Evolution of Waste Rock Management and Cover System Design at BHP Billiton Iron Ore, Mt Whaleback Operations Western Australia

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MEND ML/ARD Workshop
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Discussion Points

- General Background
- Evolution of Conceptual Models for Performance
  - Cover Systems
  - Waste Rock Management
- Key Points
Background

- Site is approximately 1,200 km N-NE of Perth next to Newman, WA
- Pilbara Region of WA – Iron Ore Rich
- Deposit discovered in 1957
- 2.5 billion year old Brockman (hematite) BIF deposits
- 1967 – Mt Newman Mining with BHP project manager, commenced large-scale mining operations
- Mining commenced 1968
- Ore transported by rail to Port Hedland (420 km) for shipment to market
BHP Billiton – Mt. Whaleback

• Largest known continuous high grade iron ore deposit (hematite iron ore)
• Per annum:
  • ~18 million wet tonnes of saleable product
  • ~53 million tonnes of waste material
• 15 to 25 years remain
• ~3.3 billion tonnes of waste in OSAs

• Carbonaceous and pyritic shale units are significantly Net Acid Generating and certain units are susceptible to spontaneous combustion
• Nodular and disseminated pyrite:
  • ~15% of waste volume
• Oxidized Overburden (BIF): barren
Climate Background

- Significant rainfall events over short periods
- High potential for evaporation

Average Annual:
- Rainfall: \( \approx 310 \text{ mm} \)
- PE: \( \approx 3,000 \text{ mm} \)
- Distinct wet – dry seasons
- December to March: \( \sim 90\% \)
- Cyclonic activity from coast
“First” Evidence of ARD

- Cyclone Bobby 1995
- ~ 500 mm
- Wettest on Record
- Uncontrolled release to Whaleback Creek
  - Low pH (~2)
  - Relatively low acidity
- Source of Toe Seepage?
Pre-1995 - no need to manage net percolation to underlying waste

ARD was thought of as a non-existing issue in the Pilbara due to climate (too dry)

1995 - Net percolation control to underlying waste required
ARD observed in response to Cyclone Bobby due to rainfall incident to W19 OSA footprint / catchment

Late 1990s - “Simple” Cover System
Use Moisture Store-and-Release Cover System concept
Rely on evaporation only
Design based on ‘single year’ modelling of wettest year
Hummocky surface (no runoff)

Early 2000s - S&R Cover System.... Not so simple!
Quality control required
Transpiration required to properly manage net percolation
Design based on continuous climatic conditions
Larger surface area catchment ‘approach’ to landform design

Late 2000s - S&R Cover System.... Slopes and Flat Upper Surface
Clear understanding for the need to rely on cover systems for long-term management of seepage from OSAs
Establishment of sustainable vegetation
Much more extensive understanding for natives species rooting and transpiration characteristics required
Much higher level of confidence with required cover thickness
Linking net percolation rates to impacts to the receiving environment
W22 Test Plots and Monitoring (1997)

- Test Plot No.1 (2m) and No.2 (4m)
  - ROM Inert Material – 1 ha
  - Relatively Horizontal Block Dump Surface

- Test Plot No.3 (2m)
  - ROM Inert Material – 0.75 ha
  - Sloping Surface

1996:
Predicted Net Percolation
1m cover: < 0.1%
Rainfall: 14 year Monitoring Period

Historic Average: ~310mm

14-Year Monitoring Period Average: ~440 mm
Measured Volume of Water – Test Plot 1 (2 m)

Rainfall (mm)

Cumulative Change in Water Volume (mm)

Net Percolation (% of Rainfall)

14-Year Average 5%
Measured Volume of Water – Test Plot 2 (4 m)

Net Percolation: 14-Year Average <<1%

Test Plot 2 (4m)
Transpiration Rates?

Vegetated Field Trials

Rooting and Transpiration Characteristics of Native Species?

Bare Surface Field Trials and Control Sites
W29 Landform and Vegetation Trials (2000)

- Senna glutinosa (white cassia - woody shrub)
- Senna notabilis (cockroach bush - small shrub)
- Acacia bivenosa (bushy shrub)
- Maireana carnosa (cottony bluebush – low shrub)
- Triodia wiseana (spinifex – grass)
The “Vision”....a Reality

Current
Construction and QA/QC

Near Surface Preferential Flow due to Segregation During Placement
Evidence of “Macro-Pore” Flow

Lower Saturation Levels

190 cm response

10 cm response

Higher Saturation Levels

Rain

190 cm

10 cm

190 cm

100 cm

100 cm

Dec-14 Dec-15 Dec-16 Dec-17 Dec-18 Dec-19 Dec-20

Waste Material

Cover Material

O’Kane Consultants
Integrated Geotechnical Engineering Services
Specialists in Unsaturated Zone Hydrology
2D Performance (bare surface)

Ponding
Waste Material Management – Conceptual Models Over Time

- **Late 1990s** - Short- and Medium-Term Strategies
  - ARD Management Catchment Scale = Evaporation Ponds
  - Introduction of Modular Mining Truck dispatch that incorporates waste material tracking
  - Encapsulation and raising of NAG waste above ground surface

- **2000s** - Medium - and Long-Term Strategies
  - W40 Soak Area
  - Strategic placement of waste and covers approx. 5m thick
  - Reduction of long-term liabilities: cost and environmental
OSA Construction pre-1995
OSA Construction – 2000s

- Inert overburden (A Class)
- NAG overburden (B and C Class)

SIDES (> 5 metres thick)

Cover (> 5 metres thick)

BASE (> 5 metres thick)

10 m

2 m

10 m
2010 – W40 Soak Areas

- Combining learnings from OSA Management and Cover System Concepts Evolution
  - Extension of existing OSAs with Inert Waste
  - Wider berms separating paddocks
  - Sloped in case of surface/berm failure
  - Capturing and containing runoff from OSA Landform
  - Prevent flow through of seepage from surrounding catchment
  - Larger, more irregular paddocks
  -Seeder with mix of native grass and shrubs

- Aim is to decrease seepage from W19 to ARD dam
Strategic Waste and Cover Placement

- **Integrated** OSA construction *(mine planning)* and closure planning
- 5m cover for all OSAs
- Implementation/planning for now = incremental cost i.e. *Reduced cost long term*
- Life of mine 15 - 25yrs
Key Points

- **Cover System Conceptual Models** adapted to increased understanding of system function and requirements

- **Cover System Field Trial Program** On-going
  - **High Intensity** Rainfall Events have **Strong Influence** on Net Percolation Rates

- **Evolution of waste management philosophy on site**
  - **Pre-1995**: limited to simplest and cheapest placement of waste material at time of extraction
  - **Post-1995**: increasing consideration for strategic planning that incorporates closure planning during operations
  - Decreases long-term liabilities both financial and environmental

- **Future studies; large scale OSA trials** to assess infiltration of meteoric waters into the Dump profile
In Closing

Cover System Longevity

Rain

Sun

Fire