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Challenges in Heap Leach Pad Design: Consideration of Thermal Conditions

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Project Background

- Operating gold mine
- Located in Northern Mongolia
- Expanding operations to include the use of a heap leach pad
- Temperature fluctuations from 40ºC to -40ºC
- Goal is to operate heap leach the entire year

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Project Goals

- Provide design parameters for heating of leaching solution
- Define the expected heat loss of the solution through the heap
- Define the expected heat loss of the solution in the PLS pond

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Modeling Approach

- Utilized combine variably saturated and thermal model of the heap
  - Allows for site specific climate
  - Allows for solution flow and temperature
- Utilized heat budget model of the PLS pond
  - Considers all sources of heat additions and losses

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Modeling Assumptions

- Ore would not be stacked later than early October, so no ice lenses within the heap
- Boiler would be used to heat solution 5ºC above starting temperature
- Engineering control would be used on pond surface

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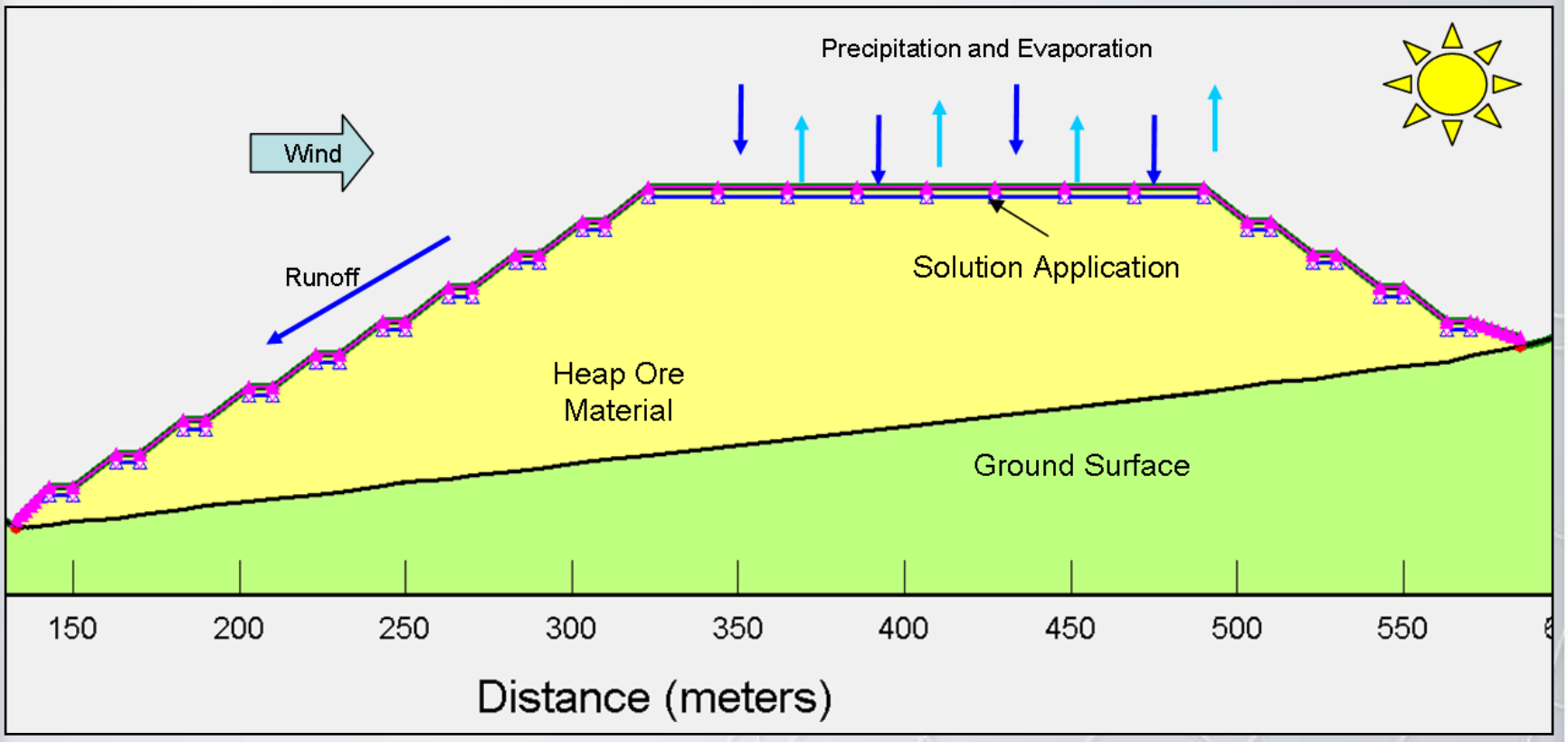
Conceptual Model of Heap



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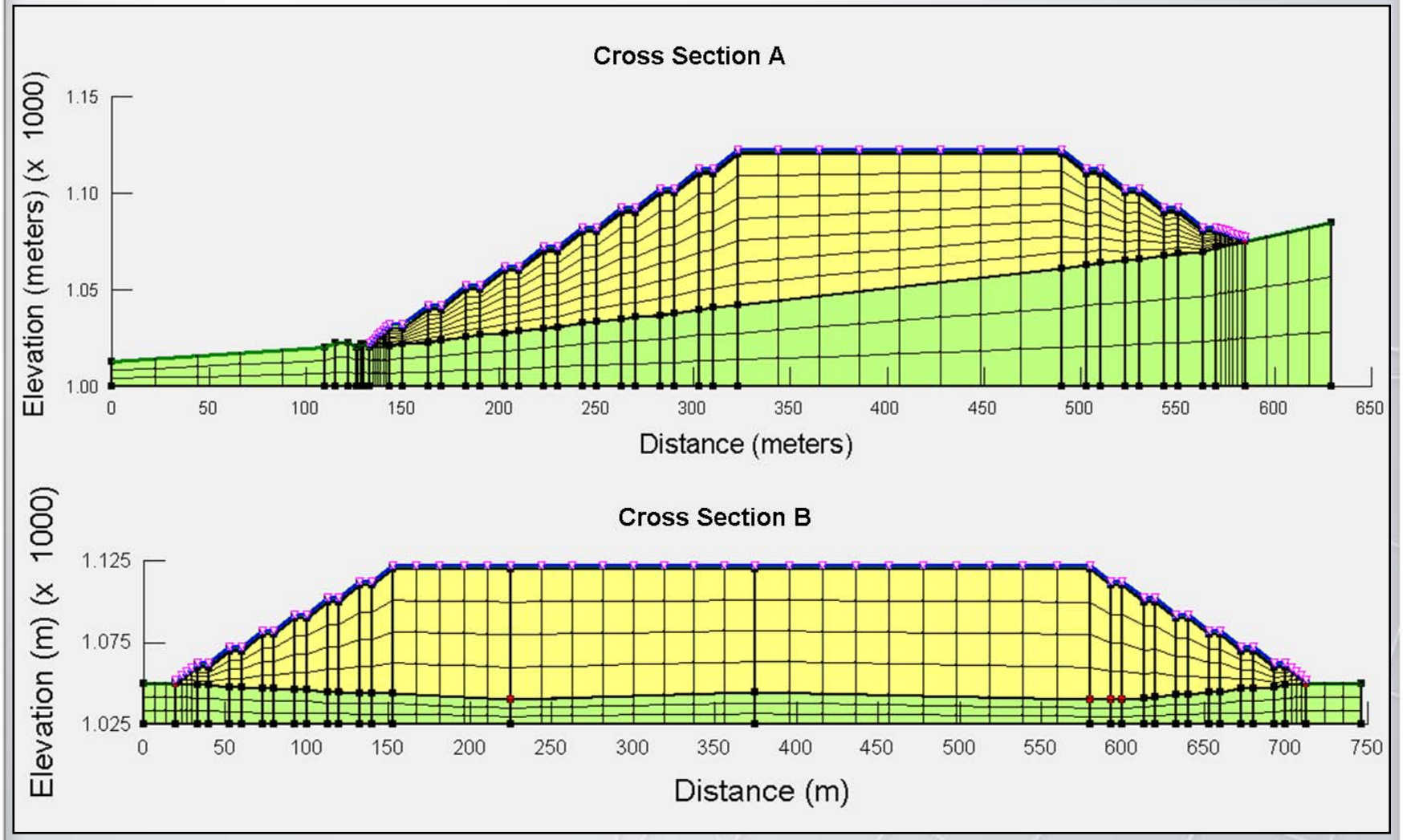
Heap Model Construction



Model Input Parameters

- Site specific climate data
- Solution application rate and temperature
- Heap leach facility design
- Unsaturated material properties of the ore
- Starting ore temperature

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Model Scenarios

- Typical Conditions
  - Solution entering the heap is at ~25ºC
- Worst Case Conditions
  - Solution entering the heap is at ~5ºC

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Heap Modeling Results

- Steady State Model
  - Used to set initial conditions
  - Ore temperature = 3ºC and 6-12% moisture
- Transient Model
  - Emitters placed at a depth of 2.5 meters is sufficient to prevent freezing
  - Heat loss within the heap is 3ºC to 5ºC
  - Provides initial conditions for heat budget model

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Heat Budget Model of PLS Pond

$$dH/dt = \Theta_R + \Theta_E + \Theta_L + \Theta_{adv} + \Theta_B$$

Where:

- Θ_R = net radiation
- Θ_E = latent heat of exchange
- Θ_L = sensible heat exchange
- Θ_{adv} = net advective exchange
- Θ_B = conduction through sediments

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Heat Budget Input Parameters

- Θ_R = net radiation
  - Solar radiation, shortwave & longwave radiation, emissivity, Stephan-Boltzmann constant, surface temperature
- Θ_E = latent heat of exchange
  - Mass evaporated and latent heat of evaporation
- Θ_L = sensible heat exchange
  - Heat transfer, wind speed, surface temperature, air temperature

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Heat Budget Assumptions

- No thermal exchange with sediments because pond is lined ($\Theta_B = 0$)
- No heat loss to advection because inflow is warmer than outflow ($\Theta_{adv} = 0$)
- Engineering control applied to pond is Bird Balls™

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Bird Balls™ as an Engineering Control

- Covers 91% of water surface
- Decreases evaporation by 90%
- Lowers freezing point by 10ºC
- Maximizes solar heating during winter

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Model Scenarios

- Typical Conditions
  - Solution exiting heap is at ~20ºC
- Worst Case Conditions
  - Solution exiting heap is at ~2ºC
- Time before top meter freezes if pumps stop

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Model Results without BirdBalls™

- Large amount of heat lost to the environment
- Typical Conditions
  - Top one meter of pond freezes in 1.5 hours
- Worst Case Conditions
  - Top one meter of pond freezes in 30 minutes

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Model Results with BirdBalls™

- Cover decreases amount of heat lost to environment
- Dark color increases heat absorbed by the surface
- Typical Conditions
  - Top one meter of pond freezes in 18 hours
- Worst Case Conditions
  - Top one meter of pond freezes in 11 hours

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Conclusions

- Heaps can be operated the entire year in extreme climates
- Must consider heat management of pond in addition to solution boiler

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Questions?

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