Timothy J. Cox, Ph.D.

Water Resources Modeler

Education

Ph.D. - Engineering Science, University of Auckland, New Zealand, 2005

M. Phil. - Science and Technology, University of Waikato, Hamilton, New Zealand, 1999

M.S. - Environmental and Water Resources Engineering, University of Colorado, Boulder, Colorado, 1997

B.S. - Civil and Environmental Engineering, Duke University, 1994

Experience Highlights

Research and development in water quality, water supply planning, and climate change analyses

Technical lead on multiple stream and lake water quality modeling studies and field investigations

Lead developer of water resources modeling software: Contaminant Allocation & Simulation Model (CASM), Simplified Lake Analysis Model (SLAM), Simplified Water Allocation Model (SWAM), Airport Deicing Management Model (ADMM)

Specializing in water resources engineering and water quality and quantity modeling, Dr. Cox has extensive experience in the development and maintenance of surface water quality and quantity computer models, as well as the application of many published models. Dr. Cox also has significant experience in stream ecology and ecosystem modeling, water quality and ecology field and laboratory research, and engineering software development.

Specialty areas:

Water Supply Planning Analysis

Climate Change Adaptation in Water Resources

Watershed Hydrologic and Water Quality Modeling

Stream and Lake Water Quality Modeling

Project Examples (NZ)

Principal Investigator, Contaminant Allocation and Simulation Model (CASM). Dr. Cox is the primary developer of Streamlined Environmental's Contaminant Allocation and Simulation Model (CASM). CASM is generalized, user-friendly software developed for a broad range of potential end users. The tool calculates the generation of a range of user-defined contaminants at a catchment scale and the fate and transport of the contaminants through the catchment's dendritic stream network. CASM models are spatially explicit, with node-based contaminant export and discharge, and include both diffuse pathway and instream attenuation. Models can be simulated at varying timescales: annual average, seasonal, or continuous monthly time-stepping. CASM includes 3 modes of simulation: deterministic, stochastic, and optimisation.

Technical Lead, Waikato River catchment nutrient modelling. *Beef and Lamb NZ (2017 – 2019)***.** As an expert witness for Beef and Lamb's review of the Waikato Healthy Rivers (HR) study and proposed Plan Change One, Dr. Cox constructed a catchment-scale nutrient load and transport model using his own software (CASM). Dr. Cox developed a baseline model to replicate the HR modeling work and then applied the software to investigate multiple mitigation strategy scenarios, including employing the software's optimisation routine. Additionally, Dr. Cox participated in expert conferencing, outside of his role with Beef and Lamb, to assess, and provide recommendations on, water quality attributes and target thresholds for the plan change.

Project Leader, Water allocation modelling in the Upper and Lower Waikato Catchments. *Dairy NZ (2016) and Fonterra (2017).* Dr. Cox was the project leader for two separate water allocation modeling studies commissioned by DairyNZ and Fonterra, respectively. Dr. Cox developed models of the Upper and Lower Waikato River catchments using his own Simplified Water Allocation Model (SWAM) software. The models include sub-catchment-based aggregate pastoral farming nodes and all major municipal and industrial water users in the catchments. Baseline hydrology is represented in the models with a series of boundary condition flows and reach gains based on available gauge data. The models will enable the dairy industry to better understand current water use in the catchment, to project future water needs and availability, and to investigate water management strategies.

Technical Lead, Fate and transport of nitrogen in treated wastewater applied to land from Omaha WWTP. *Watercare Services Ltd (2015).* Dr Cox developed a risk-based probabilistic model of the path-ways of nitrogen from a land disposal system using inputs of biochemical assays, geohydrological data, and climate data. The model focuses on the shallow sub-surface and includes impacts, via the root zone, of varying vegetation types. The model was used to show that most of the nitrogen applied in treated wastewater was lost by denitrification in unsaturated and saturated zones between the irrigation sites and the harbour and that effects on the harbour would be negligible, even with an increase in the volume of treated wastewater.

Technical Lead, Modelling effects of implementing the Rotokauri Structure Plan on Water Quality of Lake Rotokauri. *Hamilton City Council/AECOM (2015).* Dr Cox was the water quality modeler for this project (using SLAM – see sidebar) to determine the effects of a greenfield urbanization project on Lake Rotokauri (a supertrophic lake). A calibrated SLAM model was used to estimate the extent of stormwater treatment necessary (particularly during the development phase) to effect a modest improvement in average chlorophyll a concentration of the lake, as well as lake N and P concentrations.

Project Leader, Modelling effects of flushing Lake Waikare with Waikato River Water. *Waikato District Council (2014).* Dr Cox was the project leader and modeler for this project which demonstrated that a modest improvement in the quality of this large shallow hypertrophic lake could be achieved by flushing with Waikato River water. Dr Cox led a field sampling program for lake sediment data. These data were used, together with the other historical lake and tributary water quality data, to construct and calibrate a state-of-the-art water quality model of the lake. He used the model to predict the effects of flushing flows on TP, TN and chlorophyll-a in the outflow form the lake.

Technical Lead, Canterbury Land and Water Plan Submission. *North Canterbury Fish and Game (2013).* Dr. Cox developed a spreadsheet model used to simulate the effects of various rules in the proposed Canterbury Land and Water Plan on stream water quality in the Asburton, Selwyn-Waihora, and Rakaia Rivers. The model was used primarily to support the Fish and Game (NZ) submission that proposed increased in irrigated areas within over-allocated and at risk catchments would result in unacceptable deterioration of stream water quality but that the application of a nutrient cap targeting the highest N emitters could create sufficient headroom to allow new, efficient irrigators to enter the catchment.

Technical Lead, Modelling a Nutrient Cap and Trade System for Lake Rotorua *(2011).* Dr. Cox developed a numerical model to assess the efficacy of a cap and trade system for controlling nitrogen inputs to Lake Rotorua. The model was developed as part of a Foundation for Research, Science, and Technology (FRST) research study. It integrates catchment hydrology and water quality simulations with large-scale economics and allows for the assessment of proposed trading schemes with respect to both environmental and economic outcomes.

Doctoral Research, Macrophyte-Focused Stream Water Quality Model Development *(2001 – 2004).* Dr. Cox's doctoral research focused on investigating the impacts of stream macrophytes on reach hydraulics and nutrient retention through numerical modeling and field and laboratory experimentation. The work included development of a macrophyte-focused stream water quality model to be used as a management tool for predictions of nitrogen fate and transport in macrophyte-dominated reaches.

Project Examples (USA)

Principal Investigator, Simplified Water Allocation Model (SWAM). Dr. Cox is the primary developer of CDM Smith's Simplified Water Allocation Model (SWAM). Model development is ongoing and funded by a combination of CDM Smith's internal R&D funds and project-specific funds. The model combines networked water allocation and reservoir routing calculations with simulations of specific water provider supply alternatives. Municipal, industrial, and agricultural demands, water rights, environmental flow targets, reuse, conservation, and the ability to simulate complex reservoir operations are key components of the model.

Principal Investigator, Developing a Practical Water Quality Model for Well-Mixed Lakes. Dr. Cox is the primary developer of CDM Smith's Simplified Lake Analysis Model (SLAM). This generalized lake modeling software combines new innovative algorithms for predicting lake sediment nutrient fluxes with standard mass balance lake water column nutrient calculations and published empirical phytoplankton formulations. It allows for limited simulation of vertical stratification and incomplete mixing between lake zones. The model is user-friendly and designed for a broad range of end users requiring planning level simulations of eutrophication in lakes and ponds. The new model has been successfully applied in multiple projects in California, Texas, and New Zealand.

Principal Investigator, Airport Deicing Management Model (ADMM). Dr. Cox is the primary developer of CDM Smith's Airport Deicing Management Model (ADMM), which routes stormwater and pollutants associated with deicing fluid through airport sub-catchments while calculating storage requirements and outfall loadings. This model has, to date, been successfully applied as an aid to airport expansion planning at over a dozen major U.S. airports.

Principal Investigator, Impacts of Instream Macrophytes on Nutrient Processing, Santa Margarita River Watershed, California. Dr. Cox led a CDM Smith research effort to quantify the impacts of instream macrophytes on nutrient fate and transport in tributaries of the Santa Margarita Watershed in California. This work involved a combination of field investigations, including nutrient tracer and nitrogen stable isotope releases, and numerical modeling. Numerical modeling was performed using a reactive transport model developed during Dr. Cox's academic research, adapted to streams dominated by large attached plants.

Technical Lead, Developing Surface Water Allocation Models for the Rufiji Basin Water Board, Tanzania. Dr. Cox led the development of water allocation models, using the SWAM software, for the largest river basin in Tanzania to support planning and permitting by the local water board. The models focus on quantifying the balance between human and commercial demands, ecological and game flow requirements, and a variable and changing climate. The models will be used for decision support in assessing new permit requests and long-term management of the basin. Dr. Cox led a 3-day training course for local water board staff on the SWAM software.

Technical Lead, Developing Surface Water Allocation Models for the State of South Carolina. Dr. Cox was the lead modeler for a multi-million dollar study to develop water allocation hydrologic models for the State of South Carolina. The models encompass the entire state, separated according to eight major river basins, and are being used to support both long and short term planning and water permitting by the State. The models were constructed using the SWAM modeling software that Dr. Cox developed.

Technical Lead, WASP, CE-QUAL-W2, QUAL2E, QUAL2K, BATHTUB Water Quality Modelling. Dr. Cox has extensive expertise in the use of published public domain water quality modeling software for both streams and lakes. Much of this work has been done in support of Total Maximum Daily Load (TMDL) assessments for both Federal and State EPA.

Technical Lead, Machado Lake Water Quality Modelling (CA). Dr. Cox developed a powerful spreadsheet model to support the evaluation of alternatives for the restoration of Machado Lake in Los Angeles (CA). This model included mechanistic simulations of nutrient dynamics, including sediment fluxes, and off-channel wetlands, and empirical predictions of summer algae levels. As part of this work, an innovative dynamic lake sediment nutrient flux model was developed and applied. Multiple in-lake remediation strategies were investigated with the model, with respect to impacts on nutrient and algae levels, including dredging, aeration and mixing, oxidation, and riparian wetlands.

Technical Lead, Colorado Nutrient Cost/Benefit Water Quality Analysis. Dr. Cox developed a series of lake water quality spreadsheet models for the State of Colorado as part of a statewide cost/benefit analysis of a proposed point source nutrient regulation. The models were applied to water supply and recreation reservoir across the State in order to quantify anticipated future water quality improvements resulting from proposed nutrient reductions. The models predict both nutrient concentration reductions and changes in lake trophic state (and accompanying decreases in algal growth).

Technical Lead, Climate Resiliency Plan, Atlanta (GA). Dr. Cox served as the climate change specialist for a comprehensive study for the North Georgia Water Planning District aimed at identifying and quantifying utility vulnerabilities to a changing and variable climate. The study focused on water supply and demand, reservoir yield, water quality, and extreme drought and storm events. Dr. Cox led the development of future climate scenarios, using both model predictions and historical observations, reflective of future projections and a 2050 planning horizon. Developed climate scenarios were used within a suite of water supply and water quality planning models.

Principal Investigator, Extreme Event Forecasting Using Climate Model Projections, Texas and Georgia. Dr. Cox was the principal investigator in an internally-funded study focused on projecting future extreme storm and drought events and deciphering complex climate projections for practical planning. This study is using a combination of historical data and daily global climate model (GCM) projections from the latest CMIP5 downscaled data set. Statistical trend analysis was applied to identify trends, past and future, in both peak 24-hour storm events and the Palmer Drought Index for the Cities of Atlanta (GA) and Austin (TX).

Principal Investigator, Stochastic Water Quality Modelling of an Impaired River Impacted by Climate Change, Oregon. Dr. Cox led an internally-funded research project focused on quantifying climate change impacts on river water quality. A stochastic water quality model was developed for a nutrient impaired reach in the Pacific Northwest using a new add-in to the U.S. Environmental Protection Agency (EPA) QUAL2K model. Stochastic climate inputs were parameterized using ensemble global climate model (GCM) projections corresponding to a 2060 planning horizon. Climate projections were translated into summer low flows using an empirical regression hydrologic model developed for the study. Probabilistic output provided valuable insight into potential climate change impacts on reach dissolved oxygen, algae, and water temperature levels with implications for native salmon populations.

Peer-Reviewed Journal Publications

“Forecasting extreme events: making sense of noisy climate data in support of water resources planning.” Journal of Water and Climate Change. H2Open Journal. Feb, 2019 (2). https://doi.org/10.2166/wcc.2018.006 (With J. Bywater, M. Heineman, D. Rodrigo, S. Wood).

“Stochastic water quality modeling of an impaired river impacted by climate change.” Journal of Environmental Engineering. June 2015. (With D.F. Turner, G.J. Pelletier, and A. Navato).

“An integrated model for simulating nitrogen trading in an agricultural catchment.” Journal of Environmental Management. 2013 (127). (With J.C. Rutherford, S.C. Kerr, D.C. Smeaton, and C.C. Palliser).

"Relationships between stream phosphorus concentrations and drainage basin characteristics in a watershed with poultry farming." Nutrient Cycling in Agroecology. 2013. (With R.L. Olsen, B.A. Engel, J.B. Fisher).

"Nitrogen fate and transport in a watercress-dominated stream." New Zealand Journal of Marine and Freshwater Research. 2012. (With J.C. Rutherford).

“Metals fate and transport modeling in streams and watersheds: state-of-the-science and USEPA workshop review.” Hydrological Processes. 2008. (22) (With B.S. Caruso, R.L. Runkel, M.L. Velleux, K.E. Bencala, D.K. Nordstrum, P.Y. Julien, B.A. Butler, C.N. Alpers, A. Marion, K.S. Smith).

“An Eulerian-Lagrangian numerical scheme for simulating advection, dispersion, and transient storage in streams and a comparison of numerical methods.” Journal of Environmental Engineering. 2008. (134:12) (With R.L. Runkel).

“Modeling effects of natural flow restoration on metals fate and transport in a mountain stream impacted by mine waste.” Journal of the American Water Resources Association. 2008 (44). (With B.S. Caruso)

“Pathways of N and C uptake and transfer in stream food webs: and isotope enrichment experiment.” Journal of North American Benthological Society. 2005. (With S. Parkyn, J. Quinn, and N. Broekhuizen).

"Thermal tolerance of two stream invertebrates exposed to diurnally varying temperature." New Zealand Journal of Marine and Freshwater Research. 2000 (34). (With J.C. Rutherford).

"Predicting the effects of time-varying temperature on stream invertebrate mortality." New Zealand Journal of Marine and Freshwater Research. 2000 (34). (With J.C. Rutherford)

Relevant Conference Papers

“Lake Waikare Water Quality Modeling: using a new model to investigate flushing strategies.” 2015. Water New Zealand Annual Conference Hamilton September 2015 (with J.G Cooke)

“Stochastic water quality modeling of an impaired river impacted by climate change.” AWRA Annual Water Resources Conference. Jacksonville, Fla. 2013. (with A. Navato, D. Turner, and G. Pelletier).

"Incorporating climate change science into water supply planning: a demonstration and comparison of methods." EWRI Water Congress proceedings. Albuquerque, New Mexico. 2012. (with M. McCluskey and K. Westphal).

“NTRADER – A simulation model to explore possible trading schemes for diffuse sources of nitrogen.” International Water Association, Diffuse Pollution Conference, New Zealand. 2011. (with S. Kerr and K. Rutherford).

“Model simulations of market-based water quality policy.” Soil and Water Conservation Society. 2011. (with S. Kerr and K. Rutherford).

“Quantifying the impacts of instream macrophytes on nutrient assimilation in a Southern California stream: implications for TMDLs.” Water Environment Federation TMDL Conference Proceedings. 2007.

“Investigating the relationships between transient storage parameters and stream solute uptake lengths.” North American Benthological Society Annual Meeting. 2007.

“Measuring the impacts of emergent macrophytes on instream nitrogen processing.” Water Environment Federation TMDL Conference. 2005. (With J.C. Rutherford).

"The creation of dead zones by emergent macrophytes and their impacts on fate and transport of nitrogen in streams." North American Benthological Society (NABS) Annual Meeting. 2003. (With J.C. Rutherford and M.J. O'Sullivan).