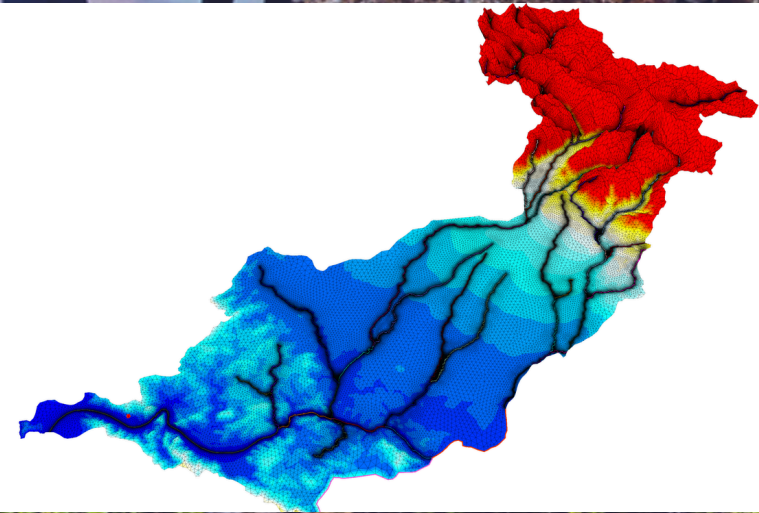




ITASCA

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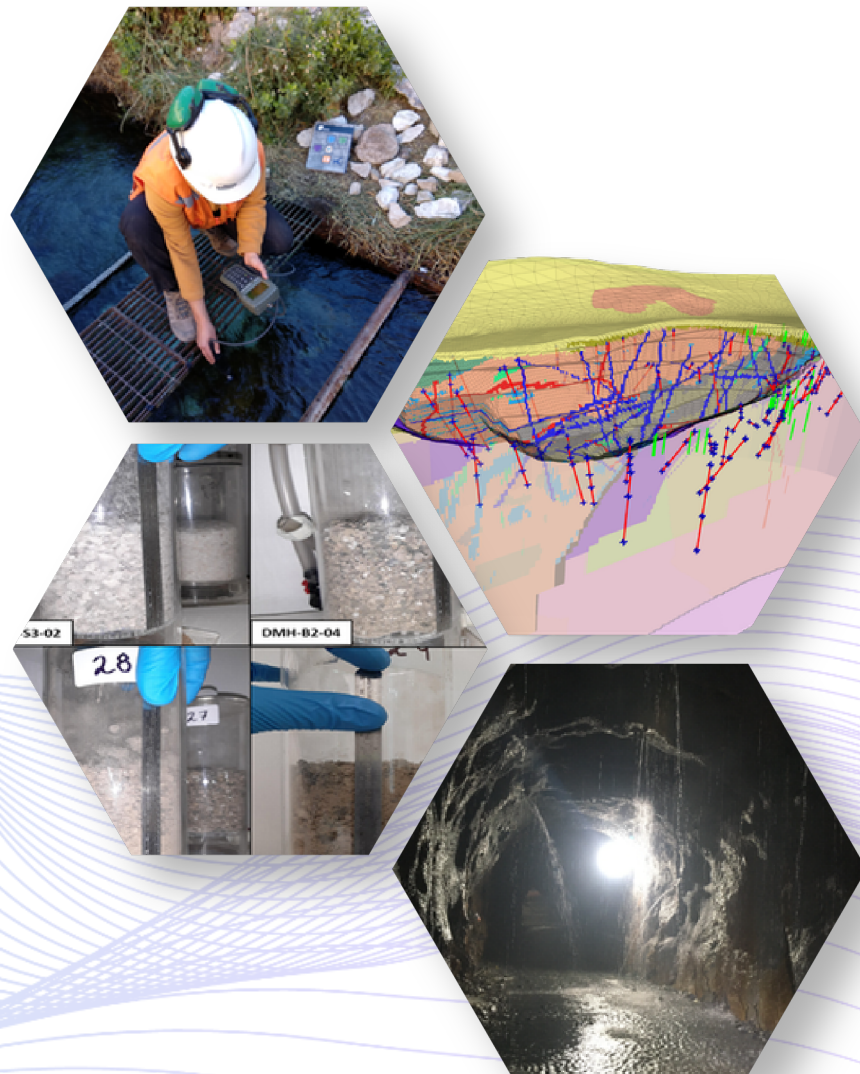
Services on Hydrogeology and Geochemistry





Our Services

- At ITASCA, we have extensive experience in interpreting **complex hydrogeological systems**, including those associated with mineralization, fractured rock, and complex geologic structures.
- Building on this expertise, we offer specialized services ranging from **hydrogeological characterization, conceptual model development, numerical model building, and strategic support** that optimize operational practices.
- Our approach integrates **data, analyses, modeling, and experience** to support informed decision-making and effective groundwater management.





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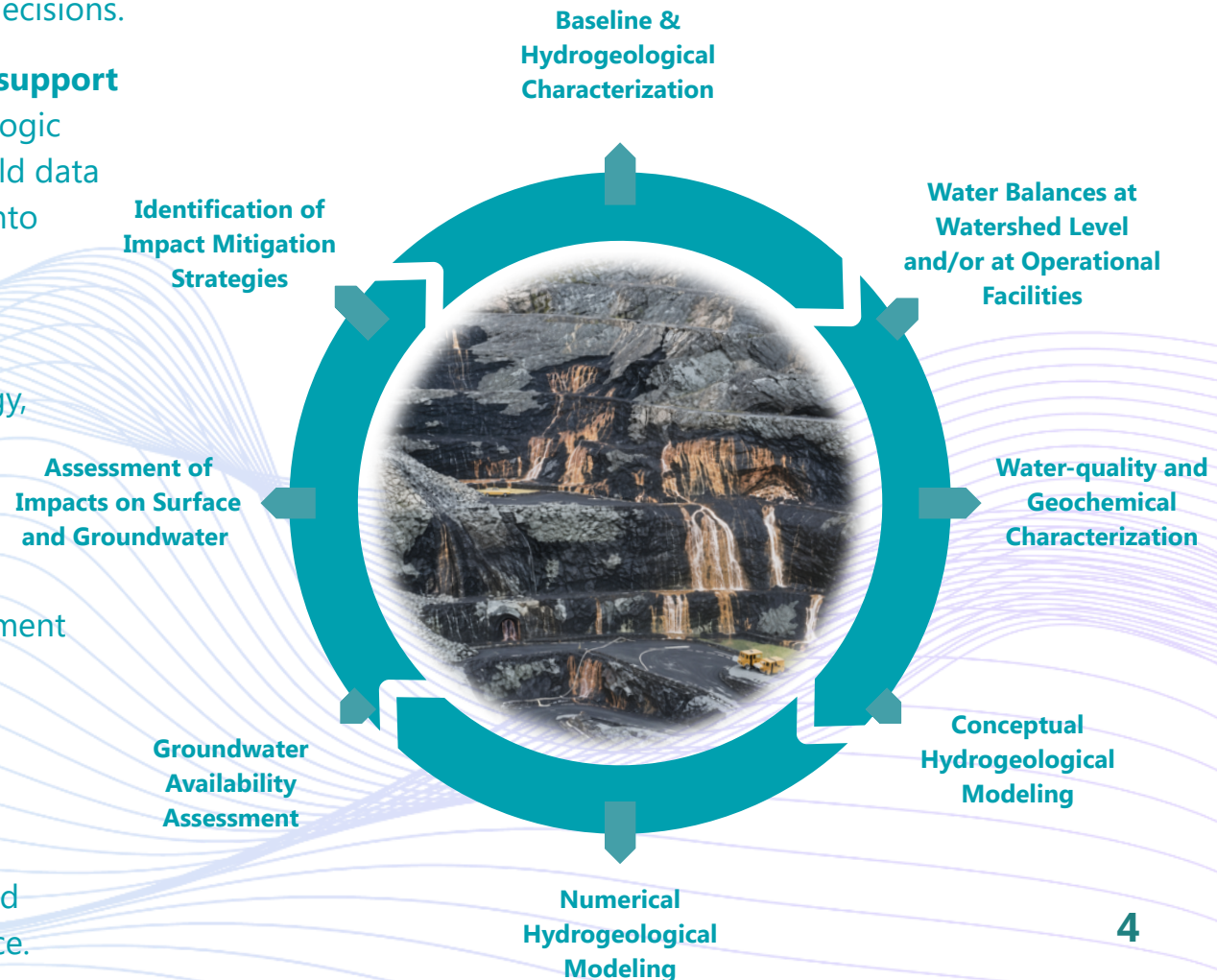
Strategic and Operational Support

ITASCA offers an **integrated technical framework**, designed to help clients understand baseline conditions, anticipate hydrogeologic impacts, support permitting, optimize operations, and independently test critical assumptions. By **combining field insight, modeling capability, and strategic review**, we provide the defensible technical basis needed to reduce risk and support sound project decisions.

We provide **operational monitoring and support services** to help clients manage hydrogeologic conditions proactively, maintain reliable field data streams, and translate monitoring results into sound operational decisions.

How we can assist:

- **Strategic** consulting, field hydrogeology, and hydrogeological modeling.
- **Support** in environmental permitting procedures.
- **Baseline** data collection, data management training and decision support.
- Consulting on **operational** aspects of hydrogeology, water resources, and hydrology.
- Technical **peer review**, geotechnical and geomechanical review and due diligence.





Hydrogeological Characterization

ITASCA offers hydrogeological characterization services to provide the robust field, analytical, and interpretive foundations required for confident project decisions. Through **integrated investigation, testing, monitoring, and geochemical assessment**, we help clients reduce uncertainty in permitting, design, and long-term water management.

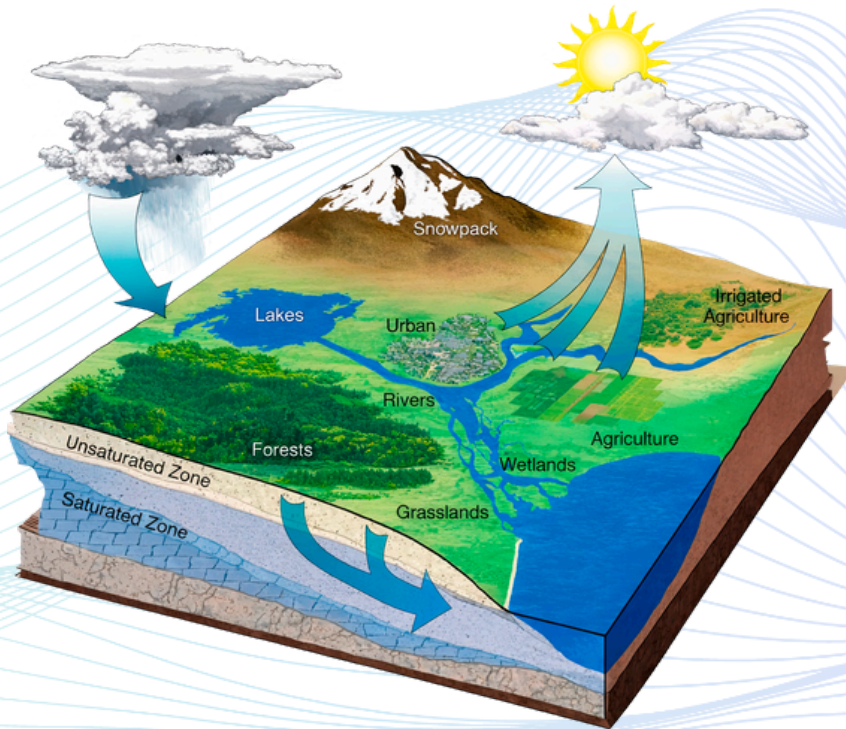
Among other activities, we offer:

- **Design** of characterization drilling campaigns.
- Hydrogeological **interpretation** of drilling and geophysics.
- **Measurement** of water levels and flow rates.
- Design of wells, piezometers, and hydrogeological instrumentation.
- Design of pumping tests and **hydraulic testing**.
- Water and soil quality **sampling**.
- Geochemical and water-quality **characterization**.
- **Identification** of natural and anthropogenic processes.



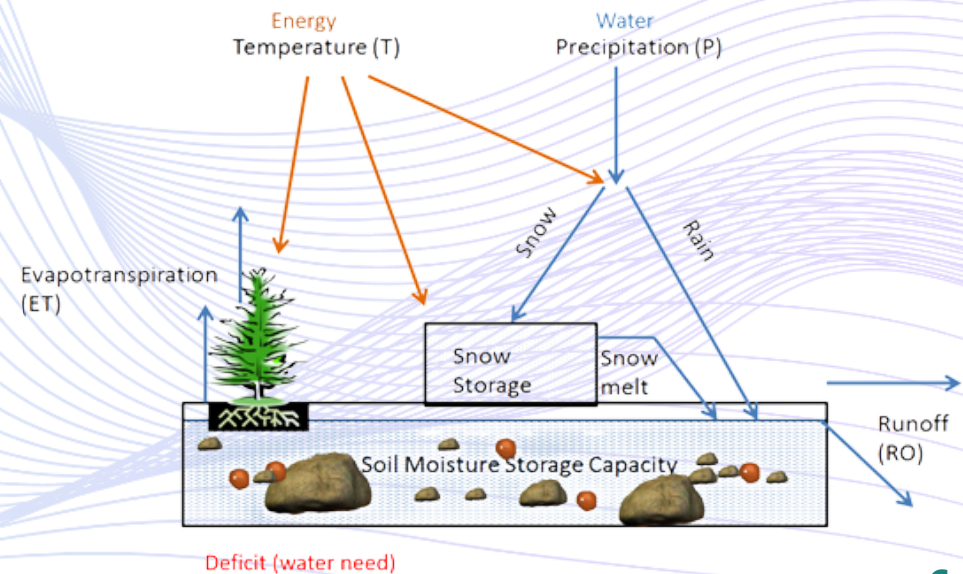
Conceptual Model Development

ITASCA provides conceptual modeling services to convert **complex hydrogeologic information into a coherent and defensible understanding of system behavior**. The work is usually aimed at supporting permitting, operational strategy, engineering design, and long-term water management. Conceptual models are the basis for numerical modeling analyses that allow estimating the timing and magnitude of system changes.



Activities in this regard include:

- Identification of **hydrologic processes**.
- Definition of **hydrogeologic units (HU)**.
- **Hydraulic behavior** of geologic structures.
- Operational and strategic **water balances**.



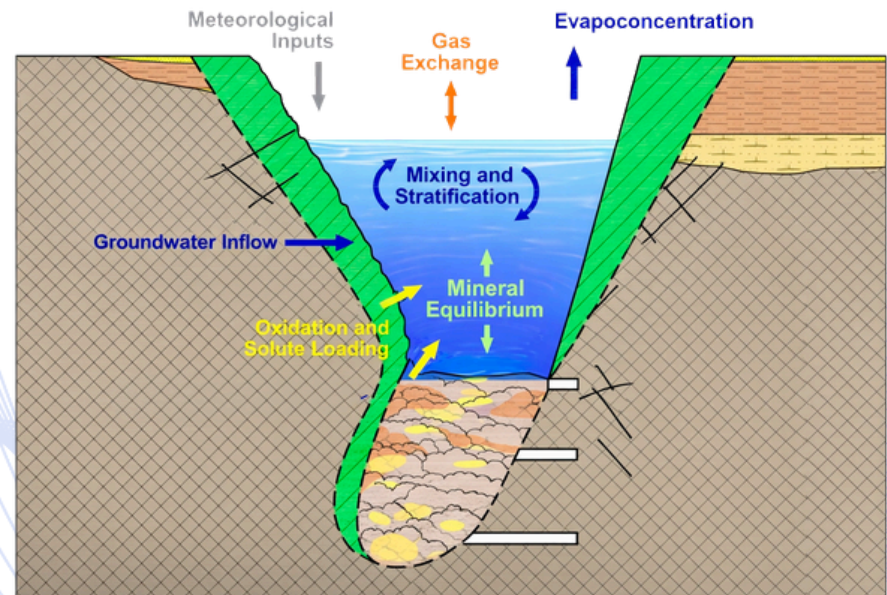
Example water balance

Hydro- and Geochemistry Analysis

ITASCA provides specialized consulting services in **water quality, geochemistry, and integrated hydrogeologic-geochemical modeling** to address critical water-quality challenges in the mining industry. By combining field data, analysis, geochemical interpretation, hydrogeologic assessment, numerical simulation, and environmental expertise, we help clients reduce technical uncertainty, anticipate water-quality risks, and support informed decision-making throughout the life of mine.

Our key areas of work are:

- **Baseline** water quality characterization.
- Mine, rock, water and **contaminant geochemistry**.
- **Pit-lake** geochemistry.
- **Integrated** hydrogeologic-geochemical and mine water system modeling.
- **Decision support** for mine planning, compliance, and closure.
- Use of **industry-standard tools** such as GoldSim to develop **dynamic mine water balance** simulations.



Hydrogeochemical processes and environmental dynamics within a pit lake

We aim to strengthen environmental performance, improve operational planning, support regulatory compliance, and contribute to the long-term sustainability of mining projects.

Numerical Model Development

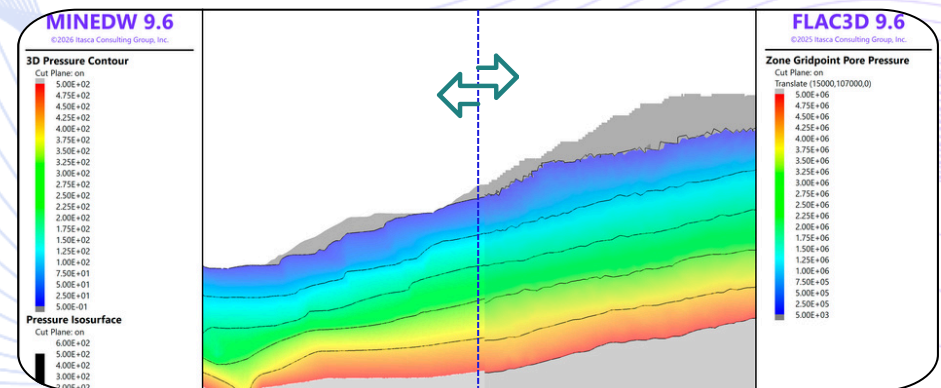
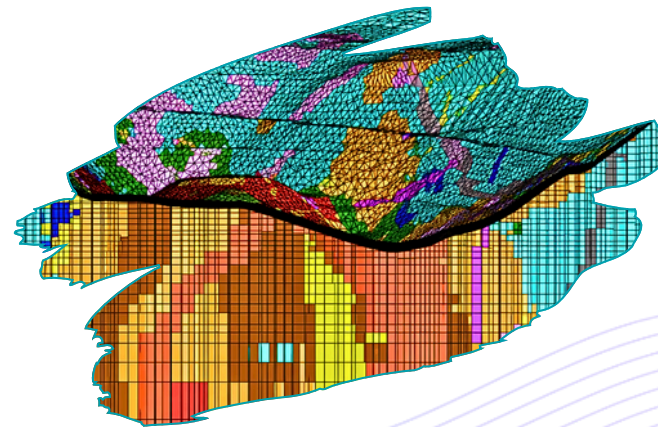
ITASCA provides modeling services to give clients a rigorous quantitative framework for understanding and managing water in complex project environments. **Through the use of models, supported by a broad suite of industry-recognized codes and proprietary tools such as *MINEDW***, we deliver the technical insight needed to support planning, design optimization, impact assessment, and long-term operational water management.

Numerical models are built at different scales and for diverse purposes, such as:

- **Watershed** models.
- Open-pit and underground **mine** models.
- **Tailings infiltration** models.

A variety of modeling codes are available at ITASCA, including the proprietary codes ***MINEDW***, ***FLAC2D/3D***, ***RIVER.lab*** and others, such as *MODFLOW*, *FEFLOW* and *SEEP/W*.

Hydrogeological models are **calibrated using groundwater levels, stream and spring flow rates, hydraulic tests and basin budgets** to represent comprehensive system behaviors and add confidence to the predictive results.

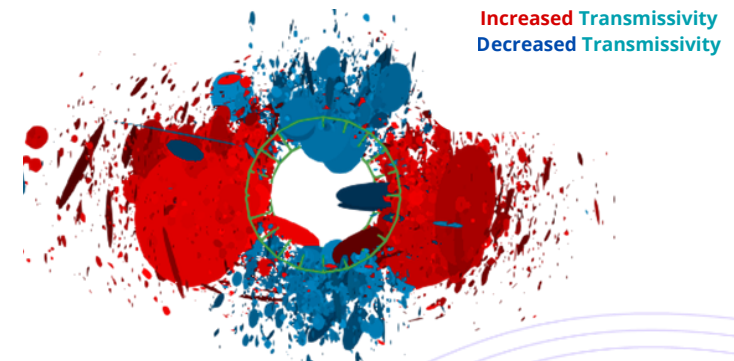


Example transfer of hydrogeological modeling results to geomechanics analysis software.

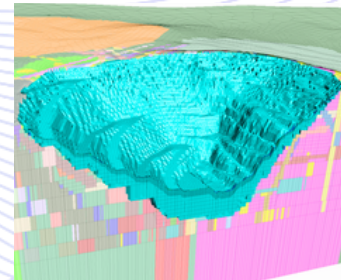
Coupled Hydro-Mechanical Processes

Traditional groundwater models are often calibrated with fixed parameters based on past conditions, even though real hydraulic properties change over time under the influence of geological, mechanical, chemical, thermal, and mining-related processes. **ITASCA addresses this by using conceptual, analytical, and coupled numerical modeling** approaches to evaluate these dynamic systems and better understand their implications for groundwater assessment and prediction:

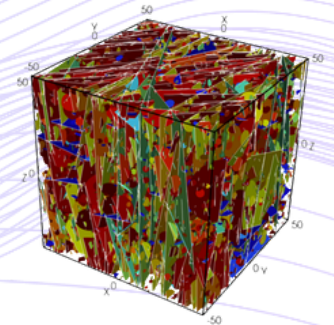
- **Conceptual understanding** of coupled processes and their likely consequences.
- Built-in coupled process simulation **capabilities of our proprietary software** (*FLAC3D*, *3DEC*).
- Semi-coupled, **sequential communication** between *MINEDW* and *FLAC3D/3DEC*.
- **Analytical interaction** between geomechanical and hydrogeological processes.
- **Discrete Fracture Network (DFN)** based hydro-mechanical simulations and **uncertainty analysis** (using the proprietary software *DFN.lab*).



Stress-induced changes in transmissivity around a tunnel



MINEDW implementation of the zone of relaxation (ZOR) for an open pit



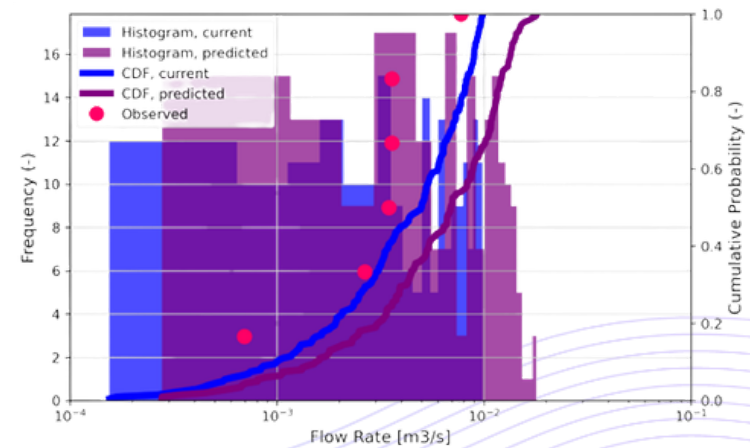
DFN realization for a structural domain



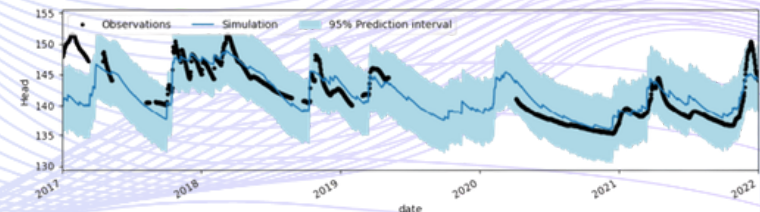
Uncertainty Management

Uncertainty is inherent to geosciences because the subsurface must be interpreted from incomplete and indirect data, so different valid explanations can exist at the same time. **ITASCA helps clients address this reality** by identifying, assessing, quantifying, and managing uncertainty throughout every stage of hydrogeological assessment and modeling:

- **Rigorous data QA/QC** to ensure fundamental data reliability.
- Development of system understanding through **features–events–processes (FEP) analysis** and alternative conceptual scenarios.
- Structured **risk analysis** to identify and prioritise key uncertainties.
- Manual and automated **uncertainty simulations using the PEST suite** to explore parameter and structural variability.
- Qualitative and quantitative **consequence assessments** that translate uncertainty into clear, decision-relevant insights.
- **Statistical interpretation**, evaluation of uncertainty and uncertainty structure.



Stochastic assessment of mine inflow rate.



Simulation results of groundwater levels with 95% prediction interval



Key Personnel in Hydrogeology and Geochemistry



Kálmán Benedek

Dr. Benedek has over 20 years of experience in hydrogeology. He has extensive experience in conceptual testing using numerical and analytical tools. He has carried out numerous reservoir evaluation projects, mine drainage projects, and other related projects. He has also been involved in numerous mining, oil, and gas projects.



Martin Brown

Civil Engineer with over 20 years of experience in water and environmental management, 10 of them from within the Chilean mining industry, leading Development and Operations areas related to hydrogeology, water resources, the environment, fluid transport, tailings storage facilities, and mine drainage.



José Luis Villa

Senior Hydrogeologist with more than 20 years of experience in numerical modeling for open-pit mines, underground mines, waste dumps, and tailings storage facilities. He has developed 1D, 2D, and 3D TSF models using Hydrus, SEEP/W, MINEDW, and FEFLOW.



Key Personnel in Hydrogeology and Geochemistry



Isidora Arriagada

Geologist with an MSc in hydrogeology and environment from the Technical University of Darmstadt, Germany. Throughout her consulting career, she has gained experience in soil and groundwater studies, hydrogeological modeling, environmental impact assessments, and the design, coordination, and execution of field campaigns and remediation projects.



José-Luis Delgado

Civil Engineer with nearly 20 years of experience in Water and Environmental Management, with a special focus on hydrology and hydrogeology as a source of water supply for the Chilean mining industry. He has led Study and Development areas related to water resources, and has also implemented water exploration and exploitation projects.



Grady O'Brien

Principal Hydrogeologist with over 30 years of hydrogeology experience for mining, agricultural, industrial, commercial, and governmental clients. He specializes in mining hydrogeology design, planning, and implementation of characterization programs, operational dewatering, and groundwater flow and chemical transport modeling.



**"We drive the evolution of engineering geology
and geosciences to improve the world,
collaboratively developing innovative solutions
for challenging problems"**

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