

# Using Spreadsheets to Evaluate the Effects of Mine Water Disposal on Surface and Ground Water



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# Spreadsheet Modeling

- Surface and ground water
- Accurate and straightforward
- Easily modified
- Basic data
  - Hydrogeologic
  - Wastewater quality and quantity
  - Treatment, storage, disposal system capacities
- Basic equations
  - Darcy's equation
  - Mixing and loading

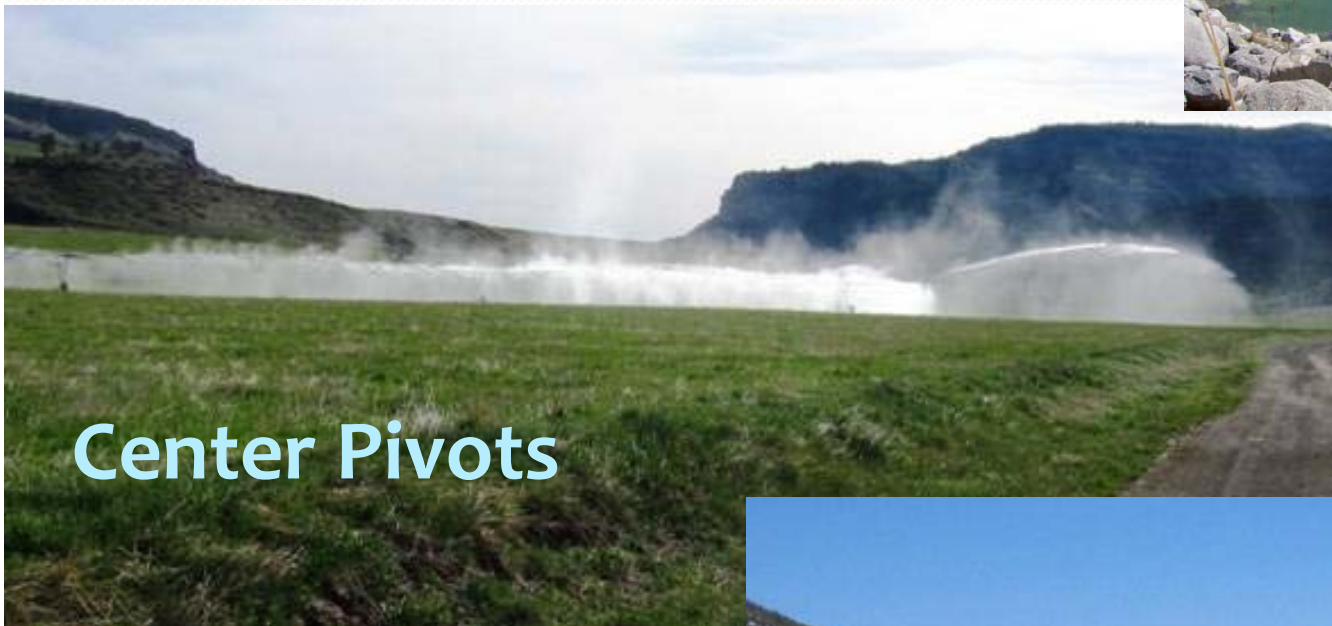
# Model Construction

- Assumptions
- Specifics of water routing
- Input data with citations
- Calculations
  - Hydraulic capacity of treatment and disposal systems
  - Volume of surface and ground water available for mixing
  - Constituent loading, concentration

# Land Application Disposal Methods



**Percolation**

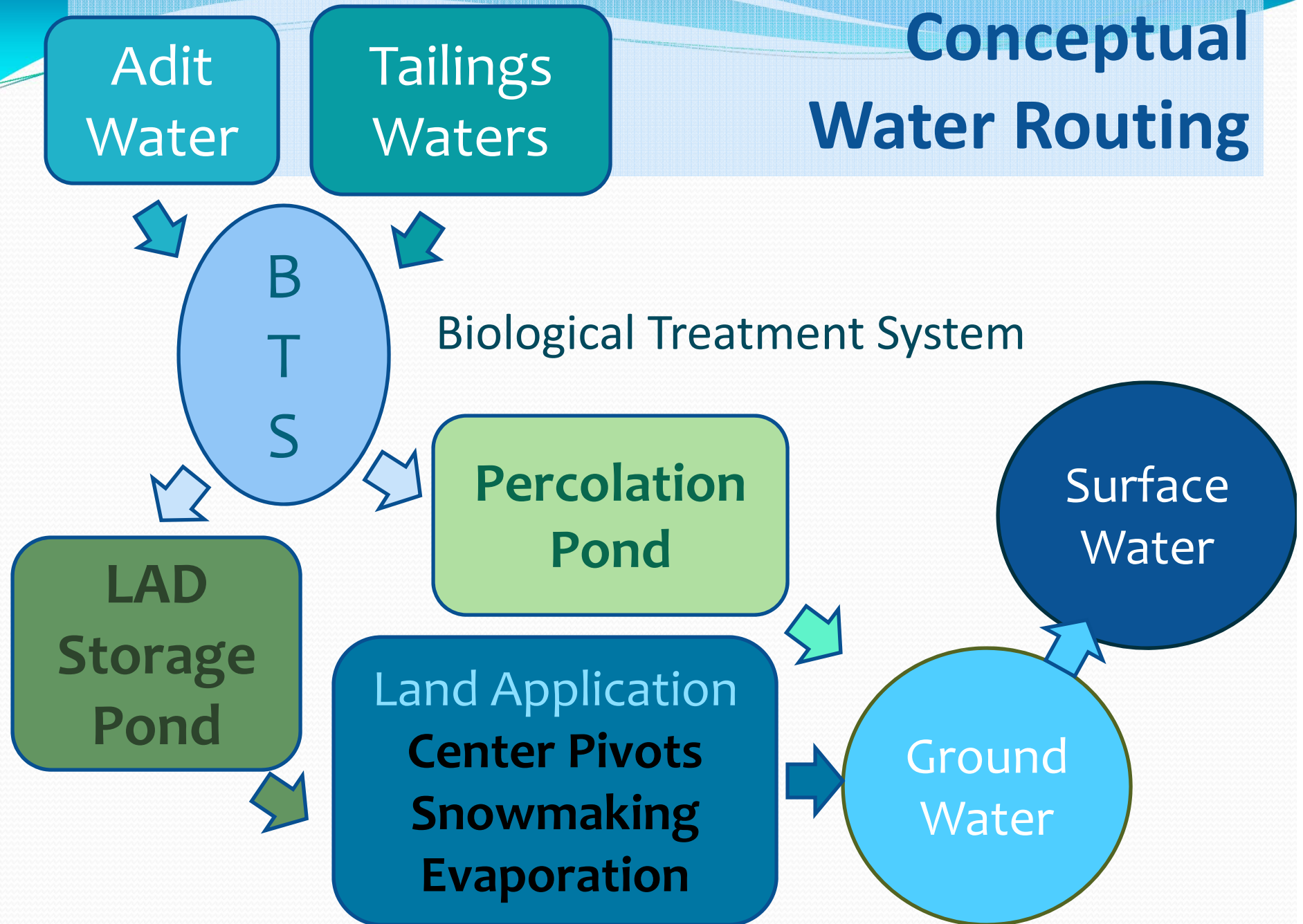


**Center Pivots**



**Snowmaking**

# Conceptual Water Routing





# Calculations made

- Mixing waters (waste streams)
- Reduction of nitrogen from plant uptake during center pivot disposal
- Evaporative increase in salt concentration
- Loads to ground and surface water
- Concentrations in ground and surface water

# Example Cell Calculations

- Load of constituent to ground or surface water

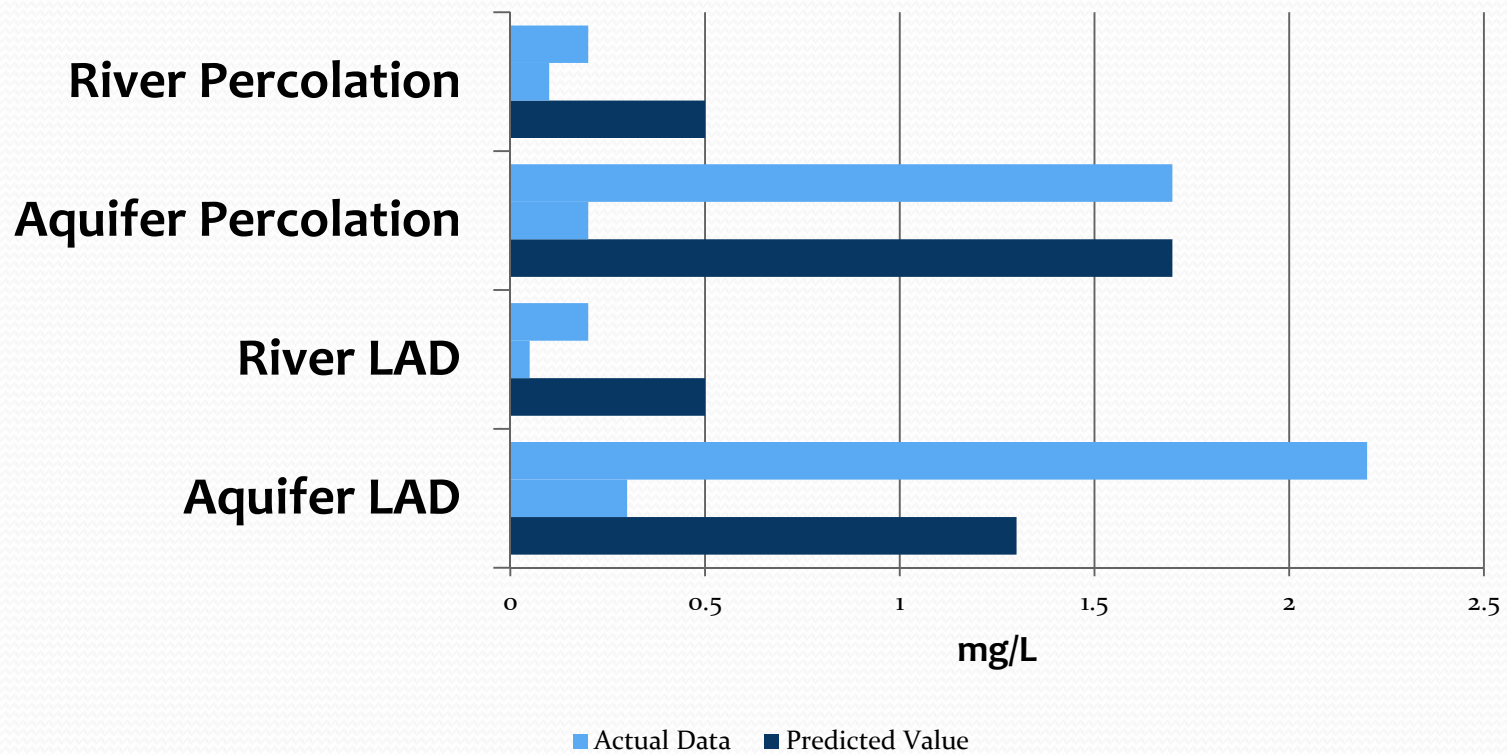
$$\text{Load} = \text{Flow rate} \times \text{Concentration} \times 0.012$$

- Ground water (GW) mixing zone
  - A aquifer, C concentration, Q volume
  - P percolated waters C and Q

$$C_{GW} = \frac{C_A Q_A + C_P Q_P}{Q_A + Q_P}$$

# Comparison of Predictions to Data

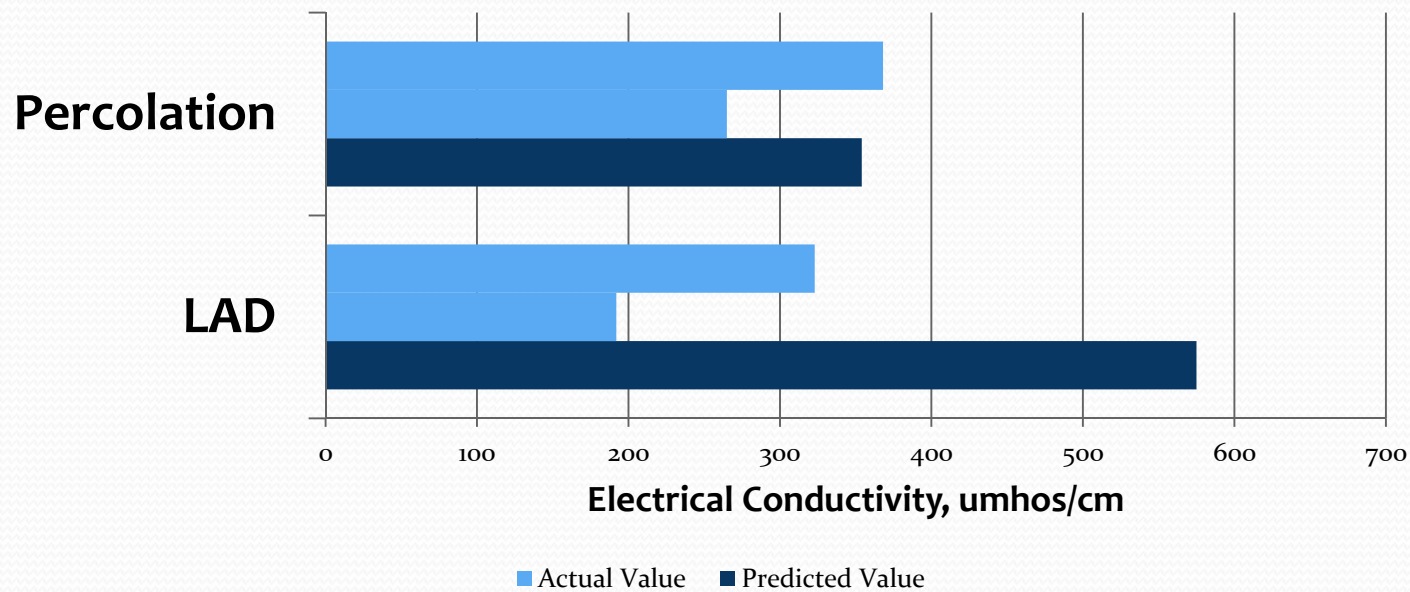
## Nitrogen Concentrations Predicted v. Actual





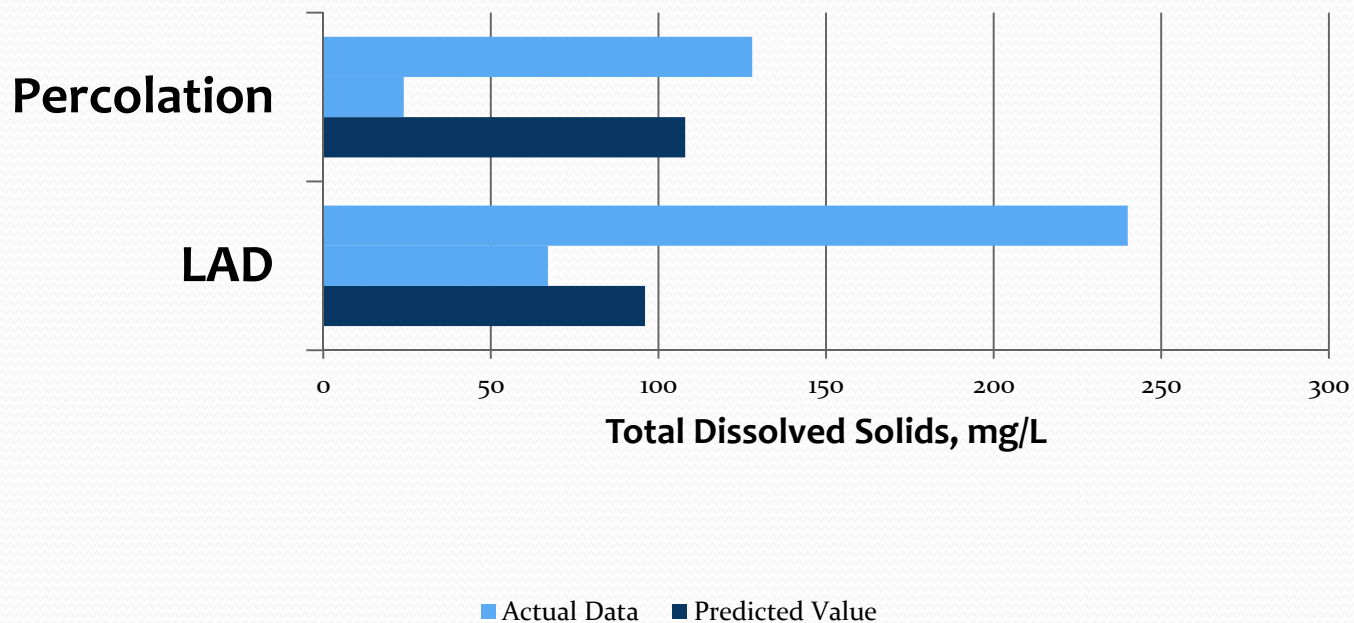
# Comparison of Predictions to Data

## Aquifer Salts Concentrations Predicted v. Actual



# Comparison of Predictions to Data

## In-stream Salts Concentrations Predicted v. Actual



# Flexibility of Spreadsheet Models

- Comments received on Draft EIS
  - Volume of supernatant water in tailings impoundments
  - Efficiency of the biological treatment system
  - Change in operational ground water concentrations
    - Spill
    - Waste rock
  - Addition or removal of components

# What did we learn?

- Center pivots treated nitrogen but increased the effect of salts
- Percolation reduced the effects of salts
- Flexibility in application rate is needed
- Center pivots require intensive management
  - Climatological data and application rate
  - Sodium absorption ratio
  - Concentrations of nitrogen and salts in soil and ground water
- Need for expansion of existing facilities



# Limitations

- Spreadsheet models best suited to less complex scenarios
- Not applicable to
  - Fracture flow systems
  - Unsaturated zone
  - Constituents attenuated in manner not describable with simpler math
  - Situations where 3D model is necessary



# Value of Spreadsheet Models

- Can be used for mine
  - Permitting
  - Operational permit revisions
  - Closure and post-closure predictions
- Identified the critical elements of water management systems
- Flexible, easily modified
- Consistent with EPA NPDES calculations

# Questions?

