

# MATTHEW J. TONKIN

Principal Hydrogeologist

## AREAS OF EXPERTISE

- Groundwater Remedy Design
- Groundwater Flow and Contaminant Transport Simulation
- Environmental Data Analysis and Interpretation
- Modeling Project Design and Management
- Water Resource Evaluations
- Model Calibration and Uncertainty Analysis

## SUMMARY OF QUALIFICATIONS

As President of SSP&A, Dr. Tonkin manages or advises on a range of projects, focused on data synthesis and analysis to support groundwater and surface water studies; leading projects for public, private and legal clients. This includes data acquisition planning; developing and applying models; collaborating with other experts; and presenting findings and recommendations to stakeholders. He received his PhD on the topic of model calibration and uncertainty analysis under the tutelage of Dr. John Doherty and teaches on these and other topics.

## REPRESENTATIVE EXPERIENCE

**S.S. Papadopoulos & Associates, Inc.**, Bethesda, MD

### WATER RESOURCE EVALUATIONS

- **Republican River Basin Interstate Compact** — Provided technical evaluation of the nature, magnitude and timing of streamflow accretions and depletions through the development of a calibrated model. Calibration data included transient water-level and stream-flow calibration targets. Implemented pilot points with regularization for aquifer parameters, and evaluated a mixed-model ANOVA applied to power conversion coefficients (PCCs) as a surrogate for metered pumping. Supported testimony before a River Master and in Supreme Court.
- **Groundwater Management**, Washington State – Joint technical lead in the development of a groundwater model of the Columbia Plateau basalts and overlying sediments. Led calibration and application of the model, including coding in MODFLOW to improve convergence; developing a dual-model approach and underlying codes to provide boundary conditions; and assessing the impacts and long-term sustainability of municipal and agricultural pumping.
- **Spring-water Bottling Company Water Supply Study**, Michigan — Evaluated possible impacts of groundwater pumping on surface water bodies including wetlands. Following calibration of a groundwater model to baseflow data and steady state and transient water levels, designed a series of non-linear predictive error analyses to assess uncertainties in predicted depletions. Conducted similar analysis at several potential spring sources over several years.
- **California Department of Water Resources (CA-DWR)** — In collaboration with CH2M-Hill, created and modified programs to calibrate the IGSM2 code Central Valley application (CVGSM2). Reviewed existing USGS and CA-DWR models and reports to support model re-structuring and re-parameterization. Re-defined aquifer parameters using pilot points; completed sensitivity analyses with the revised model to guide calibration; co-authored reports outlining a stepwise model development and calibration strategy.
- **Saline Incursion Management**, Washington State — To evaluate the sustainability of a water resources that is subject to saline incursion and upconing, participated in the development of a variable-density model, and led the design and implementation of a transient calibration strategy

**YEARS OF EXPERIENCE: 20+**

### EDUCATION

**PhD**, Civil Engineering, 2009, University of Queensland, Australia  
**MSc**, Hydrogeology, 1994, University of Birmingham, UK  
**BSc**, Applied Geology, 1993, University of Birmingham, UK

### PROFESSIONAL HISTORY

**S.S. Papadopoulos & Associates, Inc.**, Bethesda, MD, 1995 to present  
**Birmingham University**, Geology Dept., United Kingdom, 1993– 1994

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that included water levels and salinities. Used the calibrated model to estimate optimal pumping rates to meet drinking water criterion for chloride at existing and proposed production-well locations.

- **Water Resource Assessment**, Minnesota — Retained by MDNR to evaluate groundwater and surface water conditions, including modeling and statistical studies conducted by the USGS and others, and provide an expert opinion on the impact of groundwater extraction on surface water.

## GROUNDWATER REMEDY DESIGN AND EVALUATION

- **West Lake Superfund Site**, Missouri — Led an assessment of the lateral and vertical extent, disposition, fate and transport of radionuclides within solid landfill water materials. Directly implemented 3D indicator-based geo-statistics to assess extents, and managed project team undertaking field work, lab studies and geochemical fate and transport modeling.
- **Hanford Site**, Washington State — Part of a multi-firm team addressing radionuclide, organic and inorganic contamination. Developed fate-and-transport models for remedy design and optimization of Central Plateau and River Corridor OUs. Developed and documented methods and guidelines to assess remedy performance and progress, and conducted a needs assessment for model-based decision support. Evaluated and simulated Uranium, Iodine, Sr90, Tc-99, CrVI, TCE, NO3 and CCl4 among other constituents, as part of several RI/FS, PP and post-ROD actions. Presented at agency and stakeholder meetings.
- **New York Department of Environmental Conservation**, New York — Provided hydrogeologic expertise and simulated the transport and fate of gasoline components to design and operate remedies. Projects required characterization and prediction of the rate and concentration of discharges to surface-water bodies. In these cases, fate-and-transport modeling was used to guide the timing and location of investigations to gather data in the projected discharge zone. Results were presented at public/civic meetings. and ITRC events and a remediation charrette.
- **Delta Consultants (on behalf of BP)**, Deer Park, New York — Analyzed the distribution and transport of contaminants arising from a fuel-spill migrating toward a large freshwater body to support investigation efforts and a comparative evaluation of remedial alternatives. Presented results to New York State Department of Environmental Conservation.
- **Otis Air Force Base**, Cape Cod, Massachusetts — Designed performance monitoring plans for several pump-and-treat systems including evaluation of the locations and impacts of chlorinated solvents and other constituents discharging to freshwater “kettle ponds”. Contributed to assessments of treatment plant design and O&M improvements, quarterly and annual reports.

## DATA ANALYSES

- **PCB-Contaminated Site** — For a confidential private client, reviewed 1100 chromatographs to characterize source area, receptor stream and sediment signatures. Wrote programs to plot, scale, and align chromatographs based on curve area, height and lab spikes. Developed cumulative-area method to identify contributions at receptors as part of an allocation process.
- **Big South Fork National Park**, Kentucky — Assessed contaminant load to a river from 80 mines. Coordinated field sampling tasks. Completed data QA/QC, analyses and interpretation. Simulated mine water mixing using Phreeqc. Prepared STORET database for the National Park Service.
- **Marion Thompson Site**, Indiana — Completed Monte-Carlo analyses of contaminant transport combining bootstrap re-sampling, published PDFs, and parameterization to represent variables.
- **Confidential Client**, San Francisco, California — To support soil removal actions, wrote programs to process numerous look-up tables, using varying assumptions for censored data, to calculate, summarize, and compare 95% UCLs for the mean for over 30 analytes.

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## ALLOCATION ANALYSES

- **Confidential Client**, California — Assessed the fate and transport of several contaminants in groundwater from numerous sources, as part of a multi-party allocation at a large Superfund site within a mixed residential-/commercial-use area.
- **Confidential Client**, California — Performed contaminant fate-and-transport modeling to support the assessment of the fate and transport of contaminants from a large number of facilities that resulted in a large comingled plume within a California basin.

## PROGRAMMING & SOFTWARE DEVELOPMENT

- **Release of MT3D-USGS** — Contributing developer to MT3D-USGS, incorporating the capabilities developed for EPA (below) plus many other features (Documented in Bedekar et al, 2016).
- **Water Level Mapping** — Co-developer of multi-event universal kriging (MEUK) to interpolate multi-event groundwater level data using analytic element trends (Documented in Tonkin et al, 2015).
- **Expansion of HSSM and MT3DMS to Simulate Multi-Species Reactive Transport** — Contracted by USEPA-ORD to enable the previously linked HSSM and MT3DMS programs to simulate the reactive transport of multiple fuel constituents with application to complex fuel spills.
- **Linkage of HSSM with MT3DMS** — Contracted by the USEPA-ORD, with Dr. Chunmiao Zheng, to link vadose simulation capabilities of HSSM to MT3DMS and provide calibration support with PEST. Developed software released in 2010 (Documented in Zheng et al., 2010).
- **Data Worth Evaluation Using Models** — Contracted by the U.S. Geological Survey to program OPR-PPR, which uses FOSM methods and the JUPITER API to evaluate the relative importance of observations and information on model parameters to predictions (Detailed in Tonkin et al., 2007).
- **Predictive Analysis with MODFLOW** — Contracted by the USGS to program MOD-PREDICT, which executes MODFLOW-2000 forward, performs sensitivity and calibration runs, and calculates summary statistics focused on predictive error analysis. (Documented in Tonkin et al., 2003).
- **Hydraulic Capture Analysis** — Co-developer of KT3D\_H2O programs that combine kriging, analytic elements and particle tracking to map groundwater levels and evaluate hydraulic capture. (Documented in Karanovic et al., 2009; Tonkin et al., 2009; Tonkin and Larson, 2002.)

## TRAINING AND SOFTWARE SUPPORT

- **MODFLOW and More Conferences** — Member of organizing committee, Integrated Groundwater Modeling Center (IGWMC), Colorado School of Mines (2013, 2015).
- **The PEST Conference** — Principal organizer and editor of electronic proceedings for model calibration and uncertainty analysis. Published on-line at [LULU.com](http://LULU.com) (November 2009).
- **Collection and Mapping of Water Levels to Assist in Remedy Performance Evaluation** — Organizer, co-instructor. Presented to USDOE and contractors at the Hanford Site (August 2009).
- **PEST Software Support** — Provided technical support for the software PEST through a list-serve hosted by S.S. Papadopoulos & Associates, Inc. (2002 to 2012).
- **Organizer and Instructor** (with **Dr. John Doherty**) of model parameterization and uncertainty analysis courses using PEST in the USA and overseas (2002 to present).
- **Instructor** (with **Dr. Mary Hill**) of “UCODE\_2005 and Pest: Universal Inversion Codes for Automated Calibration” (2006, 2007, 2009, 2011); “Programming with the JUPITER-API” (2008).
- **ITRC Workshop Instructor** — “MTBE & TBA Comprehensive Site Assessment and Successful Groundwater Remediation”. New York (2003), Denver (2004), San Francisco (2005).
- **Structural Mapping Supervisor** — Birmingham University, United Kingdom. Assisted professors in developing mapping training for introduction to curriculum (1994).

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## AWARDS & HONORS

- 2005 – ITRC Industry Recognition Award (co-recipient)
- 2004 – NGWA Outstanding Groundwater Remediation Project Award (co-recipient)
- 1994 – ENTEC Award for MS Program and Thesis
- 1993 – British National Environmental Research Council (NERC) MS scholarship
- 1993 – Individual Structural Geological Mapping Award
- 1988 – Royal Air Force Flight Training Scholarship

## PROFESSIONAL SOCIETIES

- Association of Ground Water Scientists and Engineers (AGWSE/NGWA)
- Geological Society of America (GSA)
- Groundwater Resources Association of California (GRAC)
- American Geophysical Union (AGU)

## APPOINTMENTS

- Interagency Steering Committee on Multimedia Environmental Models (ISCMEM), 2005-present
- Interstate Technology and Regulatory Council (ITRC) MTBE Team, 2002-2006.

## PUBLICATIONS & PRESENTATIONS

- Bedekar, V., E.D. Morway, C.D. Langevin, and M. Tonkin, 2016. MT3D-USGS Version 1: A U.S. Geological Survey Release of MT3DMS Updated with New and Expanded Transport Capabilities for Use with MODFLOW. U.S. Geological Survey Techniques and Methods Report #6-A53, Reston, VA. 69 p.
- Tonkin, M.J., J. Kennel, W. Huber, and J. Lambie, 2015. Multi-Event Universal Kriging (MEUK), *Advances in Water Resources*, v. 87, pp. 92–105, January. doi:10.1016/j.advwatres.2015.11.001
- Royer, P. D., M.J. Tonkin, and T. Hammond, 2014. Conjunctive Water Use in Confined Basalt Aquifers: An Evaluation Using Geochemistry, a Numerical Model, and Historical Water Levels. *Journal of the American Water Resources Association (JAWRA)*, v. 50, Issue 4, pp. 963–976, August. DOI: 10.1111/jawr.12151.
- Tonkin, M.J., J. Kennel, W. Huber, and J.A. Lambie, 2013. Hybrid Analytic Element Universal Kriging Interpolation Technique Built in the Open Source R Environment. Presentation at the American Geophysical Union, Fall Meeting 2013, Abstract #H52E-03.
- Tonkin, M. and Z. Tajani, 2012. Piecewise-Continuous Boundaries Using the MODFLOW FHB and MT3DMS HSS Packages. *Ground Water*, v. 50, no. 2, pp. 296-300, DOI: 10.1111/j.1745-6584.2011.00811.x.
- Bedekar, V., C. Neville, and M. Tonkin, 2012. Source Screening Module for Contaminant Transport Analysis Through Vadose and Saturated Zones. *Ground Water*, v. 50, pp. 954–958. doi:10.1111/j.1745-6584.2012.00954.x
- Bedekar, V., R.G. Niswonger, K. Kipp, S. Panday, and M. Tonkin, 2011. Approaches to the Simulation of Unconfined Flow and Perched Groundwater Flow in MODFLOW. *Ground Water*, v. 50, no. 2, pp 187-198. DOI: 10.1111/j.1745-6584.2012.00811.x.
- Ma, R., C. Zheng, M. Tonkin, and J. Zachara, 2011. Importance of Considering Intraborehole Flow in Solute Transport Modeling under Highly Dynamic Flow Conditions. *Journal of Contaminant Hydrology*, v. 123, Issues 1-2, April 1, 2011, pp 11-19.

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- Hunt, R., J. Luchette, W. Schreuder, J. Rumbaugh, J. Doherty, M. Tonkin, and D. Rumbaugh, 2010. Using a Cloud to Replenish Parched Groundwater Modeling Efforts. *Ground Water*, v. 48, no. 3, pp. 360-365.
- Shannon, R., M. Karanovic, and M. Tonkin, 2010. Hydraulic Capture Estimated using Universal Kriging with Hydrologic Drift Terms. Presentation at the 19<sup>th</sup> Annual Maryland Groundwater Symposium, Baltimore, MD, 47.
- Tonkin, M.J. (Editor), 2010. *PEST Conference Proceedings*. Potomac, MD, November 2009. Available at [www.LULU.com](http://www.LULU.com).
- Zheng, C., J. Weaver, and M. Tonkin, 2010. MT3DMS, A Modular Three-dimensional Multispecies Transport Model: User Guide to the Hydrocarbon Spill Source (HSS) Package. Prepared for U.S. Environmental Protection Agency, Athens, GA.
- Tonkin, M., and J. Doherty, 2010. Citation and Acceptance of the 2009 M. King Hubbert Award. *Ground Water (published online)*. January 2010.
- Tonkin, M., S. Dadi, and R. Shannon, 2009. Collection and Mapping of Water Levels to Assist in the Evaluation of Groundwater Pump-and-Treat Remedy Performance. SGW-42305 (Rev. 0). Prepared for the US Department of Energy, Richland, WA, September 2009.
- Karanovic, M., M. Tonkin, and D. Wilson, 2009. KT3D\_H20: A Program for Kriging Water-Level Data Using Hydrologic Drift Terms. *Ground Water*, v. 45, no. 4, pp. 580-586, July/August, DOI: 10.1111/j.1745-6584.2009.00565.x.
- Tonkin, M. J., 2009. Efficient Calibration and Predictive Error Analysis for Highly-Parameterized Models Combining Tikhonov and Subspace Regularization Techniques. Doctoral Thesis, University of Queensland, Australia.
- Weaver, J., J. Zhang, M. Tonkin, and R.J. Charbeneau, 2009. Modeling the Transport of Ethanol Fuel Blends with the Combined HSSM and MT3D Models. Presentation at the 21<sup>st</sup> Annual National Tanks Conference and Expo, Sacramento, CA, March 30 – April 01, 2009.
- Tonkin, M., and J. Doherty, 2009. Calibration-Constrained Monte Carlo Analysis of Highly-Parameterized Models Using Subspace Techniques. *Water Resources Research*, v. 45. W00B10, doi 10.1029/2007WR006678.
- Tonkin, M., C. Arola, and D. Miller, 2007. Decision-Level Modeling within a Feasibility-Study Process: An Application at the Hanford Site. Presentation at the Association of Engineering and Environmental Geologists 50th Anniversary, Los Angeles, CA, September 26–28, 2007.
- Tonkin, M., and J. Doherty, 2007. An Efficient Calibration-Constrained Monte Carlo Technique for Evaluating Model Predictive Uncertainty. *in Proceedings of an International Conference on Calibration and Reliability in Groundwater Modeling: Credibility of Modeling (ModelCARE2007)*, Copenhagen, Denmark, September 2007. IAHS Publication 320.
- Hunt, R., J. Doherty, and M. Tonkin, 2007. Are Models Too Simple? Arguments for Increased Parameterization. *Ground Water*, v. 45, no. 3, pp. 254-262.
- Tonkin, M., J. Doherty, and C. Moore, 2007. Efficient Non-Linear Predictive Error Variance for Highly Parameterized Models: *Water Resources Research*, v. 43. W07429, doi 10.1029/2006WR005348.
- Tonkin, M., C. Tiedeman, D. Ely, and M. Hill, 2007. OPR-PPR, a Computer Program for Assessing Data Importance to Model Predictions Using Linear Statistics, Constructed Using the JUPITER API. Prepared in Cooperation with the U.S. Department of Energy. Techniques and Methods 6-E2. U.S. Geological Survey.

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- Muffels, C., H. Zhang, J. Doherty, R. Hunt, M. Anderson, and M. Tonkin, 2006. Incorporating PROPACK into PEST to Estimate the Model Resolution Matrix for Large Groundwater Flow Models. Presentation at the American Geophysical Union (AGU) Fall Meeting, Moscone Center, San Francisco, CA, December 2006.
- Muffels, C., J. Doherty, M. Anderson, R. Hunt, T. Clemo, and M. Tonkin, 2006. LSQR and Tikhonov Regularization in the Calibration of a Complex MODFLOW Model. Presentation at the Geological Society of America Annual Meeting, Philadelphia, PA, October 2006.
- Muffels, C., M. Tonkin, H. Zhang, M. Anderson, and T. Clemo, 2006. Application of LSQR to Calibration of a MODFLOW Model: A Synthetic Study. *in Proceedings of MODFLOW and More 2006, Managing Ground-Water Systems*, International Ground Water Modeling Center, Colorado School of Mines Golden, CO, May 2006, v. 1, pp. 283-287.
- Tonkin, M., M. Karanovic, A. Hughes, and C. Jackson, 2006. New and Contrasting Approaches to Local Grid Refinement. *in Proceedings of MODFLOW and More 2006, Managing Ground-Water Systems*, International Ground Water Modeling Center, Colorado School of Mines Golden, CO, May 2006, v. 2, pp. 601-605.
- Tonkin, M., and J. Doherty, 2005. A Hybrid Regularized Inversion Methodology for Highly Parameterized Environmental Models. *Water Resources Research*, v. 41, no. 10, October. W10412, doi:10.1029/2005WR003995.
- Tonkin, M., and M. Becker, 2005. Environmental Insite: A Software Package for Ground Water Data Visualization. *Ground Water*, v. 43, no. 4, pp. 466-470. Software Spotlight.
- Tonkin, M.J., 2005. Model Analysis Using the JUPITER API. Presentation at the Annual Public Meeting of the Interagency Steering Committee on Multimedia Environmental Models (ISCMEM), American Geophysical Union (AGU), Washington, DC, August 2005
- Tonkin, M., J. Weaver, C. Zheng, C. Muffels, and J. Rumbaugh, 2005. Coupled Free and Dissolved Phase Transport: New Simulation Capabilities and Parameter Inversion. *in Proceedings of the 2005 National Ground Water Association (NGWA) Conference on MTBE and Perchlorate, Assessment, Remediation, and Public Policy*, San Francisco, CA, May 2005.
- Muffels, C., M. Tonkin, J. Haas, and D. Trego, 2005. Predictive and Post-Audit Mass Flux Estimates. *in Proceedings of the National Ground Water Association (NGWA) Ground Water Summit*, San Antonio, TX, April 2005.
- Tonkin, M. (as Contributing author to Interstate Technology & Regulatory Council (ITRC)). MTBE and Other Fuel Oxygenates Team), 2005. Overview of Groundwater Remediation Technologies for MTBE and TBA. February 2005.
- Neville, C. and M. Tonkin, 2004. Modeling Multi-Aquifer Wells with MODFLOW. *Ground Water*, v. 42, no. 6, pp. 910-919.
- Tonkin, M. and C. Muffels, 2004. Assessing Hydraulic Capture through Combined Analytic Elements and Interpolation. EPA Groundwater Forum, Sacramento, CA, October 2004.
- Tonkin, M., S. Larson, and C. Muffels, 2004. Assessment of Hydraulic Capture through Interpolation of Measured Water Level Data. Presentation at the Conference on Accelerating Site Closeout, Improving Performance, and Reducing Costs through Optimization: Environmental Protection Agency, Federal Remediation Technology Roundtable, Dallas, TX, June 2004.
- Tonkin, M., T. Clemo, and J. Doherty, 2003. Computationally Efficient Regularized Inversion for Highly Parameterized MODFLOW Models. *in Proceedings of MODFLOW and More 2003: Understanding through Modeling*, International Ground Water Modeling Center, Colorado School of Mines, Golden, CO, September 16, 2003, v. 2, pp. 595-599.

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- Tonkin, M., M. Hill, and J. Doherty, 2003. Modflow-2000, The U.S. Geological Survey Modular Ground-Water Model – Documentation of Mod-Predict for Predictions, Prediction Sensitivity Analysis, and Enhanced Analysis of Model Fit. Prepared in Cooperation with the U.S. Department of Energy. U.S. Geological Survey Open-File Report 03-385.
- Lolcama, J., H. Cohen, and M. Tonkin, 2002. Deep Karst Conduits, Flooding, and Sinkholes: Lessons for the Aggregates Industry. *Engineering Geology*, v. 65, no. 2-3, pp.151-157.
- Tonkin, M., and S. Larson, 2002. Kriging Water Levels with a Regional-Linear and Point-Logarithmic Drift. *Ground Water*, v. 40, no. 2, pp. 185-193.
- Neville, C., and M. Tonkin, 2001. Representation of Multi-Aquifer Wells in MODFLOW. in *Proceedings of MODFLOW 2001 and Other Modeling Odysseys*, International Groundwater Modeling Center, Colorado School of Mines, Golden, CO, September 2001, v. 1, pp. 51-59.
- Cohen, H., M. Tonkin, and C. Neville, 2000. Determination of Hydraulic Conductivity Distribution in a Heterogeneous Glacial Sand Aquifer: Correlation between Estimates Based on Impeller Flow Meter Data and Grain Size Distributions. Society for Sedimentary Geology/International Association of Sedimentologists Research Conference: *Environmental Sedimentology: Hydrogeology of Sedimentary Aquifers*, Santa Fe, NM, September 24-27, 2000.

## DEPOSITIONS

- 2016 Waverley View Investors, LLC. vs. United States of America. Case No. 15-371L. Dec. 15.
- 2016 Samantha Hall vs. Conoco, Inc. *et al.* Case# 14-CV-670-HE. Mar. 3.
- 2014 Jerilyn K. Allen *et al.* vs. EXXON Mobile Corporation. Case# C-11-8536. Apr. 4.
- 2011 State of New York vs. 913 Portion Road Realty Corp, et al. Case# 26495-M. Jul. 29.
- 2008 Jeff Alban et al. vs. ExxonMobil Corporation et al. Circuit Court of the State of Maryland, County of Baltimore. 03-C-06-010932. Feb. 6.

## TESTIMONY AT TRIAL

- 2017 Waverley View Investors, LLC. vs. United States of America. Case No. 15-371L. Jan. 18.