



HYDROGEOLOGY

Assessment and Management of Groundwater

Groundwater is a vital resource. Its importance continues to increase, as available surface water resources become fully utilised, and environmental pressures restrain the development of large surface impoundments. In many arid areas groundwater is, and will remain, the only viable source of fresh water.

Groundwater is also a fragile resource. Water currently stored in aquifers may have been recharged hundreds or even thousands of years ago, and flow rates through the subsurface may be very slow. Damage caused by poorly planned exploitation or by chemical pollution may be difficult or impossible to remedy.

Hydrogeology is the science of water movement through soils and rocks. Practical application of hydrogeology requires a thorough understanding of the natural processes of groundwater recharge, flow, and chemical evolution, and it also requires a good knowledge of the technologies available for groundwater evaluation, exploitation and protection.

C. M. Jewell & Associates Pty Ltd (CMJA) draws on 30 years of international and Australian experience solving groundwater-related problems. Our expertise spans the full range of services required to locate, evaluate, monitor, develop and protect groundwater. The services we can provide include the following.

- Location of groundwater supplies using geomorphological, geological, photo-geological and geophysical techniques
- Groundwater resource evaluation using well and aquifer testing, and hydrogeochemical techniques
- Groundwater development using boreholes, spearpoints, dug wells and infiltration galleries
- Groundwater quality monitoring
- Artificial recharge
- Groundwater contamination assessment and remediation
- Mine water management
- Investigation and management of dryland salinity problems
- Design and management of the groundwater aspects of solid and liquid waste disposal, including landfill, wastewater disposal by irrigation or infiltration, and wastewater reinjection.

Hydrogeology is a specialised field with applicability to a wide range of engineering, environmental and agricultural problems. Several interesting examples of CMJA's experience in hydrogeological investigations are provided below.

Examples of CMJA's expertise

Landfill operations

Solid waste-management facilities such as landfills can affect the quality of underlying groundwater resources. It is therefore vital to get the best possible advice.

Our hydrogeologists have considerable depth of expertise and project experience. We can assess the suitability of a site for a proposed new landfill development, and predict potential impacts. We can also manage installation, monitoring and investigation for contaminants at existing landfill operations. Described below is a hydrogeological investigation – conducted by CMJA – for the Whylandra Landfill in Dubbo, Central West NSW.

The Whylandra Landfill has been in operation since 1977. We evaluated existing information on the hydrogeology of the surrounding area; this indicated that Mesozoic-age sandstone lithologies underlie the entire landfill area, and constitute the only zone available for groundwater movement. A number of deep piezometers were drilled through deeply weathered sedimentary rocks, and the zone of saturation (water table) located at over 40 metres depth.

Our overall assessment of climate, hydrogeology and waste containment practices indicated that there was little risk of significant groundwater contamination resulting from leachate movement. We completed our investigations with landfill gas testing, which again showed little cause for concern.

Effluent irrigation of land

Increasingly, water authorities are recognising the benefits of properly managed effluent irrigation systems, and so hydrogeologists are often called upon to help mitigate the effects of effluent discharge on groundwater resources.

CMJA's hydrogeologists have a strong background and field experience in hydrogeological investigations of this type. Our work has covered a wide variety of industries including feedlots, sewage discharges, milk processing facilities, dewatering re-injection and landfill leachate discharge.

The innovative free-stall dairy operated by Moxey Farms at Gooloogong, NSW, is one example of a project assisted by an effluent irrigation investigation carried out by CMJA. An outline is provided below.

Proposals to expand dairy effluent irrigation at Moxey Farms were assessed in relation to their potential impact on groundwater. The farm is underlain by an alluvial sequence that hosts a multi-layer aquifer system. The groundwater quality of this aquifer system was potentially vulnerable, following the use of dairy effluent to irrigate areas used for pasture and fodder production.

Investigative work comprised extensive electromagnetic surveys to locate higher permeability sand lenses, DC resistivity soundings to enhance depth resolution, backhoe test pit examination, soil permeability testing, drilling of boreholes into the unconfined aquifers and delineation of pre-irrigation groundwater quality.

CMJA's investigations identified those pasture areas with greater sensitivity to contamination from effluent irrigation. We also designed and implemented a programme to monitor shallow groundwater quality.

Mining

CMJA has conducted a wide range of investigations for the mining industry. These include locating suitable groundwater resources to support mining operations, conducting impact assessments of mining/quarrying operations on neighbouring groundwater resources, and designing and installing groundwater monitoring programs.

When it is proposed to mine below the water table, assessments must take into account all impacts resulting from dewatering and aquifer depressurisation. Similarly, the potential impacts of open-cut or underground mines on natural surface water and groundwater flow systems must be assessed.

Risk-based assessments regarding the potential for aquifer contamination, or the identification of contaminant migration pathways, may also be requested. Regulatory authorities will often require such work before considering an application to develop and/or expand a mining operation.

CMJA has conducted numerous mining impact assessments. Our clients have included Peak Hill Gold (Peak Hill Gold Mine), Tailings Treatment (Tomingley), Enhance Place Pty Ltd (Enhance Place Colliery near Lithgow, NSW), David Mitchell Pty Ltd (Sulcor Limestone Mine and Attunga Limestone Quarry, both near Tamworth), Concrete Quarries Pty Ltd (Exeter Basalt Extraction Area, Southern Tablelands, NSW), ACI Industrial Minerals (silica sand mining at Tanilba Northern Dune, Port Stephens, NSW), Rocla Quarry Products (Calga, Central Coast) and Kelian Equatorial Mining (East Kalimantan, Indonesia).

Groundwater modelling of flow and solute transport

Groundwater professionals are frequently challenged to make predictive quantifications of groundwater behaviour. They may need to assess how much groundwater is present, by using *flow modelling*; or they may be required to predict the concentration of solutes contained within flowing groundwater, by using *contaminant transport modelling*.

Depending upon the objectives, models can vary from a simple analytical equation embedded in a spreadsheet program through to a highly complex time-variant numerical model designed to simulate subtle changes in groundwater movement within a complicated geological environment over a period of several decades.

We use several of the industry standard modelling codes and integrated modelling software programs, including Visual MODFLOW, INTERSAT/INTERTRANS, SEEP/W and SEEP 3D. Also available to us are supporting software packages such as Visual Groundwater, Mapinfo and Surfer.

More important than the modelling packages are the users, however. CMJA's hydrogeologists have the experience and insight to make the critical choices in designing the model approach most appropriate to the application.

One CMJA groundwater modelling project was that undertaken for the Eastern Distributor Motorway, Sydney, NSW. The motorway link from Woolloomooloo to Sydney Airport involves a tunnel through sandstone and a 'parkway' excavated below the water table in the Botany Sands aquifer. On behalf of the main contractor, Leighton, CMJA carried out a suite of modelling studies, using analytical and numerical finite element and finite difference techniques. These were used to assess the regional and local impacts of both the construction dewatering and the permanent structure, and to optimise a dewatering system design and the implementation of a re-injection system.

Other groundwater modelling assignments include the Parkes borefield (water supply), Thredbo Landslide Inquiry (expert witness), and Beemery cotton farm (irrigation).

Specialist equipment and methods

CMJA is fully equipped to undertake all hydrogeological investigations and can employ a range of innovative investigative tools to help with assessments. Our equipment includes:

- Grundfos MP1 variable-speed, electro-submersible sampling pump, suitable for use in purging standard 50-millimetre diameter sampling bores;
- Hydrolab H20G down-hole hydrochemical probe;
- soil vapour probes;
- electrical conductivity, pH, DO and redox meters;
- specialist sampling pumps and bailers; and
- hydraulic conductivity (slug-testing) equipment.

In addition, where applicable, CMJA uses the following groundwater geophysical methods:

- electromagnetic (TEM) soundings;
- electromagnetic (FEM) ground conductivity surveys;
- DC resistivity soundings and traversing;
- down-hole geophysics (gamma, neutron, caliper, EM and resistivity).

CMJA has the capability to deal with all facets of hydrogeology. Whether you require us to locate suitable groundwater supplies to support a mining or irrigation operation, to assess the impacts of proposed or existing operations on underlying groundwater resources, or to design and implement a groundwater monitoring program, we have the experience, knowledge and technology to help you.

We tailor each project to your specific requirements and your project goals, and also take into consideration the need to provide supporting information to regulatory authorities or operational planners.

CMJA also offers a full-service consultancy in hydrogeology, which extends from water sampling to expert testimony.