



MICHAEL J. KING, R.G., C.E.G., C.HG.
Principal: The *Hydrodynamics* Group, LLC

Gas Storage Engineering
Hydrogeology
Geological Engineering

Michael King is a Principal for *Hydrodynamics*, an applied research consulting engineering firm. Mr. King is a Registered Geologist, Certified Engineering Geologist, and Hydrogeologist with over 47 years of experience in the field of natural gas storage engineering, Compressed-Air Energy Storage (CAES), hydrogeology, and environmental engineering. Mr. King's career has focused on natural gas storage and CAES projects throughout the United States and overseas. Mr. King's natural gas storage engineering experience started with Natural Gas Pipeline Company (NGPL) with responsible for gas storage operations at 4 natural gas storage fields in the Midwest. He continued his work as a natural gas storage engineer consultant for energy storage projects in the U.S.A., Republic of Georgia, and Republic of Trinidad & Tobago. He applied his gas storage expertise to the study and development of 17 CAES projects in solution mined salt caverns, depleted gas fields, aquifer, and mine storage systems.

EDUCATION

1973	BS	GEOLOGY, University of Missouri-Rolla
1975	MS	GEOLOGICAL ENGINEERING, University of Missouri-Rolla

REGISTRATION/LICENSES

2022	Professional Geology No. 997/State of Kansas
2021	Professional Geology No. 733517/State of Arizona
2017	Professional Geologist No. 10601997-2250/State of Utah
2016	Professional Geologist No. 37874/Manitoba, Canada
2010	Professional Geologist NO. G-0347/State of Nebraska
2001	Professional Geologist No. 256/State of Washington
2000	Professional Geologist No. 1008/State of Missouri
1999	Professional Geologist No. M64501/Alberta, Canada
1998	Professional Geologist No. 1133/State of Wisconsin
1995	Certified Hydrogeologist No. 157/State of California
1993	Certified Engineering Geologist No. 1741 / State of California
1992	Registered Geologist No. 5312 / State of California
1992	Registered Geologist No. 759 / State of Idaho

EXPERIENCE

1996	Principal Geological Engineer-- <i>Hydrodynamics</i> , WA
1995-1996	Senior Geologist- Converse Consultants
1992-1994	Principal Hydrogeologist--AGS, Inc., CA
1988-1992	Vice President--ASE Drilling, Inc., CA
1987-1988	Senior Hydrogeologist--GEO/Resource Consultants, CA
1982-1987	Vice President--Energy Systems & Resources, Inc., CA
1978-1982	Senior Geologist--URS/John A. Blume Associates, CA

1975-1978 Senior Gas Engineer--Natural Gas Pipeline Company of America, IL

PROFESSIONAL ASSOCIATIONS

American Association of Petroleum Geologists
Society of Petroleum Engineers
Association of Engineering Geologists
Navy League of the United States & U.S. Naval Institute

TECHNICAL REVIEW COMMITTEES

- Electric Power Research Institute, Pittsfield CAES Field Test Program
- Skagit-Hanford Nuclear Power Project License Review
- Yucca Mountain Nuclear Waste Repository Oversight-Inyo and Esmeralda Counties
- Book Review: Berkowitz, N., 1997, *Fossil Hydrocarbons*, Academic Press.

Gas Storage Engineering

Mr. King was a Gas Storage Engineer for NGPL, where he was mentored by Dr. Donald L. Katz (Father of Natural Gas Storage). Mr. King was responsible for gas storage operations at the Loudon, Herscher, Cooks Mill, and North Lancing natural gas storage fields in the Midwest. Mr. King tutored Michael in gas storage technology. Routine duties included daily management of storage inventory; analysis of well performance; supervision of well maintenance-work over-replacement programs; reservoir performance modeling; and well testing. The implementation of a annual geophysical well logging program was one of his key work duties. Additional duties included seasonal management of natural gas storage inventories to match NGPL's market demands.

Natural Gas Storage in Republic of Trinidad & Tobago

Mr. King was the lead scientist in the siting of natural gas storage facilities in the Republic of Trinidad & Tobago. The goal of the initial feasibility study of gas storage in Trinidad & Tobago was to determine the technical and economic feasibility of several geological candidate sites to both provide an adequate strategic gas supply to Trinidad, and allow the NGC to balance short falls in natural gas supply at an acceptable capital cost. Potential natural gas storage structures were screened, and candidate sites were identified and evaluated for their storage potential. The Mahaica depleted gas field was a prime candidate site. Mr. King designed a Mahacia gas storage facility that included modeling gas field development and performance, well field and pipeline gathering system layout, gas storage well design, and design of a gas field monitoring program.

Natural Gas Storage in Republic of Georgia

Michael King was the lead scientist in the siting of natural gas storage facilities in the Republic of Georgia. The goal of the initial feasibility study of gas storage in Georgia was to determine the technical and economic feasibility of several geological candidate sites to both provide an adequate strategic gas supply to Georgia, and to allow the Georgians to balance winter and summer gas demands at an acceptable capital cost. Potential natural gas storage structures were screened, and candidate sites were identified and evaluated for their storage potential. The Rustovi abandoned gas field was a prime candidate site. Mr. King designed a Rustovi gas storage facility that included modeling gas field development and performance, well field and pipeline gathering system layout, gas storage well design, and design of a gas field monitoring program.

Natural Gas Storage System Risk Assessment Studies

Mr. King assisted Koch Ag & Energy Solutions to develop a customized risk assessment tool to evaluate project risk as part of their oversight of third-party natural gas storage sites. He developed a numeral ranking system for screening candidate natural gas storage caverns and/or

reservoirs that were applicable to Koch's risk assessment program. In addition, *Hydrodynamics* also evaluated third party natural gas storage sites for Koch to determine the technical merits and risk of acquiring these facilities. Mr. King also participated in a technical risk assessment analysis for CAES development of the Nebraska Public Power District's Big Springs depleted natural gas storage field.

He applied a numerical risk assessment was applied to 1) assess feasibility, 2) identify risk, 3) develop efficient well design and test objectives, 4) provide guidance on gas storage development, and 5) how to adapt gas storage tools to CAES development of a abandoned gas field.

CAES Experience

Michael King is one of the lead scientists in the siting, field-testing, and development of underground geologic structures for CAES. Mr. King conducted research on the development of CAES in depleted gas and aquifer storage systems. Mr. King's CAES project team has worked together on our 17 CAES projects since 1997 that are listed below.

Salt Cavities

- Austin Power CAES Siting Study
- Chasima Energy West Texas CAES Study
- Ireland CAES Site Analysis
- Pathfinder Magnum Utah CAES Design and Development

Aquifers

- Sacramento Municipal Utility District- Freeport Geological Structure
- EPRI Pittsfield CAES Field Test Program
- Iowa Dallas Center Project
- Vincent Structure Iowa Project

Depleted Gas Fields

- Sacramento Municipal Utility District- Thornton and Lodi Geological Structures
- AltaLink Alberta Canada CAES Siting Study
- Gaelectric, Ltd. Big Springs CAES Depleted Gas Field Analysis
- Gaelectric, Ltd. Huntley CAES Nitrogen Gas Field Analysis
- Lodi Natural Gas Storage Field Development and CAES Analysis
- Nebraska Public Power District CAES Candidate Site Analysis
- Nicor Pittsfield Commercial CAES Feasibility Analysis
- Pacific Gas & Electric CAES Analysis

Mine

- First Energy Norton Mine CAES Project

Drilling Technology

Mr. King has extensive hands-on experience with the drilling and construction of exploration core-holes, natural gas and CAES storage wells, and large water supply wells. He managed exploration core-hole drilling programs for the Iowa CAES project, Lodi gas storage project, and the Yucca Mountain Nuclear Waste Program. Mr. King was a partner with ASE Drilling where he managed drill rig operations for installation of over 500 water supply wells in California. At NGPL he drilled new natural gas injection/withdrawal wells, and implemented the safe drill rig abandonment of failed gas wells. He also has working knowledge of well annual casing cementing technology.

PUBLICATIONS

King, M.J., Moridis, G., 2022: Pending, *Compressed Air Energy Storage in Aquifer and Depleted Gas Storage Reservoirs*: Chapter in Handbook of Energy Storage, Willey Press, London, UK.

King, M.J., Apps, J., 2013: *Compressed Air Energy Storage: Matching the Earth to the Turbo-Machinery-No Small Task*: Proceeding to the Electrical Energy Storage Application and Technology Conference, San Diego, CA. Oct. 20-23.

King, M.J., McGill, M.J., 2009, *Compressed Air Energy Storage*, Encyclopaedia of Energy Engineering, Taylor & Francis Group, New York, New York.

Bredehoeft, J.D., King, M.J., 2009, *The Potential for Contaminant Transport Through the Carbonate Aquifer Beneath Yucca Mountain*: Hydrogeology Journal, November.

Bredehoeft, J., Fredrick, C., King, M., 2008 *Groundwater Flow Through the Funeral Mountains, Death Valley National Park, California*: Flow and Transport Processes, Proceedings International High-Level Radioactive Waste Meeting, American Nuclear Society, Las Vegas, NV. Sept. 7-11, 2008, pg. 5-13.

King, M.J., Bredehoeft, J.D. 1999, *The New Federal Food and Drug Administration Spring Regulations: A Unified Approach to Compliance*, Water Technology Journal, April.

King, M.J., Bredehoeft, J.D., 1997, *San Francisco Zoo Wells Versus San Francisco Ground Water Master Plan - A Case For Modeling*, Proceedings, American Water Resources Association Annual Conference, Long Beach, CA, (Pending October 21)

Bredehoeft, J.D., King, M.J., Tangborn, W., 1995, *An Evaluation of the Hydrology at Yucca Mountain: The Lower Carbonate Aquifer and The Amargosa River*, Oversight Committee for the Yucca Mountain High Level Nuclear Waste Repository, Inyo County, California, and Esmeralda County, Nevada.

King, M.J., Bredehoeft, J.D., Tangborn, W., 1995, *Ground Water Resource Development: A Comparison of Three Methods of Analysis*, Bulletin of the Association of Engineering Geologists, Pending.

King, M.J., 1987, *Compressed-Air Energy Storage System Technology: Pittsfield, Illinois Test Experience*, Proceedings, 22nd Intersociety Energy Conversion Engineering Conference, Philadelphia, PA.

King, M.J., and Scholl, R.E., 1981, *Analysis of Low-Rise Building Damage*, U.S. Department of Energy, Nevada Operations Office.

King, M.J., 1981, *Compressed-Air Energy Storage (CAES) Market, Criteria, Economics*, Bulletin, Technical Note, Association of Engineering Geologists, Vol. 18, No. 4.

King, M.J., and Skeji, R.E., 1980, *Energy Storage in Aquifers*, Proceedings, Rockstore 80 Conference, Sweden.

King, M.J., 1979, *Compressed-Air Energy Storage (CAES), Hume, Illinois*, Proceedings, Sixth Annual UMR-DNR Conference on Energy, Rolla, MO.

King, M.J., 1978, *Engineering Resource Unit Approach to Engineering Land-Use Planning*, Bulletin, Association of Engineering Geologists, Vol. 15, No. 3.

Thesis: King, M.J., 1973, *Engineering Land-Use Planning, Harry S Truman Dam Site Area, Missouri*.