



**MONTGOMERY
& ASSOCIATES**

Water Resource Consultants

Statement of Qualifications **MINING HYDROGEOLOGY**



ARIZONA | CALIFORNIA | COLORADO | NEVADA | UTAH | CHILE | PERÚ

elmontgomery.com

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Company Profile

Four decades of hydrogeologic support to the international mining community

Montgomery & Associates (M&A) is a water resources consulting firm specializing in groundwater development and management. With clients in industries such as mining, municipal, industrial land development, tribal, and agricultural, M&A provides services in six main areas: mining hydrogeology; environmental hydrogeology; water resource planning; hydrologic modeling; water rights and impacts; and water supply and recharge. For the mining industry, M&A has developed innovative ways to model dewatering processes, perform water balances, manage operations using customized monitoring tools, and characterize aquifer conditions under challenging chemical and temperature regimes. We conduct analyses and investigations to support mine feasibility, permitting, and environmental impact studies. M&A's client list includes most of the world's major domestic and international mining entities.

Since Dr. Errol L. Montgomery founded the company in 1984, M&A has built a reputation for technical excellence and addressing clients' water resource challenges. M&A's team consists of specialists in hydrology, hydrogeology, soil science, policy and



U.S. office locations

regulatory affairs, groundwater flow modeling, GIS analyses and 3D visualization, database management, and instrumentation and monitoring. M&A's management team is made up of a deep bench of professionals with more than 20 years of experience, nearly all of whom have advanced degrees plus one or more professional registrations. M&A staff members are recognized as industry leaders and

frequently present at conferences, participate in professional organizations, and serve on advisory boards.



South American office locations

Headquartered in Tucson, Arizona, M&A also has offices in Utah, Nevada, Phoenix, Denver, and multiple locations in California. South American offices are located in Santiago, Chile, and Lima, Perú.

Services for the Mining Industry

Feasibility Studies

[Comprehensive approaches to assessing the feasibility of mining projects](#)

M&A conducts field testing, monitoring, and modeling to provide a framework for understanding existing conditions, determining dewatering requirements, water supply availability and water control requirements, and projecting future impacts to water resources and the environment. Our decades of experience in mining hydrogeology prove their value when critical decisions need to be made — especially when decisions rely on detailed hydrogeologic investigations and analyses. Our capabilities include:

- Using the results of field testing and analysis to generate conceptual hydrogeologic models
- Deploying field instrumentation to monitor hydraulic, hydrochemical, and atmospheric parameters
- Drilling and testing to characterize hydrogeologic and water quality conditions and to estimate aquifer parameters required for modeling
- Modeling to determine pit-dewatering requirements, mine-supply wellfield capacity, mine water disposal, and post-closure water management conditions, tailings water management requirements, and the potential impacts to surface and groundwater resources

Environmental Impact Studies

[Defensible approaches for evaluating the impacts of mining on water resources](#)

New and expanding mines with a federal nexus must prepare an environmental impact statement (EIS) or environmental assessment (EA). M&A works with third party contractors to prepare the water resource portions of such submittals, using hydrologic models, proven field characterization methods, and remote sensing approaches to document existing or historical conditions and assess potential impacts. M&A also provides valuable support for the public input process. We interface with federal, state, local, and tribal agencies, as well as with special interest groups. Our public presentations are clear, objective, and defensible, communicating complex concepts to a range of audiences. Our capabilities include:

- Designing and implementing data-collection programs
 - Characterizing water resources at the site-specific and regional scales
 - Developing models
 - Formulating alternative actions and evaluating the impacts to water quality and quantity under these alternatives using numerical and analytical models
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- Designing methods for assessing impacts
- Preparing reports, submittals, and presentations for public comment and collaboration, and effectively responding to public comments

Hydrologic Modeling

Practical models for better water management decisions

Groundwater Flow Modeling. M&A's hydrologic modeling team includes a dozen professionals who are proficient in a variety groundwater flow and contaminant transport models for both saturated and unsaturated media, including MODFLOW, MODFLOW-SURFACT, MODFLOW-USG, FEFLOW, GoldSim, MT3D, and PEST. The results of our groundwater models can be integrated with decision support models to further quantify uncertainties and analyze cost-benefit scenarios. In addition, we often use geologic block modeling software (such as Leapfrog) to develop input and present results in a way that is accessible to project stakeholders.

Decision Support Modeling. M&A creates flexible planning tools that integrate a range of interrelated factors to quantify uncertainty and simulate outcomes. These decision support models (DSMs) vary in scope, from simple to complex; often, relatively inexpensive models can provide valuable information for guiding water-resource planning decisions. All models feature custom dashboards. M&A uses a range of tools to develop DSMs — dynamic simulation models (GoldSim®), databases (Access or Excel), numerical groundwater flow models, and ArcGIS. We can also conduct quantitative risk analyses to provide information about the likelihood of an event occurring and also its cost. M&A has used DSMs to design monitoring programs for tailings impoundments by considering uncertainties about aquifer properties and contaminant sources, distribution, and migration pathways. We use DSMs to identify the best pumping scenario for wellfields at mining operations.

Geologic Block Modeling. Geologic models are ideal for developing and communicating a conceptual understanding of the project area's subsurface characteristics. These models can incorporate hydrogeologic units, aquifer parameters, wells and other infrastructure, geochemistry, geophysics, and features of interest such as confining units that separate various aquifer zones, water levels, surface streams, topography, contaminated aquifer zones, saline interfaces, and economic resources such as ore bodies and lithium-rich groundwater zones. M&A primarily uses Leapfrog® software to develop geologic block models. Leapfrog models can be migrated into groundwater models such as MODFLOW and applications such as Groundwater Vistas, MineSight, Surpac, and Vulcan. M&A has used Leapfrog models to site dewatering wells near open-pit mines, estimate economic resources such as lithium and potassium in salar aquifers, and quantify the amount of total estimated recoverable storage of groundwater in a basin. Leapfrog models can be manipulated in 3D space, facilitating project planning and stakeholder decision-making.

Mine Dewatering

Field and modeling services for effective dewatering strategies

Mines can face dewatering challenges during design, operation, and closure. M&A provides testing, data analysis, dewatering estimates, and groundwater modeling services to characterize and project conditions in complex, fractured-rock hydrogeologic environments. Our local-scale models are calibrated to observed data and tested for sensitivity to various input parameters so that we can predict pit and underground dewatering requirements. These models are often coupled with regional models to simulate the long-term effects of mine closure. Our capabilities include:

- Instrumentation
- Designing / implementing drilling and testing programs to characterize fractured-rock systems
- Analyzing hydraulic data to estimate aquifer parameters
- Developing models to project pit dewatering requirements, filling rates, and pore pressures
- Projecting local and regional water levels under mining and post-closure conditions
- Developing pit-lake water balances
- Designing monitoring programs to ensure regulatory compliance and community understanding

Tailings Water Management

Operational and environmental solutions for mine tailings

Management of tailing storage facilities (TSFs) must address impacts to groundwater quality (sulfates and other regulated constituents) and tailing impoundment conditions. M&A provides a range of services related to managing tailings water, including design of monitoring systems for traditional monitor well and piezometer networks. We often work in tandem with geotechnical engineers to ensure that the appropriate expertise is applied to TSF issues in planning, operations, closure, and reopening. M&A also installs instrument stations in the TSF interior that remotely monitor water content and pressure conditions under dynamic tailing deposition conditions. We design interceptor wellfields and develop pumping strategies to control groundwater impacts associated with seepage of tailing water into the groundwater system. Specific capabilities include:

- Developing comprehensive water balances for TSFs using both deterministic (spreadsheet based) and stochastic (GoldSim modeling) methods
 - Characterizing ambient groundwater conditions and impacts from tailings operations
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- Monitoring hydrologic conditions within operating impoundments to assist geotechnical engineers with evaluation of TSF stability
- Sampling groundwater, surface water, and soil to ensure regulatory compliance
- Providing support for permitting new TSFs and complying with regulatory requirements at planned, operational, and closed facilities
- Modeling tailings water movement and discharge
- Designing mitigation measures for regulatory compliance

Environmental Compliance

Compliance support for mining operations, from feasibility through closure

M&A offers a range of solutions that focus on simplifying the process of meeting compliance and reporting obligations. We also have the staff and tools for optimizing data collection efforts to ensure that clients are allocating resources as cost-effectively as possible. In addition, M&A provides support for aquifer protection — specifically, characterization, monitoring, contaminant fate and transport, and hydrogeologic report preparation. We also have experience conducting investigations to support mine closure, from the both regulatory compliance and remediation perspectives. These investigations include predicting post-closure conditions such the formation and passive or managed containment of pit lakes. Our capabilities include:

- Characterizing hydrogeologic and water quality conditions
- Identifying regulatory requirements and options for obtaining permits and approvals; designing / administering programs to satisfy permitting requirements
- Designing monitoring programs and data-acquisition systems
- Preparing compliance documents, permit applications, and supporting documents
- Training mine staff and developing standard operating procedures for compliance activities

Mine Water Supply

Water supplies to meet the needs of mining operations

Because many mines are located in areas that are remote, arid, and/or hydrogeologically complex, developing water supplies can be challenging. In addition, pumping can impact nearby water resources and environments in ways that are unacceptable or need to be mitigated. M&A provides technical and planning support, evaluating all options to identify the most reliable, institutionally viable, and environmentally acceptable water supply alternative. When warranted, we also assess the feasibility of mitigation actions such as using artificial recharge to replace water withdrawn for mining supplies. Our capabilities include:

- Characterizing groundwater quantity and quality conditions to identify appropriate water supply sources
- Conducting reconnaissance-level investigations
- Designing and supervising the construction of exploration, monitoring, and production wells
- Projecting the effects of withdrawals on water resources
- Modeling to determine wellfield capacity and pumping impacts
- Optimizing wellfield operations
- Monitoring the effects of mining operations on water levels and water quality

Mine Closure Planning

Mine closure planning from feasibility to legacy

Water-related issues with mine closure must be considered at the earliest stages of feasibility studies. M&A engages early on in mine development planning allowing us to provide water-related mine closure planning technical support through the life of the mine. This involvement ensures compliance with permitting, technical, and environmental issues. M&A's extensive modeling capabilities are used during mine closure planning to determine groundwater recovery rates of dewatered mines, as well as pit lake filling rates. Our capabilities include:

- Providing water-related closure consulting for mines from feasibility to legacy
- Negotiating with state and federal regulators
- Researching, applying, and maintaining water rights and regulatory permits
- Modeling of pit lake filling rates
- Providing compliance solutions for mining legacy properties
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Brine Resources

JORC and NI 43-101 estimates of economic brine resources for planning and development

Unlike traditional mineral resources that occur as solid deposits, mineral-enriched brines reside within porous- and fractured-rock aquifers. Estimating the mineral resources and reserves in a brine deposit presents technical challenges; this process requires understanding the spatial and temporal variability of brine densities and concentrations and also the variability of flow characteristics in the host aquifer. M&A helps clients develop sound mining plans by exploring, characterizing, quantifying, and developing their mineral reserves. Our capabilities include:

- Conducting field and modeling investigations to define drainable resources and economically extractable reserves
- Developing variable-density groundwater flow models to predict how mineral concentrations change with pumping
- Predicting sustainable production rates
- Providing expert review and assessment of technical reports and site conditions
- Preparing technical reports by Qualified Persons following JORC and NI 43-101 international standards for public reporting

Production Drilling Oversight

M&A provides drilling oversight and managed on-site sampling procedures for core and rotary drilling programs. We log core and chips both on- and off-site to inform local geology modeling. We work with mine site geologists to expedite sample preparation and shipment for analytical testing.

- Conducting on-site geologic logging and sampling oversight
 - Assisting mine staff with rig management and drill planning
 - Coordinating adjustments to the sampling program with mine site geologists and corporate geologist
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Mining Hydrogeology Services

