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Driver: Changes in US Mining Law

- Recent legislation in several States requires operating mines to post a financial assurance bond to cover the closure cost.
- The bond amount is based on a preliminary assessment of the closure/closeout activities that would be required.
- The assessment typically includes detailed studies and analyses.
Objectives of Closure-Closeout Plan

- Meet Environmental Standards
  - Groundwater, Surface Water, Air Quality
- Site Safety
- Reclamation and Self-Sustaining Ecosystem
- Post-mining Industrial Uses
- Consistent with Continued Economic Mining
- Meet State Interest in Bonding
Traditional Approach

- Similar to earlier “bottom up” approach for performance assessment analysis
- Individual process models/analyses were satisfactory but lacked integration
- Uncertainty not explicitly represented forcing “conservative” assumptions
- No basis for establishing priorities
- Results in very high financial assurance bond
GoldSim Approach

- “Systems” approach
- Build on existing studies/data
- Explicitly represent uncertainty
- Use model to
  - Compare alternative plans
  - Reduce financial assurance bond
  - Guide/integrate additional studies
  - Explore new closure concepts
  - Expedite issue resolution process
Case Study

- Confidential client
- Large metal mine that produces concentrate and PLS
- Financial assurance – closure/closeout studies have been underway for several years
- Client (and consultants) were unable to integrate components
- Expensive to consider new alternatives and perform “what if” analyses
Model Requirements

- Integrate system components
- Regulatory compliance projections
- Integrated cost model
- Extensible – provide basis for feasibility studies
Typical Processes/Issues
What does the model include?

• 100 year climate record
• Abstraction models for:
  – Stockpile infiltration (pre and post-cover)
  – Seepage (stockpiles and tailing ponds)
  – Stockpile and surface runoff
  – Water management/treatment
  – Contaminant transport in groundwater
  – Operating and capital costs
• Based on site data where available
What can the model be used for?

- Integrate information from ongoing and future studies
- Gain a diagnostic understanding of the mine system during closure/closeout
- Issue resolution, prioritization, “what if?” experiments
- Basis for performing the feasibility study
- Quantitative basis for reducing financial assurance
Conceptual Model for Main Wash

- Natural Recharge
- Recharge from West
- Recharge Mass from West
- Mixing between alluvium and aquifer
- Base and Flood Flow in Creek
- Evapotranspiration Losses
- Shallow Seepage
- Seepage into Fractures
- Recharge from East
- Stockpile Infiltration
- East

Water Balance Check

_Ck_Groundwater

_Ck_Surface_Alluvium

_Ck_Combined_Flow
South Area Groundwater Flow Conceptual Model

Recharge from Various Sources
Regional Groundwater Flow Direction

North

Crop Uptake

Extraction_Well_Conc_SO4
Dynamics of Water Management Strategy

- Good example of how the model can be used to “diagnose” system behavior and perform “what if” experiments
- Water management strategy - dashboards allow strategies to be evaluated quickly and improved upon (e.g., optimize water treatment facility capacities, evaporation and pumping schemes, storage ponds, etc.)
Conceptual Model of Process Water Management System
ETS and Nanofiltration

Dynamic response of water management system

- WTP_surface_reservoirs
- Pit_Lake_Reservoir
Effect of Evaporation and Draindown on ETS and Nanofiltration Volumes

Dynamic response of water management system

Time (yr)

(gal)

(gal/mon)

0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20

WTP_surface_reservoirs Pit_Lake_Reservoir process_ Evaporation
Nanofiltration and HDS

Dynamic response of water management system

Time (yr) vs. (gal) and (gal/mon)

- WTP_surface_reservoirs
- Pit_Lake_Reservoir
- HDS_Pump_Rate
- Nano_Pump_Rate
- Evaporation
Contribution of Runoff

Dynamic response of water management system

Time (yr)

(gal)

(gal/mon)

WTP_surface_reservoirs
Pit_Lake_Reservoir
HDS_Pump_Rate
Nano_Pump_Rate
stockpile_runoff_total
process
Evaporation
North Area Closure Cost Components by Alternative

- Alt. 1
- Alt. 3
- Alt. 5 split
- Alt. 5
- Alt. 6

Cost ($)

Closure Alternative

- Cover
- Regrading
- Other Capital
- Analytical
- Pumping
- HDS
- Nanofiltration
- ETS
Water Contribution by Source (Alternative 5)

- Runoff: 19%
- Surficial Seepage: 12%
- GW Into Pit: 4%
- Extracted GW: 4%
- Collected GW: 4%
- Cobre: 9%
- SP Process Water: 2%
Sulfate Concentration in Nanofiltration Influent

![Graph showing sulfate concentration over time for different alternatives.]
SO4 Concentration in Groundwater at South AOC Permit Boundary

Groundwater Concentration at South Site Boundary (SO4)

![Graph showing SO4 concentration over time](image-url)
Value of Systems Model

- Diagnostic understanding of system
- More rigorous and technically defensible basis (no missing or inconsistent pieces)
- Provides integrated model for addressing cost/benefit questions
- Easier to communicate (story hangs together, model is graphical and transparent)
- Addresses many of the existing requirements (e.g., study meets intent of feasibility study)
- Check on previous conclusions - performance, meeting standards, cost
- Integration of groundwater impacts