

ORGANIZADO POR



INSTITUTO  
DE INGENIEROS  
DE MINAS  
DEL PERÚ



PERUMIN  
29 CONVENCION MINERA

# **“Tailings Storage and Heap Leaching in a Combined Facility – A First for the Mining Industry”**

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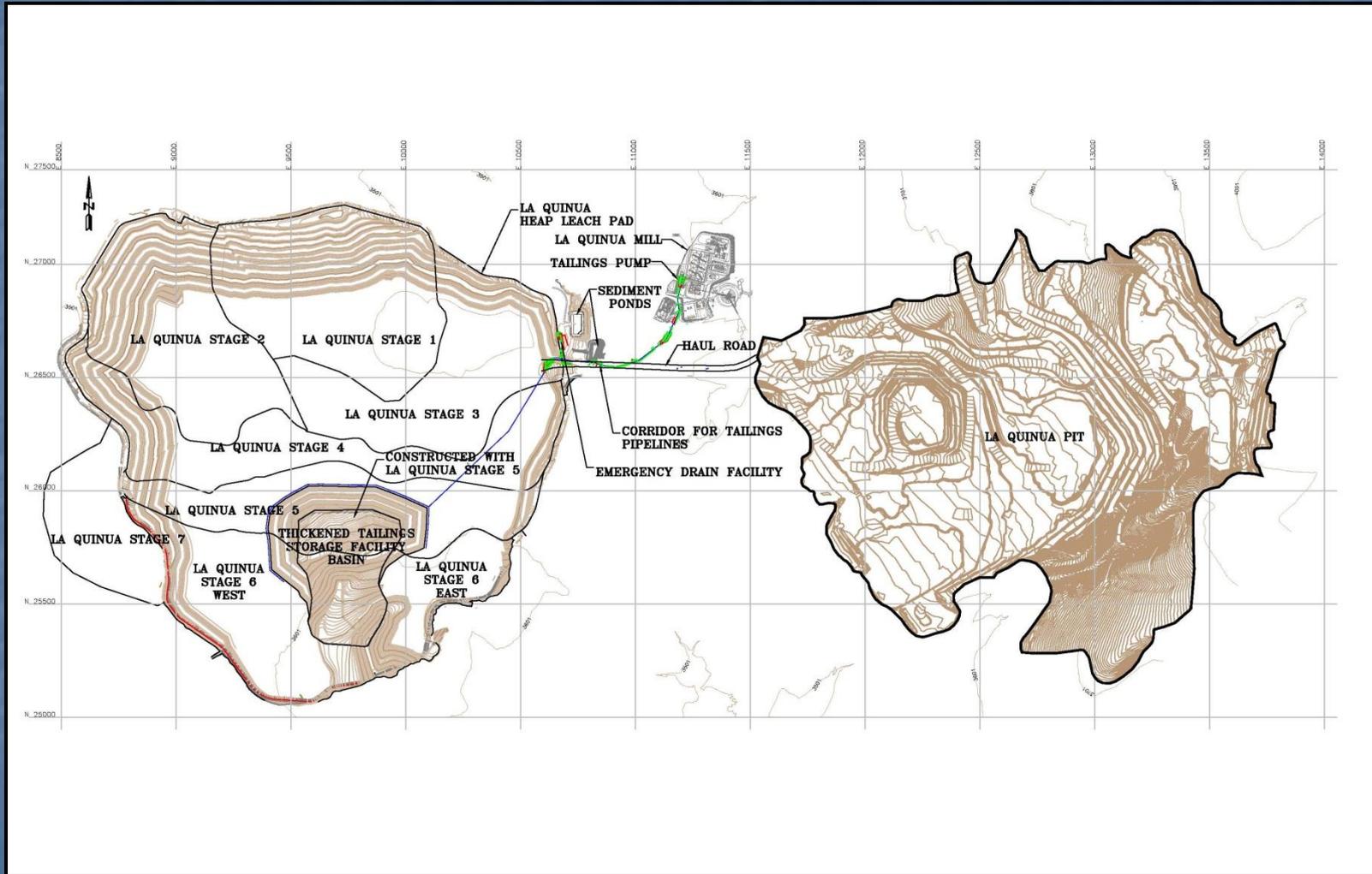
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Knight Piésold and Co.**

ENCUENTRO DE  
**OPERADORES**

# Overview

- **New La Quinua gold mill at the Yanacocha Mine has a thickened tailings storage facility (TTSF) contained entirely within a large (530 Mt and 130 m high) active heap leach pad (HLP)**
- **Unprecedented in the mining industry**
- **Provides the operator with cost, land use and closure efficiencies**
- **Constructed between 2006 and 2008 as part of the staged expansion of the La Quinua HLP – tailings deposition commenced in April 2008**

# General Arrangement Plan



# Artificial Oblique View Looking North



# Aerial View Looking West During Construction



# Key Design Issue

- **Leach ore embankments retaining tailings needed to provide the high level of security required of other major tailings dams**
- **However, the leach ore is placed in thick (16 m) uncompacted lifts to maintain adequate permeability for leaching and is irrigated with a high solution rate (10 L/hr/m<sup>2</sup>)**
- **Loose structure made static and dynamic liquefaction a key issue**

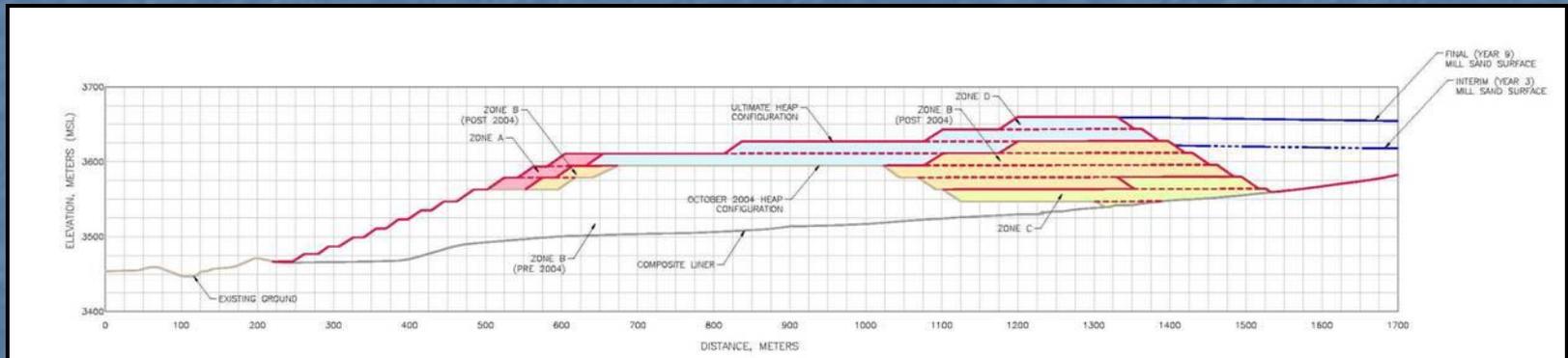
# Design Approach

**Keep the ore that becomes saturated or near saturated when under leach well-removed from the outer faces of the embankments and contained behind large unsaturated structural shells**

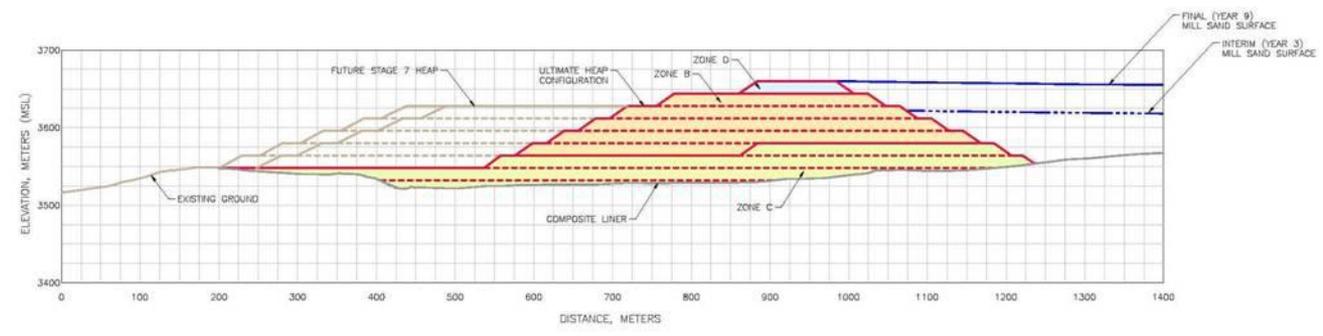
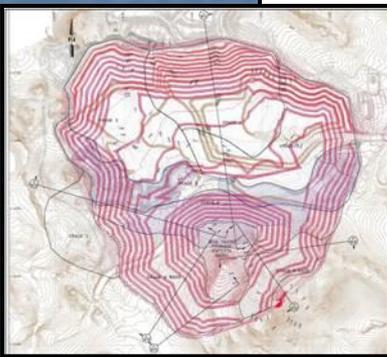
# Design Solution

- **Provide the embankments with wide cross sections to support loading and leaching and thus wide shells**
- **Place the ore in coarser (lower) and finer (higher) zones to promote vertical downward drainage and reduce lateral spread of flow**
- **Thicken the tailings to reduce the amount of water entering the combined facility**
- **Use a rotational tailings deposition method from the inside crests of the embankments to build drained and stable beaches against the embankments**

# Wide Zoned Cross Sections



**A**  
**8-1** NORTH SECTION (UPSTREAM)

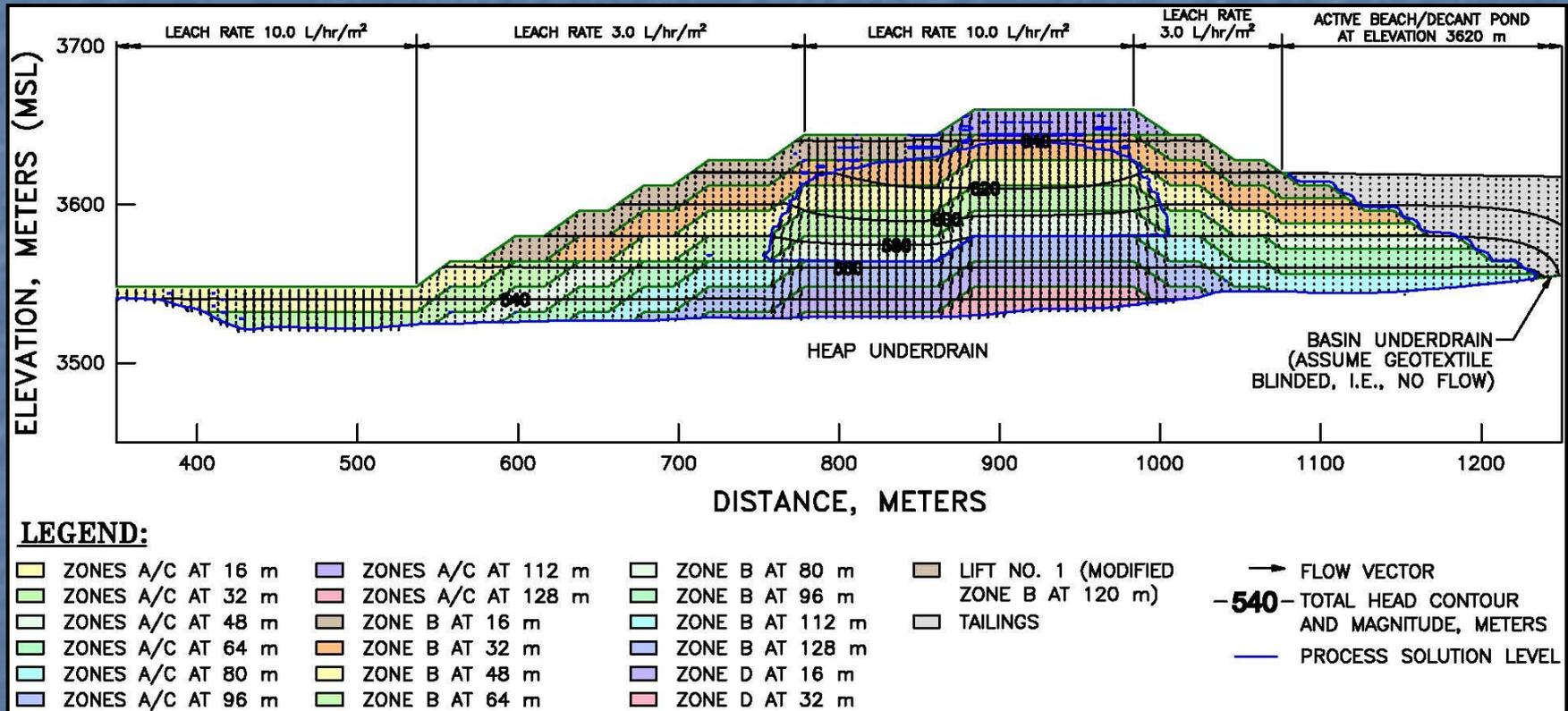


**B**  
**8-1** WEST SECTION (DOWNSTREAM AND UPSTREAM)

# Drained Beach Development

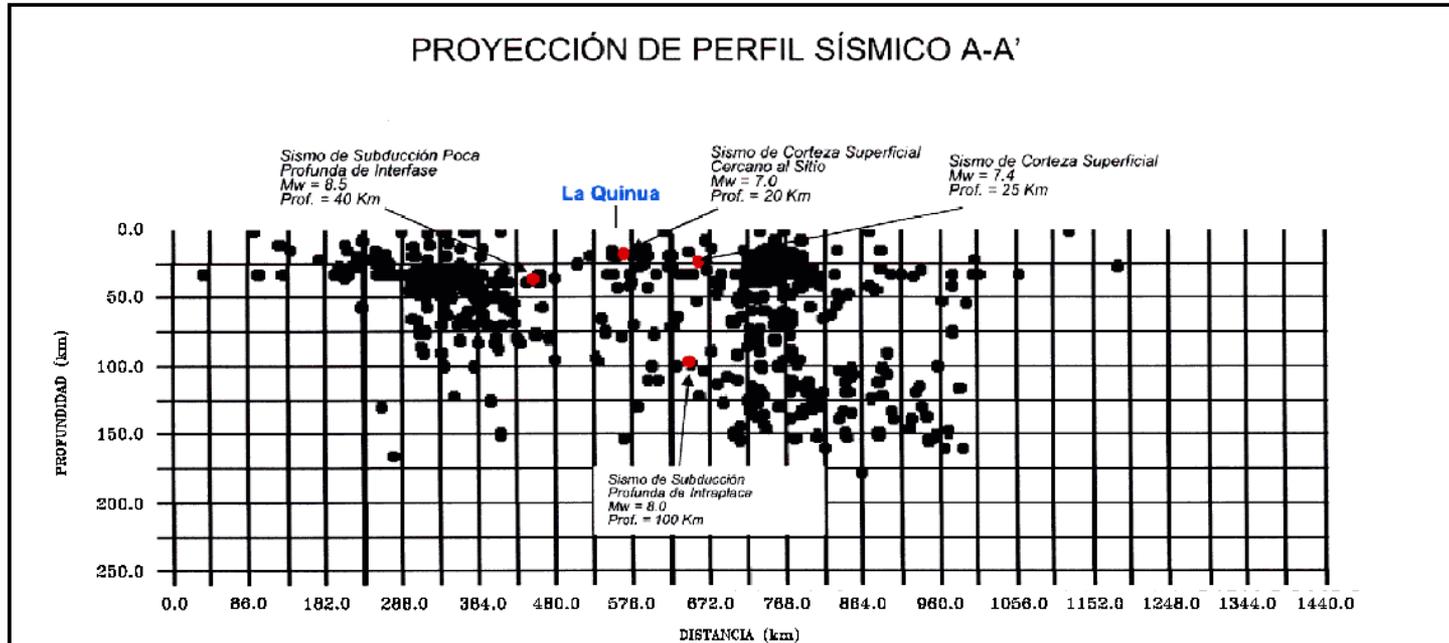


# Hydraulic Model Results



**Saturated zone is in center of embankment – flow vectors are vertically down – consistent with design objective**

# Seismic Risk of the Site



Maximum Design Earthquake (MDE) is equal to the Maximum Credible Earthquake (MCE)

Deep intraplate event below the Andes

Magnitude 8.0

Distance and depth 90 and 100 km, respectively

Resulting peak horizontal ground acceleration at the site is 0.41 g

**NOTE:**

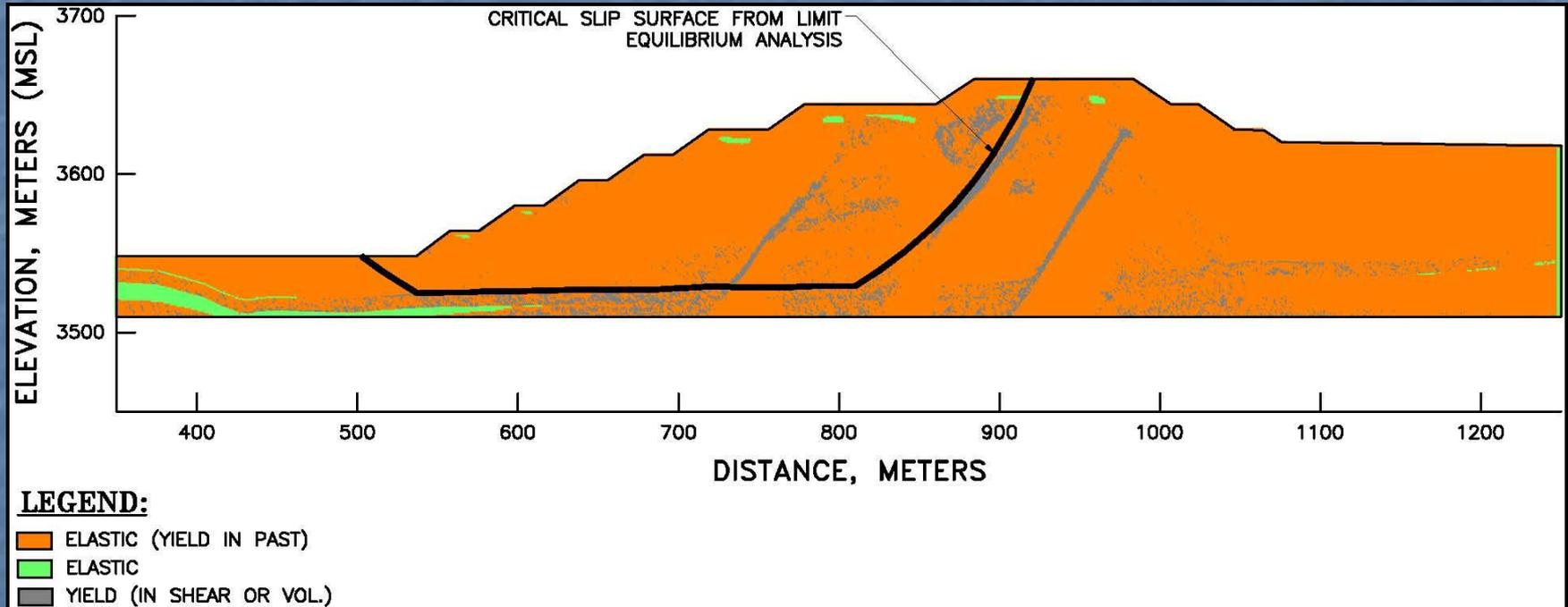
This figure has been reproduced from Dr. Jorge E. Arbo's report entitled "Análisis de Peligro Sísmico", La Quinua, June 2008. This report is provided in Appendix B.

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LA QUINUA GOLD MILL PROJECT					
<b>EXTREME EARTHQUAKE INTENSITY DISTRIBUTION DETERMINISTIC SEISMIC ANALYSIS SECTION A-A'</b>					
<b>Knight Piésold</b>					
DESIGNED BY:	JA	DATE:	PROJECT NUMBER:	FIELD NUMBER:	REVISION:
DRAWN BY:	DAD	12201	119-53	4-8	0
APPROVED BY:	N/A	DATE:	SCALE:		

# Design Earthquake

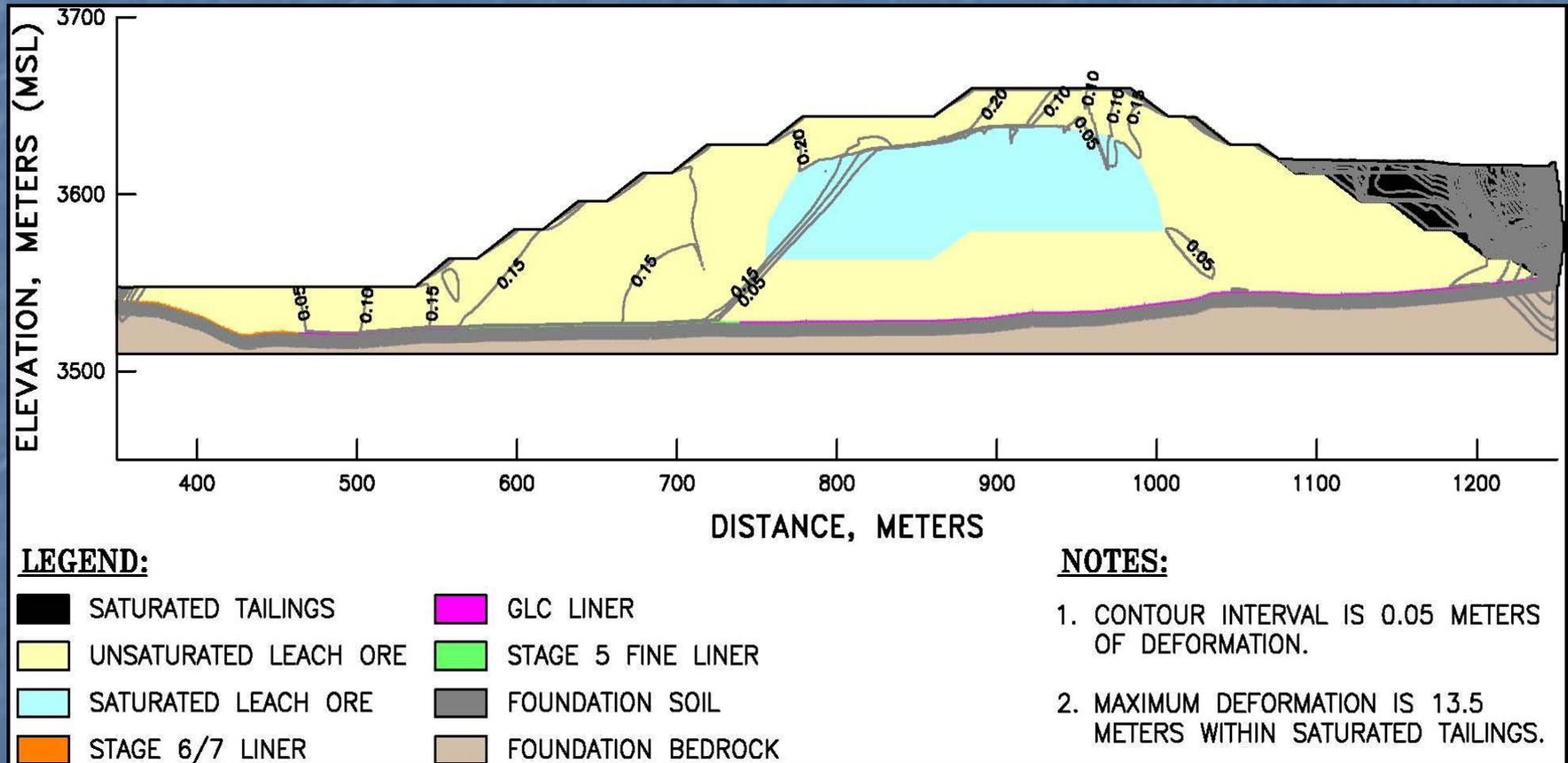
- **Maximum Design Earthquake (MDE) is equal to the Maximum Credible Earthquake (MCE)**
- **Deep intraplate event below the Andes**
- **Magnitude 8.0**
- **Distance and depth 90 and 100 km, respectively**
- **Resulting peak horizontal ground acceleration at the site is 0.41 g**

# Dynamic Stability Model Results



Shear bands from earthquake loading closely match the critical slip surfaces from static limit equilibrium analyses – along liner interface

# Dynamic Stability Model Results



## Contours of total deformation

- Maximum horizontal 15 cm along liner
- Maximum vertical 25 cm at crest

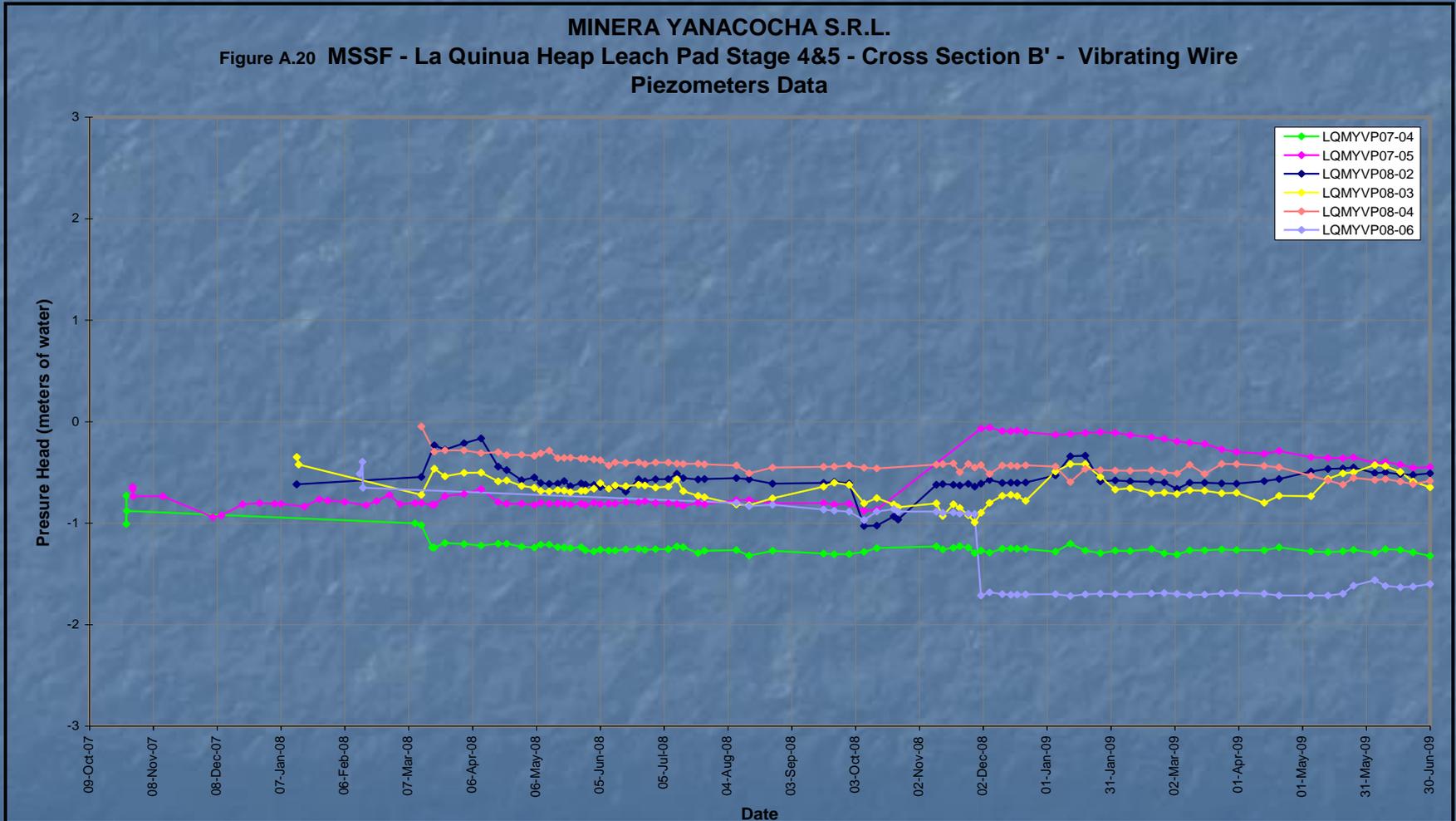
# Actual Leach Ore Placement

- **Sonic drill used to provide continuous samples of ore in the HLP**
- **Not adequate differentiation of fines content in designated zones**
- **Operation will put more emphasis on maintaining adequate unsaturated outer shells via controls on leach solution application and monitoring of instrumentation**

# Heap Leach Ore Piezometer Results Section B

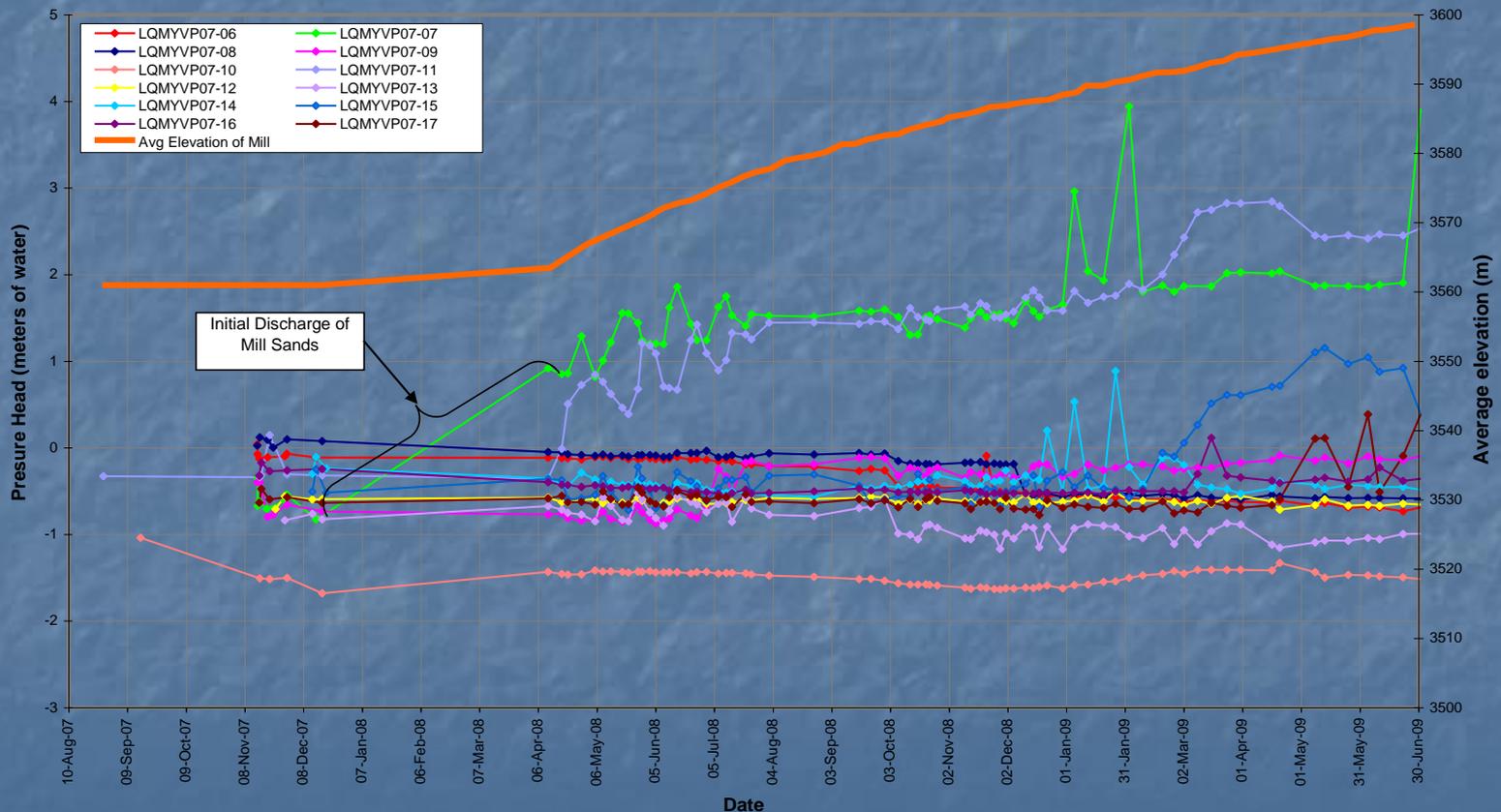
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Figure A.20 MSSF - La Quinoa Heap Leach Pad Stage 4&5 - Cross Section B' - Vibrating Wire Piezometers Data



# Tailings Facility Piezometer Results

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 Figure A.27 MSSF - La Quinoa Heap Leach Pad Stage 5&6 - DAM - Vibrating Wire Piezometers Data



# Water Management System



# Tailings Deposition System



# Conclusions

- **The La Quinoa TTSF is unique**
- **Contrary to standard tailings dam practice, it contains embankments of leach ore placed in thick, uncompacted lifts that are subject to application of large quantities of leach solution and percolation flows**
- **Dynamic analyses have shown that there is the potential for liquefaction or strain softening of saturated or near saturated internal zones but the overall predicted deformations are minimal**
- **Ultimate control on stability is by leach solution application rate**
- **Operation to date is meeting design objectives**
- **A comprehensive geotechnical investigation will be completed with follow-up dynamic deformation analyses based on actual materials placed**