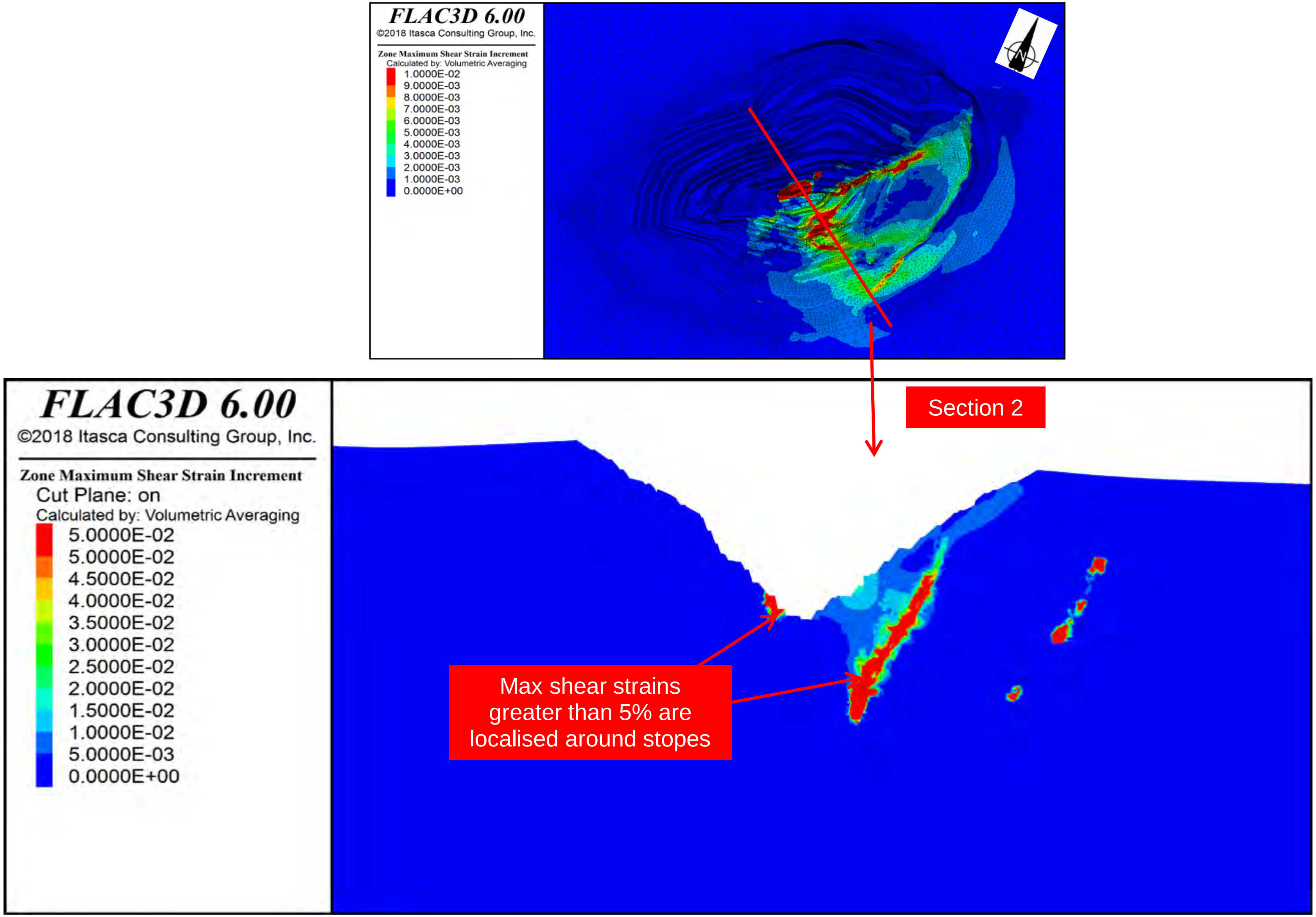
After Year 8 underground working



After Year 9 underground working

PSM
Pells Sullivan Meynink

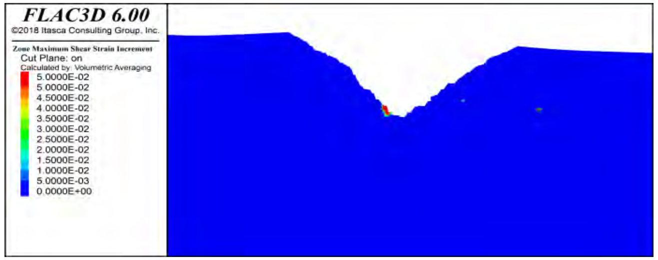
Anderson Lloyd Waihi, New Zealand Numerical Model - Run 7 PREDICTED TOTAL DISPLACEMENT OF SECTION 1 FOR YEARLY SEQUENCE	
PSM125-283R	**Appendix H6**



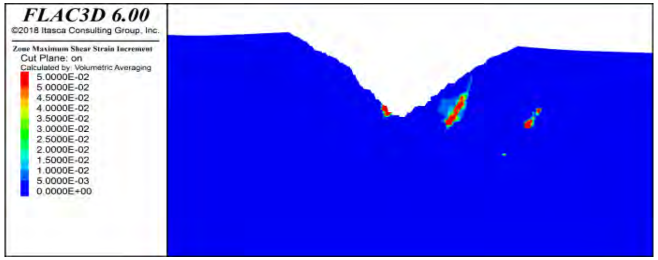
Anderson Lloyd
Waihi, New Zealand
Numerical Model - Run 7
PREDICTED MAX SHEAR STRAIN OF SECTION 2 AFTER YEAR 9

Pells Sullivan Meynink

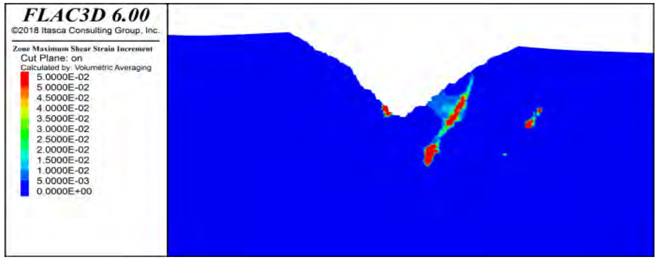
PSM125-283R	**Appendix H7**



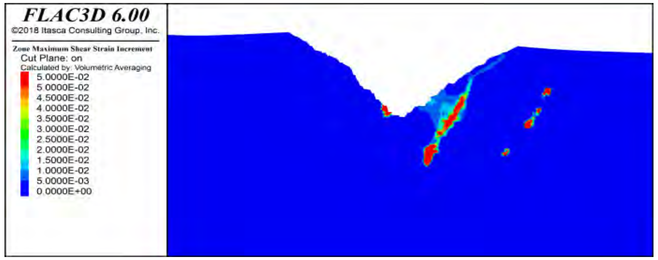
After Year 2 underground working



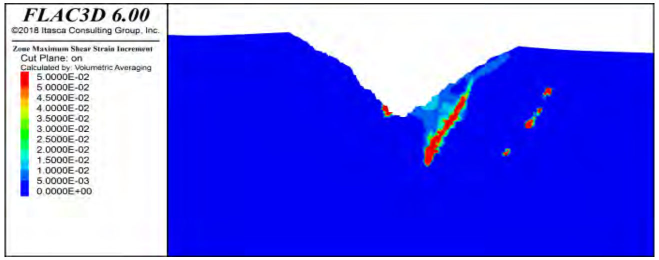
After Year 3 underground working



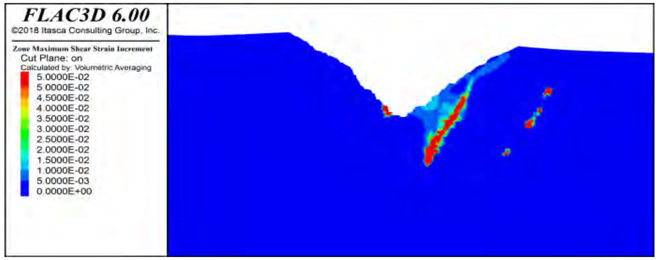
After Year 4 underground working



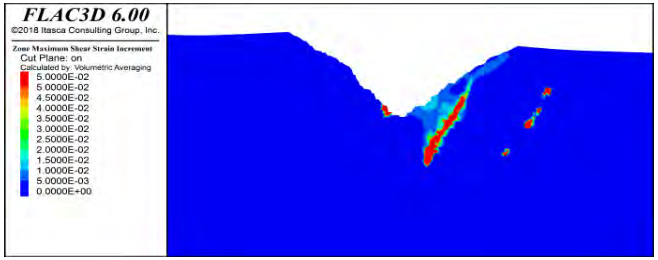
After Year 5 underground working



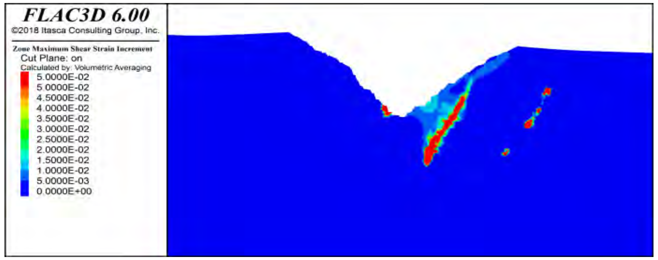
After Year 6 underground working



After Year 7 underground working



After Year 8 underground working

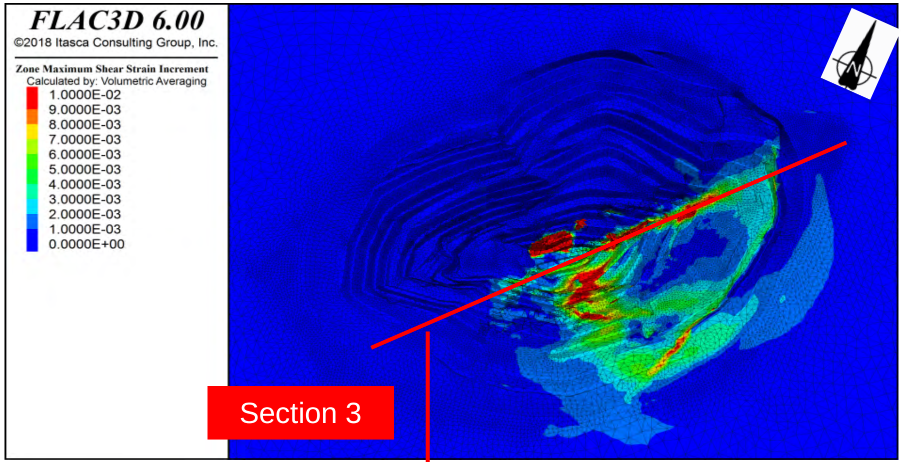


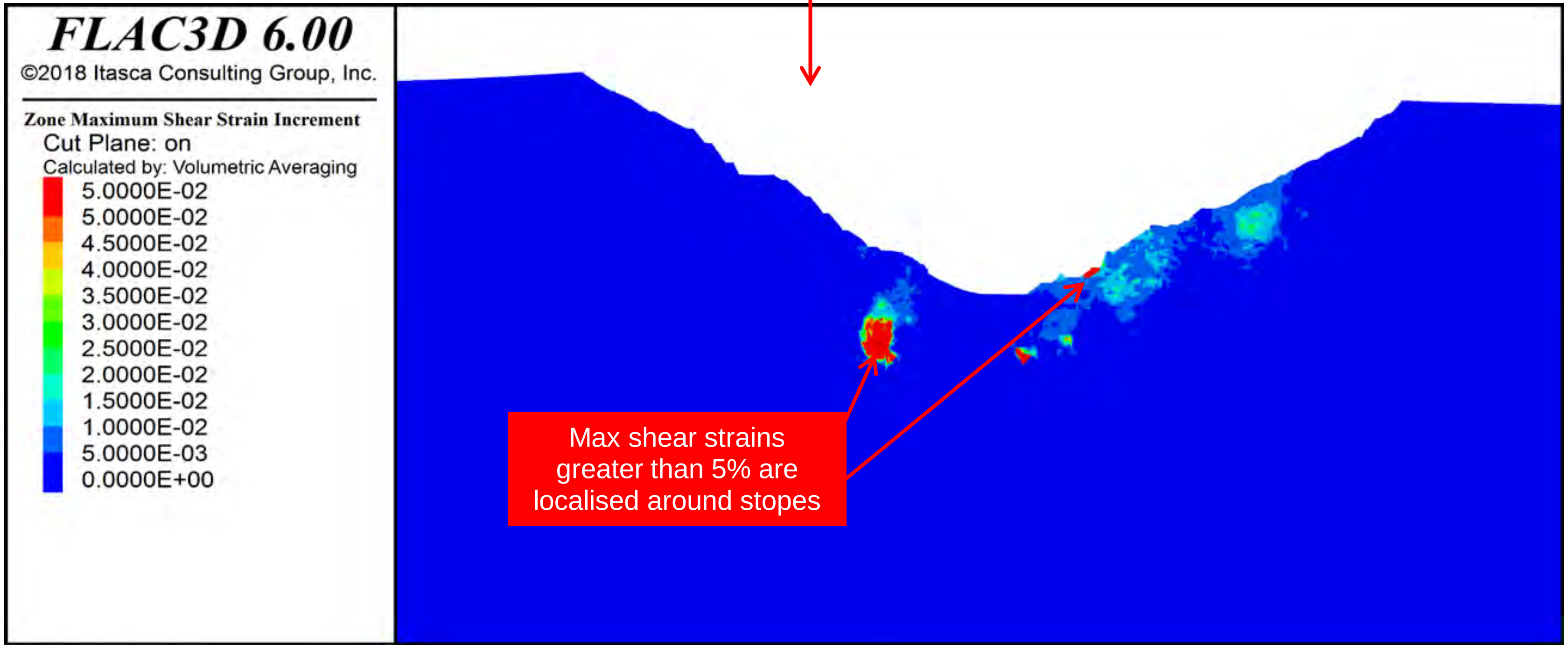
After Year 9 underground working

PSM

Pells Sullivan Meynink

Anderson Lloyd Waihi, New Zealand Numerical Model - Run 7 PREDICTED MAX SHEAR STRAIN OF SECTION 2 FOR YEARLY SEQUENCE	
PSM125-283R	**Appendix H8**

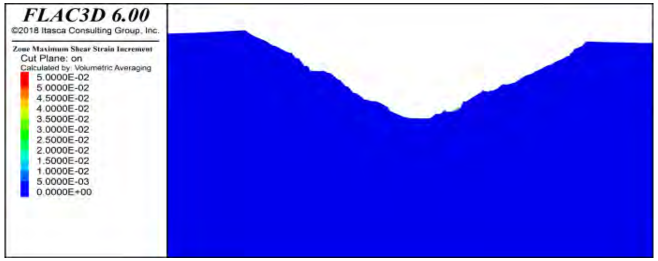




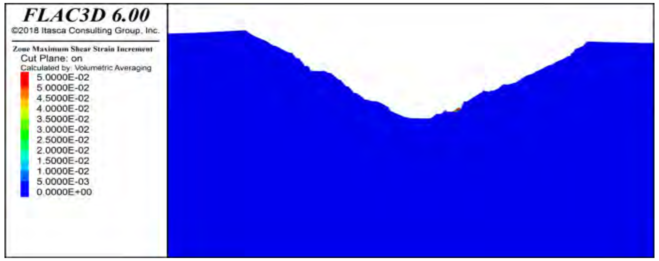
PSM

Pells Sullivan Meynink

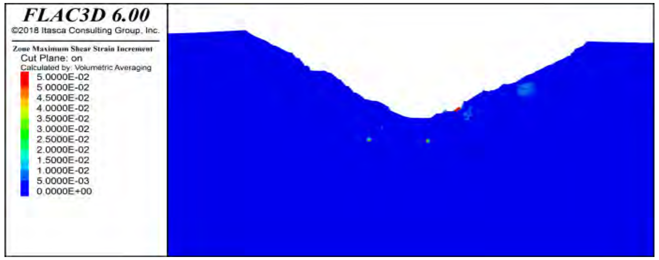
Anderson Lloyd Waihi, New Zealand Numerical Model - Run 7 PREDICTED MAX SHEAR STRAIN OF SECTION 3 AFTER YEAR 9	
PSM125-283R	Appendix H9



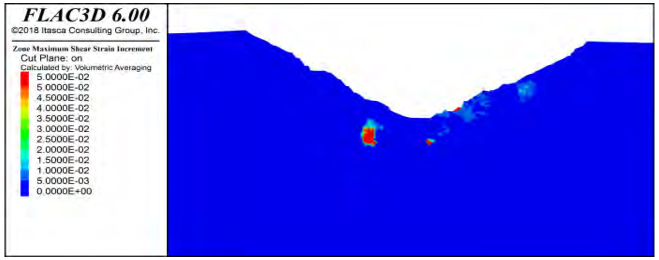
After Year 2 underground working



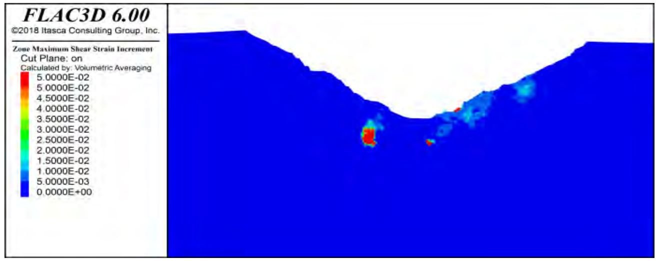
After Year 3 underground working



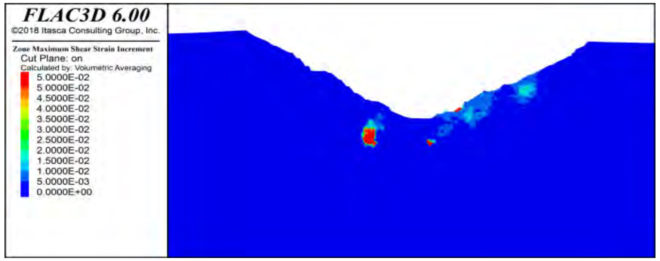
After Year 4 underground working



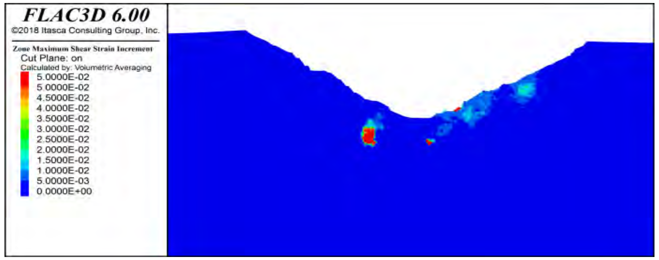
After Year 5 underground working



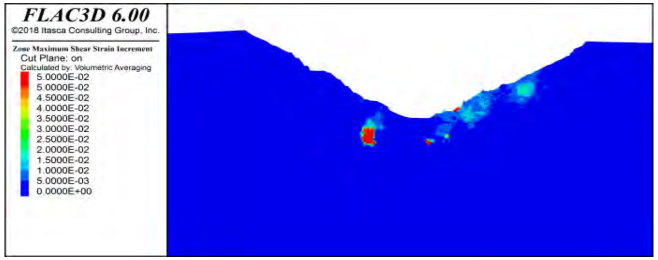
After Year 6 underground working



After Year 7 underground working



After Year 8 underground working



After Year 9 underground working

PSM

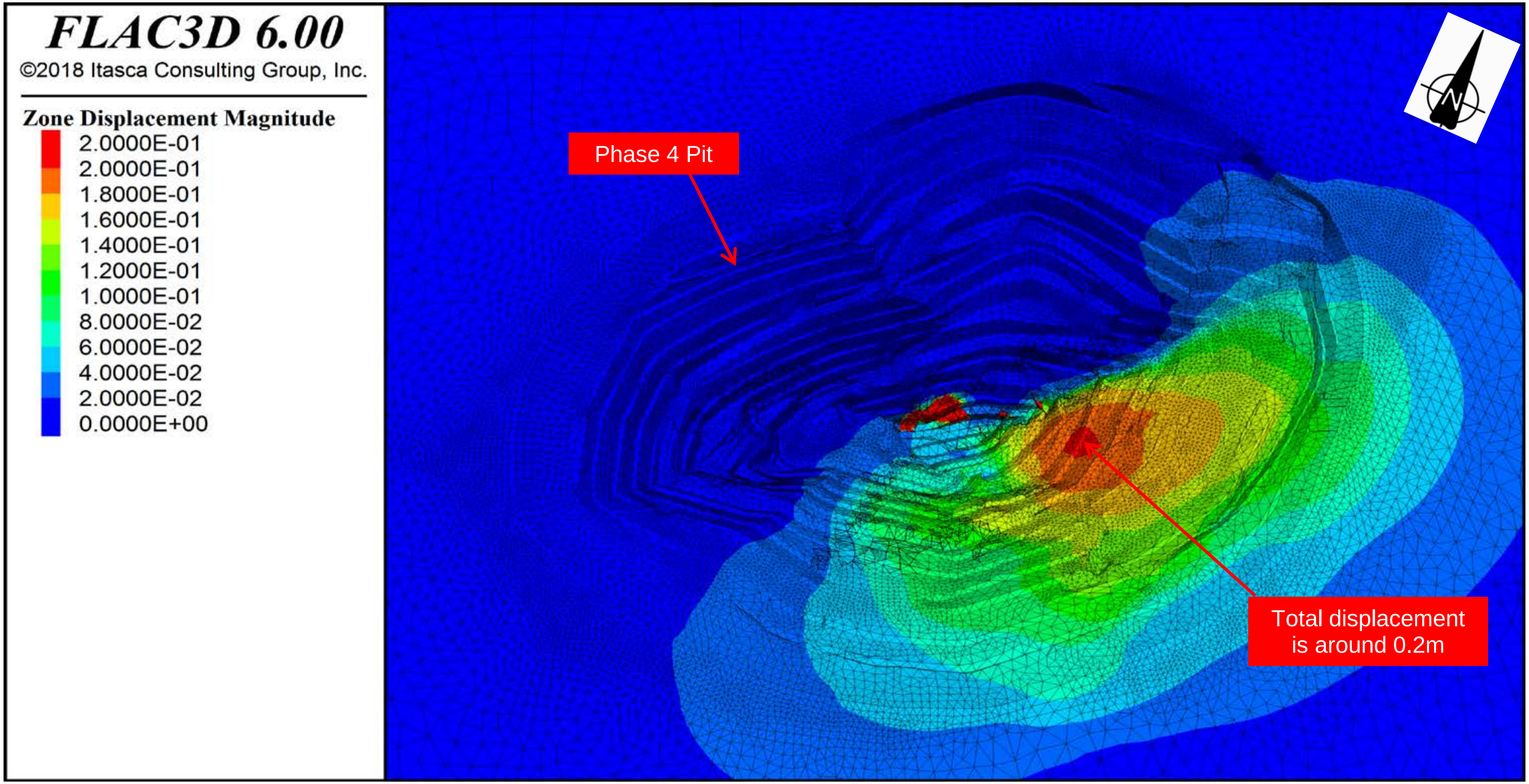
Pells Sullivan Meynink

Anderson Lloyd
Waihi, New Zealand
Numerical Model - Run 7
PREDICTED MAX SHEAR STRAIN OF SECTION 3 FOR YEARLY SEQUENCE

PSM125-283R	**Appendix H10**

APPENDIX I

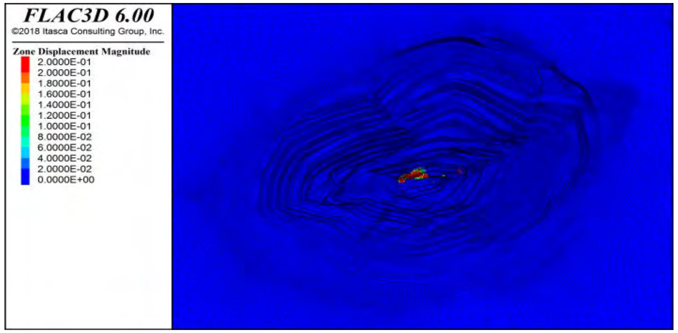
FLAC3D OUTPUTS – RUN 8



Anderson Lloyd Waihi, New Zealand Numerical Model - Run 8 **PREDICTED TOTAL DISPLACEMENT AFTER YEAR 9**	
PSM125-283R	**Appendix I1**

PSM

Pells Sullivan Meynink



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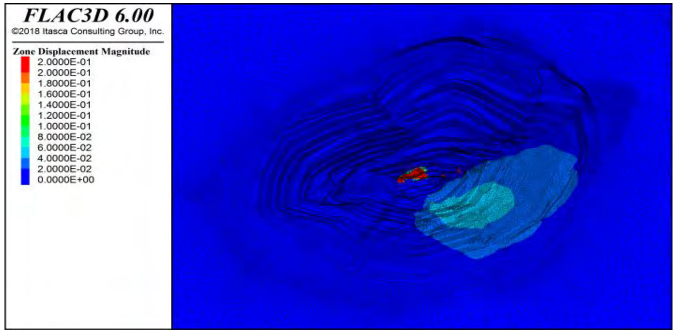
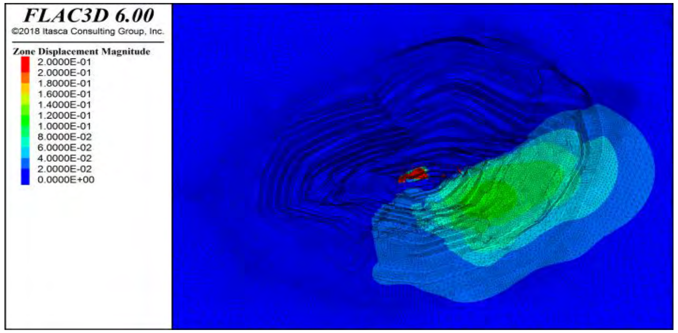
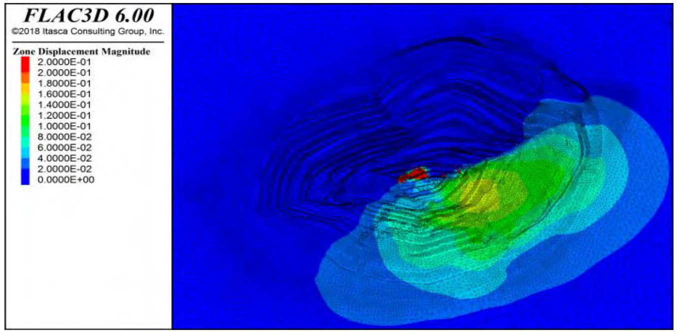


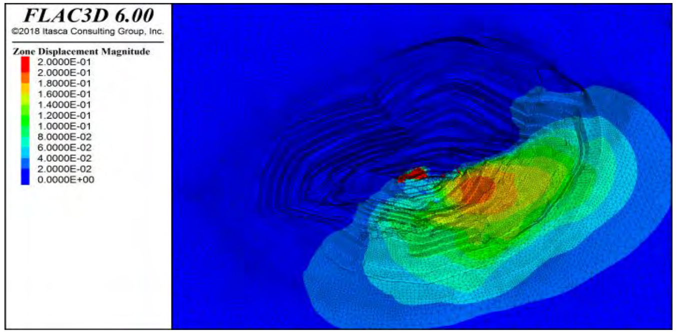
After Year 3 underground working



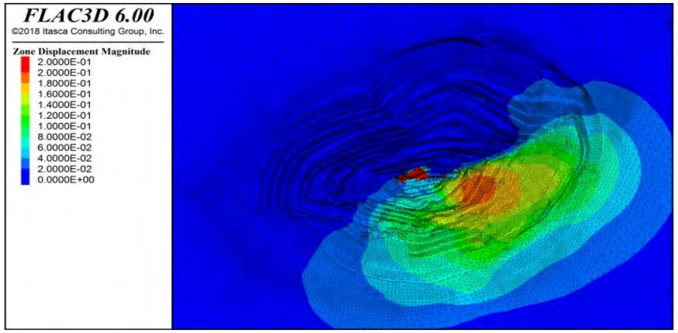
After Year 4 underground working



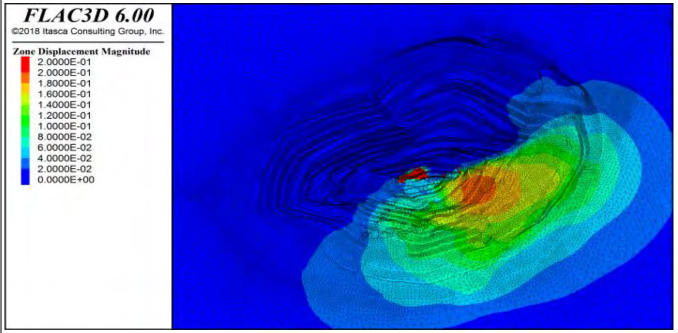
After Year 5 underground working



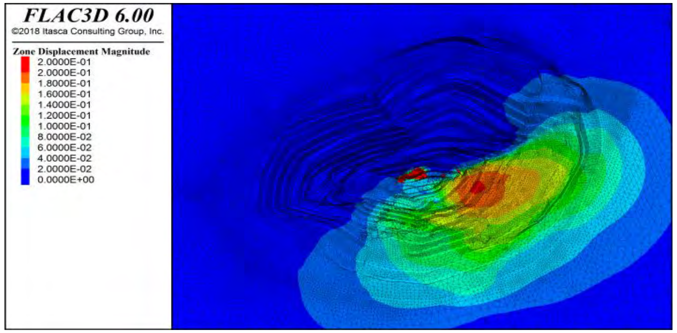
After Year 6 underground working



After Year 7 underground working



After Year 8 underground working



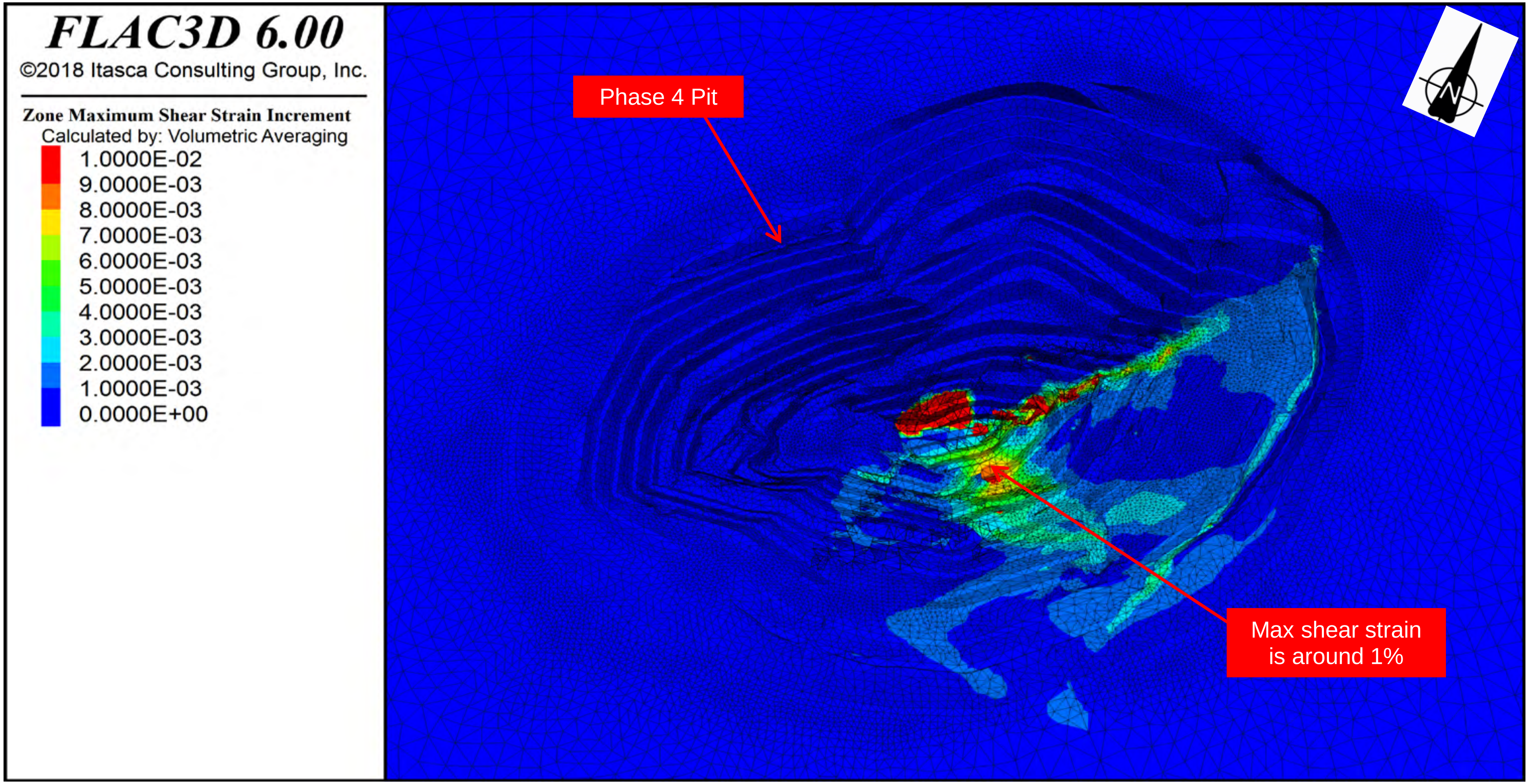
After Year 9 underground working

Anderson Lloyd
Waihi, New Zealand
Numerical Model - Run 8
PREDICTED TOTAL DISPLACEMENT FOR YEARLY SEQUENCE

PSM125-283R	**Appendix I2**

PSM

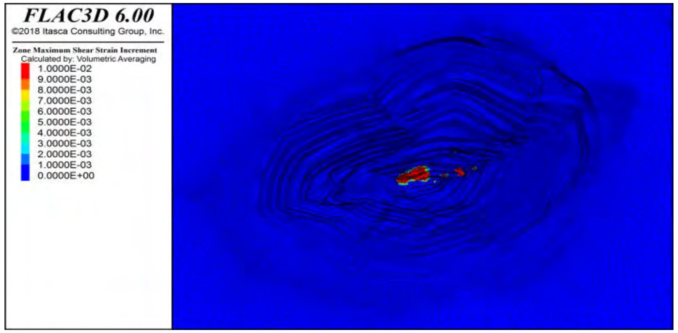
Pells Sullivan Meynink



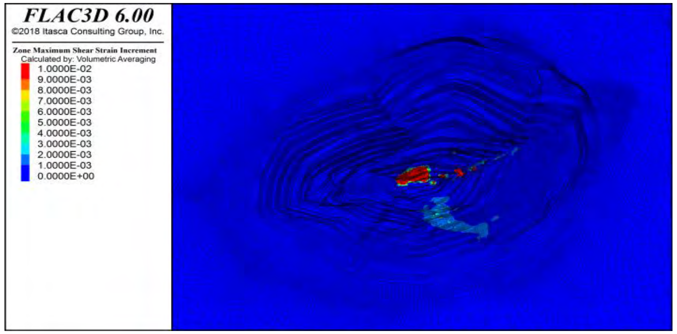
Anderson Lloyd Waihi, New Zealand Numerical Model - Run 8 PREDICTED MAX SHEAR STRAIN AFTER YEAR 9	
PSM125-283R	Appendix I3

PSM

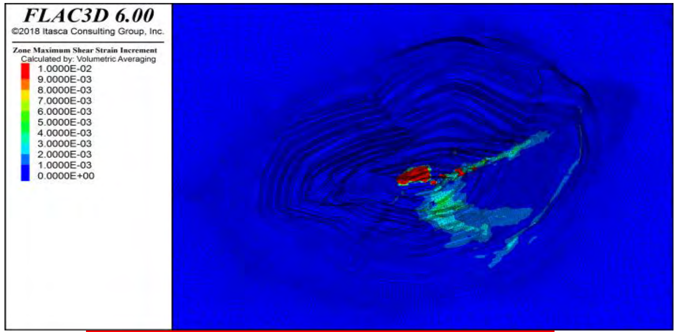
Pells Sullivan Meynink



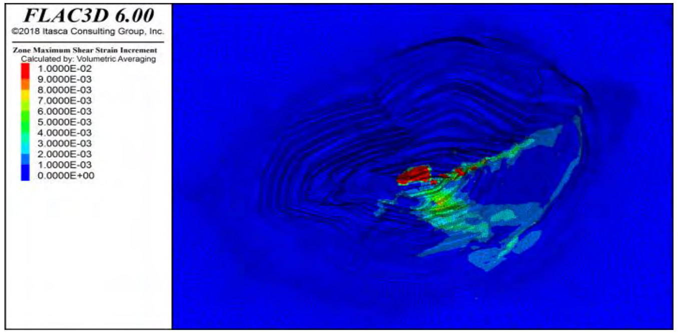
After Year 2 underground working



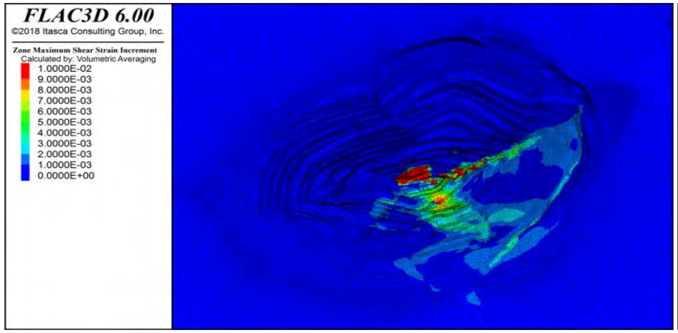
After Year 3 underground working



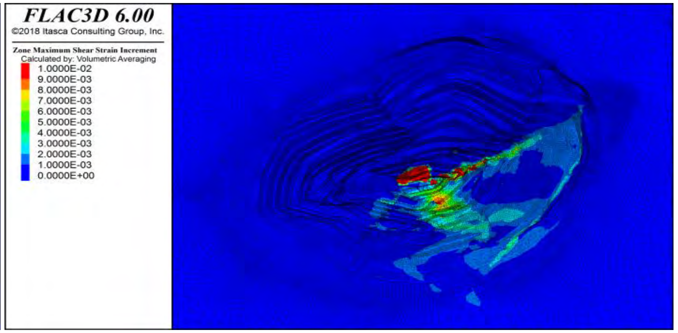
After Year 4 underground working



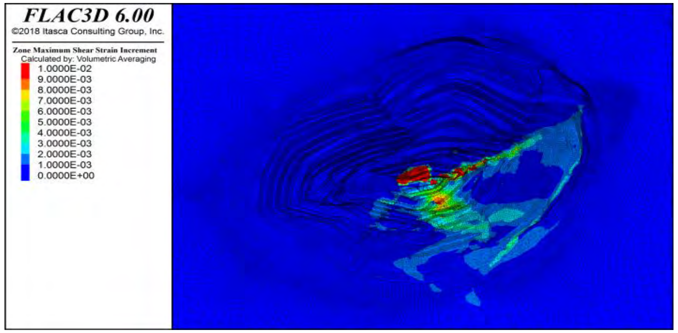
After Year 5 underground working



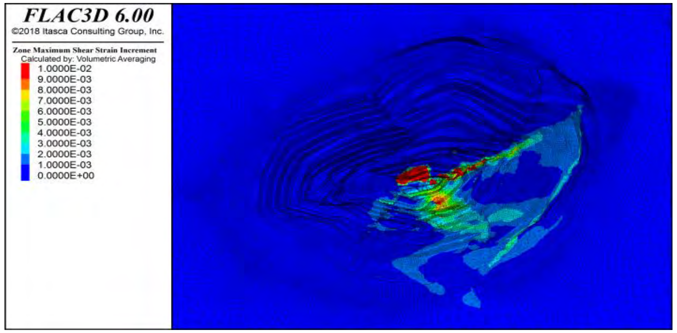
After Year 6 underground working



After Year 7 underground working



After Year 8 underground working



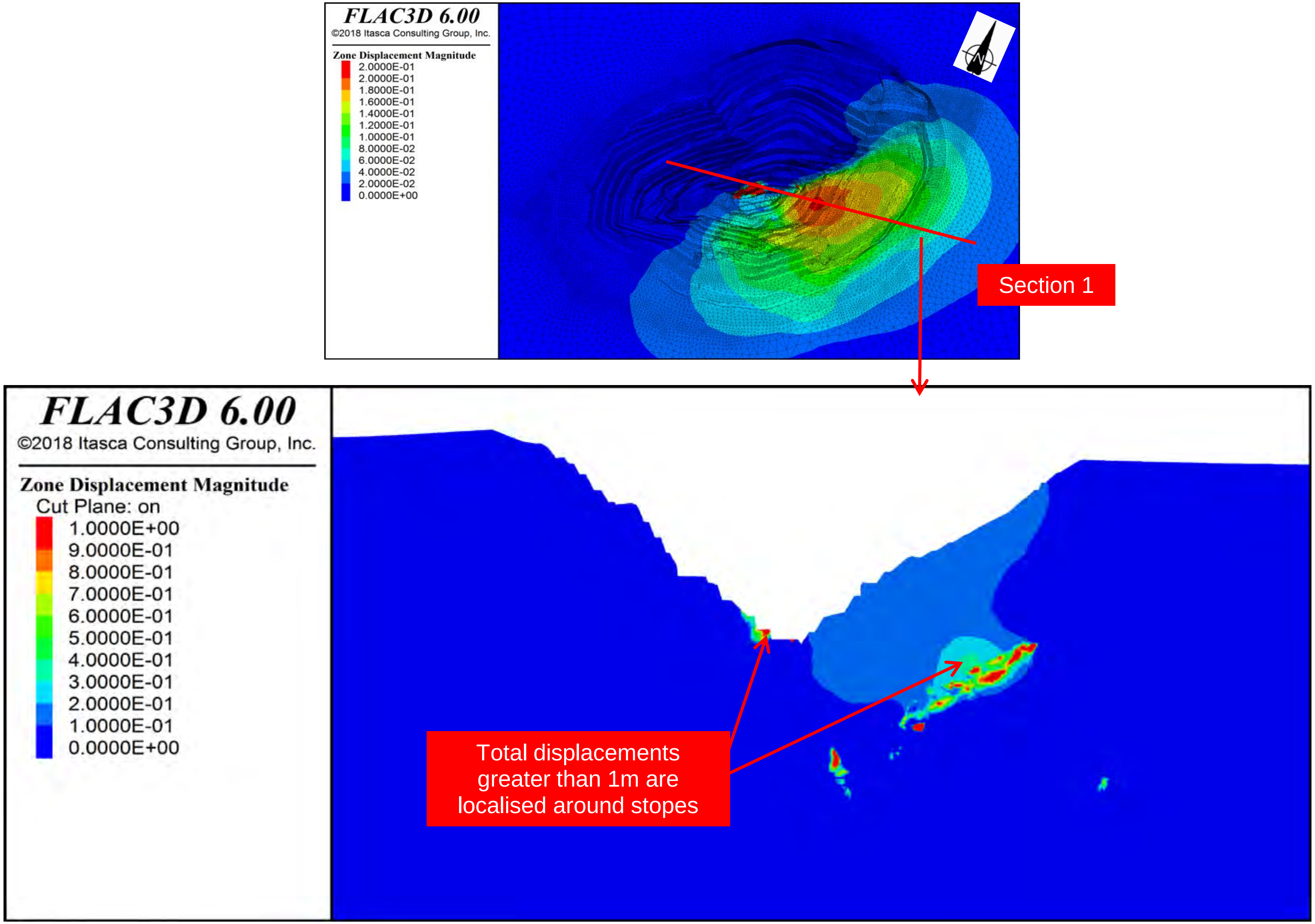
After Year 9 underground working

PSM

Pells Sullivan Meynink

Anderson Lloyd
Waihi, New Zealand
Numerical Model - Run 8
PREDICTED MAX SHEAR STRAIN FOR YEARLY SEQUENCE

PSM125-283R	**Appendix I4**



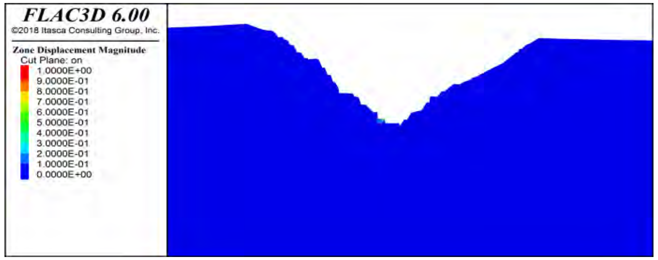
PSM

Pells Sullivan Meynink

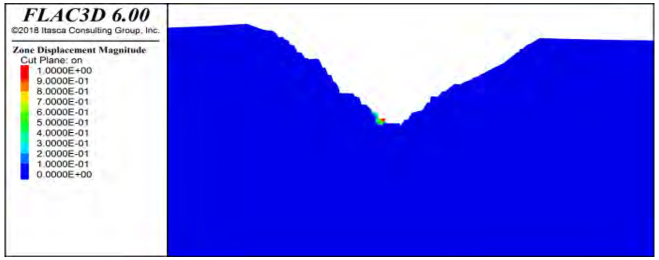
Anderson Lloyd
Waihi, New Zealand
Numerical Model - Run 8

PREDICTED TOTAL DISPLACEMENT OF SECTION 1 AFTER YEAR 9

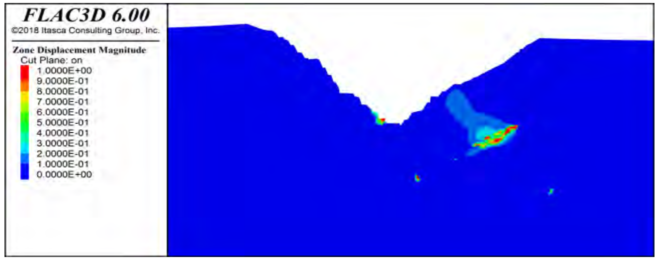
PSM125-283R	Appendix I5



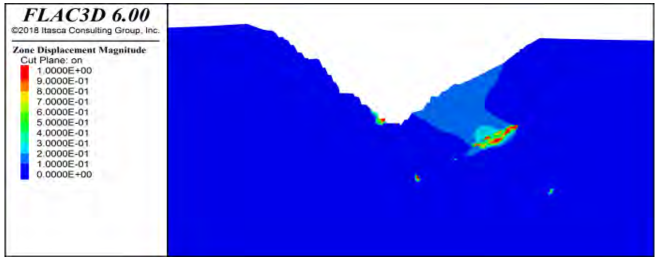
After Year 2 underground working



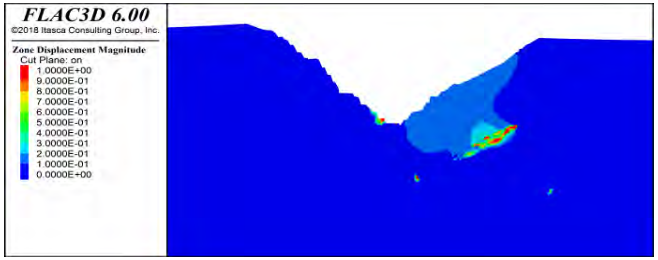
After Year 3 underground working



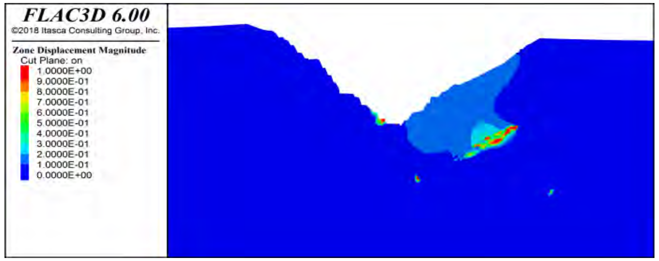
After Year 4 underground working



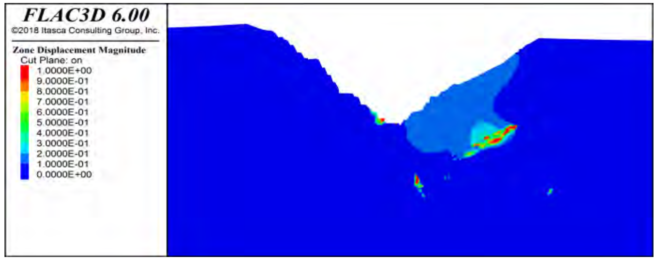
After Year 5 underground working



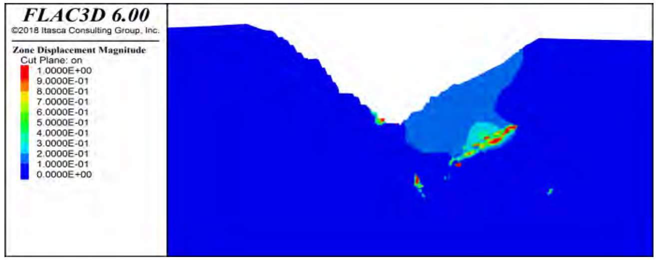
After Year 6 underground working



After Year 7 underground working



After Year 8 underground working

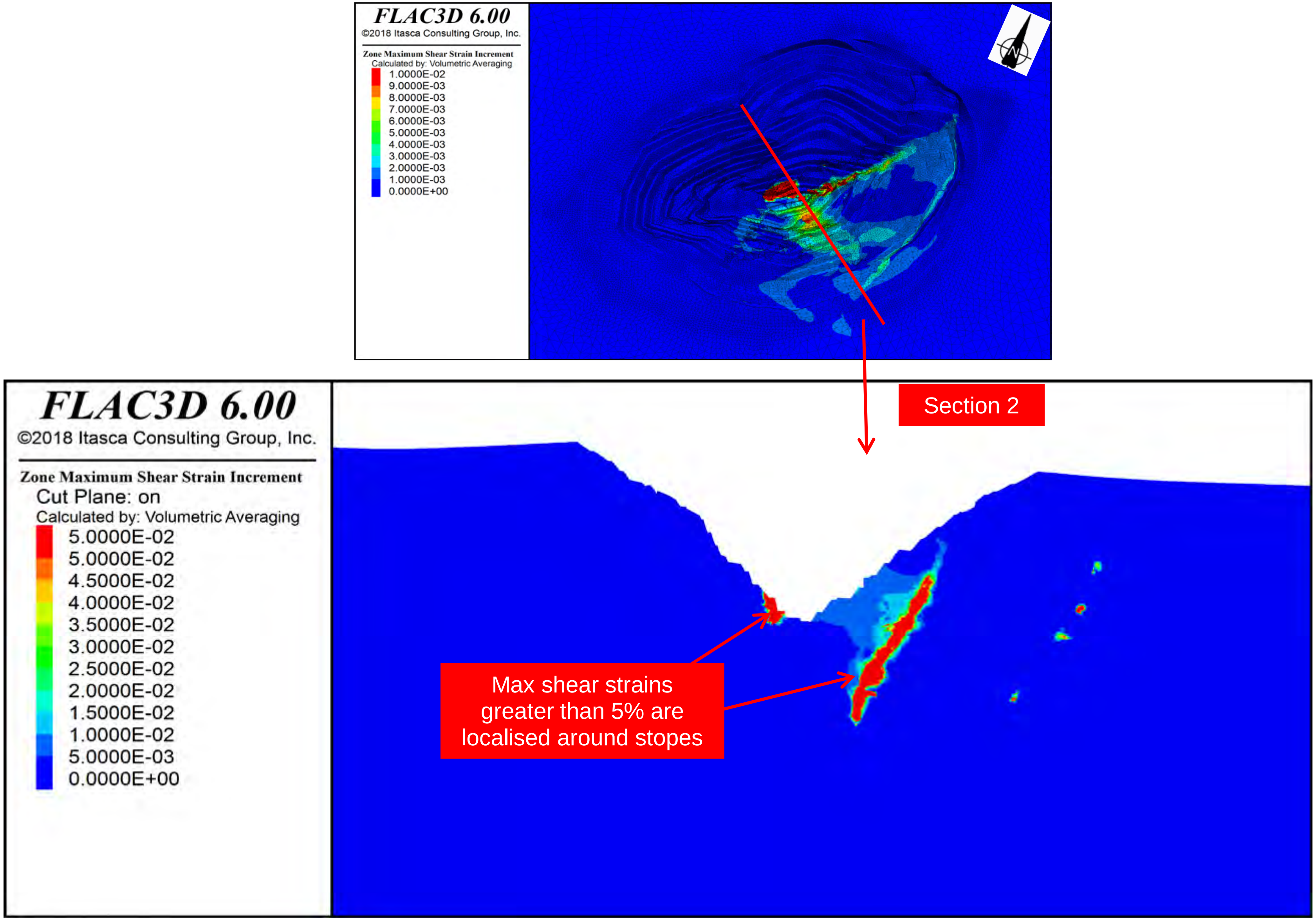


After Year 9 underground working

PSM Pells Sullivan Meynink

Anderson Lloyd
Waihi, New Zealand
Numerical Model - Run 8
PREDICTED TOTAL DISPLACEMENT OF SECTION 1 FOR YEARLY SEQUENCE

PSM125-283R	**Appendix I6**



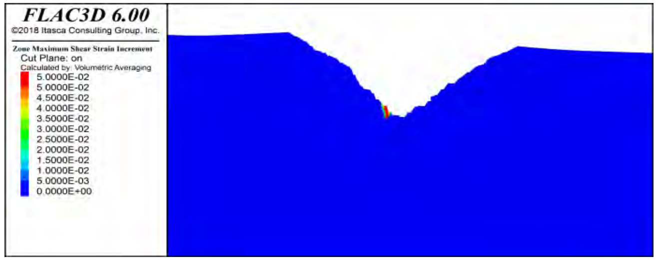
Anderson Lloyd
Waihi, New Zealand
Numerical Model - Run 8

PREDICTED MAX SHEAR STRAIN OF SECTION 2 AFTER YEAR 9

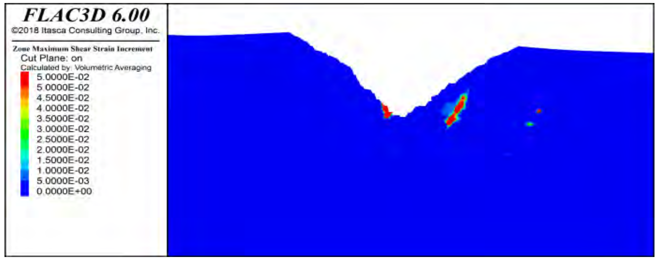
PSM125-283R	Appendix I7

PSM

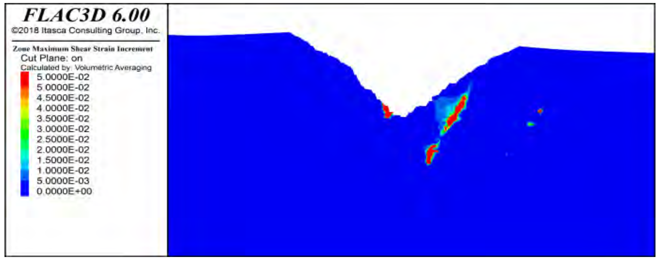
Pells Sullivan Meynink



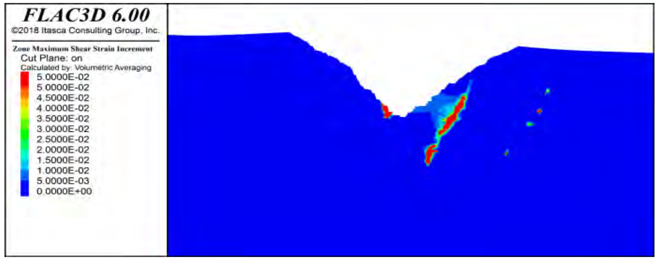
After Year 2 underground working



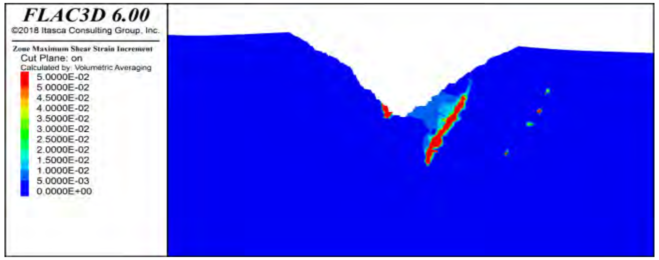
After Year 3 underground working



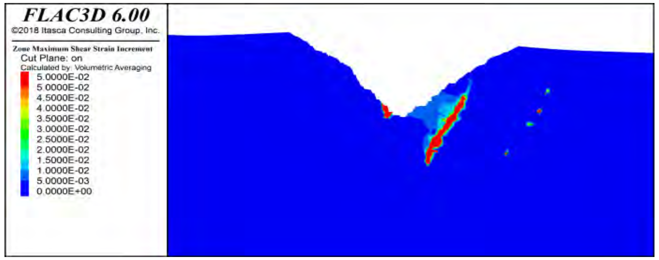
After Year 4 underground working



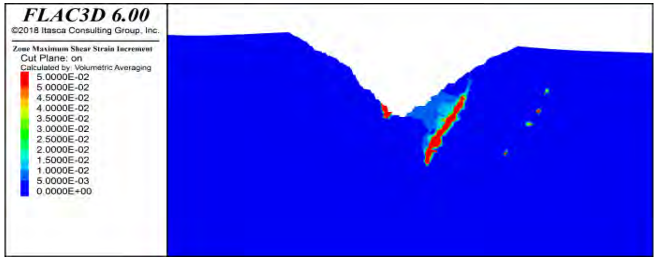
After Year 5 underground working



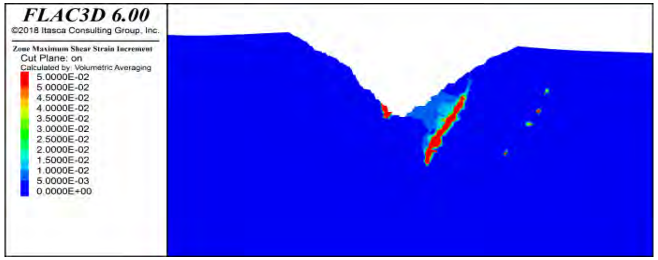
After Year 6 underground working



After Year 7 underground working



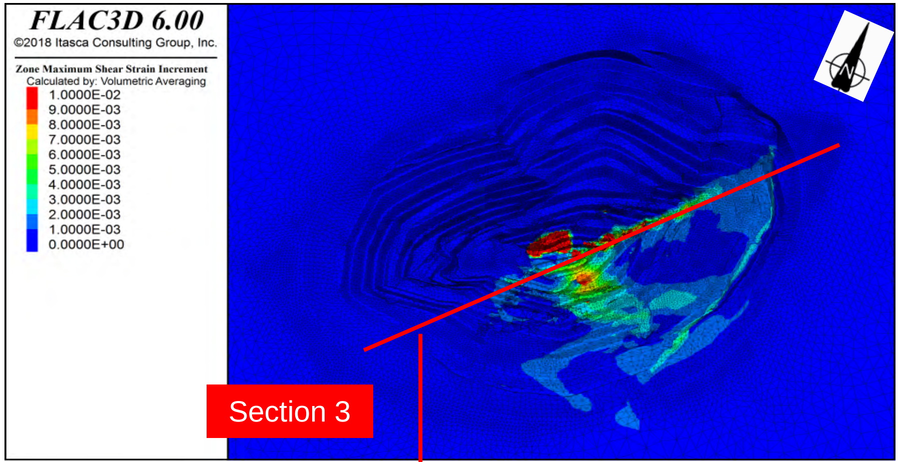
After Year 8 underground working

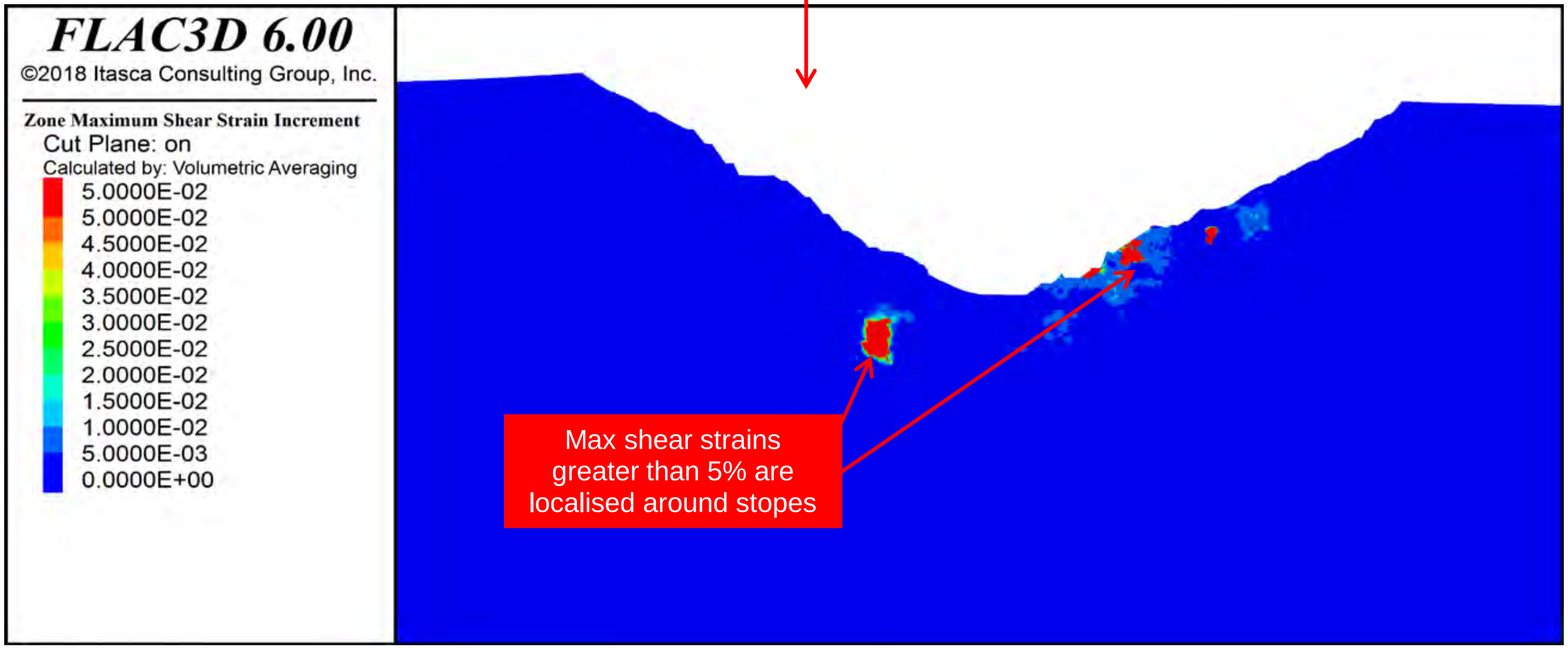


After Year 9 underground working

Pells Sullivan Meynink

Anderson Lloyd Waihi, New Zealand Numerical Model - Run 8 PREDICTED MAX SHEAR STRAIN OF SECTION 2 FOR YEARLY SEQUENCE	
PSM125-283R	Appendix I8





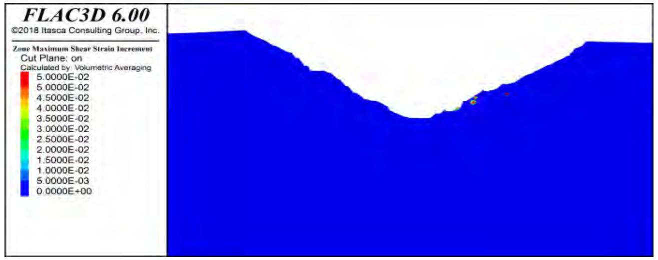
Anderson Lloyd
Waihi, New Zealand
Numerical Model - Run 8

PREDICTED MAX SHEAR STRAIN OF SECTION 3 AFTER YEAR 9

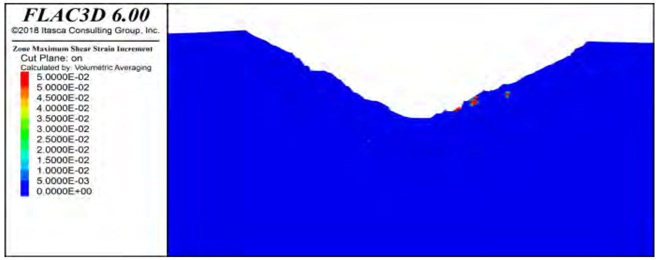
PSM125-283R	Appendix I9

PSM

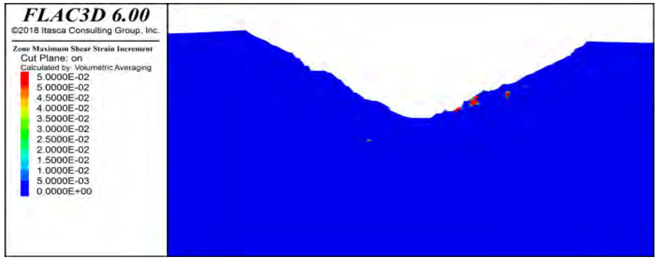
Pells Sullivan Meynink



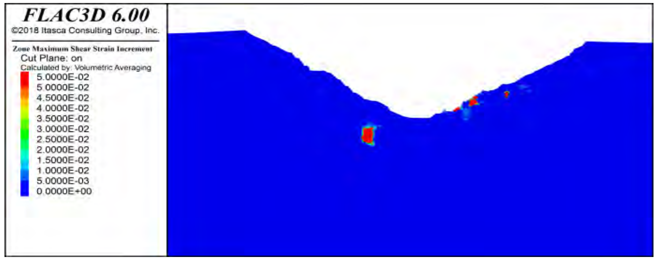
After Year 2 underground working



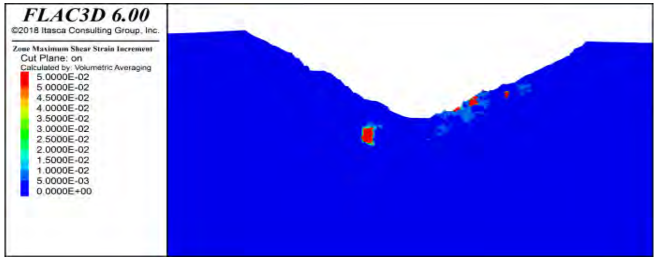
After Year 3 underground working



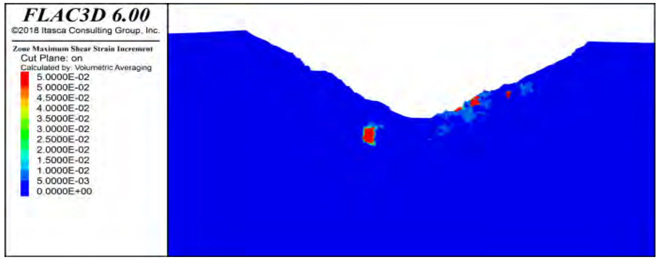
After Year 4 underground working



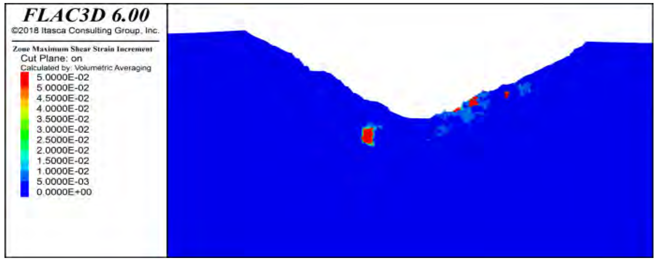
After Year 5 underground working



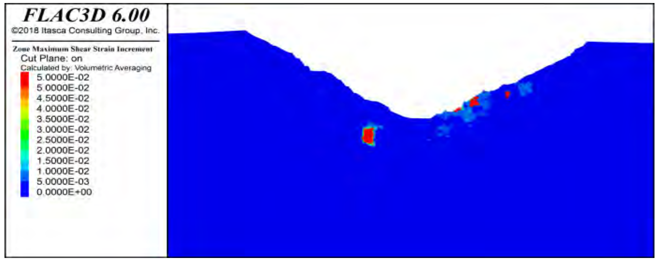
After Year 6 underground working



After Year 7 underground working



After Year 8 underground working



After Year 9 underground working

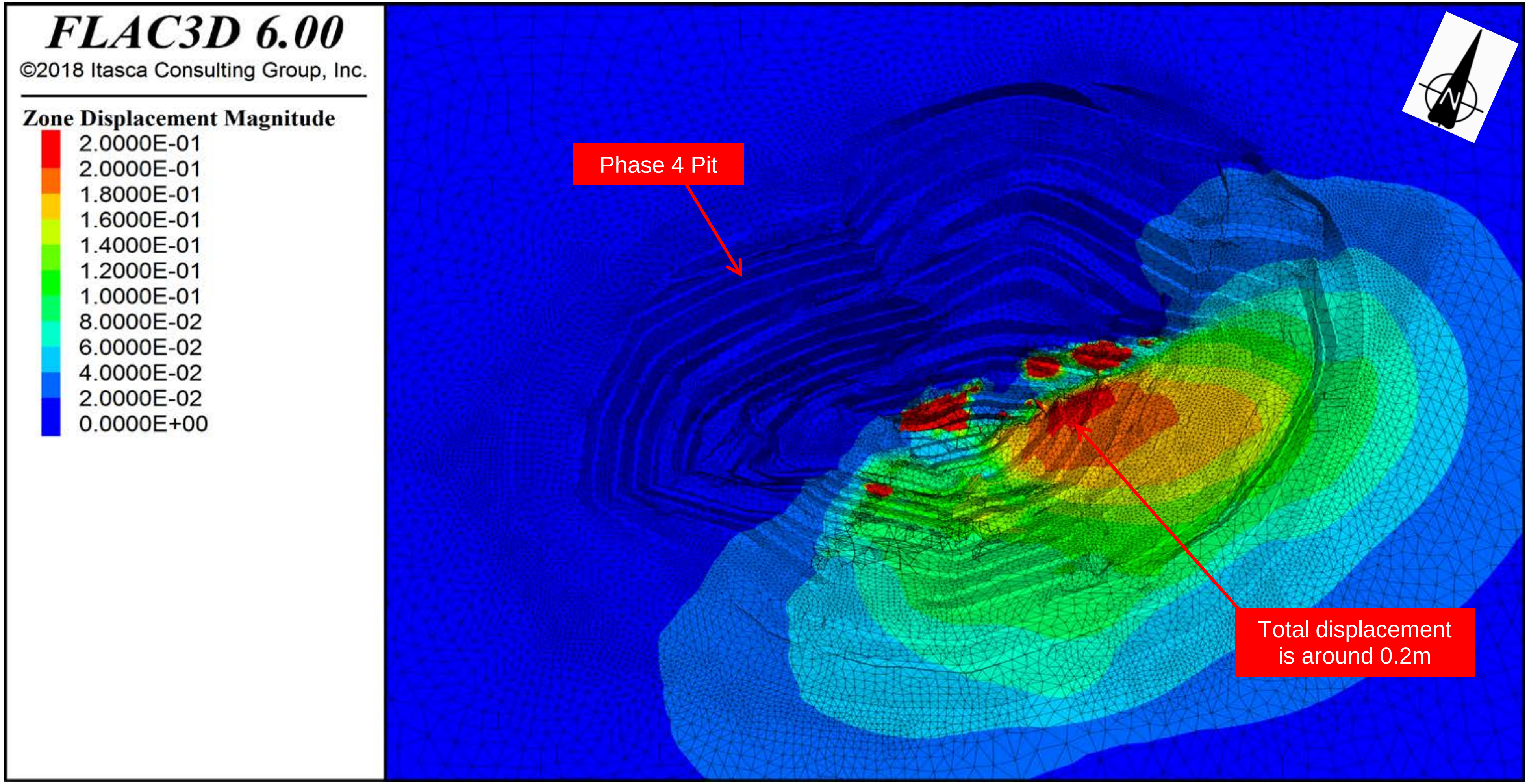
PSM

Pells Sullivan Meynink

Anderson Lloyd **Waihi, New Zealand** **Numerical Model - Run 8** **PREDICTED MAX SHEAR STRAIN OF SECTION 3 FOR YEARLY SEQUENCE**	
PSM125-283R	**Appendix I10**

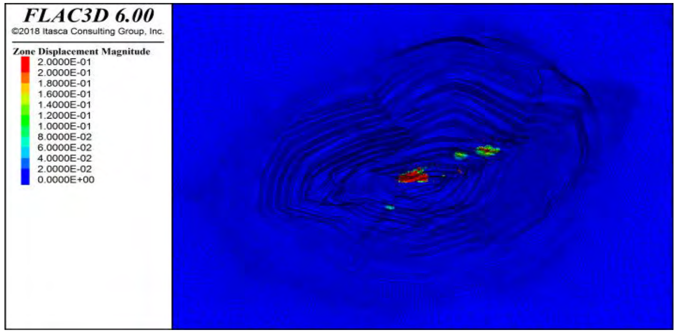
APPENDIX J

FLAC3D OUTPUTS – RUN 9

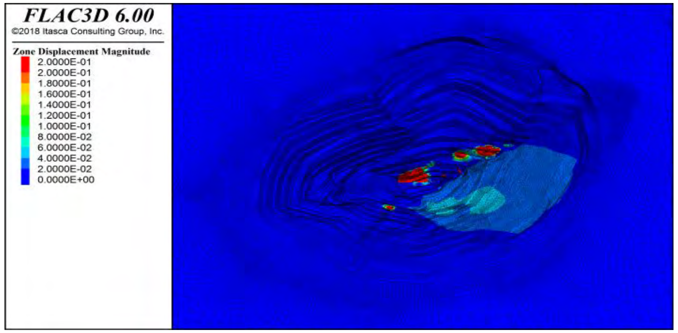


Anderson Lloyd Waihi, New Zealand Numerical Model - Run 9 PREDICTED TOTAL DISPLACEMENT AFTER YEAR 9	
PSM125-283R	Appendix J1

PSM Pells Sullivan Meynink



After Year 2 underground working



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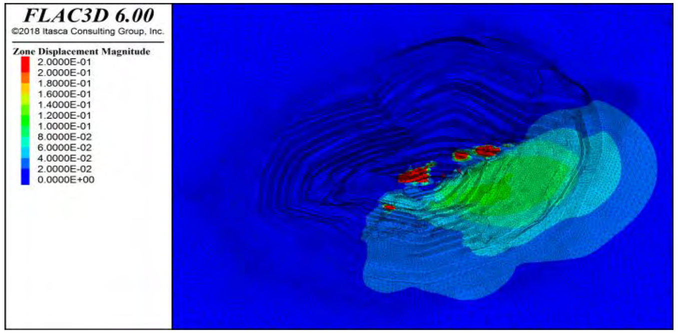
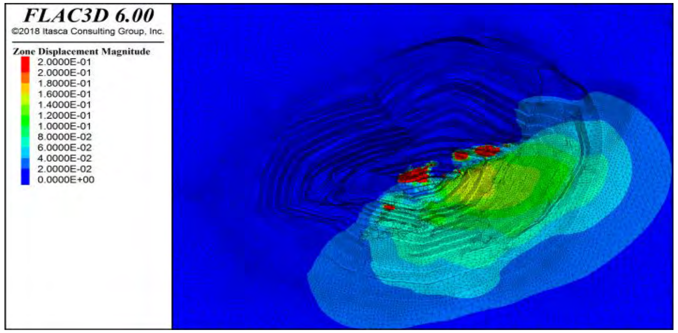


After Year 4 underground working



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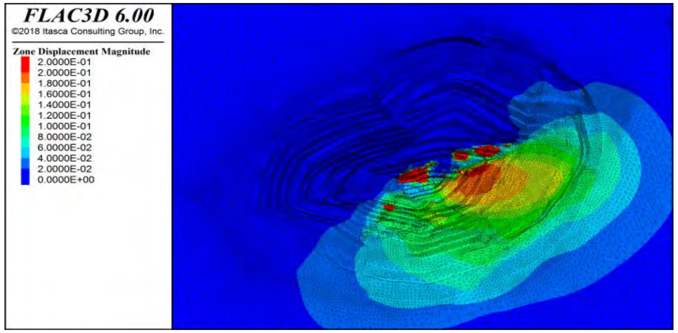
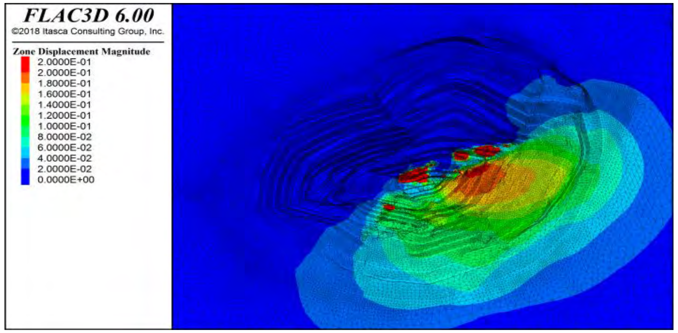
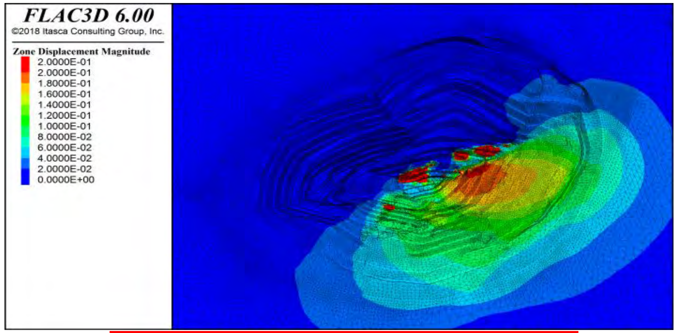


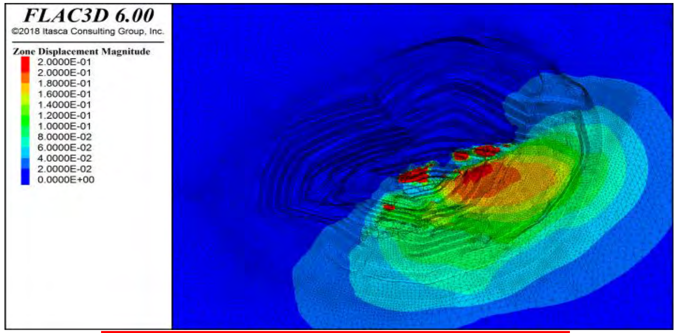
After Year 6 underground working



After Year 7 underground working



After Year 8 underground working



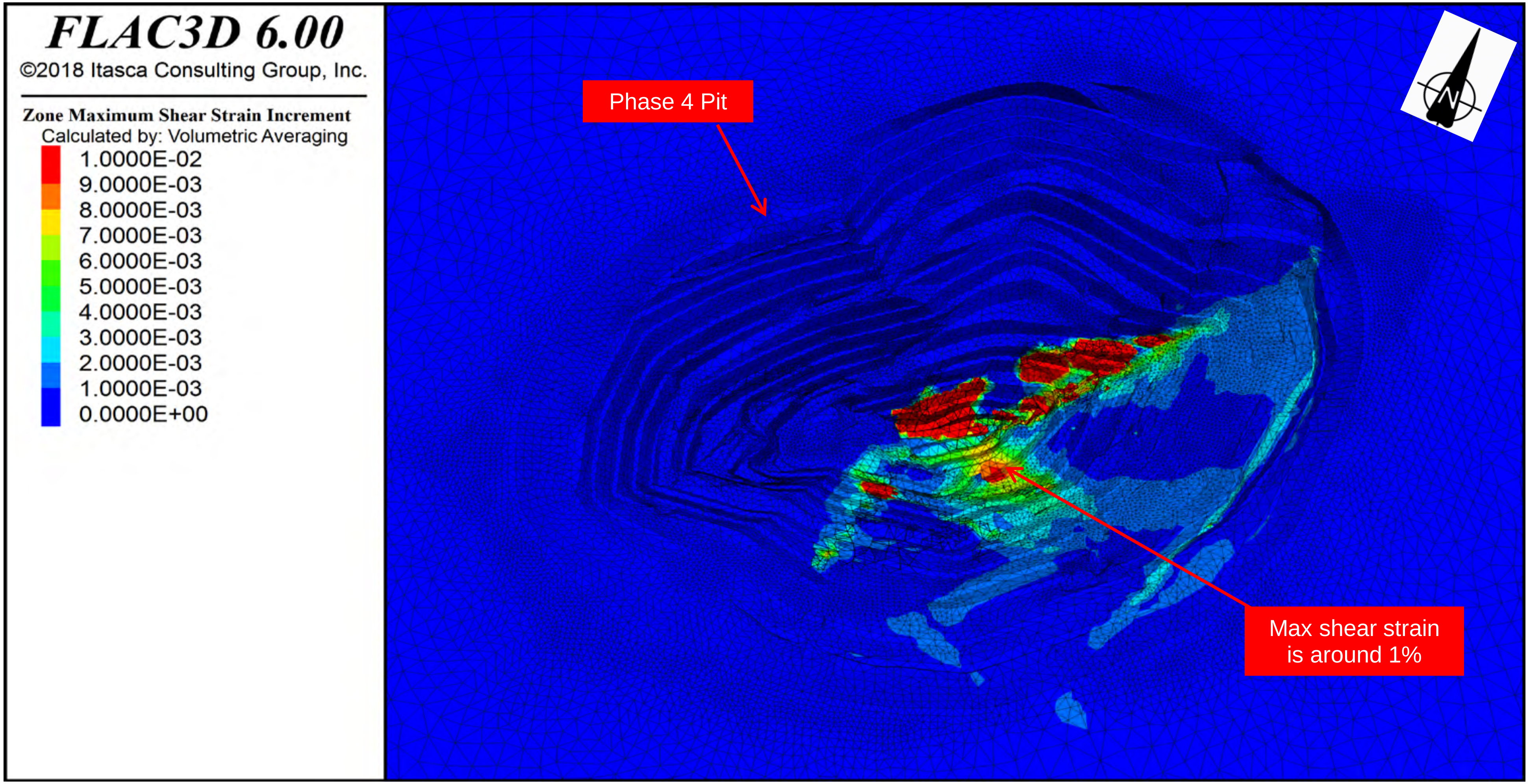
After Year 9 underground working

PSM

Pells Sullivan Meynink

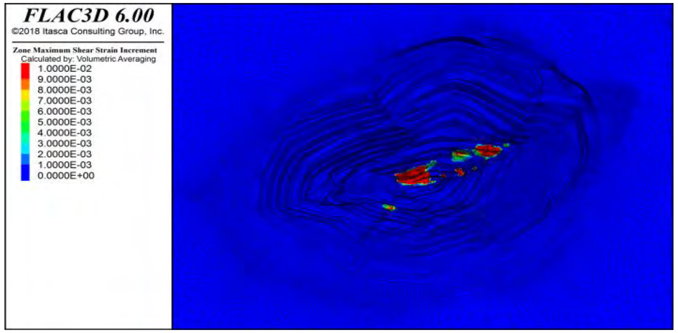
Anderson Lloyd
Waihi, New Zealand
Numerical Model - Run 9
PREDICTED TOTAL DISPLACEMENT FOR YEARLY SEQUENCE

PSM125-283R	**Appendix J2**

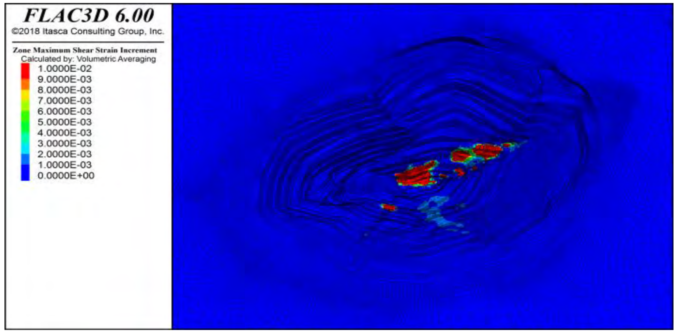


Anderson Lloyd Waihi, New Zealand Numerical Model - Run 9 PREDICTED MAX SHEAR STRAIN AFTER YEAR 9	
PSM125-283R	Appendix J3

Pells Sullivan Meynink



After Year 2 underground working



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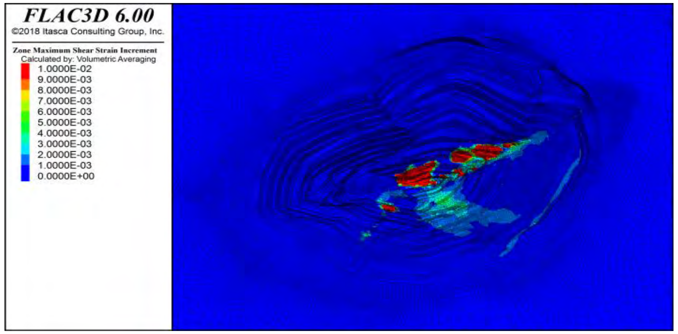
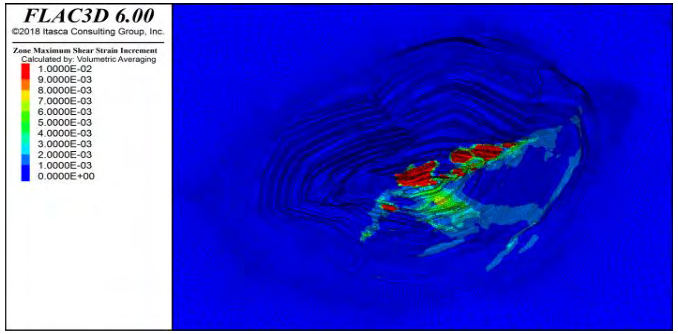
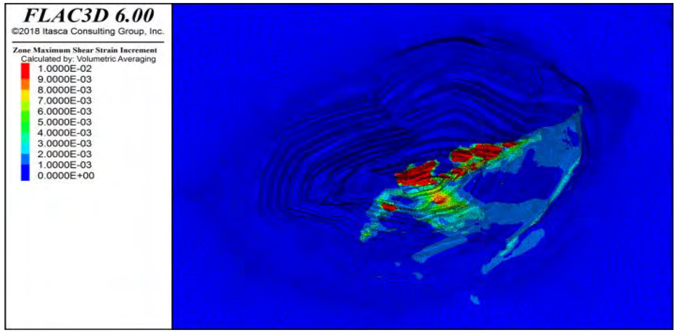


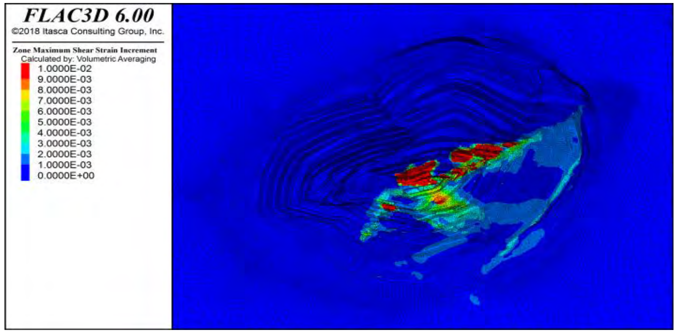
After Year 4 underground working



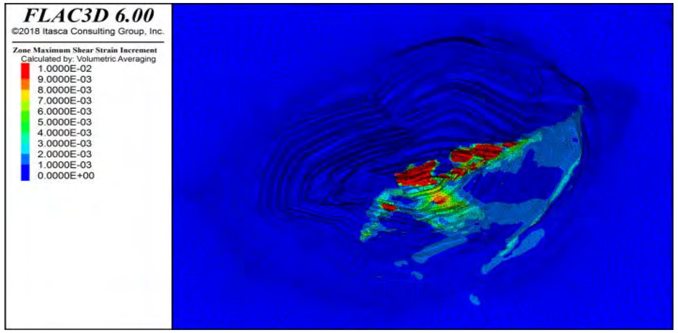
After Year 5 underground working



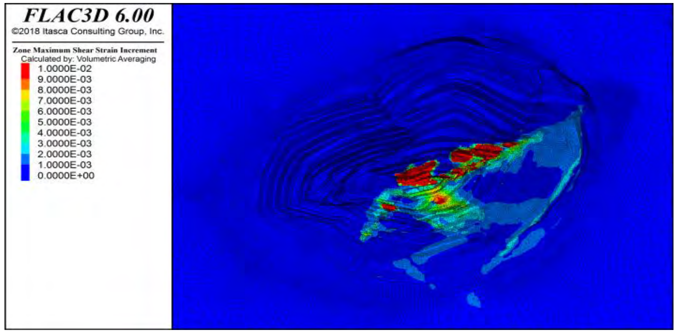
After Year 6 underground working



After Year 7 underground working



After Year 8 underground working

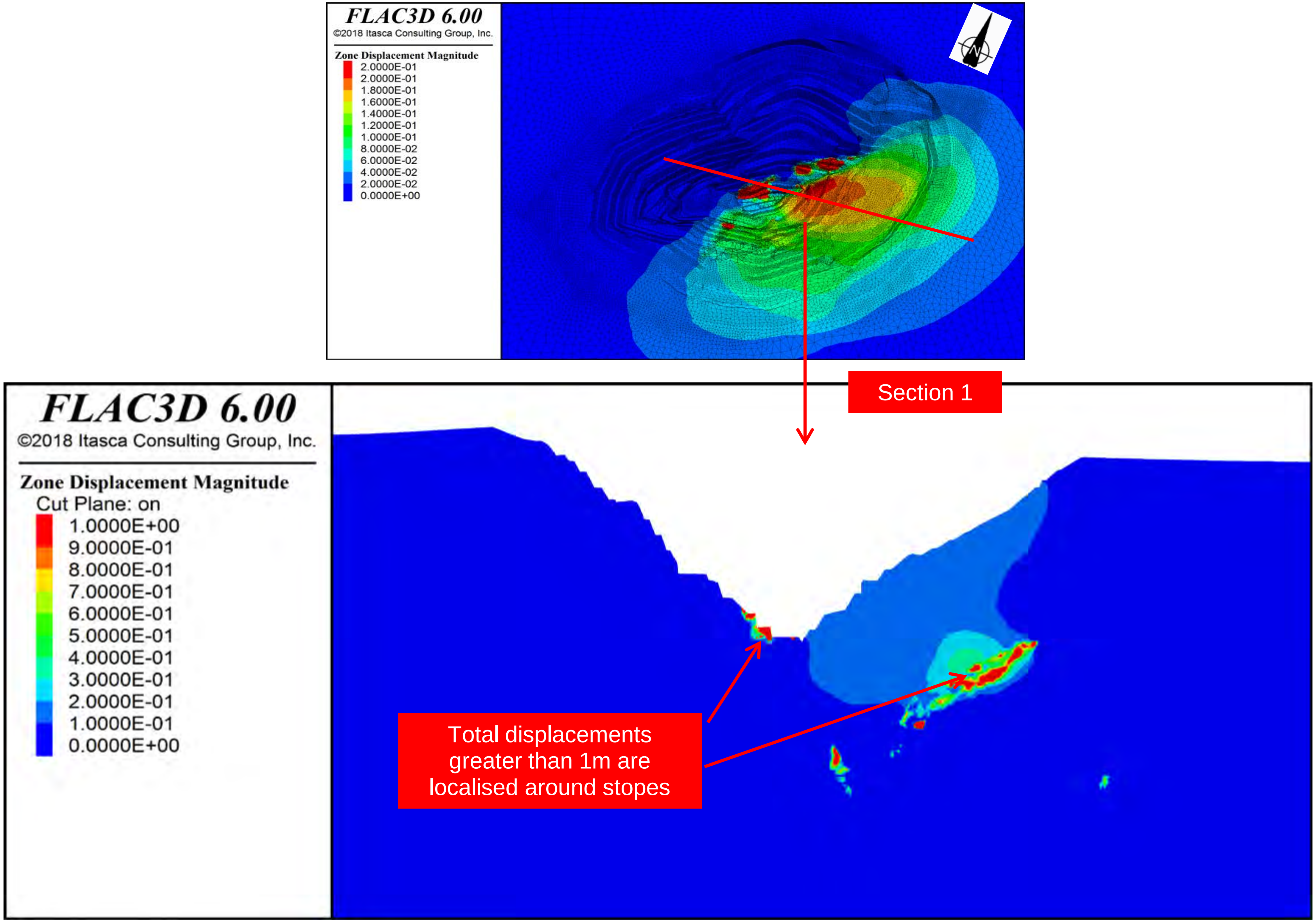


After Year 9 underground working

Anderson Lloyd
Waihi, New Zealand
Numerical Model - Run 9
PREDICTED MAX SHEAR STRAIN FOR YEARLY SEQUENCE

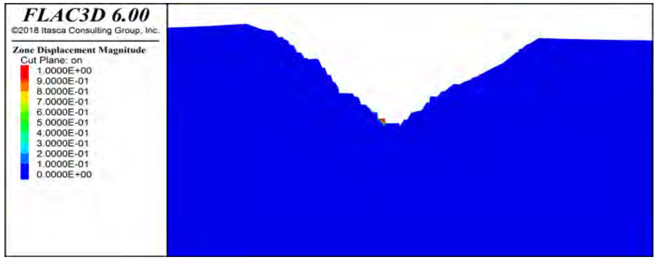
PSM125-283R	**Appendix J4**

Pells Sullivan Meynink

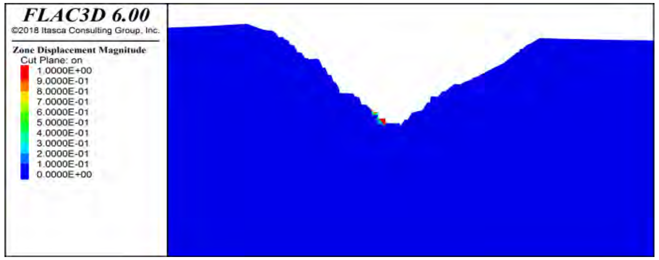


Anderson Lloyd Waihi, New Zealand Numerical Model - Run 9 **PREDICTED TOTAL DISPLACEMENT OF SECTION 1 AFTER YEAR 9**	
PSM125-283R	**Appendix J5**

Pells Sullivan Meynink



After Year 2 underground working



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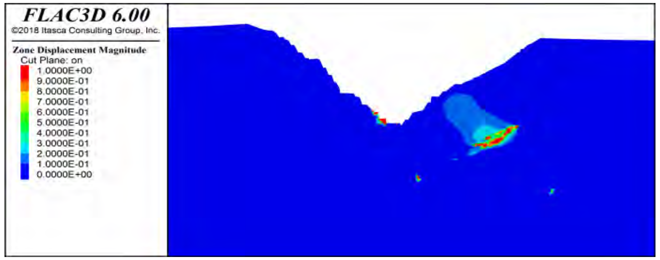
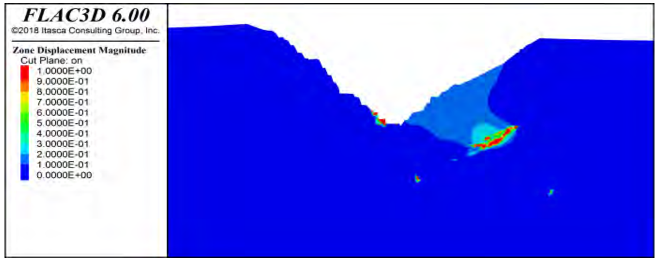
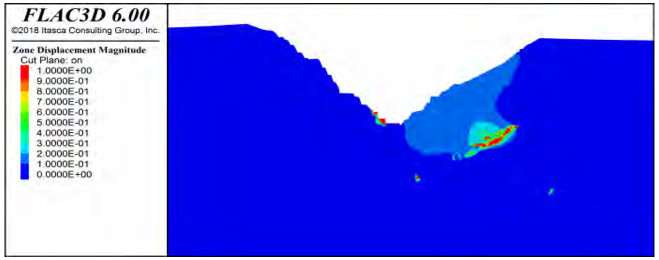


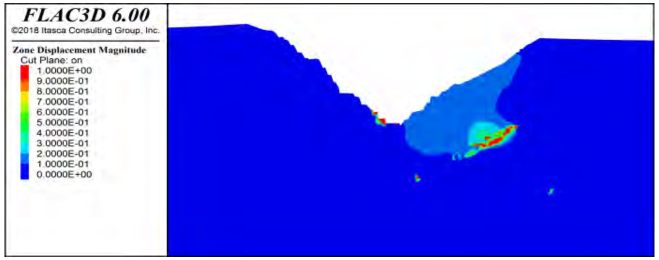
After Year 4 underground working



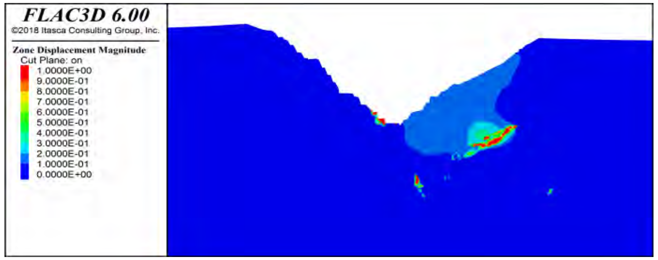
After Year 5 underground working



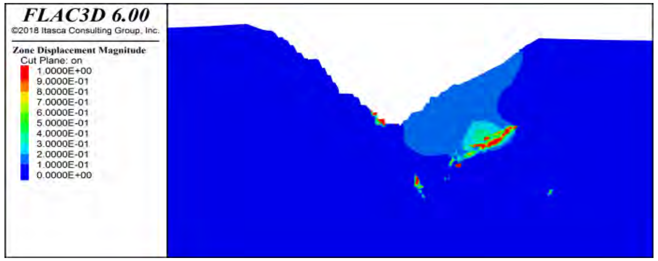
After Year 6 underground working



After Year 7 underground working



After Year 8 underground working



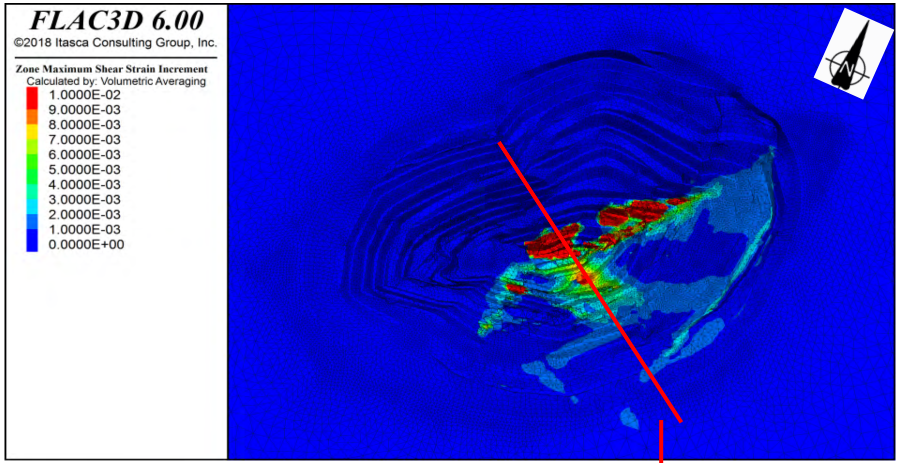
After Year 9 underground working

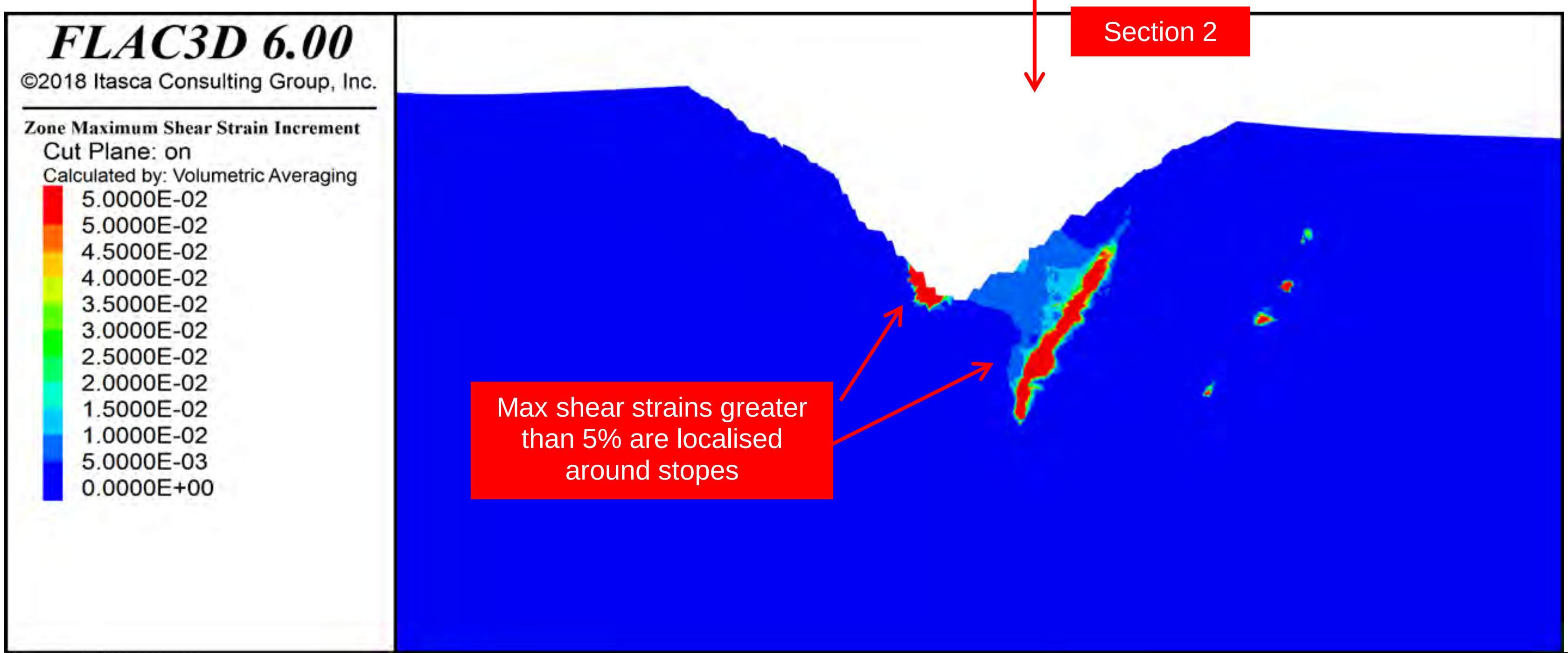
PSM

Pells Sullivan Meynink

Anderson Lloyd
Waihi, New Zealand
Numerical Model - Run 9
PREDICTED TOTAL DISPLACEMENT OF SECTION 1 FOR YEARLY SEQUENCE

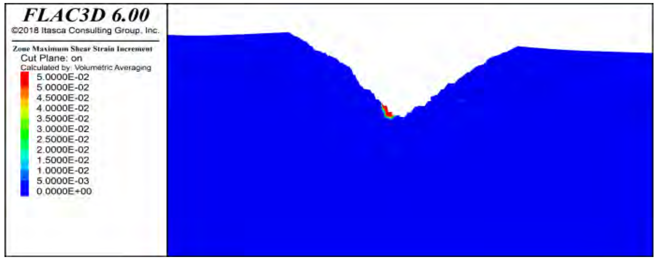
PSM125-283R	**Appendix J6**



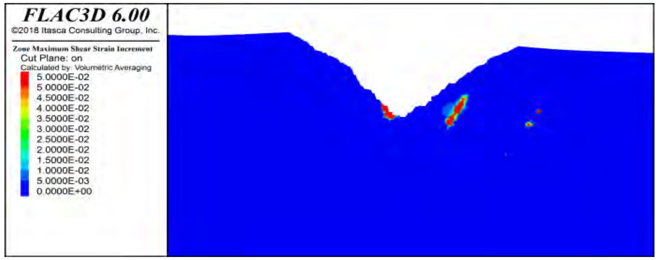


Pells Sullivan Meynink

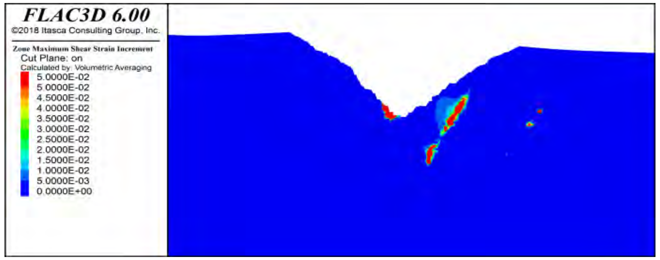
Anderson Lloyd Waihi, New Zealand Numerical Model - Run 9 **PREDICTED MAX SHEAR STRAIN OF SECTION 2 AFTER YEAR 9**	
PSM125-283R	**Appendix J7**



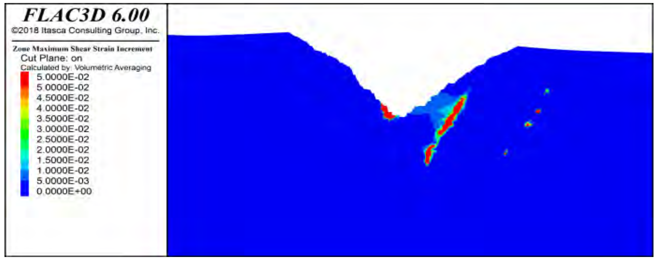
After Year 2 underground working



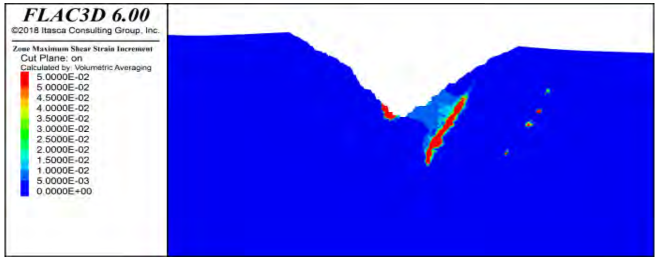
After Year 3 underground working



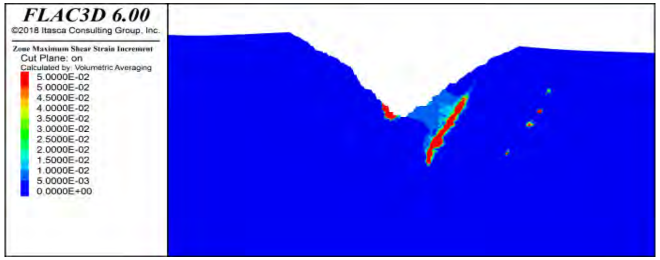
After Year 4 underground working



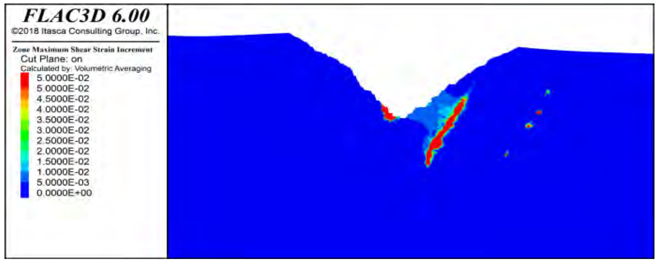
After Year 5 underground working



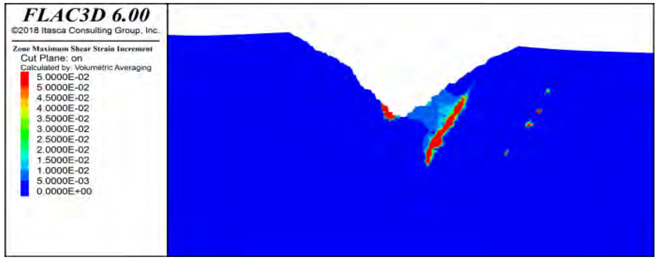
After Year 6 underground working



After Year 7 underground working



After Year 8 underground working



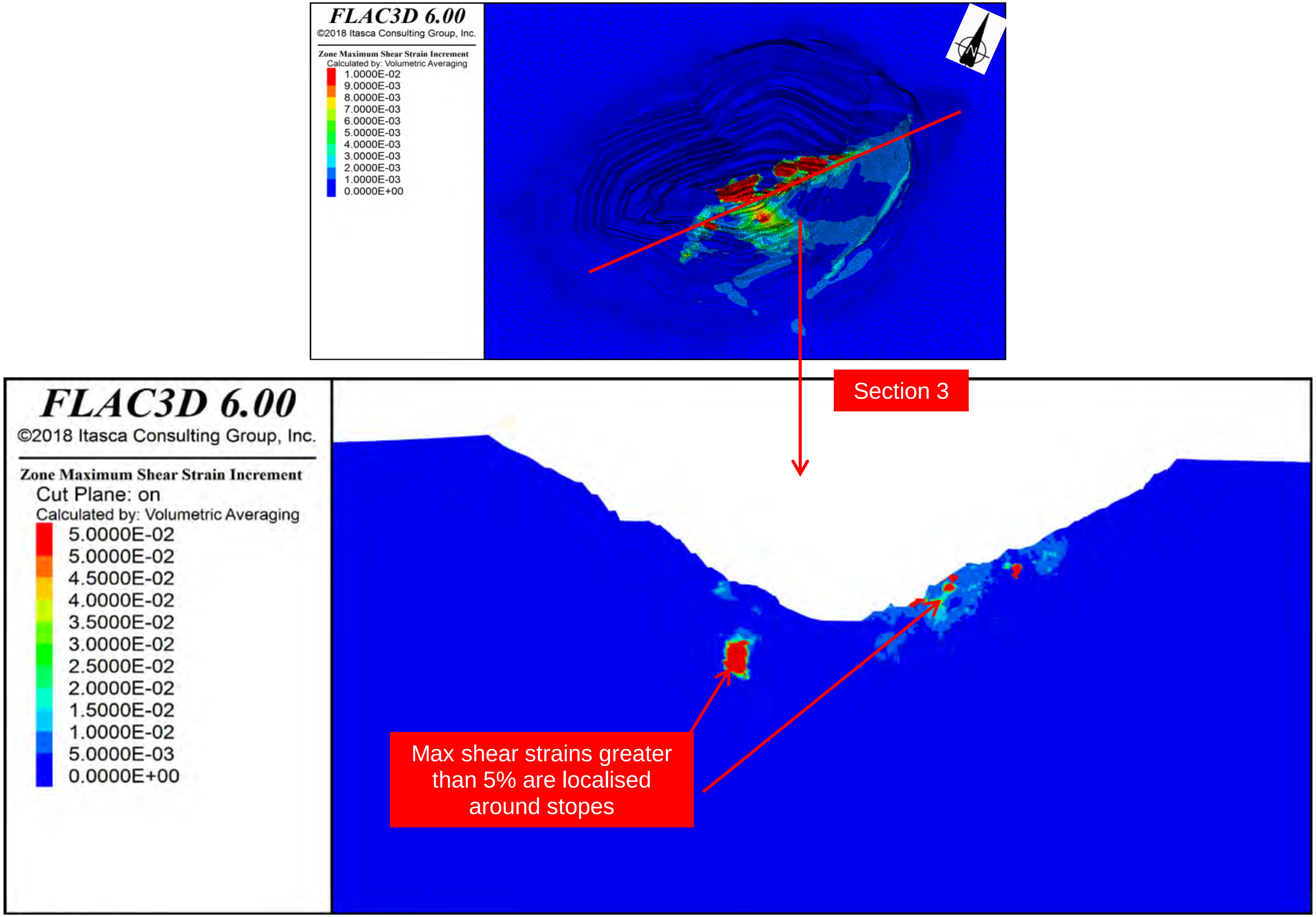
After Year 9 underground working

PSM

Pells Sullivan Meynink

Anderson Lloyd
Waihi, New Zealand
Numerical Model - Run 9
PREDICTED MAX SHEAR STRAIN OF SECTION 2 FOR YEARLY SEQUENCE

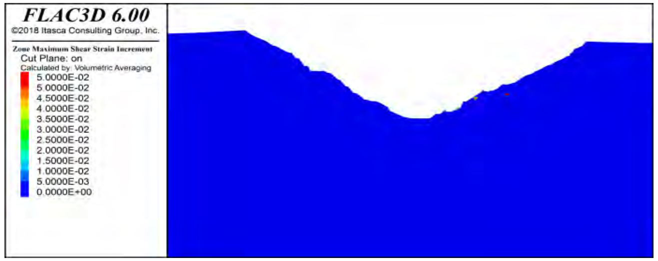
PSM125-283R	**Appendix J8**



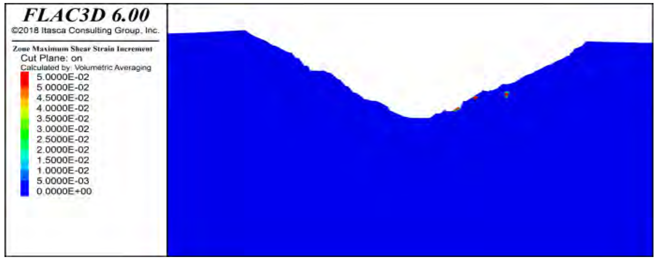
Anderson Lloyd **Waihi, New Zealand** **Numerical Model - Run 9** **PREDICTED MAX SHEAR STRAIN OF SECTION 3 AFTER YEAR 9**	
PSM125-283R	**Appendix J9**

PSM

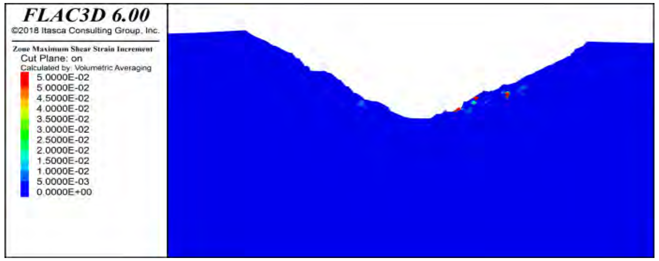
Pells Sullivan Meynink



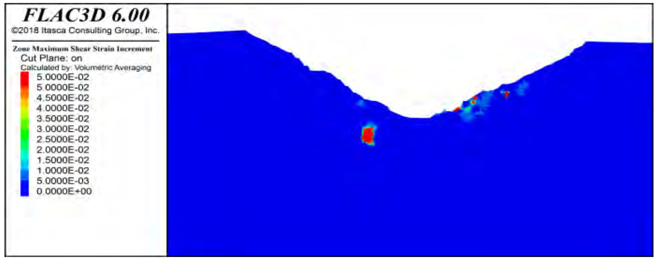
After Year 2 underground working



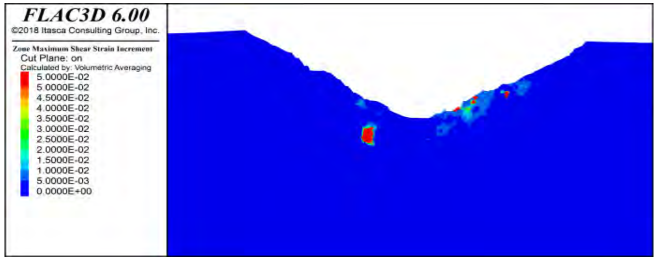
After Year 3 underground working



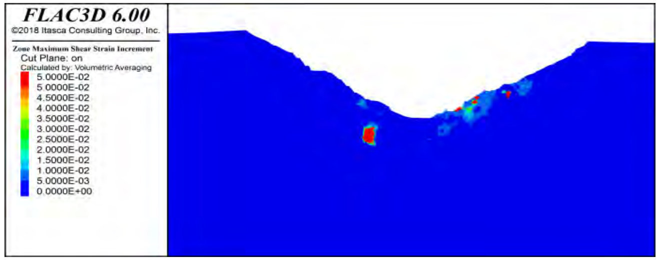
After Year 4 underground working



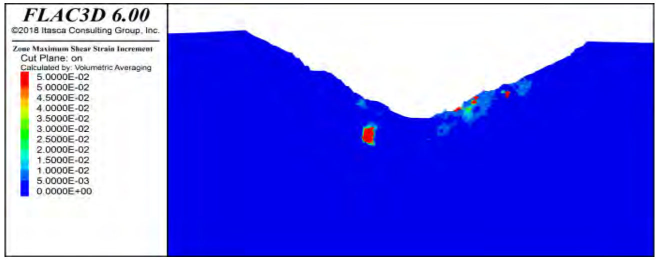
After Year 5 underground working



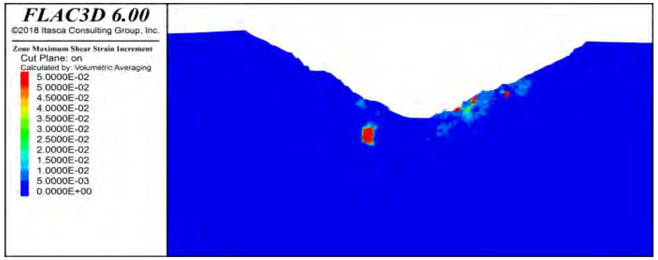
After Year 6 underground working



After Year 7 underground working



After Year 8 underground working



After Year 9 underground working

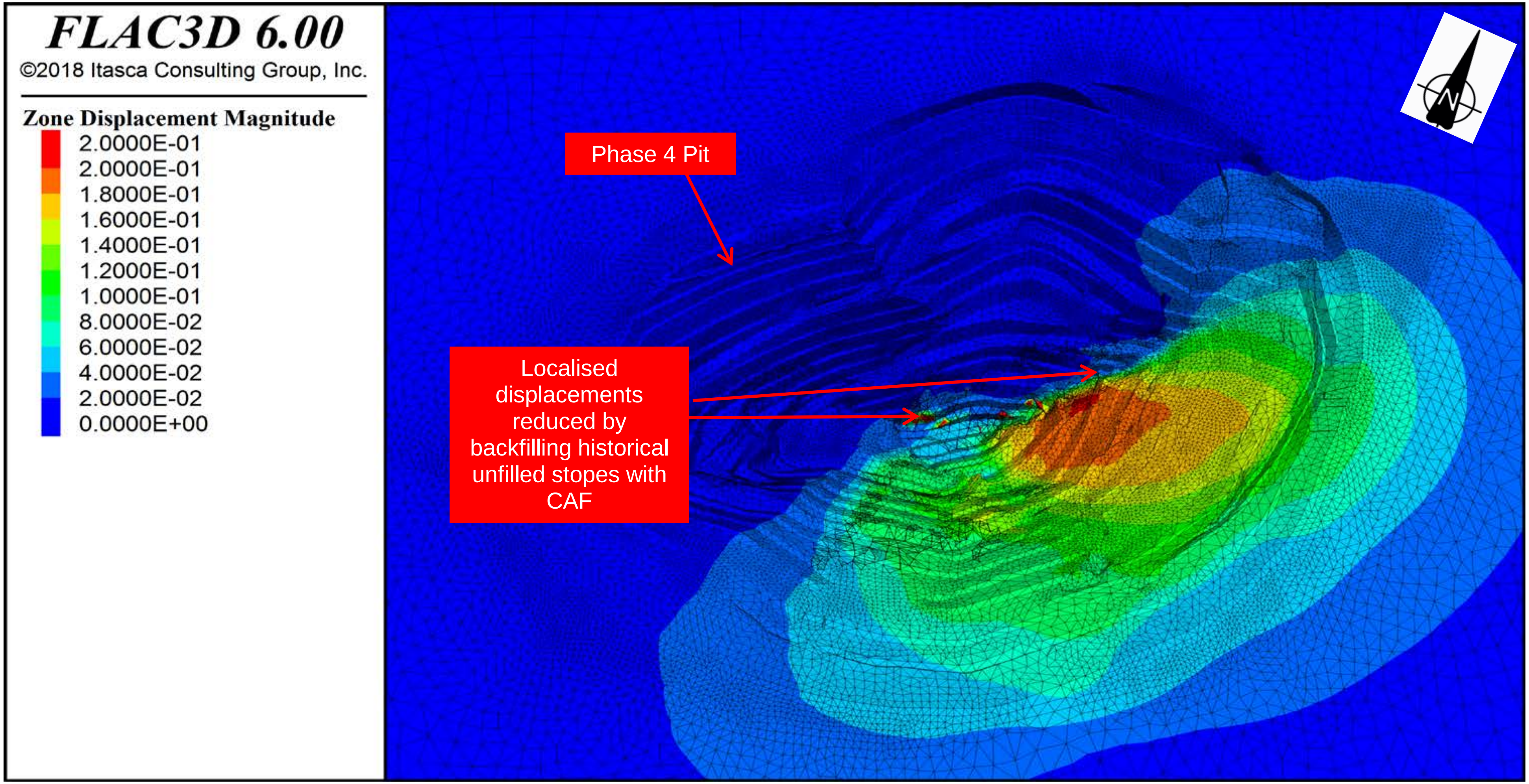
PSM

Pells Sullivan Meynink

Anderson Lloyd Waihi, New Zealand Numerical Model - Run 9 PREDICTED MAX SHEAR STRAIN OF SECTION 3 FOR YEARLY SEQUENCE	
PSM125-283R	Appendix J10

APPENDIX K

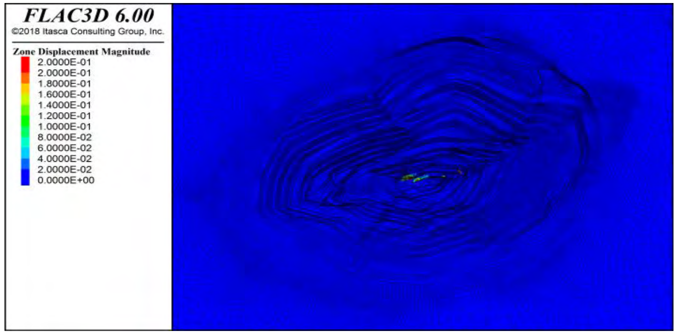
***FLAC3D* OUTPUTS – RUN 10**



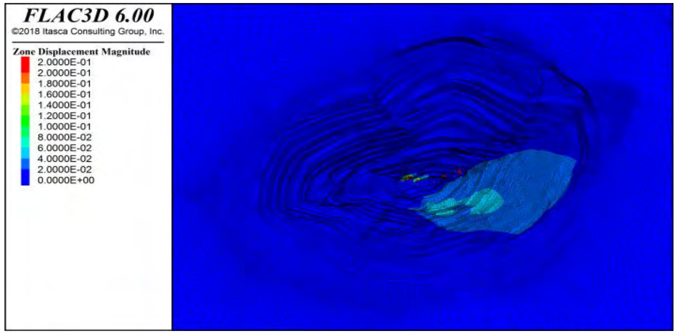
Anderson Lloyd
Waihi, New Zealand
Numerical Model - Run 10
PREDICTED TOTAL DISPLACEMENT AFTER YEAR 9

PSM125-283R	Appendix K1

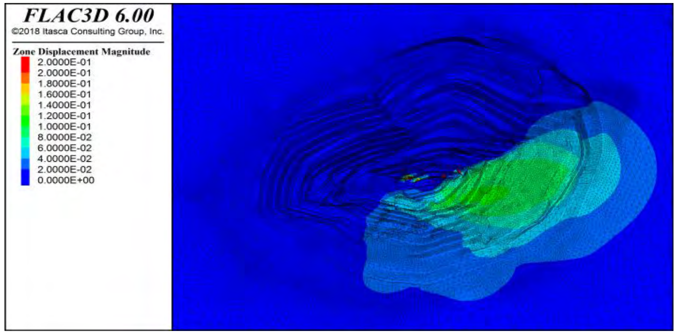
Pells Sullivan Meynink



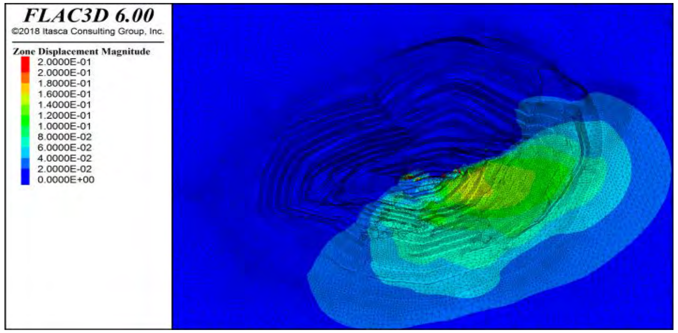
After 2019 underground working



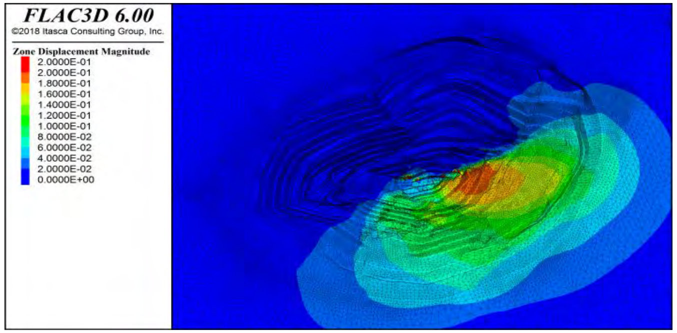
After 2020 underground working



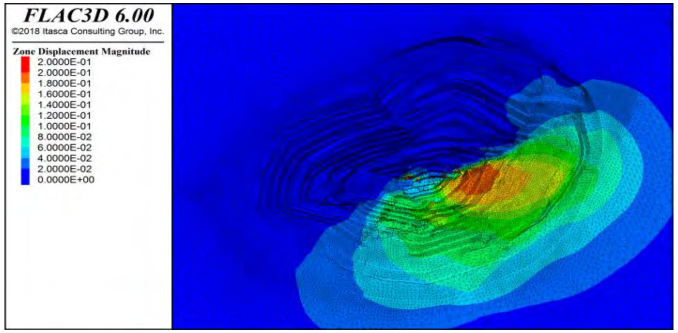
After 2021 underground working



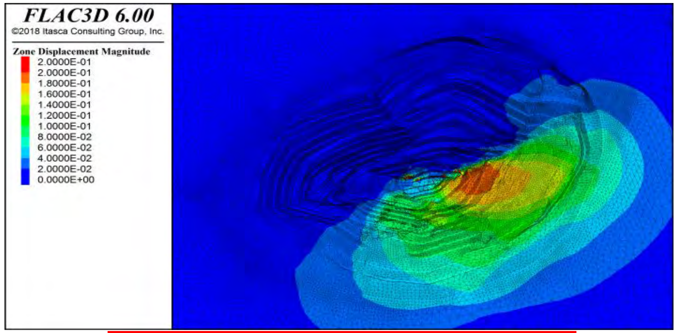
After 2022 underground working



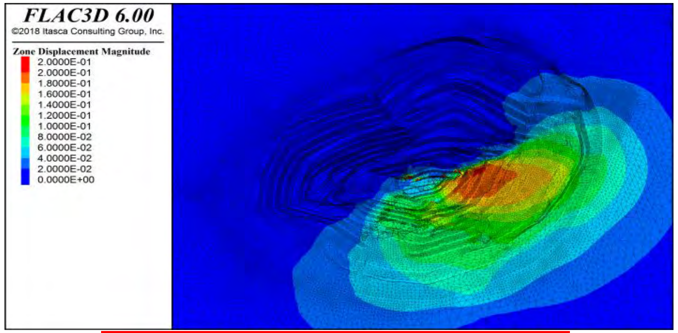
After 2023 underground working



After 2024 underground working



After 2025 underground working

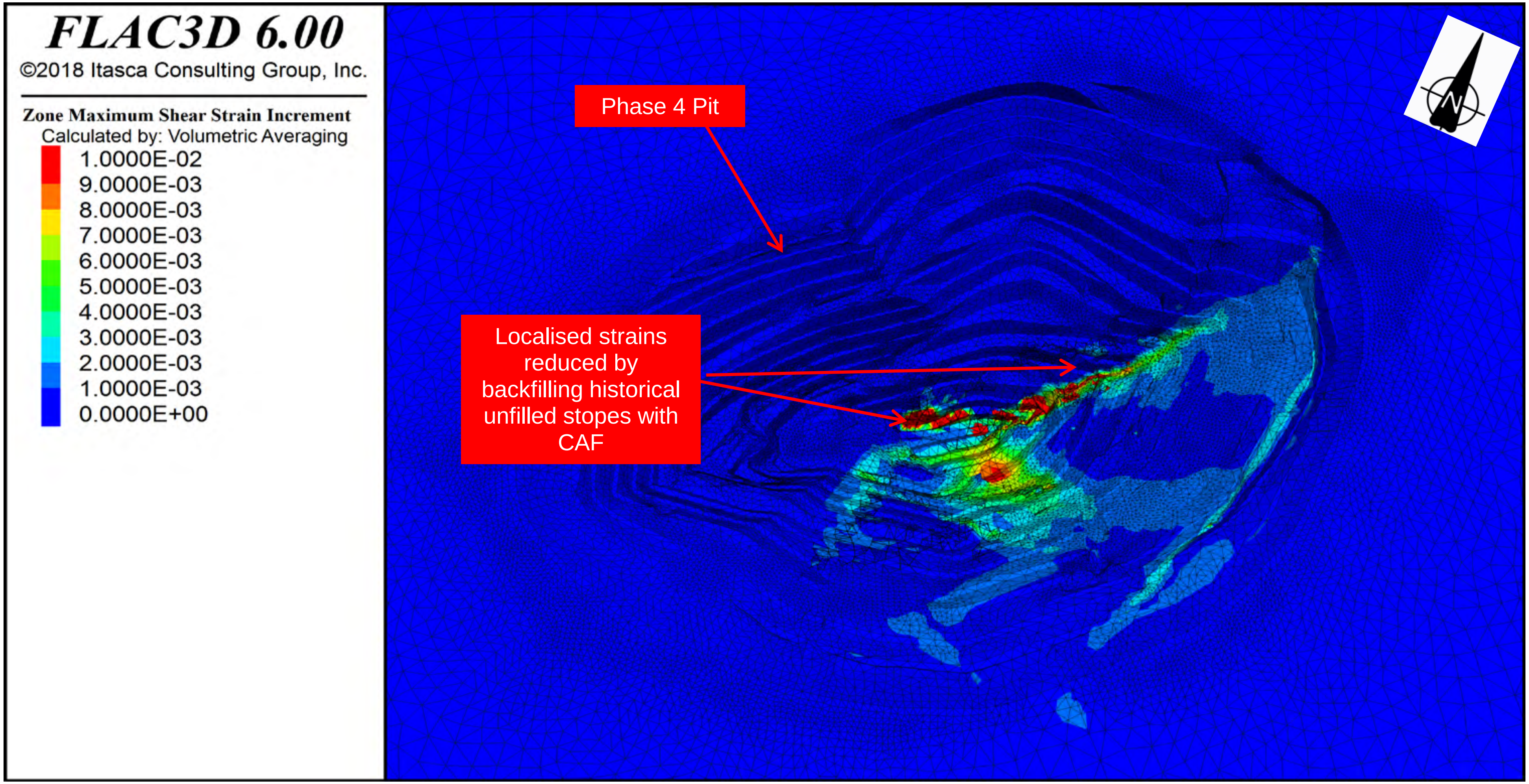


After 2026 underground working

Anderson Lloyd
Waihi, New Zealand
Numerical Model - Run 10
PREDICTED TOTAL DISPLACEMENT FOR YEARLY SEQUENCE

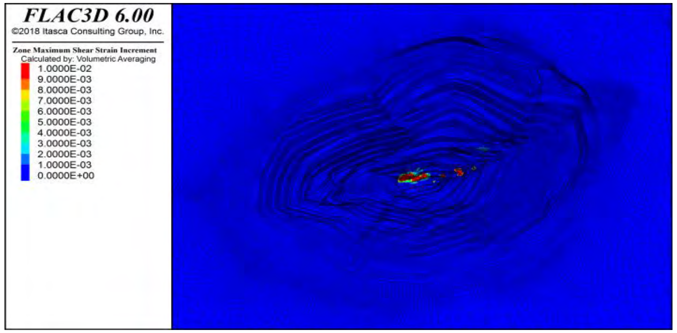
PSM125-283R	**Appendix K2**

PSM **Pells Sullivan Meynink**

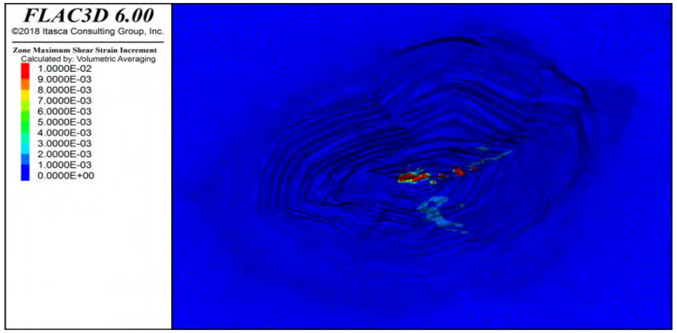


Pells Sullivan Meynink

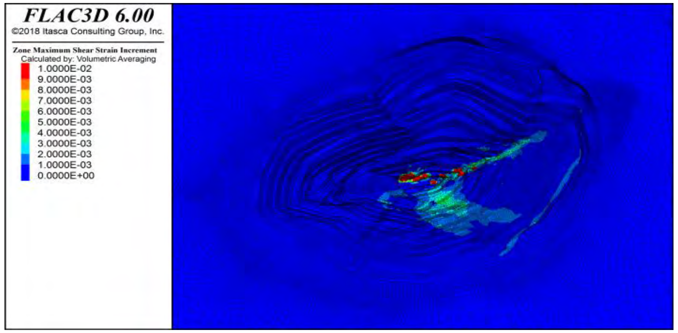
Anderson Lloyd Waihi, New Zealand Numerical Model - Run 10 PREDICTED MAX SHEAR STRAIN AFTER YEAR 9	
PSM125-283R	Appendix K3



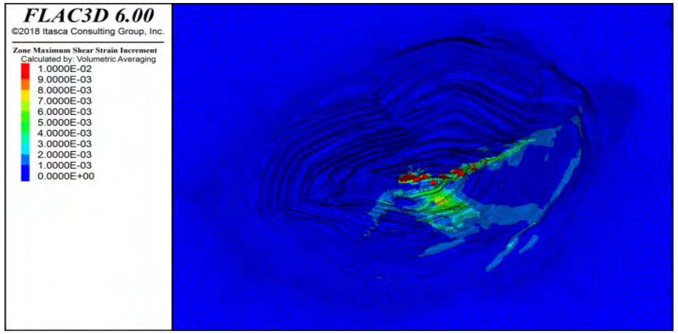
After Year 2 underground working



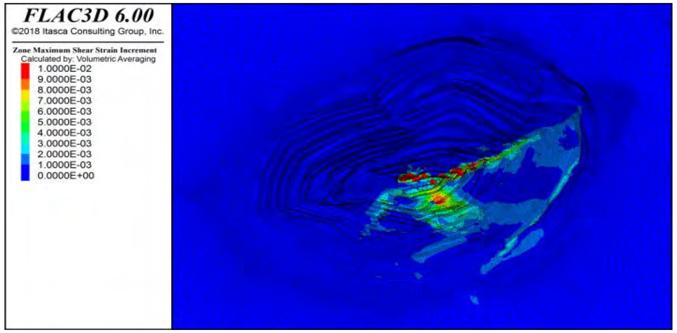
After Year 3 underground working



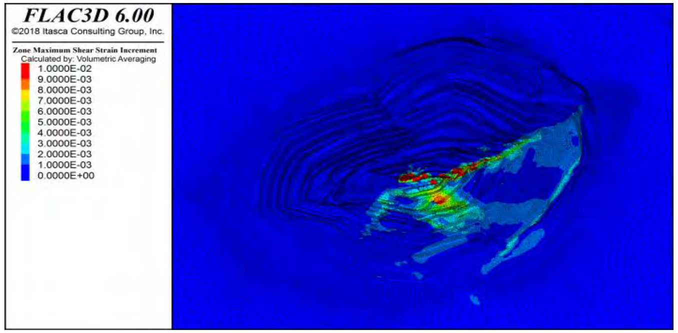
After Year 4 underground working



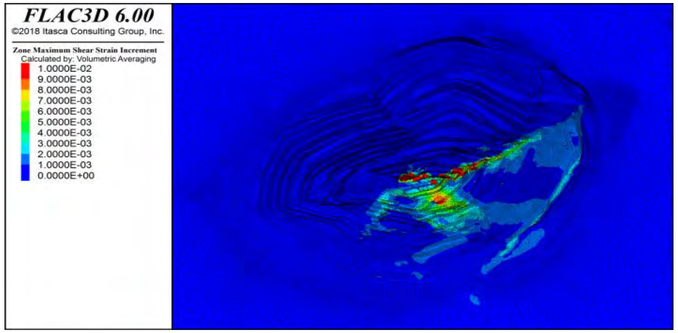
After Year 5 underground working



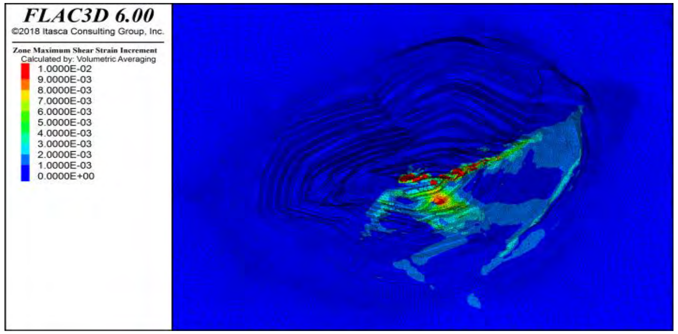
After Year 6 underground working



After Year 7 underground working



After Year 8 underground working



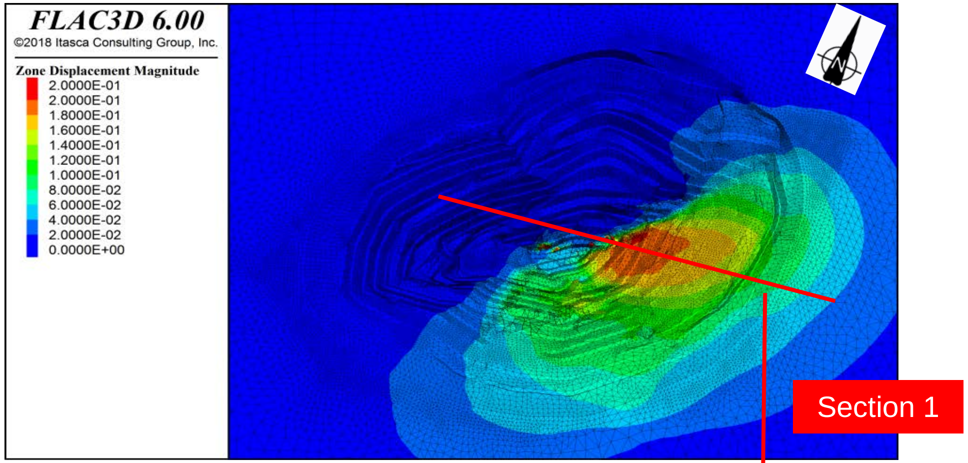
After Year 9 underground working

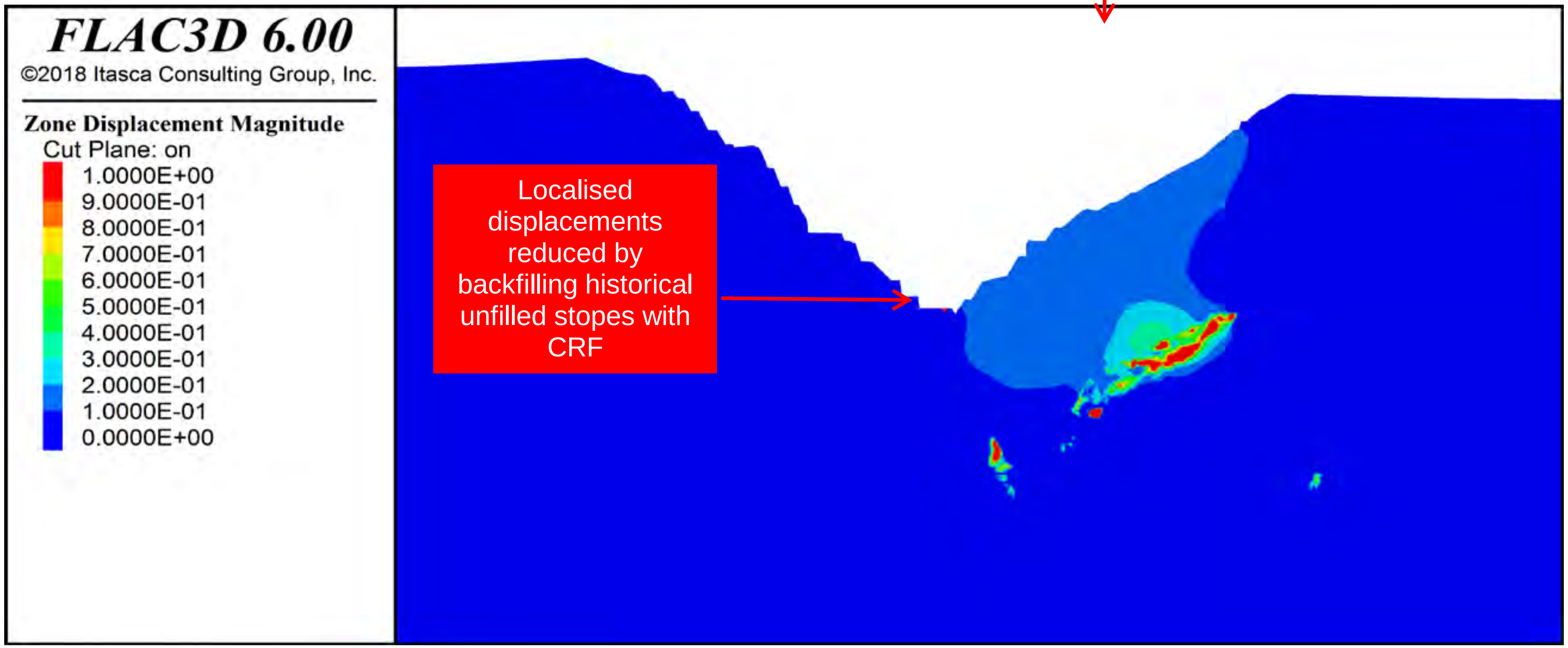
PSM

Pells Sullivan Meynink

Anderson Lloyd
Waihi, New Zealand
Numerical Model - Run 10
PREDICTED MAX SHEAR STRAIN FOR YEARLY SEQUENCE

PSM125-283R	**Appendix K4**





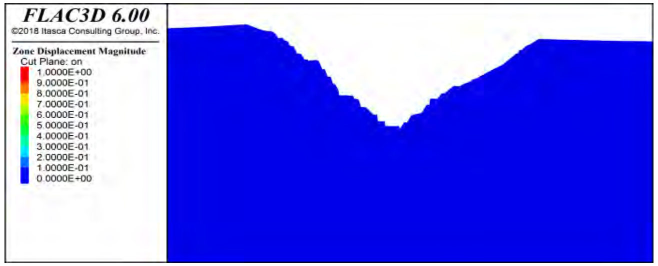
Anderson Lloyd
Waihi, New Zealand
Numerical Model - Run 10

PREDICTED TOTAL DISPLACEMENT OF SECTION 1 AFTER YEAR 9

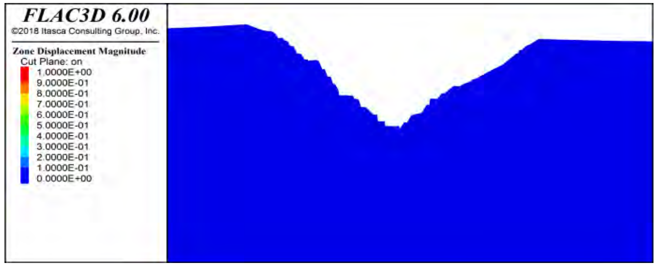
PSM125-283R	Appendix K5

PSM

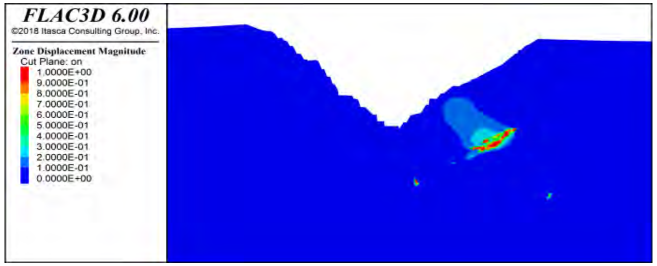
Pells Sullivan Meynink



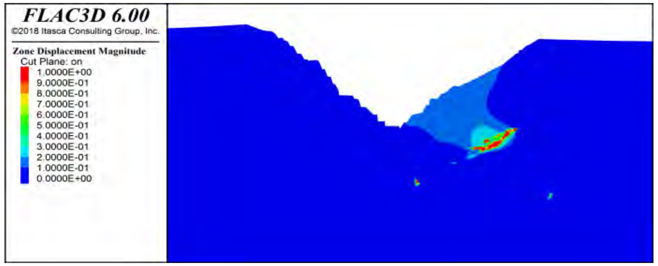
After Year 2 underground working



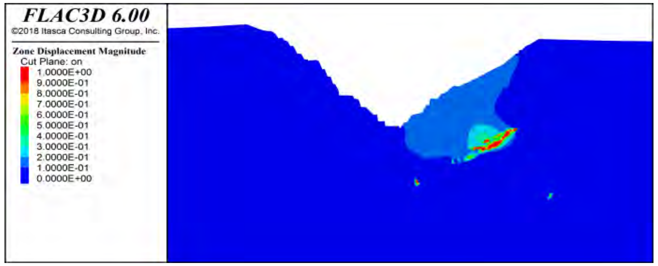
After Year 3 underground working



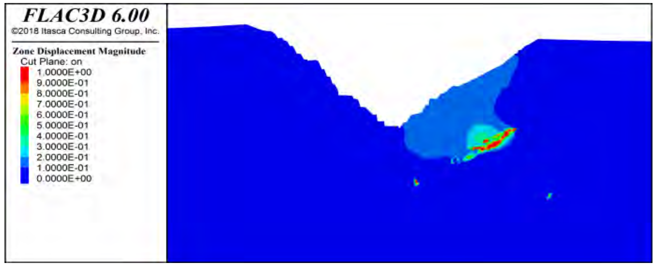
After Year 4 underground working



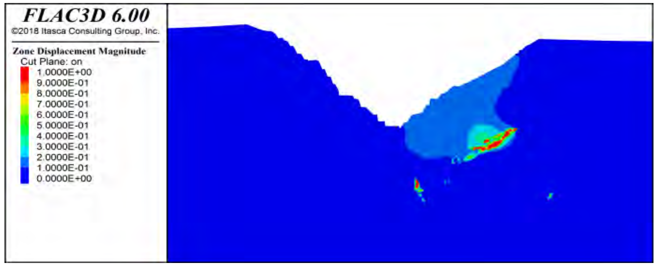
After Year 5 underground working



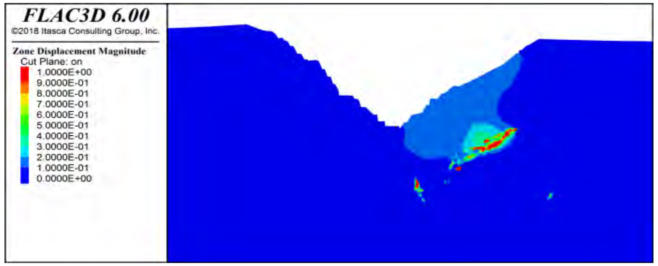
After Year 6 underground working



After Year 7 underground working



After Year 8 underground working



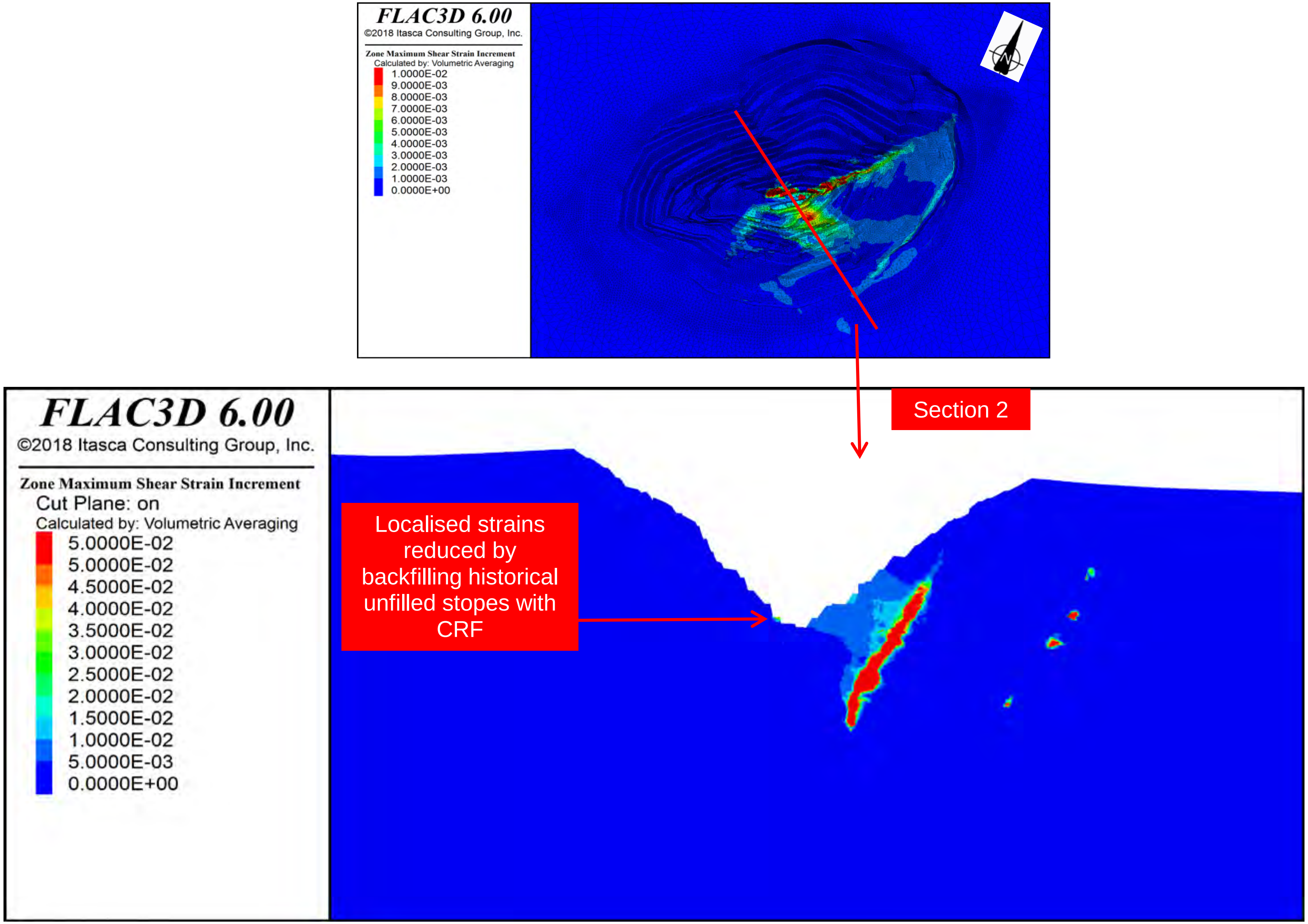
After Year 9 underground working

PSM

Pells Sullivan Meynink

Anderson Lloyd
Waihi, New Zealand
Numerical Model - Run 10
PREDICTED TOTAL DISPLACEMENT OF SECTION 1 FOR YEARLY SEQUENCE

PSM125-283R	**Appendix K6**



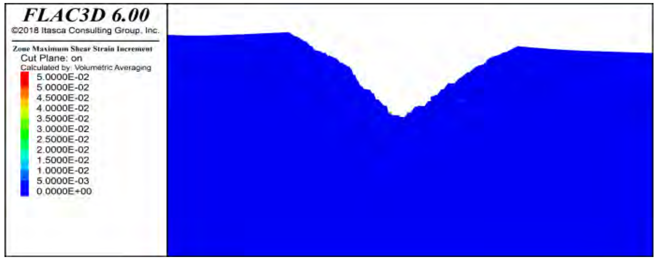
Anderson Lloyd
Waihi, New Zealand
Numerical Model - Run 10

PREDICTED MAX SHEAR STRAIN OF SECTION 2 AFTER YEAR 9

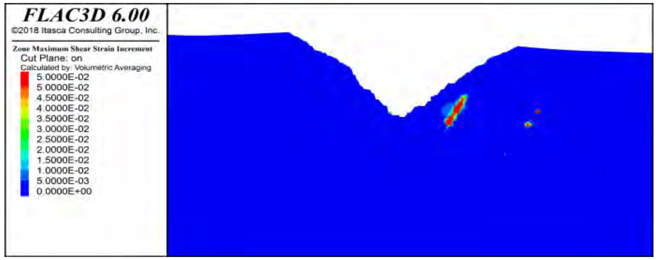
PSM125-283R	**Appendix K7**

PSM

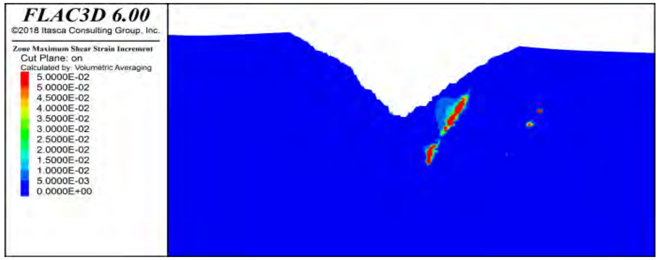
Pells Sullivan Meynink



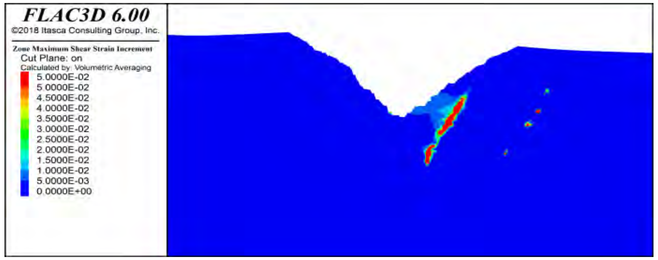
After Year 2 underground working



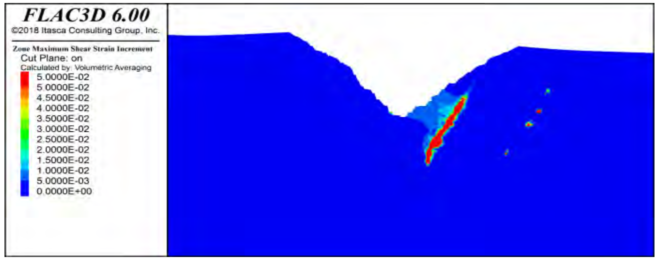
After Year 3 underground working



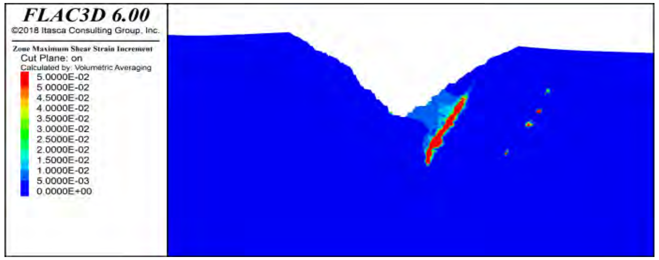
After Year 4 underground working



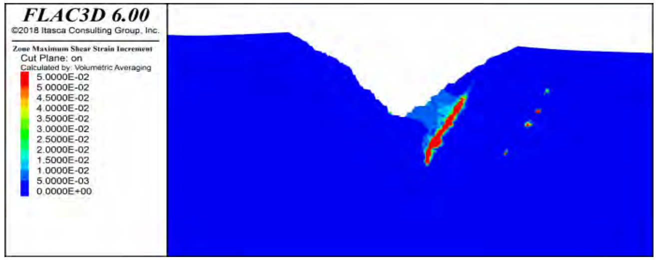
After Year 5 underground working



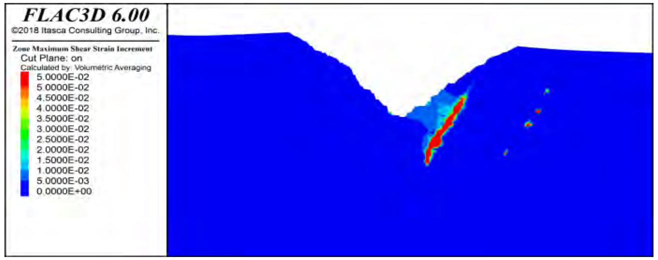
After Year 6 underground working



After Year 7 underground working



After Year 8 underground working



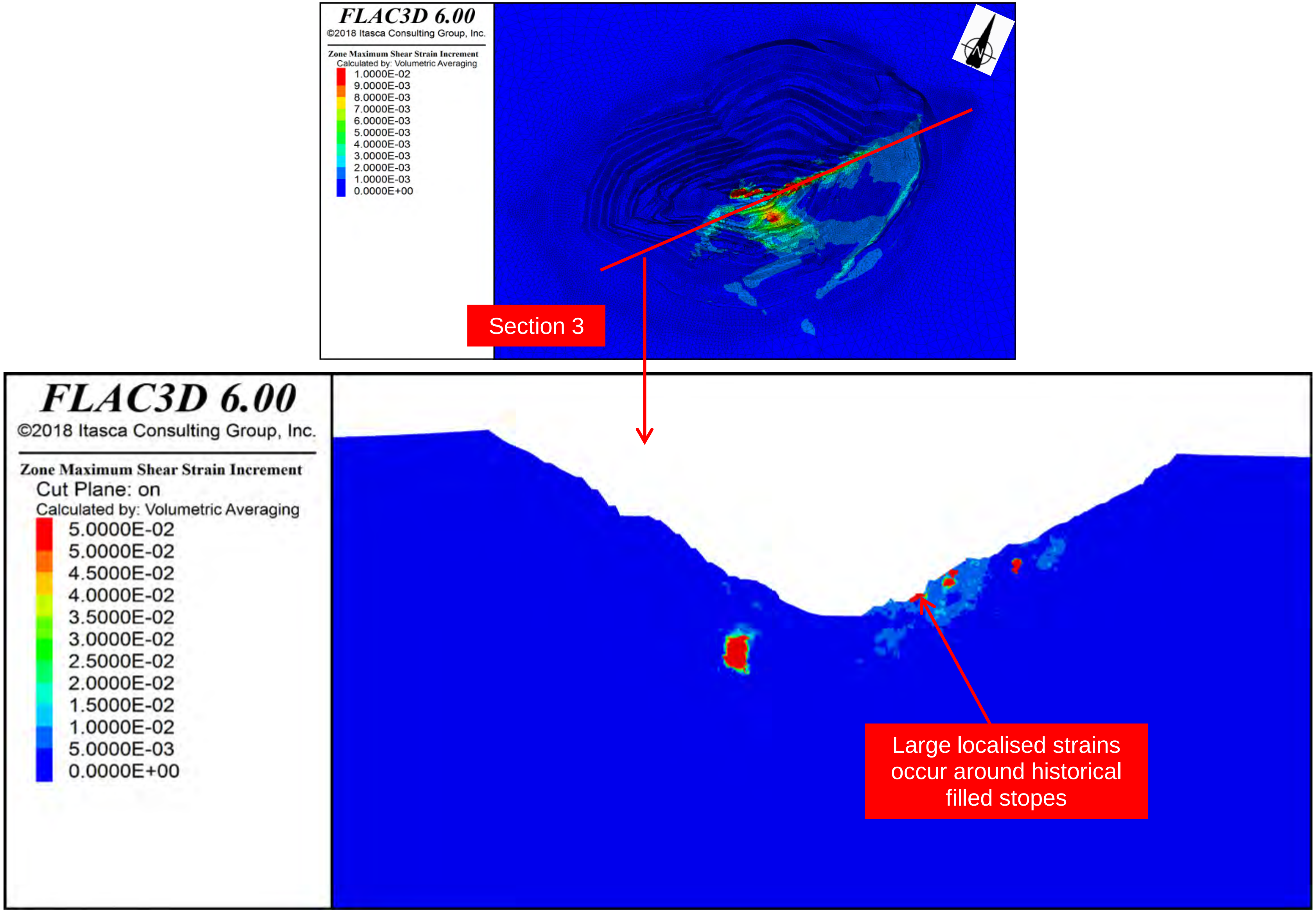
After Year 9 underground working

PSM

Pells Sullivan Meynink

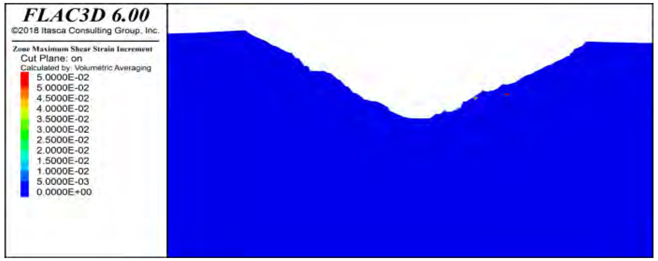
Anderson Lloyd
Waihi, New Zealand
Numerical Model - Run 10
PREDICTED MAX SHEAR STRAIN OF SECTION 2 FOR YEARLY SEQUENCE

PSM125-283R	**Appendix K8**

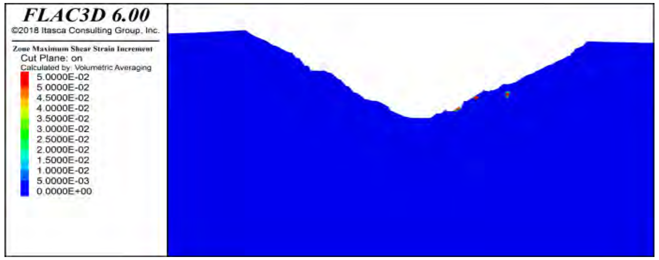


Pells Sullivan Meynink

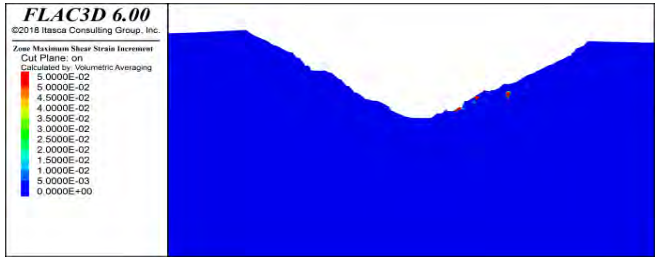
Anderson Lloyd Waihi, New Zealand Numerical Model - Run 10 PREDICTED MAX SHEAR STRAIN OF SECTION 3 AFTER YEAR 9	
PSM125-283R	Appendix K9



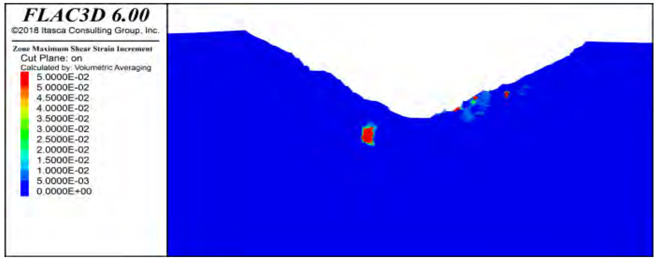
After Year 2 underground working



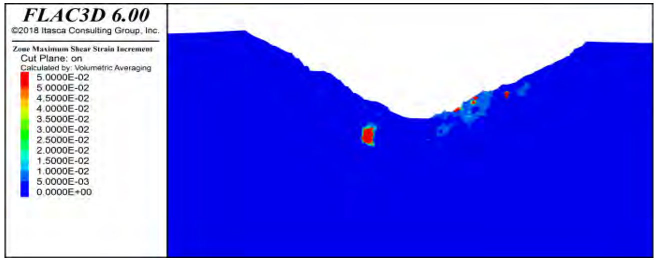
After Year 3 underground working



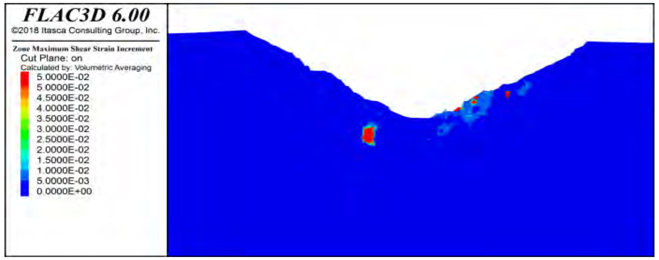
After Year 4 underground working



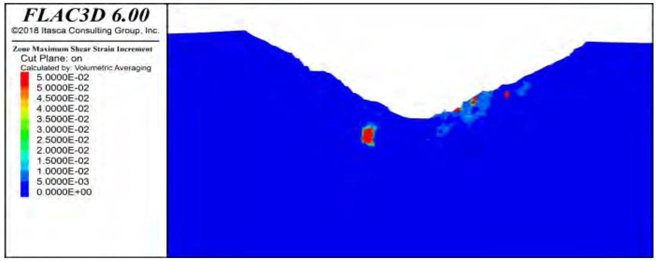
After Year 5 underground working



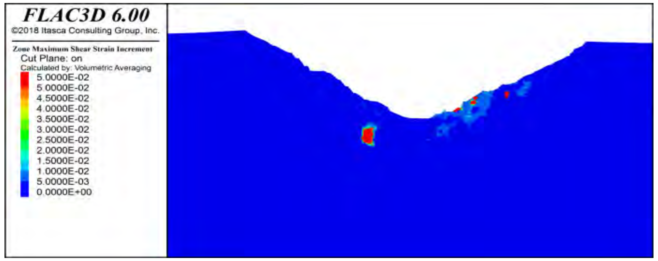
After Year 6 underground working



After Year 7 underground working



After Year 8 underground working



After Year 9 underground working

PSM Pells Sullivan Meynink

Anderson Lloyd Waihi, New Zealand Numerical Model - Run 10 PREDICTED MAX SHEAR STRAIN OF SECTION 3 FOR YEARLY SEQUENCE	
PSM125-283R	**Appendix K10**

Pells Sullivan Meynink
Engineering Consultants
Rock-Soil-Water

G3 56 Delhi Road
North Ryde NSW 2113
P: 61-2 9812 5000
F: 61-2 9812 5001
mailbox@psm.com.au
www.psm.com.au

MEMORANDUM

COMPANY:	**ANDERSON LLOYD**
ATTENTION:	**STEPHEN CHRISTENSEN**
OUR REF:	**PSM0125-285M**
FROM:	**GARETH SWARBRICK**
DATE:	**24 May 2018**

RE: COMMENTS FROM DR PETER FULLER REGARDING TO PSM0125-283 DRAFT

This memorandum presents the responses to the comments from Dr Peter Fuller regarding to the report PSM0125-283 DRAFT dated 09 April 2018. Dr. Fuller's comments are in *black italics* and the responses are in *blue italics.*

As requested, I have reviewed what I'll refer to as the Interaction Report. Like the MP4 report, it's also an early draft with a few typos and a duplicate page but I have not noted these in my comments and request below.

This report covers the setting up and running of a full 3D model of the local region of the MP4 pit and all proposed mining in Martha Underground (MUG) except the Rex vein down to levels substantially below the deepest proposed mining level. This has been no mean feat and striking a balance between resolution of the modelled behavior and hence resolution of results and the time for each model run is not easy. In my opinion PSM have achieved a very satisfactory result in this regard. The analysis has dealt appropriately with the uncertainty of various parameter values by analysing the effects of relatively large parameter variations on the behavior predicted by the model. Given the scale of what is proposed in Project Martha, I regard the results from this work as an essential part of the overall assessment of the project.

While the draft report quite concisely covers an assessment of model output, there is some additional information I require before commenting on its overall adequacy to enable its review for the s42A Staff Report. This is outlined below:

Request for additional information and clarification

1. *In the first dot point at the top of text p5, does "MUG development" just include stope openings or is some mine development (ie access) also included?*

   MUG (now simply termed the Martha Underground Mine in the revised report) development just includes the stopes opening and the drives (ie access) are not explicitly considered in the modelling.

2. *Can it be confirmed that mining in the Rex vein has not been included in the model. The PSM report on MP4 states that this is the case but it also needs to be clarified in this report.*

   It is confirmed that the mining in the Rex vein has not been included in the model.

3. *The geology model particularly for the upper N wall of the MP4 pit appears to differ from that shown in both the MP4 report and the Surface Settlement report. Is this the case and if so, is there a reason for the difference and is it likely to make any material difference to the model output?*

   Due to the difficulty in meshing generation of the complex geometry, only major geotechnical units are considered and also some modifications were required. Consequently some areas of the geology model are different to the reports. The maximum variation is controlled around 5 to 10 m. It is expected that the simplification will not result in large differences in the model output but this is hard to be quantitatively measured.

4. *It is noted that the stope voids have been modelled as being filled with very soft elastic material. What modulus 'filling' has been used in the model and how does this compare with the modulus used for rockfill?*

   The modulus of 1 MPa is used for modelling the stope voids instead of a true open void. This is to avoid numerical instability and prevent over closure of the stope walls. This modulus is one-tenth of the modulus used for the loose rockfill.

5. *In section 6.3, can some details of the post failure behaviour of the various modelled materials be included. This will be helpful when reviewing and assessing the results from the study.*

   The constitutive material model used is the Mohr-Coulomb model with the softened strengths. The mathematical formulation behind the numerical model is based on behaviour of materials approaching either equilibrium or steady plastic deformations. As a result, the model is unable to reliably predict large post-failure deformations for situations which are far-off from equilibrium state and for situations with non-steady plastic deformations. Therefore, it is emphasised that the model is likely to underestimate the post-failure displacements. The displacement predictions will mainly be used to assess the deformation trend and to identify locations of relatively higher displacement.

6. *In section 7.3, paragraph 1, can the meaning of bracketing 'parameters with the least confidence' be clarified.*

   The "parameters with the least confidence" means that parameters with highest uncertainty.

7. *Section 8.1 refers to Sections 1,2 and 3 and while it becomes clear where these are located after reading section 8.2, can the Figure references showing their location also be included in section 8.1.*

   The Figures showing Section 1,2 and 3 have been included in Section 8.1.

8. *Section 8.2 refers to the backfill included in Run 4 as being "compacted rock fill". Is this CAF, ie cemented rock fill?*

   Yes, "compacted rock fill" refers to CAF (cemented aggregate rockfill).

9. *Is it correct to assume that of the three results Sections, Section 2 best represents the opening size and shape of old stopes under the base of the N wall of MP4 or are those old stopes larger (ie wider and/or deeper) than in Section 2 further to the east?*

   Yes, Section 2 best represents the open size and shape of the old stopes under the base of the N wall of MP4. The width of the stopes is quite uniform around that location.

10. *The Figures showing Sections 1,2 and 3 need to include the viewing direction. Although this is implied knowledge of those familiar with the site, it's clarification should avoid misinterpretation!*

    This has been included in the revised report.

11. *What is the reason for virtually none of the underground stopes showing any local distortion in the model output? Is this a function of the modulus of the stope void filling material mentioned in point 4 above?*

    Yes, the distortion of underground stopes is the function of the modulus of the backfill material. This can be seen from the sensitive study, there are less localised displacements and strains around the stopes by increasing the modulus of the backfill materials. This is also why the modulus of 1 MPa is used for modelling the stope voids instead of a true open void, as mentioned in point 4 above. This helps to reduce the distortion and facilitate numerical computation convergence.

12. *In the Conclusions section, point 4 refers to "errors" in stope volumes. Is this intended to mean variations, both planned and unplanned? It is noted that "inaccuracies" is used in section 8.8 presumably to make the same point.*

    Both "errors" and "inaccuracies" mean the variations in modelled stope volumes compared with the design volumes of the planned stopes. This is not intended to model any unplanned stopes but to assess how sensitive of results to the volume of the stopes being modelled.

13. *When comparing results shown in Figure 31 to those in Figure 41 for example, can a note be included to alert the reader that the colour coded scales in these two Figures are substantially different. There are possibly other comparisons where this comment needs to be included as well. In some displacement colour codes, the max. value (of 2 for example) is the same as the bottom of the red zone. Is the upper value meant to be 2.2 for this example?*

A note has been included in the Figures when the colour coded scales are different in the finalized report. For the example mentioned above, the upper value is still meant to be 2.

14. *With the simulated mining of increased tonnes defined as Volume 2, has this been achieved by making stoped areas longer, deeper or wider or some combination of these?*

    The approach adopted in modelling the stopes is to input the geometry surfaces of the stopes and identify the elements within the geometry surfaces. The increased volume (defined as Volume 2) is achieved by identifying more elements closing the geometry surfaces of the stopes. Hence, the stopes modelled in Volume 2 are expanded in three dimensions compared with the design condition.

15. *In displacement result plots (all shown as contoured zones in plan) there is no indication of the movement direction and whether this varies particularly across zones of highest displacement. It would be helpful if some examples of movement directions could be shown for the three Sections.*

    This has been shown in the revised report.

16. *Point 7 in the Conclusions section refers to MUG not resulting "in large scale instability". Has the model been run to a stage whereby movement/shear stress in zones of largest movement has reached some steady state condition?*

    The term "large scale instability" refers to the equilibrium condition cannot be reached in the model (ie, the results cannot be converged). The models have only been run to a stage where the equilibrium condition can be reached – i.e. a steady state condition where all interacting forces have equilibrated. As indicated in point 5, the model is unable to reliably predict large post-failure deformations hence it is likely to underestimate the post-failure displacements.

17. *In the second listed point 1 in the Conclusions section, please clarify if the recommendation is to stabilize all "unfilled historic stopes" with CAF or with uncemented rockfill. In Table 7.5, can the status of backfill in stopes, both old historic ones and proposed ones be clarified for each Run. A suggestion is to create a new Table showing Run # versus whether backfill exists, and backfill type (ie rockfill or CAF) in initially unfilled old historic stopes, and in planned new MUG stopes. Is it planned to mine some old historic <u>filled</u> stopes and if so, what type of backfill has been modelled for the fill in these after they have been mined?*

    Our analysis has shown that backfilling of proposed stoping by rockfill provides a substantial benefit to overall pit performance. In our analyses we also considered what additional benefits could be gained by the use of CAF in strategic areas of historical stoping. While the benefits were measurable they are confined to localized areas at the base of the north wall and not of a significant benefit to pit stability generally. We have reworded our report to better encapsulate these findings whereby use of CAF would provide some limited benefit but not improve pit slope performance overall. More discussion on ways to manage these areas is discussed in PSM125-282R Rev 2.

We have also included new table (Table 7.2) has been created to show the Run vs Backfill Condition in the revised report.

18. *Also on the subject of backfill, does Run 6 have all but the upper 30m of old historic stopes filled with rockfill (ie uncemented fill) or are these modelled as being open with only the upper 30m of old stopes below the pit filled with CAF? You'll note from these last two points 17 and 18 that the matter of backfill and which areas have been modelled with what type of backfill is currently unclear to me.*

    In Run 6, only the historical unfilled stopes 30m below the pit are backfilled with CAF and other locations of the historical unfilled stopes are modelled as being open. The new table Table 7.2 shows the Run vs Backfill Condition in the finalized report.

19. *And finally!, a stated objective in section 3 of the report was to assess the influence of MUG on surrounding areas. Can some comment on this be included in the report.*

    The model simulates an area of ground 2000 m wide and 1500 m long in plan incorporated the pit and proposed underground working. Due to the proposed underground working, the displacements and strains occur mainly on the pit walls and around the underground stopes. There is little to no disturbance to the areas away from these locations on surrounding areas and this assessment has been included in the revised report.

For and on behalf of
PELLS SULLIVAN MEYNINK

GARETH SWARBRICK
Principal Geotechnical Engineer