Estimating Mine Inflow Rates Real Time Using Analytical Methods

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Need for such a model?

- Some difficulties encountered in measuring inflow rate
  - *Mine geometry*
  - *Inflow point not accessible*
- Estimating and tracking inflow rates
  - *Designing pumping systems*
  - *Grouting*
  - *Transient changes*

Aquifer Response to Mine Inflow

- Mine inflow induces stress to aquifer and responds accordingly
- Mine inflows effectively handled as dewatering boundary points (e.g., pumping well, general head boundary)
- Mine inflow aquifer response and inflow prediction modeling often approached with both numerical and analytical techniques

Groundwater Flow Models

- Numerical models very powerful and able to simulate complex scenarios, but "cost" comes in setup and run time.
- Analytical models easy set up and short run times, but "cost" comes in simplicity and assumptions.

Spreadsheet Application

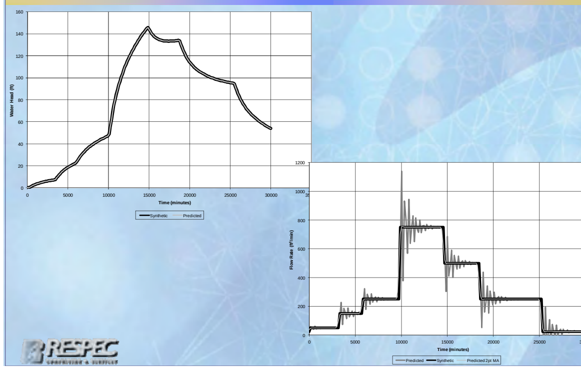
- Analytical solution selected
  - *Application required frequent updates and therefore short run times*
  - *Model complexity sacrificed for speed*
- Theis solution utilized in this case study, but other solutions have been utilized
  - *Exponential Integration Approximation*
- Application involved coupling Theis solution to a numeric solver to indirectly predict inflow

Spreadsheet Application "Flow diagram"

Verification

- Synthetic data set developed
  - *Hydraulic properties*
  - *Pumping Rates*
  - *Radial distances to observation wells*
- Forward predicted hydraulic heads with Theis solution in AQTESOLV
- These predicted hydraulic heads in conjunction with hydraulic properties and radial distance were used to predict pumping rates in this spreadsheet application

Verification

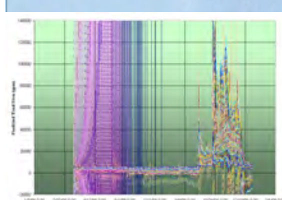


Case Study

- Mosaic K2
  - *Underground potash mine*
  - *Mine inflow since late 1985*
  - *Transient inflow rates*
  - *Inflow into old room workings and inaccessible until rehabilitated*
  - *Pressure monitoring*
  - *Accurate flow measurements difficult in some areas*
  - *Grout to control and maintain inflows*

Calibration

- 210 model runs
  - *Optimized residual between observed and predicted inflow rate*
  - *Transmissivity varied from 0.15 to 60 cm²/s*
  - *Storage varied from 1E-3 to 5E-6 ft/ft*



Spreadsheet Application

- Takes less than 10 minutes to update data and run
- Utilized at least daily and sometimes more frequently to provide real-time
- Proven itself to be reasonable estimator that can perform quickly and efficiently
- Doesn’t take the place of numerical model

Acknowledgements

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Thank you for your attention!
Questions?
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