Waste Characterization and Predicted Drainage Chemistry at the Antamina Mine after 10 Years of Operations

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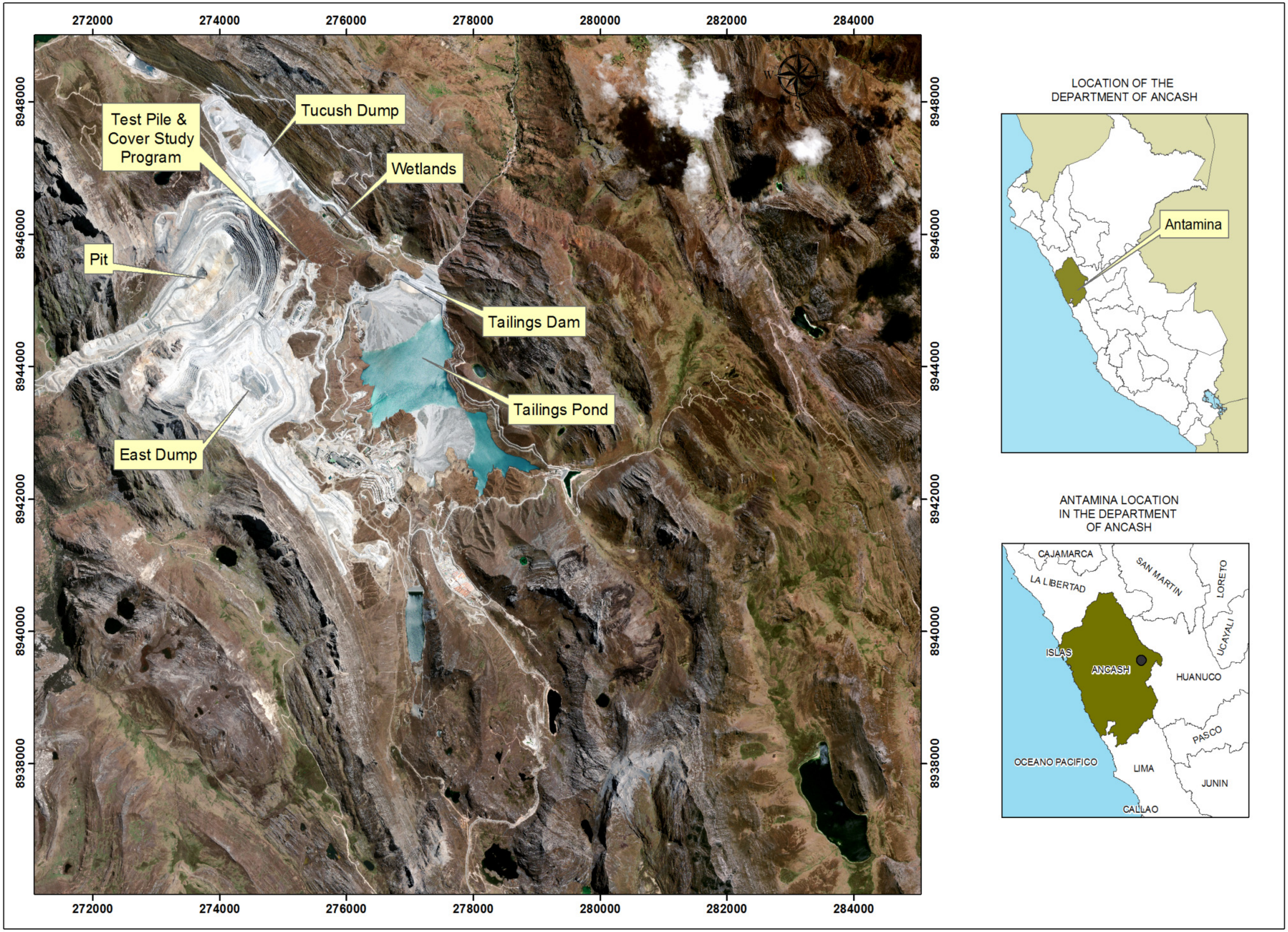
Outline

1. Introduction to Antamina
    - Property
    - Geology and waste classification system
    - Current and New WQ regulations
2. Comparison between original EIA and present day
    - Project description
    - Predicted and current ML/ARD
    - Derivation of the waste classification system
    - Predicted vs. current drainage chemistry
3. Future estimates and management challenges

INTRODUCTION TO ANTAMINA



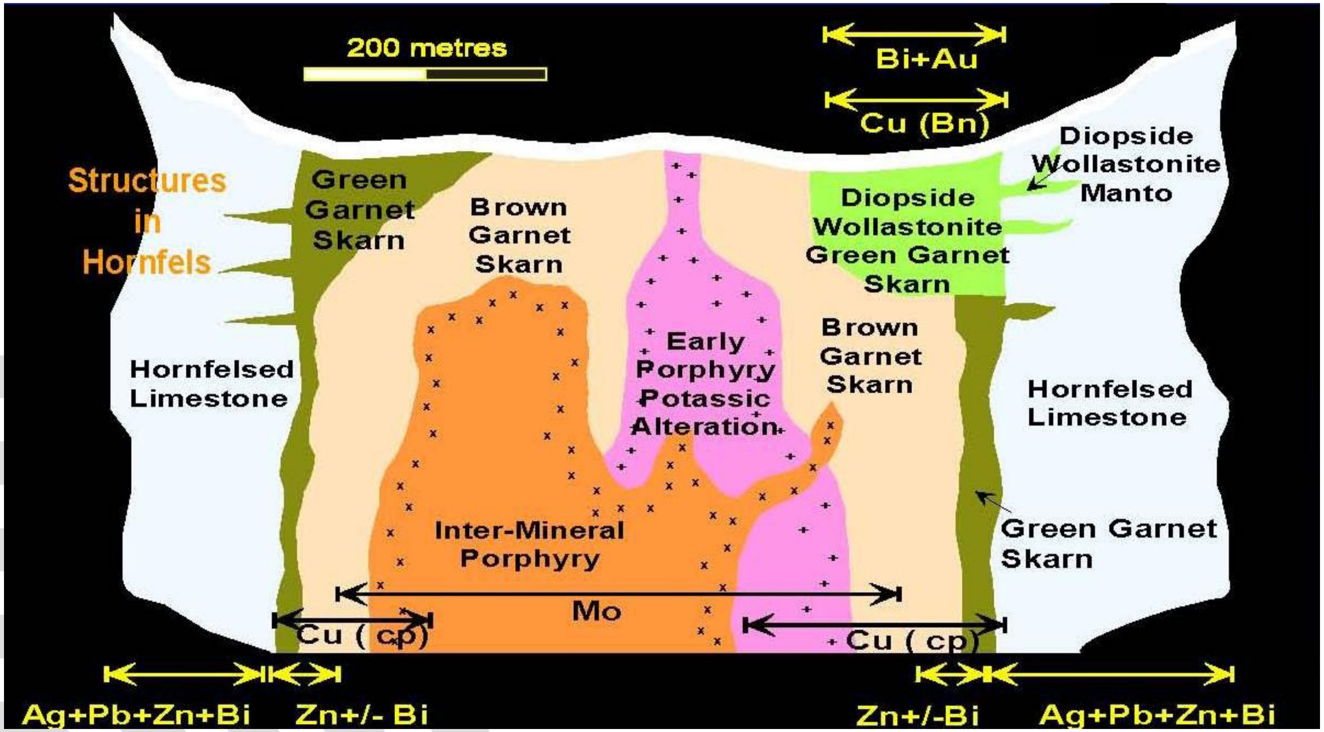
Tucush Dump
Test Pile &
Cover Study
Program
Wetlands
Pit
Tailings Dam
Tailings Pond
East Dump
272000
274000
276000
278000
280000
282000
284000
8948000
8946000
8944000
8942000
8940000
8938000
LOCATION OF THE
DEPARTMENT OF ANCASH
Antamina
ANTAMINA LOCATION
IN THE DEPARTMENT
OF ANCASH
CAJAMARCA
LA LIBERTAD
SAN MARTIN
LORETO
UCAYALI
ISLAS
ANCASH
HUANUCO
PASCO
OCEANO PACIFICO
LIMA
JUNIN
CALLAO

Timeline

1. Pre-mining baseline studies 1996 – 1997
2. EIA Approval 1998
3. EIA Addendums 1999
4. Peak Rock Program 2000
5. Full Production Capacity 2001
6. Waste Rock Classification System 2002

Geology

1. 5 general rock groups, 22 waste types
   - Intrusive
   - Skarns (brown garnet endoskarn, green garnet exoskarn)
   - Hornfels, Marble, Limestones



Current Waste Classification System

	Class	Limit	
A	Reactive Material	Skarn/Intrusive Hornfels/Limestone/Marble >1500 ppm Zn, > 400 ppm As >3 % total sulphur; > 10% visual staining	
B	Potentially Reactive Material	Hornfels/Limestone/Marble 700 - 1500 ppm Zn < 2-3 % total sulphur	
C	Non-Reactive Material	Hornfels/Limestone/Marble < 700 ppm Zn < 400 ppm As < 2-3% total sulphur Only Grey Hornfels and Grey and Black Marble are sent to Tailings Dam	<10% FeOx (material routed to Tailings Dam) FeOx (no restriction, material to Tucush)

Water Quality Limits

Parameter	Effluent Limits		In-Stream Limit	
	Current	New (Oct 2012)	Current	New (Feb 2016)
Sulphate	-	-	-	300
Conductivity	-	-	-	<2000
Calcium	-	-	-	200
Arsenic Tot	1.0	0.1	0.2	0.05
Copper Tot	0.3	0.5	0.5	0.2
Molybdenum	-	-	-	-
Zinc Tot	1.0	1.5	25	2

EIA PROJECT DEFINITION

VS.

CURRENT CONDITIONS

Comparison between then and now
Key Project Description Details

1998 EIA	2011 VALUES
Life of Mine: 2024	Life of Mine: 2029
1998 Life Of Mine Projections: • 500 Mt tailings • 1.36 Bt Waste Rock	2011 Life of Mine Projections: • 1.05 Bt tailings • 2.2 Bt waste rock
Mill throughput: 70 ktpd	Mill throughput: 104 ktpd current average 130 ktpd in Jan 2012 145 ktpd in Jan 2013
3 waste dump sites	2 waste dump sites
6 ore types	8 ore types
232 m high rockfill dam, 670 ha	285 m rockfill dam, 796 ha

1998 EIA Waste Rock Geochemistry Conclusions

1. Skarn-hosted mineralization like Antamina has a low potential to generate ARD or to become a source of widespread metal contamination, though it may be sulphide-rich
2. Non-PAG - Limestone, Marble and most green garnet skarn
3. Uncertain - Intrusives
4. PAG - Brown garnet skarn
5. Intrusive samples show Mo leaching under neutral conditions
6. Zn leached from all rock types

Waste Classification System Needed!!

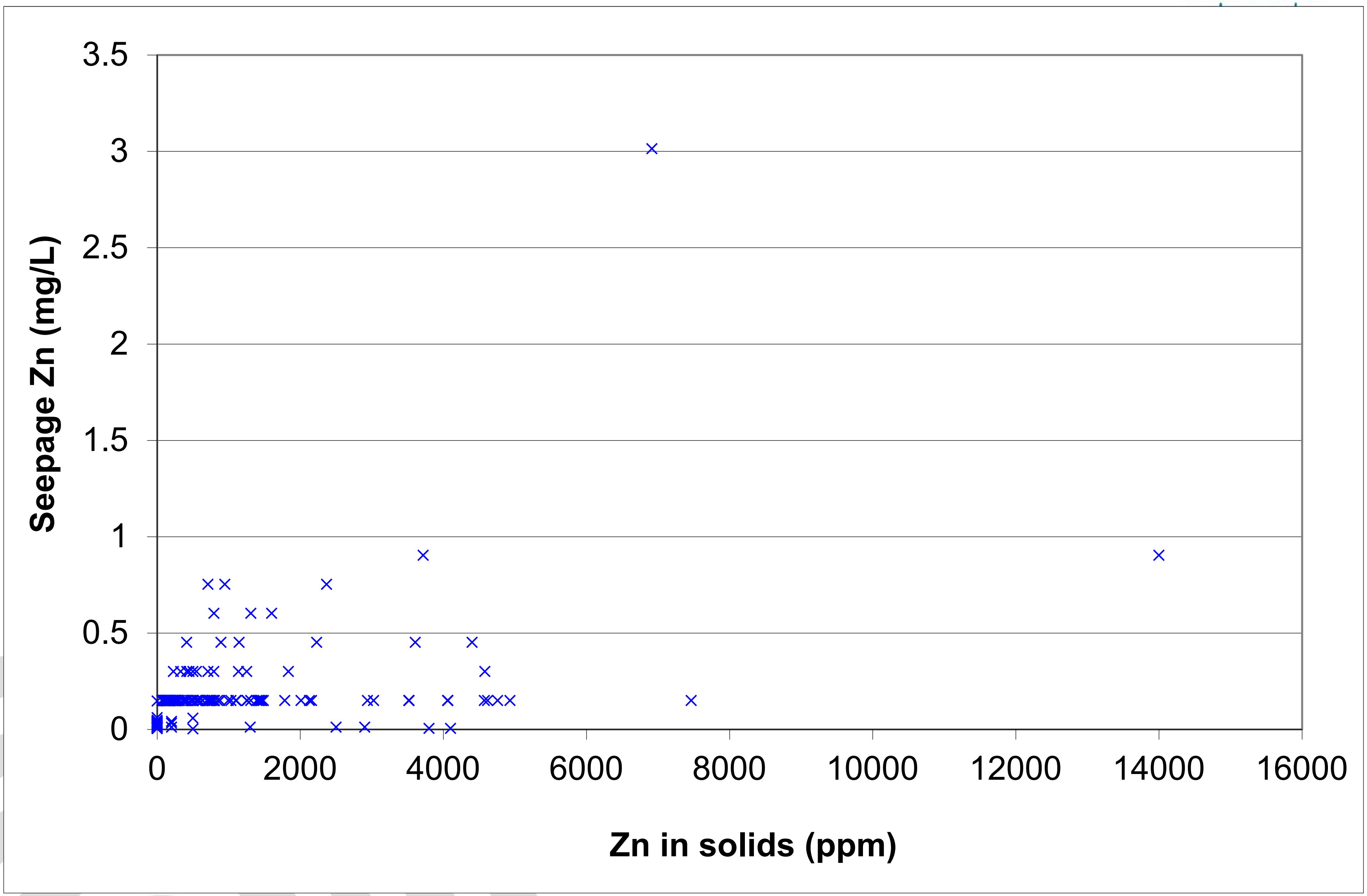
WASTE ROCK CLASSIFICATION SYSTEM DEVELOPMENT

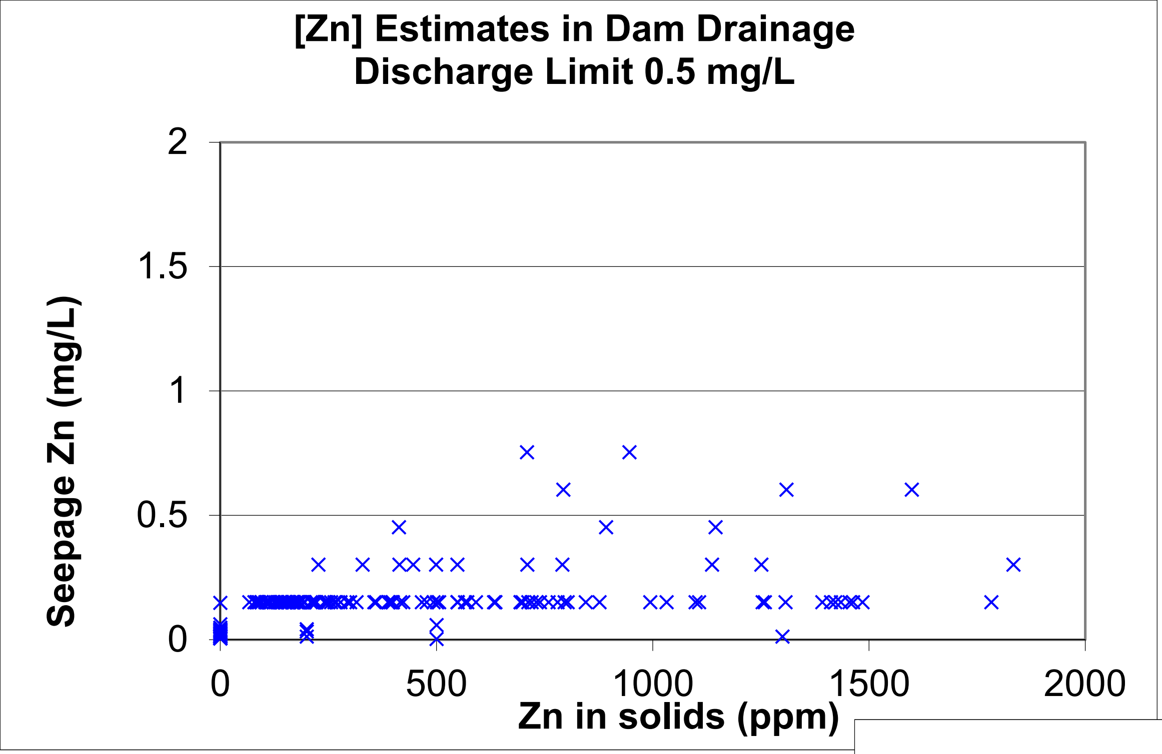
Derivation of Waste Classification System

Purpose was to develop a criterion for segregation of dam construction versus other waste material:

- Segregation of material suitable for Dam Construction was undertaken as part of the Peak Rock Program (2000)
  - Took loading rates from SFE tests and applied those to the mass of material placed in the dam then calculated the concentration in the dam seepage
  - Compared the resulting concentration to a site effluent discharge limit for zinc of 0.5 mg/L

Zinc Estimates in Dam Drainage
Derivation of lower limit 700 ppm





EIA Discharge Limit

= 0.5 mg/L

New LMP

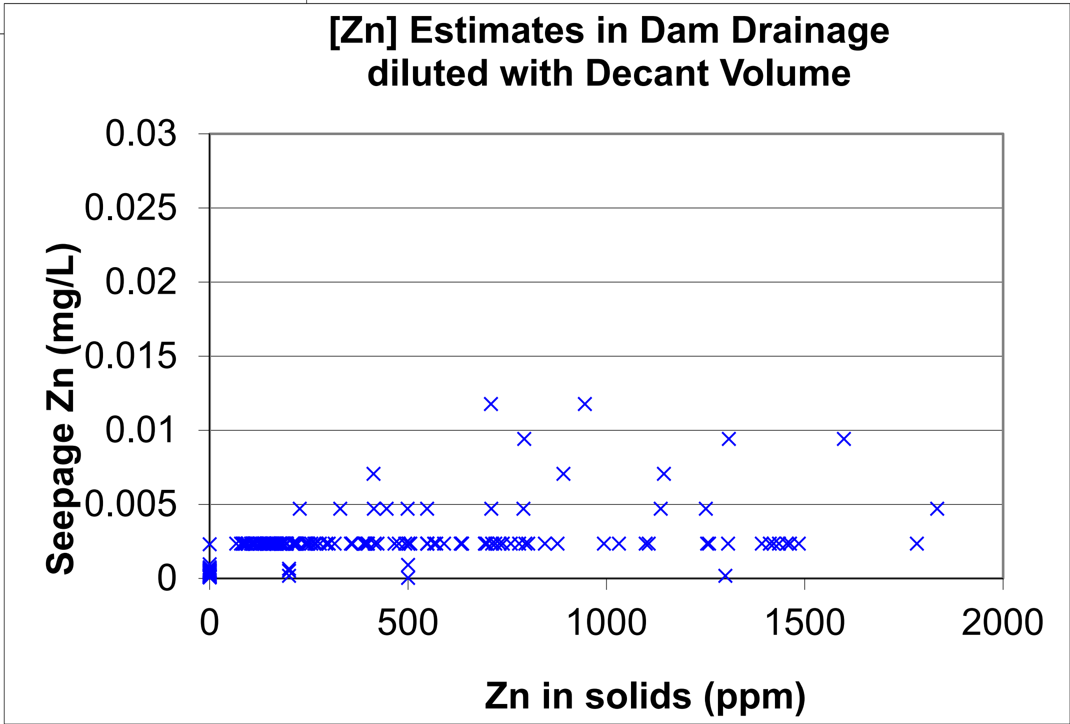
= 1.5 mg/L

EIA Receiving Water Limit

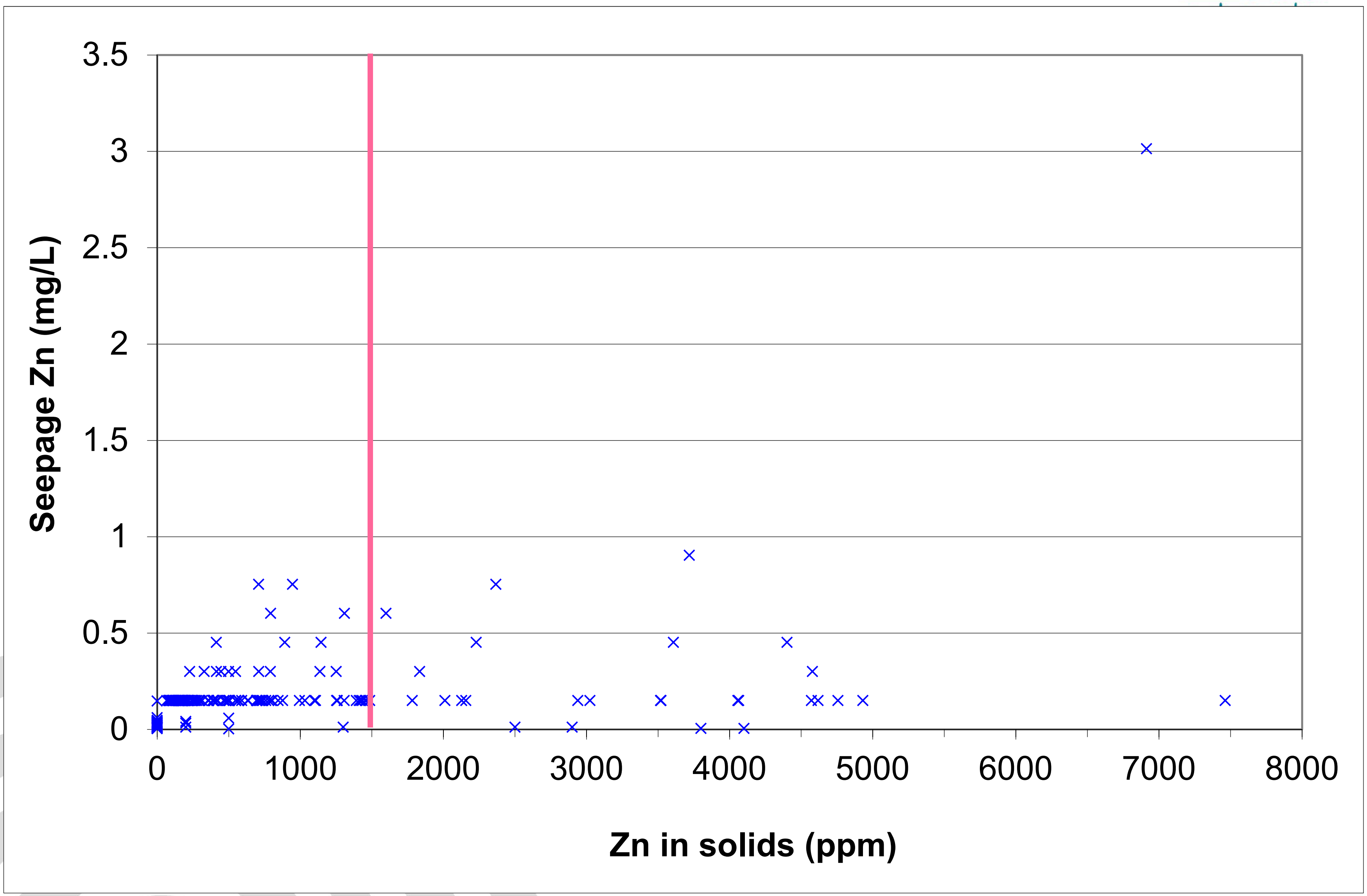
= 0.13 mg/L

New ECA

= 2 mg/L



Zinc Estimates in Dam Drainage
Derivation of upper limit 1500 ppm



Refinements to the Classification System

1. Between 2000 and 2002 the classification system was refined
   - Sulphide content was established (> 3% for reactive material)
   - As solid phase content was defined based on the exposure of As minerals in the pit walls, an assessment of leaching chemistry and gut feel by geologists (400 ppm As cutoff)
2. Between 2004 and 2007
   - Intrusive Material regardless of sulphide was designated Reactive A material
   - Data collection has been underway to be able to refine or eliminate Class B, no conclusions

Re-Assessment of Dam Leaching

Similar exercise was undertaken to evaluate the leaching effects of using other types of Hornfels and Marbles as dam construction material

- Results remain true that the Grey Hornfels and Grey and Black Marbles have the lowest effect on Ayash water quality.
- There was no effect on Zn concentrations by changing the material type sent to the dam
- But there was a change in Ayash River SO4 concentation

DRAINAGE CHEMISTRY PREDICTIONS
VS.
PRESENT DAY CONCENTRATIONS

EIA Estimate of Operational TSF Pond

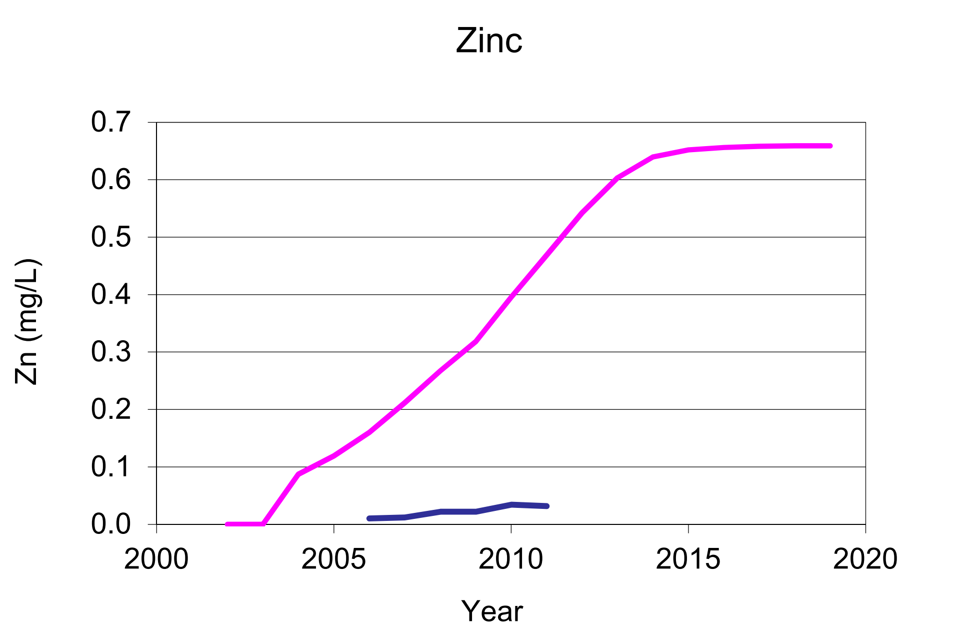
	1998 EIA TSF Pond Operational WQ	2011 TSF Pond Operational WQ
pH	7 – 9	9 – 10
SO4	Not estimated	700 - 1500
CN total	0.01 – 0.03	0.04 – 1.5
As	0.002 – 0.004	0.001 – 0.009
Cd	<0.0002	0.0002 – 0.0013
Cu	0.01 – 0.03	0.4 – 4.0
Cr	<0.001	<0.002
Fe	<0.1	0.001 – 0.12
Mo	Not estimated	0.4 – 0.6
Pb	<0.002 – 0.004	<0.001
Hg	0.0002	<0.0002
Ni	<0.0005 – 0.001	0.001 – 0.02
Zn	0.05 – 0.10	0.001 – 0.05

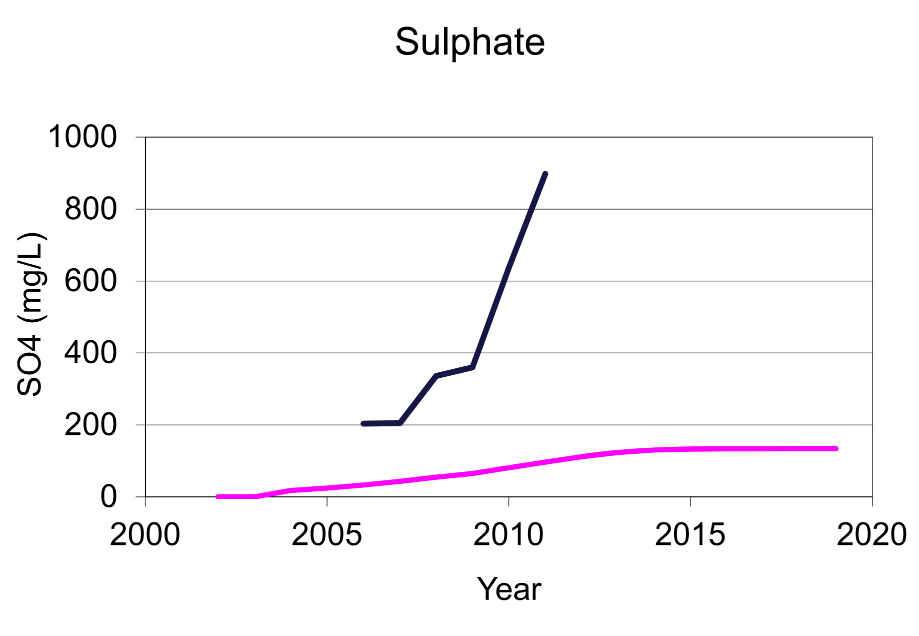
EIA Estimate of Year 10 Receiving WQ

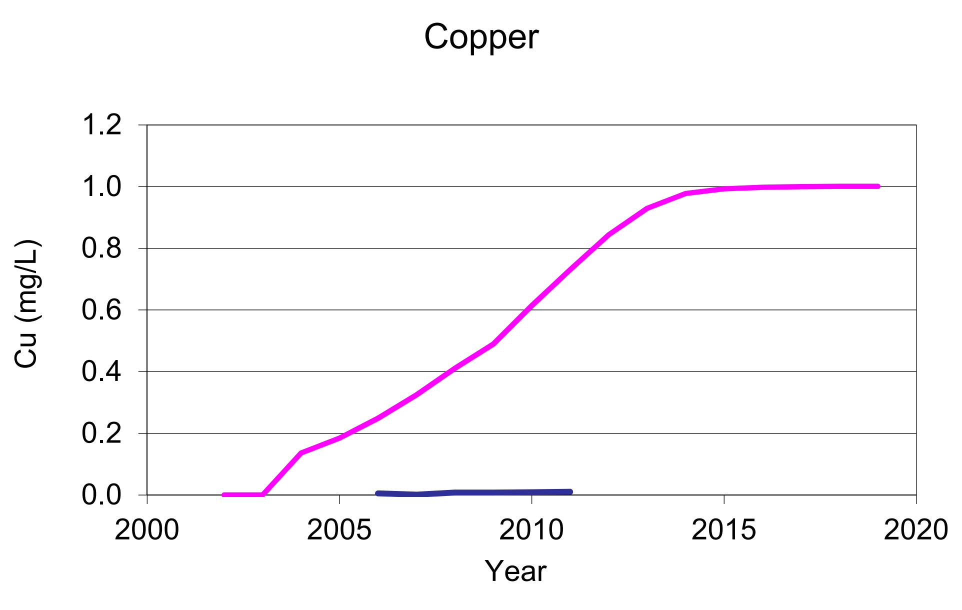
ANTAMINA

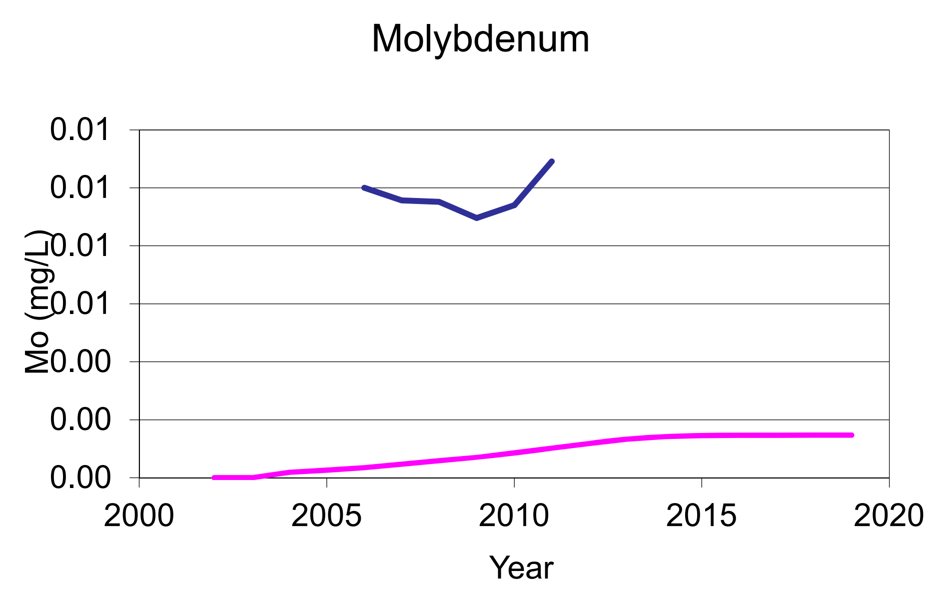
Parameter	1998 EIA Estimated Concentrations (at 10 yrs of Operations) (mg/L)	2011 Concentrations (mg/L)	In-Stream Limit as of Feb 2016 (mg/L)
pH	Not shown	8.2 – 8.5	6 - 9
SO4	Not estimated	38 - 230	300
Copper	0.009	0.01 – 0.02	0.2
Lead	0.002	0.001 – 0.015	0.05
Molybdenum	0.044	0.01 – 0.18	-
Zinc	0.044	0.006 - 0.012	2

2006 Projected LOM WQ Tucush Dump

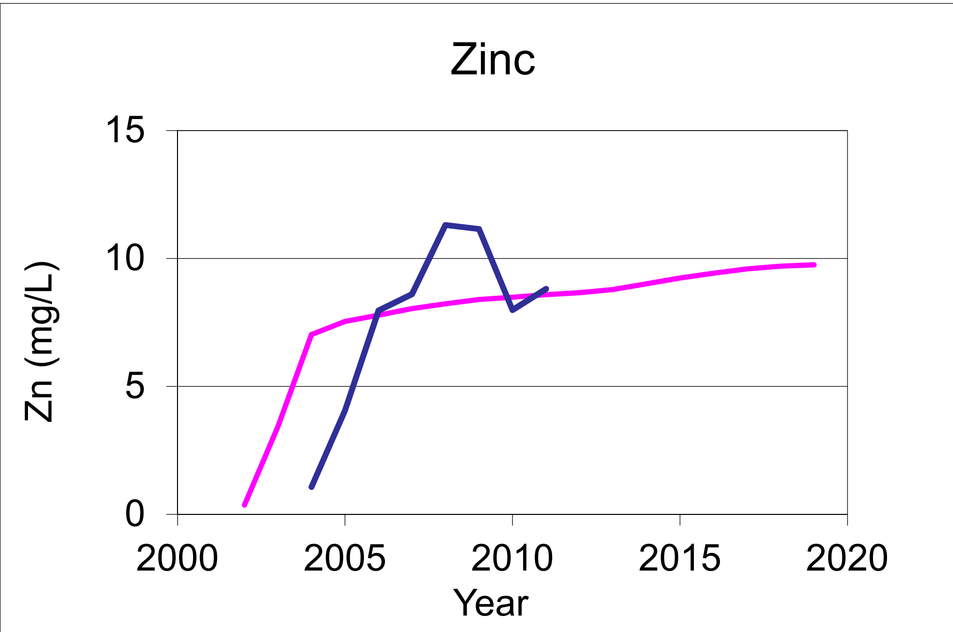


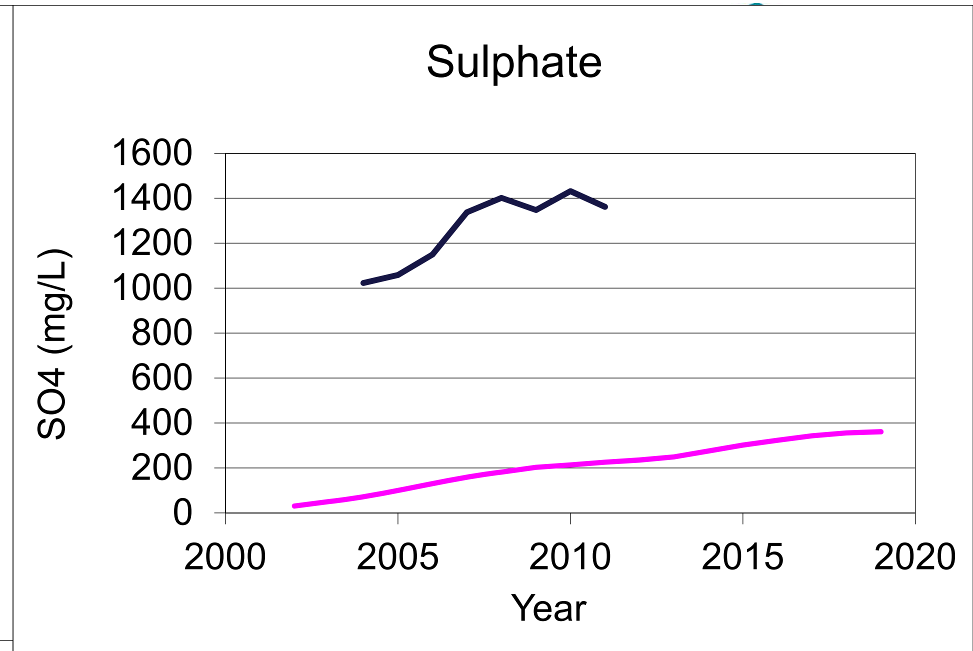


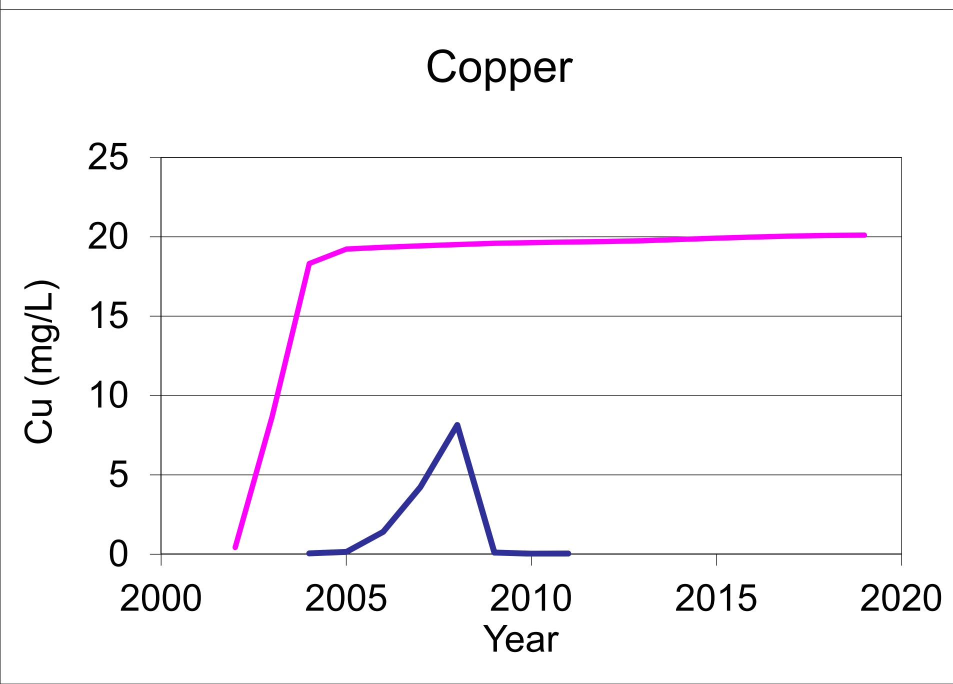


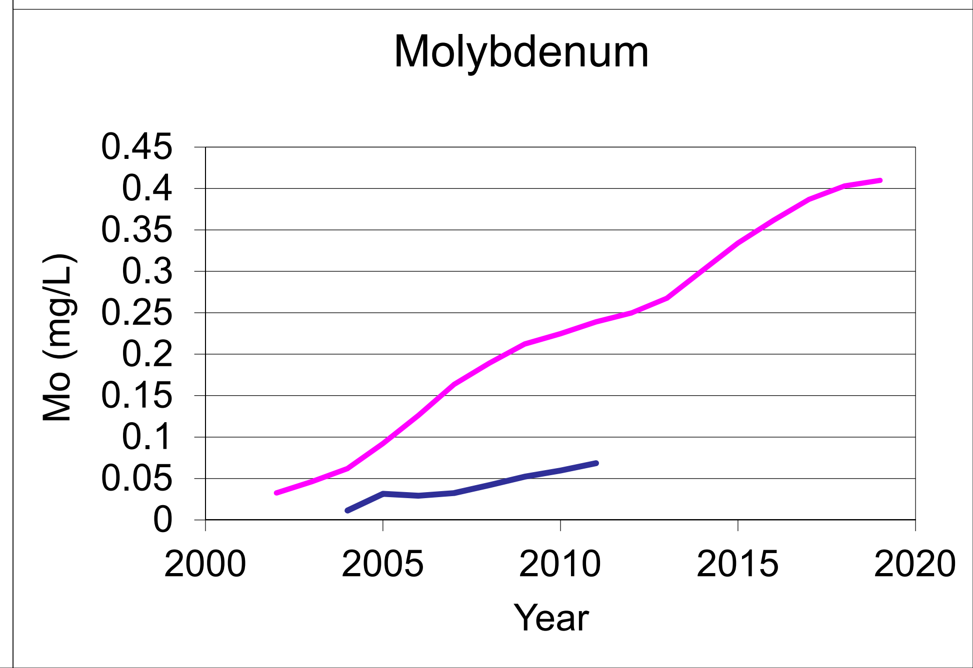


2006 Projected LOM WQ East Dump









Future Projections at In-Stream Compliance Point

	1998 EIA Estimated Conc. (at 10 yrs of Operations) (mg/L)	2011 Conc. (mg/L)	Projected In-Stream Conc. at the end of ops	In-Stream Limit as of Feb 2016 (mg/L)
pH	Not shown	8.2 – 8.5	8.4	6 – 9
SO4	Not estimated	38 - 230	550 – 600	300
Cu	0.009	0.01 – 0.02	0.039	0.2
Mo	0.044	0.01 – 0.18	0.07	-
Zn	0.044	0.006 - 0.012	0.036	2

Conclusions ML/ARD

1. Overall EIA conclusion was that the Antamina mine would not produce substantial ARD and become a source of widespread metals. So far, this is true.
2. Zn was thought to be the main element of concern in the EIA and the water quality modelling focused on Zn conc.
3. Waste rock classification system was derived based on Zn to segregate waste that could be used for dam construction from the remainder of waste based on a zinc criteria first.
   - The classification system is still used today and thought to be successful based on the relatively young age of the Antamina waste dumps and dam, zinc concentrations are low.

Conclusions Water Quality

1. EIA water quality modelling were low compared to present day, but not bad estimates
2. Water quality modelling of dump seepage undertaken in 2006 consistently underpredicted SO4 and overpredicted Cu and Zn, Mo was more difficult.
3. SO4 has been identified as the parameter of concern going forward. Antamina is currently evaluating treatment options to maintain compliance in Feb 2016 when the new limits are imposed that include SO4
4. Future modelling continues to assume Zn and Cu will be parameters of concern

GRACIAS.
SOMOS ANTAMINA
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