SUBSIDENCE MONITORING & MANAGEMENT PLAN

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1 INTRODUCTION

Subsidence at the Resolution Copper (RC) project is predicted to occur in a typical slow and gradual process from approximately year 6 when the cave from the underground mining is expected to reach surface. This gradual subsiding of the surface and growth of the subsidence bowl will then occur as mining continues through its estimated 40-year life of the project and in a much smaller and slower capacity for a number of years after mining has ceased.

The dimensions, rate of change, the relative horizontal & vertical displacements of the subsidence footprint have been predicted by the ITASCA Consulting Group, Inc, through the use of their explicit finite-difference program (*FLAC3D)* that employs an industry accepted and well established caving algorithm to simulate large scale rockmass deformation and displacements.

There are a number of areas of importance that occur in and around the proposed mining operation that will receive particular attention in this monitoring and management programme. RC is committed to protecting and preserving these areas.

- *Apache Leap*
- *Queen Creek & Devils Canyons*
- *Highway US -60*

Additionally, Resolution Copper will maintain public access to the *Oak Flat Campground* (and area comprising approximately 50 acres and 16 developed campsites) as long as it is safe, with safety determined by compliance with Mine Safety and Health Administration (MSHA) regulations and guidance. Resolution will allow continued public access to Oak Flat Campground after the land exchange has been completed and the parcel is privately owned by Resolution Copper. The duration and extent of access would be determined by compliance with MSHA safety requirements. Based on subsidence impacts predicted in the EIS, public access is expected to continue for more than thirty years and may never be restricted.

This monitoring and management plan will outline the methodologies and strategies to ensure that the impact of subsidence is continuously monitored, managed and communicated throughout the life of the mine and thereafter.

2 Overall Strategy for Subsidence Monitoring & Management

- Subsidence Monitoring Methodology
  - Will be subdivided into multiple phases of instrumentation installations and will be subjected to time dependencies as the mining progresses with subsequent growth in the surface subsidence footprint.

- Subsidence Management Methodology
  - Will use the predictions from the 2017, July 17th ITASCA report on surface subsidence for the RC operation in conjunction with actual field measurements obtained from the various instrumentation. A graphical comparative tracking tool will be used to measure and track actual data to modeled data. This will provide valuable early trends and projections on subsidence progression and rates of growth, which in turn will allow for early mechanism understandings and if required, implementation of any mitigation strategies.

3 Monitoring Methods & Instrumentation

Surface subsidence at RC will be monitored using a number of different methods and instrumentation types using proven technology and best practice as seen throughout the industry. As such, methods and instrumentation may change over time. The frequencies of measurement recommended in the relevant phases represent a best initial estimate on how caving and the associated subsidence will progress. When caving commences and data starts becoming available, adjustments must be made on the monitoring frequency based on actual subsidence behavior to ensure that the data is fully representative of conditions.

The table below is a list of what is proposed, and the primary purpose and encompasses the entire subsidence monitoring window period from pre to post mining activities (Phase 1 through to 6).

Instrumentation/Monitoring Method	Purpose/Reasoning
InSAR (Interferometric synthetic aperture radar)	Measure changes in surface displacements (primary vertical sense with lateral calibration to other instruments) across a very large area.
Aerial Photogrammetry (Drone Technology)	Measure vertical & lateral (using targets in the field) displacements through 3D point cloud analysis of the surface. Furthermore, it also provides high definition images for observational analysis of subsidence behavior.
Robotic Prism Network using a Total Survey Station	Monitoring of survey prisms anchored to the surface at strategic points to validate the relative displacements captured through InSAR & Photogrammetry analyses.
LIDAR (Light Detection & Ranging)	Terrestrial laser scanning of important features like “Apache Leap” where steep rock faces are monitored for toppling/rotational type of displacements.

TDR's (Time Domain Reflectometers)	Monitor shallow to deep seated subsurface rockmass deformations and assist in tracking of cave propagation to surface in Phase 2. TDR's are limited in that they can only provide area/ location of ground movement and not magnitude.
Open Holes	Track & monitor the propagation of the cave to surface using simple borehole camera and/or weighted probe.
Cave Smartmarkers & Beacons with Detectors	Monitor cave growth, propagation and flow of material in the cave and sensitivities to draw
Wireless Wireless In-Ground Monitoring ("Geo4Sight")	Monitor shallow to deep seated subsurface rockmass deformation with magnitude and direction ability.
Inclinometers	Monitor near surface to ~ 250m (max) rockmass displacements. Limited to depths of ~ 250m and cannot tolerate high levels of rockmass deformation. Plan to use early on in phase 3 as a means to validate the Geo4Sight deformation interpretations. Can be phased out later in the monitoring programme.
Soil Extensometers (Multi-Point)	Monitor superficial (1-2m below surface) lateral displacements of overburden materials. Particularly useful close to areas of concern/importance as they are very sensitive and provide a high degree of accuracy.
Surface Monuments (Concrete Lock Blocks)	Monitor vertical, but primarily the lateral surface displacements (direction & magnitude) for calculating the angular distortion for any selected area.
Crack Mapping	Field observations of subsidence induced tension crack formation. Survey measurements of location, length, aperture and vertical offset. This monitoring should be started soon after breakthrough (Phase 3 onwards) and observations can be done initially using the photogrammetry images to identify onset and followed by field measurements and installation of "crackmeters" to monitor growth and trends.

4 Subsidence Monitoring

- Subdivided into 4 discrete caving related progression events and 6 phases of instrumentation and monitoring (Figure1)

Zones for Phased Monitoring & Instrumentation Installation

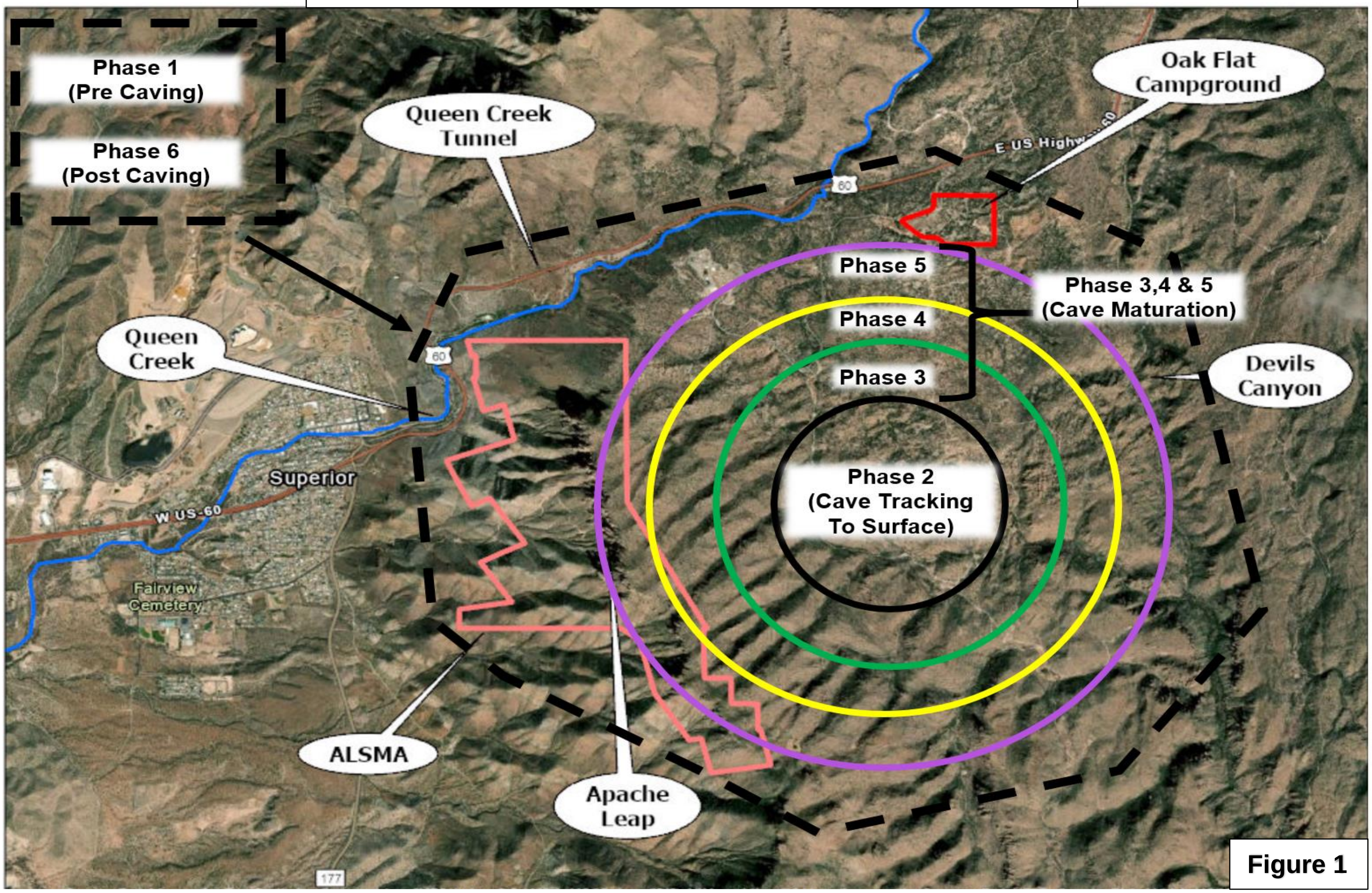


Figure 1

4.1 Pre-Caving (Phase 1)

This phase supplements baseline data readings of the entire area encompassing all the features/areas of particular interest as indicated in the figure above (Figure 1). This is to establish if there are any observable displacements that might be occurring in the absence of mining and if there are any seasonal fluctuations that are evident. It also allows one to establish fixed ground control targets and system calibration for future data processing and monitoring. Due to the very steep and high cliffs that comprise Apache Leap, in addition to the InSAR monitoring, it is further recommended to conduct terrestrial LIDAR with the intent of monitoring for any pre-mining toppling/rotational displacements of the rock faces.

Area/Zone/Phase	Monitoring Type	Frequency
Hatched Black Line (Regional Area with +/- 100m beyond the focus areas)	InSAR (Satellite Imagery)	2 x Annually
Apache Leap	LIDAR (Terrestrial)	2 x Annually

4.2 Caving to Surface (Phase 2)

During this phase the Cave has been initiated through production undercutting and steady state caving is achieved when the cave starts to propagate to surface. The modelling results from ITASCA suggests that it will be around year 6 when the cave reaches surface. Resolution will actively monitor the cave propagation rate, boundaries and track the cave geometry in this phase. This phase also allows for the refinement of exclusion zone boundaries and the timing of their implementation based on expected breakthrough of the Cave.

Note: This is also the time that the phase 3 monitoring network will be installed at least 6 months before expected cave breakthrough.

Area/Zone/Phase	Monitoring Type	Frequency
Polygon - Hatched Black Line (Regional Area with +/- 100m beyond the focus areas)	InSAR (Satellite Imagery)	2 x Annually
Apache Leap	LIDAR (Terrestrial)	2 x Annually

Solid Black Circle (Phase 2)	Cave Network Smart Markers/Beacons with Detectors	Continuously
	Time Domain Reflectometry Coaxial Cables	Continuously (Real-Time OR set at minute/hour reporting intervals)
	Micro-Seismic System	Continuously (Real-Time Data Acquisition with auto processing of events)
	Open Holes	Quarterly
	Aerial Photogrammetry (Drones) for Image & Point Cloud creation	2 x Annually Monthly for 3 months just prior to cave breakthrough
Solid Green Circle (Phase 3 – Baselining Data)	Inclinometers	Quarterly
	Wireless In-Ground Monitoring ("Geo4Sight")	Continuously (Real-Time Remote Data Acquisition)
	Soil Extensometers (Multi Point)	Continuously (Real-Time Remote Data Acquisition)
	Surface Monuments (Concrete "Lock Block" Targets)	As Per Photogrammetry Schedule Handheld GPS Confirmations – Quarterly
	Robotic Total Station Prism Network	Initial cycle every 6 hours

4.3 Cave Maturation after Breakthrough (Phase 3, 4 & 5)

These 3 phases of monitoring are tied to the gradual radial outward growth of the subsidence footprint as the cave matures. The ITASCA model (2017) will be used as a guide as to when the various phases of instrumentation installations are required and the estimated duration of the monitoring within each phase.

The reason for the multi-phased approach in this stage of cave maturation is to ensure that monitoring data is maintained as instruments will be gradually damaged and destroyed with increased deformation as the subsidence bowl enlarges.

The instrument types and monitoring methodology in all these phases will largely be duplicated with some minor field adjustments being made in terms of depth and dip of the subsurface instrumentation.

Area/Zone/Phase	Monitoring Type	Frequency
Polygon - Hatched Black Line (Regional Area with +/- 100m beyond the focus areas)	InSAR (Satellite Imagery)	2 x Annually
Apache Leap	LIDAR (Terrestrial)	2 x Annually
(Phase 3 – Green Circle) **Req'd (est) - Year 6 to 10** (Phase 4 – Yellow Circle) **Req'd (est) - Year 10 to 25** (Phase 5 – Purple Circle) **Req'd (est) - Year 25 to 40 (LOM)**	Inclinometers Wireless In-Ground Monitoring (Geo4Sight) Aerial Photogrammetry (Drones) for Image & Point Cloud creation Soil Extensometers (Multi Point) Surface Monuments (Concrete "Lock Block" Targets Robotic Total Station Prism Network Crack Mapping	Monthly Continuously Monthly (Adjust to bi-weekly if acceleration or anomalies observed- applies to Phase 3, 4 & 5) Continuously As Per Photogrammetry Schedule Continuously (Start with a ~ 6 hour cycle & adjust as required) Initially using aerial images from photogrammetry on same schedule/frequency. After onset of cracks. Quarterly (Phase 3), Monthly (Phase 4 & 5)

4.4 Post Caving (Phase 6)

This phase is characterized by time dependant compaction of the broken material within the mobilized zone of the cave. This compaction of material results in residual subsidence or “creep” which can occur over several years in the former mobilized zone, however the incremental changes or rate of subsidence reduces rapidly in an exponential fashion. Industry case studies indicate that a conservative estimation for full residual creep decay is in the order of 15 years. Another important aspect to note here is that historic post mining subsidence data gathered from San Manuel (large caving operation located in Arizona that ceased underground operations more than 20 years ago) revealed that the lateral extent of the fracture zone boundary remained static with the subsequent material compaction (time dependent creep) all occurring within the mobilized zone of the cave.

Based on this information, RC will continue to monitor the subsidence, any trends and potential impacts on key areas and infrastructure at the intervals below.

As mentioned, because the drop off in subsidence is very rapid after mining has ceased, the use of regional aerial monitoring techniques such as InSAR in combination with reduced LIDAR targets and frequency of measurements is sufficient to track any future subsidence growth or trends.

Area/Zone/Phase	Monitoring Type	Frequency
Hatched Black Line (Regional Area with +/- 100m beyond the focus areas)	InSAR (Satellite Imagery)	2 x Annually
Apache Leap	LIDAR (Terrestrial)	Annually (Increase frequency dependent on data trends obtained from InSAR)
Phase 3, 4 & 5	All remaining functional remote monitoring equipment used in Phase 3, 4 & 5	Quarterly data with threshold triggers

5 Subsidence Management

The monitoring plan outlined in the preceding section and the data obtained from the various instrumentation will be a fundamental input source in the overall management of subsidence. Tracking against predicted states of subsidence will provide insights into trends and will allow for projections and implementation of early mitigation measures, if required.

The data combined with the ITASCA numerical model predictions (Assessment of Surface Subsidence Associated with Caving Resolution Copper Mine Plan of Operations, July 17, 2017, Ref# 2-5605-01: 17R25) will be used as a basis for comparison to actual field measurements and associated subsidence profiles. An explanation of the process and the steps follow.

5.1 Subsidence Management Methodology, Triggers Levels and Associated Actions

- Figure 2 is a plot of angular distortion at year 40 (end of mining life) and as depicted by the hatched black lines, all the areas of specific importance and focused attention are located at various distances from the modelled centre of crater (CoC).

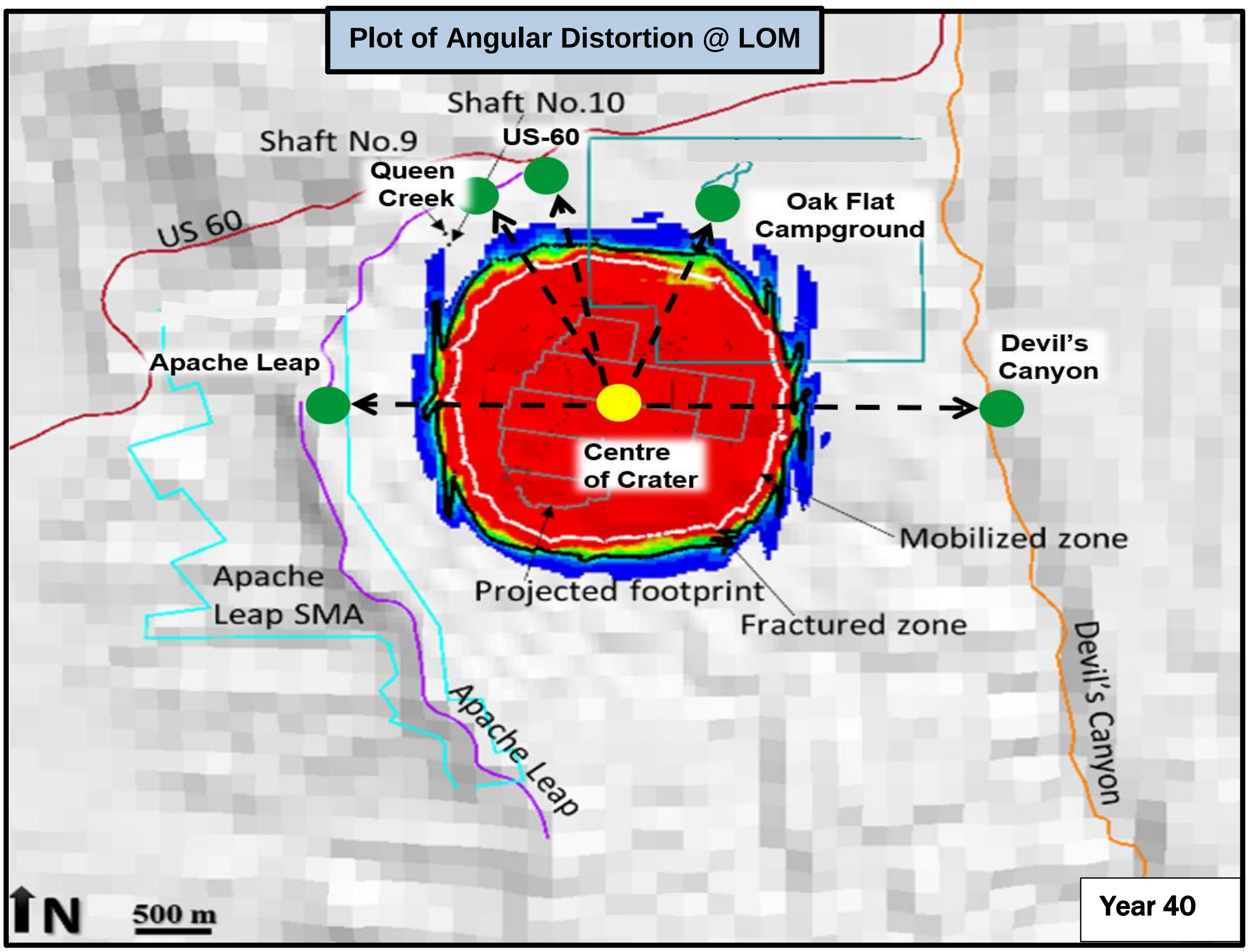


Figure 2

Angular distortion, β, is the ratio of the differential settlement (Δ or δ) between 2 points divided by the distance (L) between them as illustrated in a graphical sense in Appendix A. The mining induced subsidence naturally creates the differential imbalance resulting in the body distortion which in turn generates various strain gradients with tension cracks and scarps ultimately appearing as a surface expression.

A plot can then be generated from the predictive model along those lines to effectively represent a section through them for any year for any chosen deformation parameter. As an example, the plot shown in Figure 2 with a final state prediction and a static zone of ~400m (1280 feet) is for Apache Leap.

- This 400m static zone where no surface displacements are predicted can be seen as representing a factor of safety and are further subdivided into zones (Trigger Action Response Plan Levels 1, 2 & 3) that will generate triggers depending on the subsidence deviation and projected trends.
- Figure 3 below shows the angular distortion profiles from the CoC to Apache Leap for three selected time steps.
- TARP levels indicated in Figure 3 represent levels of deviation tolerances from the modelled condition. Level 1 = <150m, Level 2 = 150m to 250m, Level 3 = >250m.

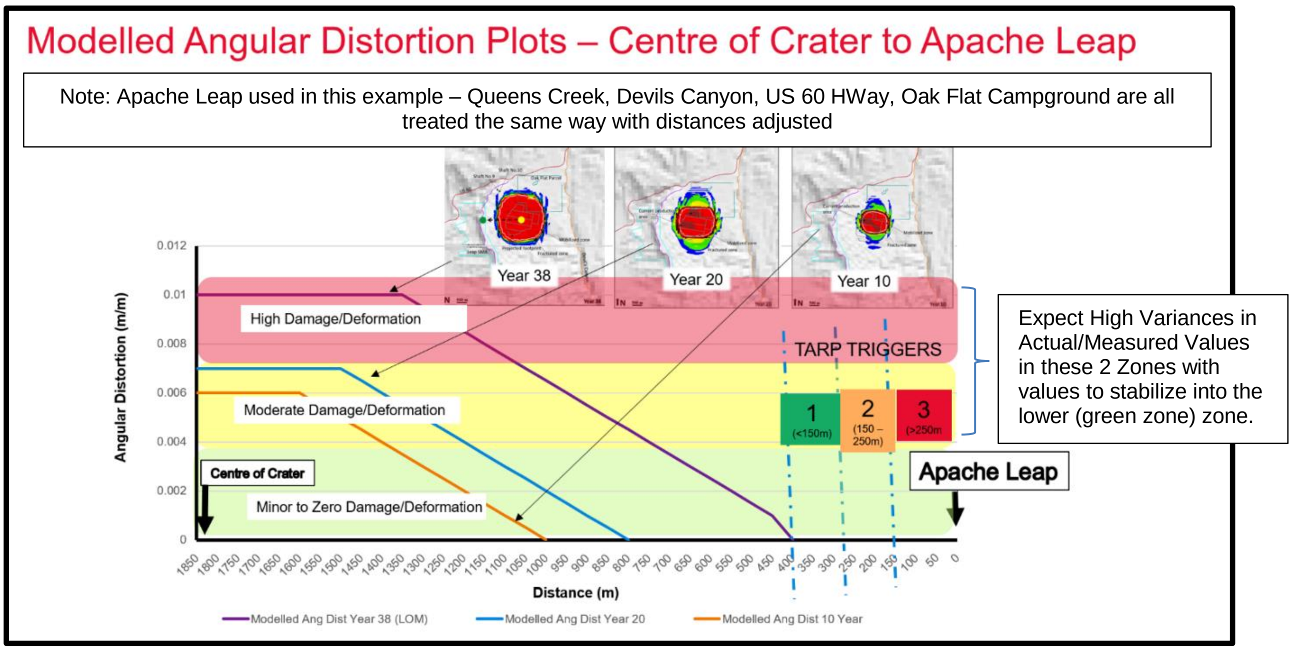
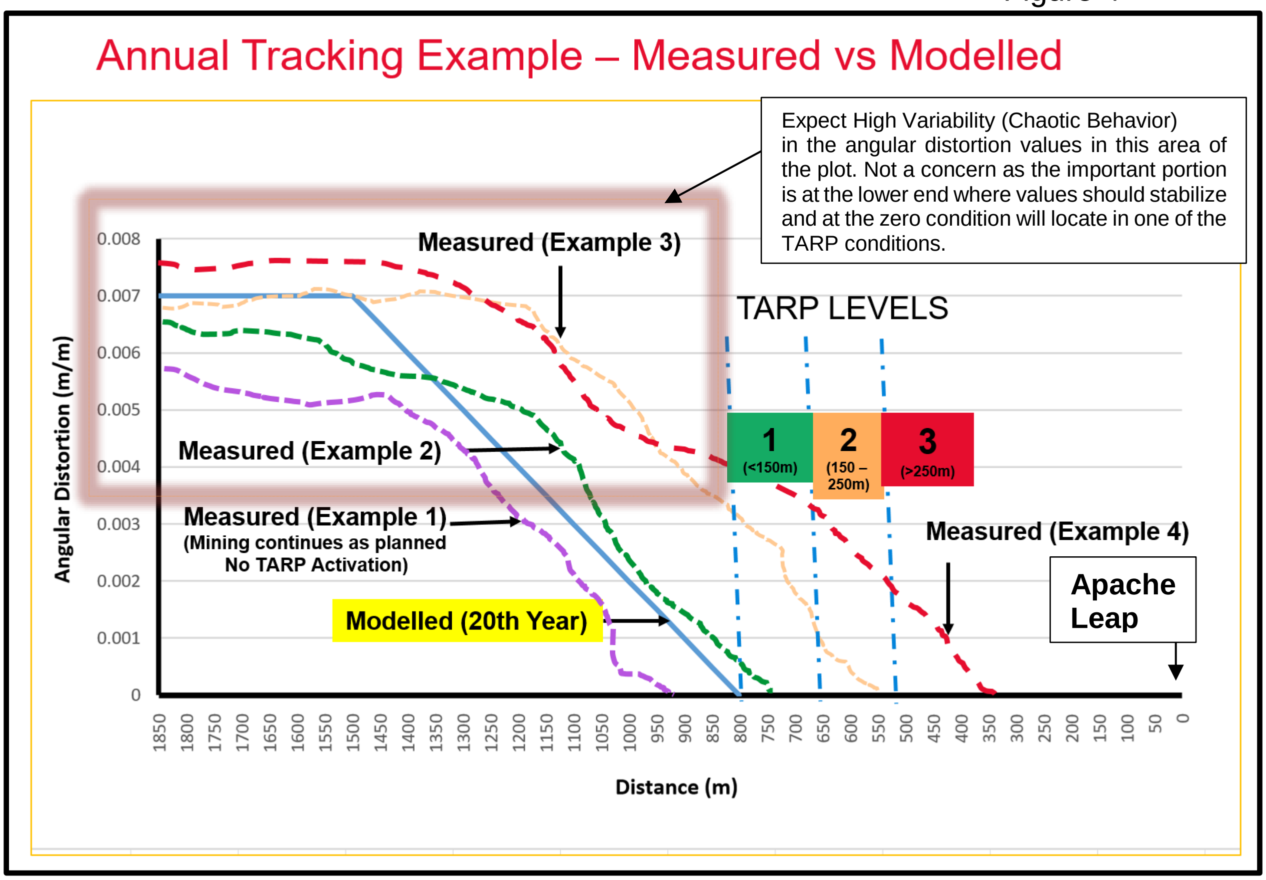


Figure 3

- The actions associated with each level are commensurate to the level condition, with level 1 being the lowest and level 3 requiring more stringent mitigations.
- The green, yellow and horizontal bars on the graph simply represent the angular distortion and horizontal strain limits used as an indicator of building damage (Harrison, 2011). They are included to show the relativity of scale and damage.

- Then using this approach and applying the offset distances obtained from the final mining step subsidence footprint as a means to evaluate potential risk of impact, generate actual plots from the field monitoring data and plot it against the relevant year from the modelled data plots as shown in Figure 4.
- If there is a "step out" or deviation in the subsidence profile during mining, and if the situation is not investigated or appropriate remedial/mitigation measures put in place, the offset will be retained through later stages of the mine's life and the areas of interest may be impacted as the subsidence bowl increases with progressive drawdown in the cave.
- As shown in Figure 4, as an example at year 20, including a modelled condition and four possible actual outcomes from the field measurements. Each one of those actuals/measured in this example will trigger a different response based on the magnitude of deviation and TARP level it falls within.

Figure 4



- Note that as per "measured Example 1" in Figure 4 that the actual falls below the modelled condition and therefore no actions are needed and mining continues as planned.
- The associated actions that apply to the TARP levels1, 2 & 3 are as per table1.

6 Reporting to USFS

For reporting to the USFS, all the subsidence data will be compiled and submitted in a format (TBD) that will capture the pertinent issues such as data observations, instrumentation and system status, data trends and tracking behavior.

Phase	Frequency
Phase 1 (Pre-Caving)	Annually
Phase 2 Caving to Surface)	2 x Annually
Phase 3, 4 & 5 (Cave Maturation after Breakthrough)	Quarterly
Phase 6 (Post Caving)	2 x Annually (First 10 years after Mining Cessation) Annually (Year 11+ after Mining Cessation)

7. *Subsidence Trigger Action Response Plan (Table 1)*

TRIGGER LEVEL	THRESHOLD/CONDITION DESCRIPTION	ACTIONS
1	Actual subsidence plotted against the modelled is in **excess of the prediction state with an offset not exceeding 150m**	1) RC to confirm the instruments are all functioning correctly and providing data on the intervals as required. 2) RC to conduct an internal data validation exercise to check on the data integrity and interpretations 3) The site Geotechnical Engineer must inform the Mine Manager of the outcome following the interrogation of the data. 4) RC Management to inform USFS of the subsidence exceedance condition 5) A field investigation to be conducted by a RC Geotechnical Engineer to assess and document the surface conditions specifically in the zone where the subsidence exceedance has occurred. 6) Geotechnical Engineer and Planning Engineer to check on production schedule and draw compliance and notify Production Manger to correct if deviations are noted. 7) Increase monitoring frequency and continue to track for any further deviations.
2	Actual subsidence plotted against the modelled is in **excess of the prediction state with an offset of 150m to 250m**	1) RC to confirm the instruments are all functioning correctly and providing data on the intervals as required. 2) RC to conduct an internal data validation exercise to check on the data integrity and interpretations. 3) RC to engage with an external and independent person/organization to conduct a similar instrumentation and data integrity review. 4) The site Geotechnical Engineer must inform the Mine Manager of the outcome following the interrogation of the data. 5) RC Management to inform USFS of the subsidence exceedance condition. 6) A field investigation to be conducted by a RC Geotechnical Engineer to assess and document the surface conditions specifically in the zone where the subsidence exceedance has occurred. 7) Geotechnical Engineer and Planning Engineer to check on production schedule and draw compliance and notify Production Manager to correct if deviations are noted. 8) Mining sequence and draw schedule to be altered to reduce potential further expansion or exceedance of the footprint by targeting production that would locate furthest from the surface feature of concern. 9) Add instrumentation (to fill any possible data gaps or improve sensitivity) and further increase monitoring frequency and continue to track for any further deviations.
3	Actual subsidence plotted against the modelled is in **excess of the prediction state with an offset of greater than 250m**	1) RC to immediately confirm the instruments are all functioning correctly and conduct an immediate data validation exercise to check on data integrity. 2) RC Geotechinical Engineer to immediately inform the RC Mine Manager on the condition observed. 3) RC Management to notify the USFS of the situation within 24hrs of having conducted the internal data validation. 4) All production (cave related drawpoint activities) to cease immediately. 5) Investigation to be initiated immediately to throroughly review the condition and identify possible causes for the exceedance level in the subsidence profile. 6) Investigation will determine the next steps, implement remedial measures as required and determine the options if restart of the cave production is possible at this time.

8. Schematic of Angular Distortion Concept (Appendix A)