

SGER- Assessment of Tsunami Impacts on Coastal Aquifers in Sri Lanka

1.0 Background

On December 26th, 2004, Sri Lanka experienced one of the worst natural disasters in its known history. The tsunami generated by the earthquake in Sumatra hit the northern, eastern and southern coastlines of the island. As the first wave struck the coastline, within minutes the second fatal wave, 6-8 m high hit the beach and reached at some locations 1.5-2.0 km inland. Artificial canals that connect the coastline with the inland aggravated the damage, as seawater from the tsunami moved along these canals, resulting in flash-floods in urban and sub-urban areas. The tsunami devastated coastal cities and villages resulting in loss of human life that has gone in to the thousands and displacing millions of people who inhabited some of the highly populated coastal areas of the island (Figure 1). Even though the destruction of property may have been limited to a few kilometers from the coastline, estimates of potentially affected areas may extend to tens of kilometers inland (Figure 2). In addition to the destruction of the infrastructure that supports local economic activity, vital resources needed for future habitation of the displaced population have been drastically affected. The rapid movement of saline water inland due to massive waves has impacted water supply sources and other natural resources in the coastal regions.

Groundwater is the main source of water supply in the affected areas. In the north and north-east, groundwater is the only source of potable water. In several rural areas that are further away from the large population centers where municipal water supply systems exist, groundwater may be the only source of potable water. Even prior to this event, these areas have been susceptible to frequent droughts with severe water shortages. The degradation of the water quality due to this disaster will further exacerbate the situation. The PI is currently coordinating a well decontamination project in the tsunami-affected areas of southwest Sri Lanka funded by LacNet, a non-profit group of Sri Lankan expatriate academics in USA (<http://www.theacademic.org/tsunami/Well/>). The technical field team associated with this project is currently involved in desalination and mapping wells in the northeast and southern coastlines. Initial assessment indicates that in some of the wells the water level has risen by almost a meter and the indications are that a subsurface salt front has propagated into the aquifer. Unlike typical saltwater intrusion problems where saline water is drawn inland through aquifers and then upcones beneath pumping wells, this disaster placed saline water above fresh groundwater in a potentially unstable configuration due to the density difference. Further, overland transport of saltwater may have lead to salinization of the unsaturated zone and associated shallow groundwater systems. In any future strategies for development and use of groundwater, it is necessary to get an assessment of both short-term and long-term effects of the tsunami on the water quality of these coastal aquifers. Important questions include: Has saline inflow widely affected groundwater quality? If so, will it be a long-term problem? Specifically, over what timescale will the quality of well water improve as regional flow, and perhaps the density instability of saline water overlying freshwater flush and dilute the saline water?

To our knowledge, there has not been a well-coordinated effort to evaluate the impact of tsunami on groundwater resources. Clearly, an urgent need exists to assess the situation in the field to identify science and technical issues to help to develop future strategies for groundwater use in the regions that are directly affected by the tsunami and also areas that have the potential to be affected in the future. Funds are requested to assemble an expert panel of groundwater scientists to visit and provide an assessment of tsunami impacts on water supplies in coastal aquifers in Sri Lanka. The panel will include researchers who are familiar with the region as wells as others who will have the appropriate background and expertise to contribute.

The environmental impacts of this disaster extend into many components of the ecological system. The expertise of many disciplines will be needed for the full assessment of all the impacts and their future implications. This panel will only focus on issues related to water quantity and quality in the coastal aquifers. The interaction of surface water bodies with affected aquifers will also be evaluated. It is our expectation that other expert panels will visit these affected areas at appropriate times and will benefit from the findings of this panel.

2.0 Goals

The primary goal of this visiting panel from the US is to provide expertise on the assessment and restoration of groundwater resources impacted by tsunami in Sri Lanka's coastal regions. However, it is expected that the experience gained from this effort will be broadly applicable for managing other coastal aquifers in Indonesia and India. The panel will visit the affected areas in the northeast and southeast in Sri Lanka. They will meet with local researchers in universities and other governmental and non-governmental agencies to study and assess the impact of the tsunami on the coastal aquifers. The efforts in Sri Lanka will be coordinated with the University of Peradeniya (<http://www.pdn.ac.lk/>) in Kandy with the participation of University of Moratuwa in Colombo, Ruhuna University located in the affected area; the International Water Management Institute (<http://www.iwmi.cgiar.org/>) located in Colombo, Sri Lanka; and the National Water Supply and Drainage Board in Sri Lanka.

The panel will perform the following tasks during their visit:

1. Visit the affected areas with field personnel to assess the impact of the tsunami on the coastal aquifers.
2. Evaluate current methods, technologies and the scope of strategies that are used to assess the extent and complexity of the problem.
3. Identify any phenomena that have not been observed or recorded in the past in relation to saltwater intrusion and flow in coastal aquifers.
4. Organize a workshop at a central location for the panel to exchange, gather and share information related to the problem.
5. Assess the technical needs and identify areas where US scientific community can assist local scientists and engineers who will be challenged by the complexities of problems on hand.
6. Review and assess existing data and identify future data needs and suggest strategies for collecting and processing new data using new and appropriate technologies for local conditions.
7. Evaluate existing technical capabilities and identify areas where immediate and long-term training is required.

3.0 Execution Plan

The execution plan consists of assembling a panel with diverse expertise in the groundwater field to visit Sri Lanka in the immediate future, visit affected areas, meet with relevant governmental and non-governmental groups, meet with local scientists and engineers,

organize an information exchange workshop and complete a technical report. The relevant details of this plan are provided here. The logistics for the visit will be finalized after funds are approved.

3.1 Panel Composition

The visiting panel will have the following as its members:

Dr. Prabhakar Clement, Associate Professor of Environmental Engineering Department of Civil Engineering, Auburn University, Alabama.

Dr. Charlie Harvey, Doherty Associate Professor, Department of Civil and Environmental Engineering, MIT, Cambridge, Massachusetts.

Dr. Tissa H. Illangasekare, AMAX Distinguished Chair and Professor of Civil Engineering, Colorado School of Mines.

Dr. Jagath J. Kaluarachchi, Professor, Dept. of Civil and Environmental Engineering, Utah State University, Logan, UT.

Dr. Leonard F. Konikow, Scientist Water Resources Division, U.S. Geological Survey, Reston, Virginia

Dr. G. (Kumar) Mahinthakumar, Assistant Professor, Department of Civil Engineering, North Carolina State University, Raleigh NC.

Dr. Jayantha Obeysekera, Director, Office of Modeling, South Florida Water Management District, West Palm Beach, Florida

Dr. Rien van Genuchten, Soil Physicist, USDA-ARS George E. Brown, Jr, Salinity Laboratory, Riverside, California.

Dr. William Yeh, Distinguished Professor and Chair, Dept. of Civil & Environmental Engineering, University of California at Los Angeles (UCLA), Los Angeles, California.

3.2 Local Collaborators in Sri Lanka

The PI has received a commitment from the University of Peradeniya to make local arrangements. Two of the faculty members specializing in groundwater and related areas will coordinate the efforts with the following organizations:

- Ruhuna University located in affected area
- University of Moratuwa in Colombo
- Water Resources Board
- Water Supply and Drainage Board
- Regional Municipal and Provincial Council Authorities
- Irrigation Department
- Coast Conservation Department
- Central Environmental Authority

The PI is also in contact with the International Water Management Institute (IWMI) based in Colombo. IWMI senior scientist Dr. Karen Villholth is currently involved in gathering data in

the affected areas. The PI has collaborated with Dr. Villholth in the past on groundwater related research.

3.3 Tentative Activities During this Visit Sri Lanka

The panel plans to spend five working days in Sri Lanka, visiting the affected areas, meeting with the personnel of water agencies involved in water management and planning, meeting with scientists at IWMI, meetings with researchers and scientists in local universities and research organizations. Arrangements will also be made to meet with the officials of Minister of Science and coordinate the proposed effort with the Center for National Operations (<http://www.cnosrilanka.org/>). An information-sharing workshop will be organized at a central location in coordination with the University of Peradeniya. The PI is in contact with the faculty and the Vice Chancellor of the University of Peradeniya. In-situ Inc, Ft. Collins, Colorado is donating equipment for water quality measurements.

The PI will visit Sri Lanka prior to the panel visit to finalize local arrangements and other programs.

4.0 Deliverables

The PI will be responsible for assembling the input from all the panel members and produce a technical report that will provide a preliminary assessment of the impacts of tsunami on coastal aquifers in Sri Lanka. This report will include:

- A summary of scientific findings related to any subsurface phenomena and processes that may not have been observed and recorded in the past.
- An evaluation of the scope, methods, and technologies currently used for the assessment of the ground water resources in the affected regions.
- A summary of the workshop designed to gather technical information from the local scientists and engineers.
- Recommendations and suggestions for both short-term and long-term strategies needed for assessment and restoration of ground water supplies in the coastal regions.
- Identify areas of research and possible technical collaboration with US scientists for the long-term assessment and restoration of groundwater resources in affected regions.
- Assessment of current data, data gaps and suggestions for future strategies and technologies for data gathering.
- Recommendations for long-term exchanges, training and joint conferences and workshops with US, international and regional participants.

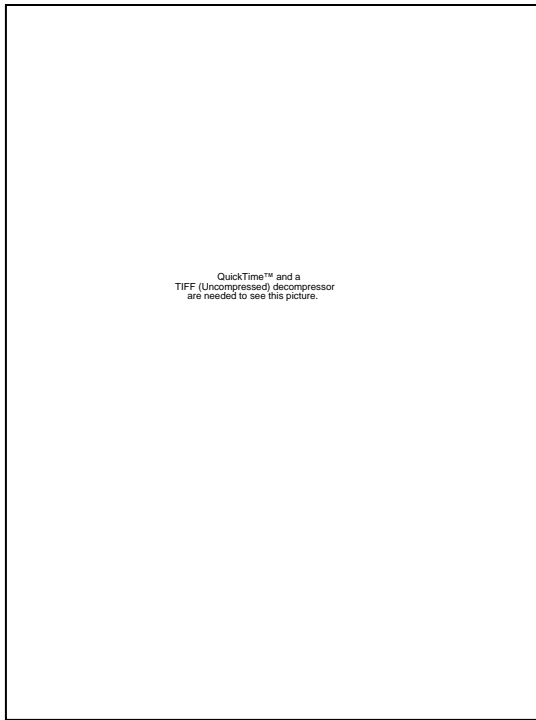


Figure 1: Population distribution



Figure 2: Tsunami affected coastal areas (Satellite picture thanks to SERTIT, France)

5.0 Budget justification

Funds are requested for a maximum of nine panel members to travel to Sri Lanka. Cost estimate is provided for economy class airfare, local board and lodging and transportation. The panel members are strongly committed to serving the people impacted by this horrendous disaster. They all have agreed volunteer their time for this noble cause.

The estimated cost is based on \$4000 per person. An additional amount \$4000 is included for contingencies, incidentals and any other unexpected costs that may incur in the field (supplies, communication etc).

In-situ Inc. of Fort Collins, Colorado is donating field instruments costing \$ 8786 to the project to be used during the field visit. These instruments include MP Troll 9000 and accessories and a reader system for conductivity, turbidity and other water quality parameter measurements.

6.0 Curriculum vitae of PI and panel members

ILLANGASEKARE Tissa H.

AMAX Distinguished Chair of Environmental Sciences and Engineering and Professor of Civil Engineering

(a) Vitae

Personal : Date of Birth: *February 19, 1949* ; Citizenship: USA

Address: Division of Environmental Science and Engineering, Colorado School of Mines, Golden, CO 80401-1887.

Professional Qualifications: Registered Professional Engineer and Hydrologist.

Education: (1) Ph.D. in Civil Engineering, 1978- Colorado State University;
(2) M.Eng. in Hydrology and Water Reso. Engin., 1974; Asian Institute of Technology
(3) B.Sc. (honors) in Civil Engineering, 1971 -University of Ceylon.

Recent Recognitions

(1). Associate Editor of *J. of Contaminant Hydrology*; *Water Resou. Resh* (past), *J. of Hydrology* and *Vadose Zone Journal*; (3) Member, NAS/ NRC Committee on Subsurface Contamination at DOE Complexes; (4) Editor, *Earth Science Review*

Professional Career

From 1998- AMAX Distinguished Chair of Environmental Sciences and Engineering and Professor of Civil Engineering; Director, Center for Experimental Study of Subsurface Environmental Processes (CESEP)

Adjunct Professor, Department of Civil, Envir. And Arch. Engineering, UC-Boulder; Research Affiliate, Applied Mathematics, UC-Boulder; Faculty Affiliate, Civil Engineering CSU.

1990-1998- Professor, Dept. of Civil Envir. & Arch. Engi., UC-Boulder.

1986-1989 - Associate Professor – Dept. of Civil Envir. & Arch. Engi., UC-Boulder

1983-1985 - Assistant Professor – Dept. of Civil Engineering, Louisiana State University.

1978-1982 - Assistant Professor (Research) - Civil Engineering, CSU.

International Collaborations (last 5 years)

Technical University of Denmark; Cambridge University; University of Barcelona; Czech Technical University; University of Copenhagen; Okayama University; Uppsala University, Sweden

Funding Sources: NSF, US DoD (SERDP), Dept.,of Education, Air Force, Army Research Office, EPA, Industry

(b) 1. Related Publications

Chao, H-C, H. Rajaram and T.H. Illangasekare,2000. Intermediate scale experiments and numerical simulations of transport under radial flow in two-dimensional heterogeneous porous medium, *Water Res. Resh*,36(10), 2869-2878.

Fernandez-Garcia, D., X. Sanchez-Villa and T. H. Illangasekare, 2002, Convergent flow tracer tests in heterogeneous media: combined experimental-numerical analysis for determination of equivalent parameters, *J. of Contaminant Hydrology*, 57, 129-145.

Saenton, S., T.H. Illangasekare, K. Soga and T.A. Saba. 2002. Effects of source zone heterogeneity on surfactant enhanced NAPL dissolution and resulting remediation endpoints, *J. of Contaminant Hydrology*, 59, 27-44.

Barth, G., Illangasekare, T.H. and Rajaram H., 2003. "The effect of entrapped nonaqueous phase liquids on tracer transport in heterogeneous porous media: laboratory experiments at the intermediate scale", *Journal of Contaminant Hydrology* 67 (2003) 247– 268

Barh, G.R., M.C. Hill, T.H. Illangasekare and H. Rajaram, 2001, Predictive modeling of flow and transport in a two-dimensional intermediate-scale, heterogeneous porous medium, *Water Resources Research*, 37(10), 2503-2512.

2. Other publications

Held R.J. and T.H. Illangasekare, 1995. Fingering of dense nonaqueous phase liquids in porous media 1. Experimental Investigation, *Water Resources Resh.*, 31(5),1213-1222.

Held R.J. and T.H. Illangasekare, 1995. Fingering of dense nonaqueous phase liquids in porous media 2. Analysis and classification. *Water Resources Resh.*, 31(5), 1223-1231.

Saba, T., T.H. Illangasekare and J. Ewing, 2001. Surfactant enhanced dissolution of entrapped NAPLs, *J. of Cont. Hydrology*, 51 (1-2) pp. 63-82

Chapter in on "hydrogeophysical case studies at the laboratory scale", editors Yoram Rubin and Susan S. Hubbard, University of California at Berkeley (to be published in 2004)

Illangasekare, T.H., Flow and entrapment of nonaqueous phase liquids in heterogenous soil formations, 1998. Book Chapter in *Physical Nonequilibrium in Soils: Modeling and Application* (ed. H.M. Selim and L. Ma), Ann Arbor Press, pp417-435.

(c) List of Collaborators (last five years)

A. Bielefeldt; University of Colorado ; A. Ramswami; University of Colorado; H. Rajaram; University of Colorado; D. Reible; Louisiana State University; C. Welty; Drexel University; K. Soga, Cambridge University; K. Jensen, Technical University of Denmark and Copenhagen University; Xavier Sanchez , Univ. of Barcelona; Tom Sale, Colorado State University; Michael Benes, Czech Technical University

(d) Thesis advisor and post-doctoral scholars

MS Thesis Supervised: 35; PhD Dissertations Supervised: 19; Post-docs: 14

Last five years

PhD: G. Barth, H-C Chao, T. Saba, B. Prucha, S. Saenton, D.F. Garcia

M.S (thesis)- Q. Moore, C. Davis, R. Richards, P. Peffer, A. Turner, S. Ulman, A. Kaplan

Post-doc: T. Saba, F. Barranco, C. Hwang, E. Hill, D. Dai, S. Saenton, Y-C Kim, M. Mathew, T. Sakaki, M. Komatsu

Current Students:

PhD: Eric Vestal, Derrick Rodriguez, J. Heiderschedit. Elena Moreno-Barbero, Jose Gago, Kent Glover, Jurka Mykiska

M.S: Ann Kaplan, Christy Woodward

(e) **Graduate Advisor:** Professor Hubert J. Morel-Seytoux, Colorado State University.

I. Prabhakar Clement,

I. Professional Preparation

P.E. Registered Civil Engineer, State of Washington, 1997. Post-doctoral Fellow, Battelle Pacific Northwest National Laboratory, Richland, Washington, 1994; Ph.D. Civil Engineering, Auburn University, 1993; MTech. (Environmental Sciences & Engineering), Indian Institute of Technology-Bombay, India, 1987; Msc (Physics), Madurai University, India, 1985; and BSc. (Physics), Madras University, India, 1983.

II. Appointments

Tenure-track Associate Professor, Department of Civil Engineering, Auburn University, Alabama, USA, August 2002- Present; Senior Lecturer, Department of Environmental Engineering, University of Western Australia, Perth, Australia, January 2000 – July 2002; Research/ Senior-Research Engineer, Battelle Pacific Northwest National Laboratory, Richland, Washington, USA, Oct 1995 – December 1999; Post-doctoral Research Associate, Battelle Pacific Northwest National Laboratory, Richland, Washington, USA, March 1994 – Sept. 1995; Graduate Assistant, Department of Civil Engineering, Auburn University, Sept 1989 - March 1994; Research Engineer, Center for Environ. Sciences and Engineering, India, June 1988 - July 1989; Project Engineer, AIC Watson Consultants Limited (currently a member of the Montgomery-Watson group in India), Bombay, India, March 1987 - May 1988.

III. Publications

Dr. Clement has published 35 journal papers, 3 book chapters, 25 conference papers, and several project reports. A detailed list is available at: <http://www.eng.auburn.edu/~clemept/>

a) Five Publications Most Closely Related to the Proposal

(*Graduate student/post-doc names are underlined)

1) Westbrook S.J., J.L. Rayner, G.B. Davis, T.P. Clement, P.L. Bjerg, and S.J. Fisher, Interaction between shallow groundwater, saline surface water and contaminant discharge at a seasonally- and tidally-forced estuarine boundary, *Journal of Hydrology*, vol (302) p. 255-269, 2005.

Simpson, M.J., and T.P. Clement, Improving the worthiness of the Henry problem as a benchmark for density-dependent groundwater flow models, *Water Resources Research*, 40 (1), doi:10.1029/2003WR002199, 2004.

3) Simpson, M.J., and T.P. Clement, Worthiness of the Henry and Elder problems for validating density-dependent flow models, *Advances in Water Resources*, vol (26) p. 17-31, 2003.

4) Simpson, M.J., T.P. Clement, and T.A. Gallop, Laboratory and numerical investigation of flow and transport near a seepage-face boundary, *Ground Water*, vol 41(5), p.690-700, 2003.

5) Clement, T.P., W.R. Wise and F.J. Molz, A physically based, two-dimensional, finite difference algorithm for variably saturated flow, *Journal of Hydrology*, v. 161, p. 71-90, 1994.

b) Five Other Significant Publications

1) Quezada, C.R., T.P. Clement, K.K. Lee, Generalized solution to multi-dimensional, multi-species transport equations coupled with a first-order reaction network involving distinct retardation factors, *Advances in Water Resources Journal*, vol 27, p. 507-520, 2004.

2) Clement, T.P., C.D., Johnson, Y. Sun, G.M. Klecka, C. Bartlett, Natural attenuation of chlorinated solvent compounds: Model development and field application, *Journal of Contaminant Hydrology*, vol.42, p.113-140, 2000.

2) Sun, Y., J.N. Petersen, T.P. Clement, and R.S. Skeen, Development of analytical solutions for multi-species transport with serial and parallel reactions, *Water Resources Research*, Vol. 35, No. 1, p. 185-190, 1999.

4) Clement, T.P., Y. Sun., B.S. Hooker, J.N. Petersen, Modeling Multi-species Reactive Transport in Groundwater Aquifers, *Groundwater Monitoring & Remediation Journal*, vol 18(2), spring issue, p. 79-92, 1998.

5) Clement, T.P., B.S. Hooker, and R.S. Skeen, Macroscopic models for predicting changes in saturated porous media properties caused by microbial growth, *Ground Water*, 34(5), 934-942, 1996.

IV. Synergistic Activities

a) Honorary Positions

- 1) Served as external PhD dissertation examiner at: The University of Western Australia, Australia (January 1999), The University of Newcastle, Australia (January 2002), and University of Hong Kong, Hong Kong (January 2002).
- 2) Associate editor of ASCE Journal of Hydrological Engineering
- 3) Member of ASCE Groundwater Hydrology and Groundwater Quality committees.

b) Honors and Awards

- Nominated for the 2005 ASCE Huber Prize
- Principal investigator of the RT3D software (a bioremediation simulation tool) development and technology transfer project. The work related to the development of the RT3D computer tool received a seal of achievement from the Federal Laboratory Consortium (FLC) for Technology Transfer. May 1999.
- Outstanding performance award in recognition for the support of the RT3D development project, Battelle Pacific Northwest National Laboratory 1999 award.
- Invited (by the 1999 awards committee) nominee and semifinalist of the Discover Magazine Award (1999) for the technological innovation work related to RT3D.
- Academic Excellence Award, Auburn University, May 1991.

c) Public Domain Computer Codes Authored Dr. Clement

- 1) BIOCHLOR, USEPA's natural attenuation design software – Reference: Aziz, C. E, C.J. Newell, J.R. Gonzales, P. Haas, T.P. Clement, Y. Sun, Natural attenuation decision support system v1.0, User's Manual, USEPA Report, Cincinnati, Ohio, EPA/600/R-00/008; <http://www.epa.gov/ada/csmos/models/biochlor.html>.
- 2) RT3D, USDOE's Bioremediation Model – Reference: Clement, T.P. (1997) A modular computer code for simulating reactive multi-species transport in 3-Dimensional groundwater aquifers, Battelle Pacific Northwest National Laboratory Research Report, PNNL-SA-28967. This work was jointly funded by DOE and private industries. The software is now supported by several industry-standard GUI's including GMS, VisualModflow, and GW-vistas. Also, available at: <http://bioprocess.pnl.gov/rt3d.htm>.

V. Collaborators & Other Affiliations

a) **Collaborators and Co-editors:** M. Sivapalan and M. Hipsey, UWA-Australia; N.L. Jones, Brigham Young University-Utah; C.J.Otto and Greg Davis, CSIRO-Australia; M.J. Truex, C.D. Johnson, T. D. Scheibe, and E. M. Murphy (Pacific Northwest National Lab); K. E. Nelson and Tim Ginn (UC Davis); G.M. Klecka (Dupont); K.K. Lee (Seoul National University).

b) **Graduate and Post-doctoral Advisors:** Prof. Fred Molz (Clemson), Prof. William Wise (Univ. Florida), and Dr. Brian Hooker (Pacific Northwest National Lab).

c) **Thesis Advisor and Postgraduate-scholar Sponsor** (Graduated 1 PhD, 3 masters, and 2 post-doctoral fellows. Currently supervising 3 PhD and 3 masters students. Also served as external advisor for 1 PhD and 2 masters students)

PhD. Dr. Matthew Simpson (now at The University of Melbourne)

Masters. Mr. Shane Wilkes (now with Golder Australia), Cristhian Quezada (now in Virginia Tech); John Phillipi

Post-docs: Dr. T.R. Gautam (now with Queensland Natural Resources Management Program)

Dr. Y. Sun (now at the Lawrence Livermore Laboratory)

External Advisor: Guoping Lu (PhD-U. of Alabama), now at Los Alamos National Laboratory; Marley Franzen (masters), Washington State University; and Clarrisa Hansen (masters BYU) now at Waterways Experimental Station.

Charles F. Harvey

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Professional Preparation

PhD, Hydrogeology, Environmental and Geologic Sciences, Stanford Univ., 1996.
MS, Hydrogeology, Applied Earth Sciences, Stanford Univ., 1992.
BA, Mathematics, Oberlin College 1986.

Appointments & Professional Experience

Associate Professor, Dept. of Civil and Environmental Engineering, MIT, 2003 - Present
Assistant Professor, Dept. of Civil and Environmental Engineering, MIT, 1998 - 2002
Assistant Professor, Dept. Engineering and Applied Science and Earth and Planetary Sciences, Harvard Univ., 1996 – 1998
Hydrologist, USGS, Richmond VA, 1988-1989.

Five Publications most closely related to the proposed project

Harvey, C. F., Swartz, C.H., Badruzzman, B., Keon, N.E., Yu. W., Ali, A., Jay, J., Beckie, R., Niedan, V., Brabander, D, Oates, P., Ahsfaque, K., Islam, S., Hemond, H.F., Ahmed, F., “Arsenic Mobility and Groundwater Extraction in Bangladesh,” *Science*, 298, 1602, 2002.
Michael, H., Mulligan, A. and Harvey, C., “Seasonal Saline Water Exchange between Aquifers and the Coastal Ocean,” *Nature*, in review -- revised manuscript requested..
Yu, W., Harvey, C. F., and Harvey, C.M., “Arsenic In groundwater in Bangladesh: A geostatistical and epidemiological framework for evaluating health effects and potential remedies,” *Water Resources Research*, 39(6), 2003.
Swartz, C.H., Keon, N.E., Badruzzman, B., Ali, A., Brabander, D, Jay, J., Islam, S., Hemond, H.F., Harvey, C.F., “Subsurface geochemistry and arsenic mobility in Bangladesh,” *Geochimica Acta*, 68(22), 2004, doi:10.1016/j.gca.2004.04.020.
Harvey, C. F., Swartz, C.H., Badruzzman, B., Keon, N.E., Yu. W., Ali, A., Jay, J., Beckie, R., Niedan, V., Brabander, D, Oates, P., Ahsfaque, K., Islam, S., Hemond, H.F., Ahmed, F., “Groundwater Arsenic Contamination on the Ganges Delta: Biogeochemistry, Hydrology, Human Perturbations, and Human Suffering on a Large Scale”, *Comptes-Rendus: Geoscience*, accepted.

Five Other relevant publications

Michael, H., Lubetsky, J., and Harvey, C. F., "Characterizing submarine groundwater discharge: a seepage meter study in Waquoit Bay, Massachusetts", *Geophysical Review Letters*, 30(6), 1297, 2003.

Harvey, C.F., K. Ahsfaque, W. Yu, P. Oates, B. Badruzzman, A. Ali, H. Michael, R. Neuman, , R. Beckie, "Groundwater Flow and Arsenic Biogeochemistry in a Bangladeshi Aquifer," *Chemical Geology*, in press.

Harvey, C. F., "Technical Comment: Groundwater Flow in the Ganges Delta," *Science*, 296, May, 2002.

Gramling, C., Harvey, C.F. and Meigs, L., "Reactive transport in porous media: a comparison of model prediction with laboratory visualization," *Environmental Science and Technology* 36, 2002.

Zinn, B., and Harvey, C. F., "When good statistical models of aquifer heterogeneity go bad: A comparison of flow, dispersion and mass transfer in Multigaussian and connected hydraulic conductivity fields," *Water Resources Research* , 39(3), 1051, 2003.

Synergistic Activities

- Co-organizer (with Shafik Islam) Organizer of National Science Foundation Workshop on the future of the Ganges-Brahmaputra Delta, in Bangladesh.
- Developed new teaching methods for groundwater hydrology combining visible dyes in physical models, with real-time numerical transport models.
- Active in MIT's undergraduate research opportunity program, typically supervising two or three undergraduates at a time.
- Member, board of directors, Sea Change, a not-for-profit institution mediating environmental disputes and providing information to local communities.
- Advisor for Terriscope, a new undergraduate curriculum at MIT focusing on earth processes
- Scientific advisor and featured scientist for proposed IMAX film, "Water Planet."

Recent Collaborators

Lucy Meigs (Sandia Labs), Roy Haggerty (Oregon State), Harry Hemond (MIT), Phil Gschwend (MIT), Shafik Islam (Univ. Cincinnati), Borhan Badruzzaman (BUET), Stephan Hug (ETH, Zurich), Roger Beckie (Univ. British Columbia), Scott Fendorf (Stanford).

Graduate Advisors

Steven Gorelick, Peter Kitanidis, Andre Journel (all Stanford University).

Thesis Advisor and Postgraduate-Scholar Sponsor

Ph.D. -- Brendan Zinn, Peter Oates, Carolyn Gramling, Winston Yu, Kaeo Duarte, Khandaker Ashfaque, Holly Michael, Rebecca Neuman

Post Doc -- Chris Swartz, Jenny Jay, Daniel Brabander

JAGATH J. KALUARACHCHI

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Logan, UT 84322-8200
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Education:

B.Sc., Civil Eng., University of Moratuwa, Sri Lanka	1980
M.Phil, Civil Eng., University of Hong Kong, Hong Kong	1984
Ph.D., Env. Sci. & Eng., Virginia Polytechnic Institute and State University, Blacksburg, VA	1988

Positions:

Professor, USU	2001-present
Head, Water Engineering Program, USU	2004-present
Visiting Professor, Royal Institute of Technology, Stockholm	1997-1998
Associate Professor, USU	1996-2001
Assistant Professor, UCLA	1991-1995
Research Scientist, VPI & SU	1988-1990
Civil Engineer, Sri Lanka	1980-1981

Honors and Citations:

Received the *Out Standing Researcher* award, Utah State University, 1996-97.
Who'sWho in Science and Engineering, Marquis Who's Who, 8th Edition, 2005 - 2006

Professional Societies:

American Society of Civil Engineers, Member
American Geophysical Union, Member
American Water Resources Association, Member
Associate Editor, *Journal of Hydrologic Engineering*, 2001-present
Editor, Groundwater Contamination by Organic Pollutants; Analysis and Remediation
ASCE Manual and Reports on Engineering Practice, No. 100
Past Chair, Ground Water Quality Committee, EWRI
Vice Chair, Watershed Council, Environmental and Water Resources Institute

List of 5 Publications Most Closely Related to the Proposed

Khadam, I. and J. J. Kaluarachchi. Applicability of risk-based management and the need for risk-based economic decision analysis at hazardous waste contaminated sites, *Environment International*, 29(4), 503-519, 2003.

Khadam, I. and J. J. Kaluarachchi. Multi-criteria decision analysis with probabilistic risk assessment for the management of contaminated ground water, *Environmental Impact Assessment Review*, 23: 683-721, 2003.

Almasri, M. and J. Kaluarachchi, Assessment and management of long-term nitrate pollution of ground water in agriculture-dominated watershed, *Journal of Hydrology*, 295, 225-245, 2004.

Almasri, M. and J. Kaluarachchi, Implications of on-ground nitrogen loading and soil transformations on ground water quality management, *Journal American Water Resources Association*, 40(1), 165-186, 2004.

Almasri, M. and J. Kaluarachchi, Modular neural network to predict the distribution of nitrate in ground water using on-ground nitrogen loading and recharge data, *in press*, *Environmental Modelling and Software*, December, 2004.

List of 5 Other Significant Publications:

Tesfamichael, A. A. and J. J. Kaluarachchi, Uncertainty analysis in pesticide residue risk assessment in drinking water, *in press*, *Human Ecology and Risk Assessment*, December, 2004.

Khadam, I. and J. Kaluarachchi, Water quality modeling under hydrologic variability and parameter uncertainty using export coefficients, *in review*, *J. of Hydrology*, November 2004.

Twarakavi, N. K. C. and J. J. Kaluarachchi, Arsenic in ground waters of conterminous United States: assessment, health risk, and cost, *Journal American Water Resources Association*, *in review*, September, 2004.

Tesfamichael, A. A., A. Caplan, and J. J. Kaluarachchi, Risk-cost-benefit analysis of atrazine in drinking water from agricultural activities and policy implications, *in press*, *Water Resources Research*, 2004.

Abedalrazq K., M. N. Almasri, M. McKee, and J J. Kaluarachchi, Applicability of statistical learning algorithms in groundwater quality modeling, *in review*, *Water Resources Research*, August 2004.

Collaborators: Prof. Vladimir Cvetkovick, KTH; Prof. Upmanu Lall, Columbia;
Prof. Arthur Caplan, USU
Name of Graduate Advisor: Dr. Jack Parker
Doctoral Advisees (last 5 years): A. Abdin, M. Rashid, M. Almasri, J. Morshed

Total Number of PhD Students Chaired: 15

Leonard F. Konikow

December 2004

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431 National Center
Reston, VA 20192
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EDUCATION: B.A. in Geology, June 1966, Hofstra University, Hempstead, NY
M.S. in Geology, March 1969, Pennsylvania State University, University Park, PA
Ph.D. in Geology, March 1973, Pennsylvania State University, University Park, PA

WORK EXPERIENCE:

10/80 to present: Project Chief, Water Resources Div. (WRD) Research Project "Digital modeling of transport in saturated zone."

Duties include evaluating and developing well-documented, reliable, and workable models to predict changes in ground-water quality due to transport and dispersion of dissolved inorganic chemicals; conduct independent research related to ground-water transport processes; and lecture at USGS training classes.

07/78 to 10/80: Ground Water Branch, WRD, U.S. Geol. Survey, Reston, VA.

Serves as member of technical staff of Ground Water Branch in its exercise of central headquarters leadership of investigations and research concerned with the Nation's ground-water resources, their physical and chemical quality, and their conservation and efficient use. Provide technical consultation and guidance to headquarters, regional, district, and research personnel on methods of network design, monitoring, and numerical simulation. Provide liaison with other divisions, Federal and state agencies, universities, and professional societies.

10/74 to 07/78: Project Chief, Research Project on "Solute Transport in Ground Water," WRD, Central Region, Lakewood, CO.

Duties included evaluating and developing well-documented, reliable, and workable models to predict changes in ground-water quality due to transport and dispersion of dissolved inorganic chemicals; conducted independent research related to ground-water transport processes.

02/72 to 10/74: Project Chief, Subsurface Waste Investigations, Colorado District Office, WRD.

Developed and applied digital models of contaminant movement in ground water to complex field problems; performed comprehensive investigations of salinity increases from irrigation, contamination from industrial waste disposal ponds, and impacts of cattle feedlots.

09/69 to 12/71: Research assistant, Pennsylvania State University, University Park, PA.

Assisted instructor of graduate hydrogeology courses; research projects included operating precipitation-gage network, stream gages, well inventories, and water-quality sampling.

PROFESSIONAL SOCIETIES:

American Geophysical Union (1970 – present; elected Fellow, 2001)

- AGU Spring Meeting Program Chairman for Hydrology (1984-87)
- Groundwater Committee (1977-1986; Chairman, 1980-1982)

Geological Society of America (1974 - present) (Fellow since 1990)

- Management Board, Hydrogeology Div., Geol. Soc. Am. (Oct. 1991-Nov. 1995)
- Chairman, Hydrogeology Division (Oct. 93-Oct. 94).

U.S. Committee on Irrigation, Drainage, and Flood Control (1974 - 1975)
International Association of Hydrogeologists (1985 - present)

- Chairman of U.S. National Chapter (Jan. 2001 – Dec. 2004)

Assoc. of Ground Water Scientists and Engineers (Technical Division of National Ground Water Association) (1990-present)

- AGWSE—Board of Directors (1996-2000)

American Institute of Hydrology (Certified as Professional Hydrogeologist) (1991-present)
California Groundwater Resources Association (2002-present)

HONORS AND AWARDS:

- Geological Society of America, Hydrogeology Division, 1985-86, Birdsall Distinguished Lecturer
- National Water Well Association M. King Hubbert Science Award (1989)
- Hydrogeology Division, Geological Society of America, 1997, O.E. Meinzer Award
- C.V. Theis Award from the American Institute of Hydrology (1998)
- Distinguished Service Award from U.S. Dept. of Interior (March 1999)
- Geological Society of America, Hydrogeology Div.—Award for Distinguished Service (2000)
- Elected as Fellow, American Geophysical Union (2001)
- President's Award, International Association of Hydrogeologists (2001)

MISCELLANEOUS:

Rocky Mountain Arsenal (Colorado) Technical Review Committee (1975-77).
Associate Editor, *Water Resources Research* (July 1981-Dec. 1984).
National Research Council, Panel on Groundwater Contamination (1981-82).
National Research Council, Water Sci. & Tech. Board, Committee on Ground-Water Modeling Assessment (1987-89).
National Research Council, WIPP Committee (1989-97).
Editorial Board, *Ground Water* journal (Feb. 93-Dec. 1995).
Adviser to U.S. AID project studying seawater intrusion in Gaza and Morocco (1994-97).
Registered Professional Geologist, State of Pennsylvania (since 1995).
National Research Council, Hydrogeology/Water Management Peer Review Panel for U.S. AID (Oct. 2000).
National Research Council, Committee on Principles and Operational Strategies for Staged Repository Systems (2001-02).

TEACHING:

- Instructor, Geology Department, Hofstra University, Hempstead, NY (07/66 to 09/66).
Organized and taught introductory course on physical and historical geology.
- Teaching assistant, Geology Department, Pennsylvania State University (01/69 to 06/69).
- Lecturer, Dept. of Environmental Sciences, Univ. of Virginia (Jan.-May 1991 and 1992).
Taught 3-credit senior/graduate courses on Ground-Water Hydrology.
- Visiting Instructor, Dept. of Geological Sciences, Stanford University (9/97 to 12/97).
Taught graduate course on Physical Hydrogeology.

- Instructor for numerous short courses and workshops for various state, Federal, and international organizations since 1971.

PUBLICATIONS:

Author or coauthor of numerous articles in peer-reviewed journals, government publications, conference proceedings, book chapters, and talks given at professional society meetings (detailed list available on request).

G. (Kumar) Mahinthakumar

Assistant Professor, Department of Civil Engineering
North Carolina State University, Raleigh NC 27695.
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www.ce.ncsu.edu/faculty/kumar

a. Professional Preparation

University of Peradeniya, Sri Lanka	B.Sc. in Civil Engineering	1985.
Asian Institute of Technology, Thailand	M.Eng in Environmental Engineering	1988.
Claremont Graduate School, CA	M.S. in Applied Mathematics	
1990.		
University of Illinois at Urbana-Champaign	Ph.D. in Civil Engineering	
1995.		

b. Appointments

Jan 2000 – present: Assistant Professor, North Carolina State University.
Jan 2000 – present: Adjunct R&D Participant, Oak Ridge National Laboratory.
Aug 1994 - Dec 1999: Research Staff Member, Oak Ridge National Laboratory.
Jun 1991- Aug 1991 and Jul 1992: Research Assistant, National Center for Supercomputing Applications
Jan 1989-July 1990: Research Associate, Harvey Mudd College, CA
Jan 1986-Oct 1986: Instructor, University of Peradeniya, Sri Lanka.
Nov 1986 – Aug 1987: Site Engineer, Samuel Sons & Co. Ltd., Sri Lanka.
Apr 1981- Aug 1981: Teacher, St. John's College, Sri Lanka.

c. Publications

Five Publications Most Relevant to project:

Mahinthakumar, G., and Sayeed, M. (2005). **Hybrid genetic algorithm - local search methods for solving groundwater source identification inverse problems**, *ASCE Journal. of Water Resources Planning and Management*, 131(1), p 45-57, January/February 2005.

Sayeed, M. and Mahinthakumar, G. (2005). **An efficient parallel implementation of hybrid optimization approaches for solving groundwater inverse problems**, *To appear in: ASCE Journal of Computing*, May 2005.

Shin, W.T., X. Garanzuay, S. Yiacoumi, B. Gu, C. Tsouris, and G. Mahinthakumar (2004). **Kinetics of soil ozonation: an experimental and numerical investigation**, In press: *Journal of contaminant hydrology*.

Mahinthakumar G., Gwo J.P., Moline G.R., Webb O. F., (1999). **Subsurface biological activity zone detection using genetic search algorithms**, *ASCE Journal of Environmental Engineering*, vol. 125, no. 12, p 1103-1112, December 1999.

Painter, S. and G. Mahinthakumar (1999). **Prediction Uncertainty for Tracer Migration in Random Heterogeneities with Multifractal Character**, *Advances in Water Resources*, 23, p. 49-57, 1999.

Five other publications:

Mahinthakumar and Saied (2002). **A hybrid MPI-OpenMP implementation of an implicit finite-element code on parallel architectures**, *International Journal of High Performance Computing Applications*, Volume 16, Number 4, Winter 2002, pp. 371-393.

Saied, F., and G. Mahinthakumar. **Efficient Parallel Multigrid Based Solvers for Large Scale Groundwater Flow Simulations**, *Computers Math. Applic.*, Vol. 35, No. 7, p. 45-54, 1998.

Mackay, D., G. Mahinthakumar, and E. F. D'Azevedo, **A study of I/O in a parallel finite-element groundwater transport code**, *Int. J. of High Performance Computing Applications*, 12(3), Fall 1998, p. 307-319.

Mahinthakumar, G., and A. J. Valocchi, **Application of the Connection Machine to Flow and Transport Problems in Three-Dimensional Heterogeneous Aquifers**, *Advances in Water Resources*, Vol. 15, 289-302, 1992.

Mahinthakumar, G., and S. R. H. Hoole, **A Parallelized Element-by-Element Jacobi Conjugate Gradients Algorithm for Field Problems and a Comparison with Other Schemes**, *Applied Electromagnetics in Materials*, Vol. 1, No. 1, 15-28, Jul 1990.

d. Synergistic Activities

- Member, American Society of Civil Engineers, 2000-present.
- Associate editor, *ASCE Journal of Computing in Civil Engineering*, 2004-present.
- Graduate coordinator, Computer Aided Engineering (CAE) program, North Carolina State University, 2001-present.
- Technical reviewer, *Journal of Computing in Civil Engineering*, *Advances in Water Resources*, and *International Journal of High Performance Computing with Applications*.

e. Collaborators & Other Affiliations

(i) Collaborators

North Carolina State University: John Baugh, Abhinav Gupta, Murthy Guddati, Clement Kleinstruer, Dan Loughlin, Ranji Ranjithan.

Oak Ridge National Laboratory: Ed D'Azevedo, Gerry Moline, Richard Ward, Pat Worley.

National Center for Supercomputing Applications: Faisal Saied.

Northern Illinois University: Nick Karonis.

Southwest Research Institute: Scott Painter.

(ii) Graduate and Postdoctoral Advisors

Albert Valocchi, University of Illinois at Urbana-Champaign.

(iii) Thesis Advisor and Post-Graduate Scholar Sponsor

Chandru Narasimhan (MS' 2001), Mohamed Sayeed (PhD.' 2004), Siva Pabolu (MS, 2002), S Partheepan (MS, 2003), Xin Jin (PhD, Ongoing), Baha Mirghani (PhD, Ongoing), Michael Tryby (PhD, Ongoing), Yong Jung (PhD, Ongoing), Kavitha Raghavachar (MS, Ongoing).

g. Awards and honors

NSF CAREER Award 2003.

Jayantha T.B. Obeysekera ('Obey')

EDUCATION

Ph.D. Civil Engineering (Hydrology and Water Resources Program), Colorado State University, Fort Collins, Colorado (1978-1981)
Master of School of Hydrology, University of Roorkee,
Engineering Roorkee, India (1977-1978)
P.G.Diploma School of Hydrology, University of Roorkee, Roorkee, India (1976-1977)
B.S. Civil Engineering (Honors), University of Ceylon, Peradeniya, Sri Lanka (1970-1975)

POSITIONS:

May, 2003 to present: Director, Office of Modeling, South Florida Water Management District (SFWMD), Florida
(Responsible for 50 modelers in sw/gw hydrology, hydrodynamics, water quality and ecology)
May, 1995 to Sep. 2003: Director, Hydrologic Systems Modeling Division, SFWMD
May, 1991: Appointed Adjunct Assistant Professor, Department of Geography & Geology, Florida
Florida Atlantic University, Boca Raton, Florida
May, 2000: Appointed Courtesy Associate Professor, Department of Civil Engineering
University of South Florida, Tampa, Florida
Jan. 1987 to Sep. 1987: Water Resources Engineer, SFWMD
Sep. 1987 to May. 1988: Staff Water Resources Engineer, SFWMD
May. 1988 to Sep. 1989: Senior Water Resources Engineer, SFWMD
Oct. 1989 to April, 1995: Supervising Professional Water Resources Engineer, SFWMD
Supervising Professional Civil Engineer, SFWMD
Jan. 1985 - Dec. 1986: Assistant Professor in Civil Engineering, Department of Civil Engineering,
Colorado State University, Fort Collins, Colorado.
Aug. 1982 - Dec. 1984: Research Scientist, International Water Resources Institute,
School of Engineering and Applied Sciences, George Washington
University, Washington, D.C.
Sep. 1981 - July 1982: Research Associate, Hydrology and Water Resources Program, Colorado
State University, Fort Collins, Colorado.
Aug. 1978 - Aug. 1981: Research Assistant, Hydrology and Water Resources Program, Colorado
State University, Fort Collins, Colorado.
Jan. 1976 - June 1976: Assistant Lecturer in Civil Engineering, University of Sri Lanka,
Katubedda, Sri Lanka.

HONORS

Gold medal for standing first in first class in Hydrology University of Roorkee, India., 1976-77
Member, Panel of Distinguished Scholars, Fourth International Hydrology Symposium on
Multivariate Analysis of Hydrologic Processes, July 15-17, 1985, Colorado State University.

PROFESSIONAL AFFILIATION AND NATIONAL COMMITTEES

Member, Surface Runoff Committee of the American Geophysical Union. (term expired)

REGISTRATION

Registered Professional Engineer (No. 40202), State of Florida

TEACHING EXPERIENCE

1. Basic Hydrology (Undergraduate), Colorado State University
2. Advanced Hydrology (Graduate), George Washington University
3. Water Resources Planning (Graduate), George Washington University
4. Computer Watershed Models in Hydrology (Graduate), Colorado State University
5. Stochastic Processes in Hydrology (Graduate), Colorado State University
6. Control of Floods and Droughts (Graduate), Colorado State University
7. Engineering Mechanics: Dynamics (Undergraduate), Colorado State University
8. Dynamic Hydrology (Graduate), Florida Atlantic University
9. Stochastic Hydrology, Florida Atlantic University

BOOKS

Co-editor, Multivariate Analysis of Hydrologic Processes, Proceedings of Fourth International Hydrology Symposium, July 15-17, 1985, Colorado State University, Fort Collins, Colorado

INTERNATIONAL EXPERIENCE

Brazil: One-week visit to write a proposal for water management in the drought-prone regions of the North and East; Spain: Invited to teach a one-week short-course on hydrologic modeling using stochastic methods at University of Valencia; Dominican Republic: Principal Investigator for hydrologic studies, Operational Studies of the Valdesia Reservoir, a project funded by the World Bank. Taught several training classes on hydrologic modeling.

Colombia: Visited two times to conduct short-course on hydrologic modeling at the National University, Medellin; Venezuela: Invited to present a paper on "Ecosystem Restoration and Sustainable Development in South Florida," Interamerican Conference on Environmental Issues, December 8-11, 1997, Universidad Simon Bolivar

Sri Lanka:

- During the last several years, taught several short-courses on hydrologic modeling to engineers at the Sri Lanka Land Reclamation and Drainage Corporation (SLLRDC).
- On several occasions during the past several years, presented seminars to engineers at the Irrigation Department and to the scientist at IWMI.
- Presented a Special Invited Lecture at the International Conference on Water Resources Management in the Changing Environment of the Monsoon Region held November 17-19, 2004 in Colombo, Sri Lanka. The title of the paper was "Integrated Water Resources Management in the USA—Experience in South Florida."
- Presented a seminar entitled "Recent Technological Advances in Hydrologic Information Systems" to about 40 engineers at the Irrigation Department in Sri Lanka (November 25, 2004).

SELECTED JOURNAL PUBLICATIONS

Jose D. Salas, J. T. B. Obeysekera, and R. A. Smith, "Identification of Streamflow Stochastic Models," Journal of the Hydraulics Division, ASCE, Vol 107, No. HY7, July, pp. 853-866, 1981.

J. T. B. Obeysekera and J. D. Salas, "Modeling of Aggregated Hydrologic Time Series," Journal of Hydrology, Vol. 86, pp. 197-219, 1986.

V. Yevjevich and J. T. B. Obeysekera, "Relationship Among Water Storage Variables" Journal of Water Resources Planning and Management, ASCE, Vol. 113, No. 3, May, 1987, pp. 353-367.

H. W. Shen, G. Q. Tabios, and Jayantha Obeysekera, "On Outlier Detection Tests," Schweizer Ingenieur und Architekt, Nr.37, 8. Sep. 1988.

W. Abtew, J. Obeysekera, and G. Shih.) "Spatial Variation of Daily Rainfall and Network Design". Transactions of ASAE. Vol. 38, No. 3. pp. 843-845, 1995.

Jayantha Obeysekera, and Ken Rutchey, "Selection of scale for Everglades landscape models," Landscape Ecology, Vol. 12, No. 1, pp7-18, 1997.

Jorge I. Restrepo, Angela M. Montoya, and Jayantha Obeysekera, "A Wetland Simulation Module for the MODFLOW Ground Water Model," *Ground Water*, Vol. 36, No. 5, September – October, 1998.

Jayantha Obeysekera, J. Browder, L. Hornung, and M. Harwell, "The natural South Florida system I: Climate, geology, and hydrology, *Urban Ecosystems*, 3, 223-244, 1999.

Mark M. Wilsnack, David E. Welter, Angela Montoya, and Jorge Restrepo, "Simulating Flow in Regional Wetlands with the MODFLOW Wetlands Package," *Journal of the American Water Resources Association*, Vol. 37, No. 3, June 2001

MARTINUS TH. VAN GENUCHTEN

Address:

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<http://www.ussl.ars.usda.gov/BIO/RVANG.HTM>

Education:

Ph.D. 1975 Soil Physics, New Mexico State University, Las Cruces, NM
M.S. 1971 Irrigation & Drainage, Wageningen University, The Netherlands
B.S. 1968 Irrigation & Drainage, Wageningen University, The Netherlands

Positions:

2003-present Research Soil Physicist, George E. Brown, Jr. Salinity Laboratory, USDA, ARS
1986-2003 Supervisory Soil Scientist & Research Leader, U.S. Salinity Laboratory, USDA, ARS.
1987-present Adjunct Professor, University of California, Riverside, CA
1978-1986 Assistant, Associate and Full Research Soil Scientist, Dept. of Environmental Sciences, Univ. of California, Riverside, CA
1975-1978 Research Staff, Dept. of Civil Engineering, Princeton Univ., Princeton, NJ
1968-1969 Assistant Hydrologist, Ministry of Agriculture, Madagascar

Selected Professional Activities/Honors:

Editor, *Vadose Zone Journal* (2001-present).
Deputy Editor (1998-2000), *Water Resources Research*.
Editor, U.S. National Report (Hydrology) to the Int. Union of Geodesy and Geophysics (1991).
Associate Editor, *Journal of Contaminant Hydrology*, *Advances in Water Resources*, *Soil Science*, *International Agrophysics* (Poland), *Nordic Hydrology* (Sweden), *Journal of Hydrology and Hydromechanics* (Slovakia) (all presently)
Fellow, American Geophysical Union (1992), Soil Science Society of America (1988), American Society of Agronomy (1991), American Association for the Advancement of Science (2003).
Soil Science Research Award, Soil Science Society of America (1996)
Outstanding Senior Research Scientist of the Year, USDA-ARS (1996)
Don and Betty Kirkham Soil Physics Award, Soil Science Society of America (1998)

Federal Laboratory Consortium (FLC) Award for Excellence in Technology Transfer (2001)

Highly Cited Researcher in Engineering, Institute of Scientific Information, ISI (2001)

Technology Transfer Award, USDA, Agricultural Research Service (2001)

Honorary Doctorate, Hanover University, Germany (2004)

Research Interests:

Water flow and solute transport in variably-saturated soil and groundwater systems; analytical and numerical methods for simulating water and solute movement in the subsurface; characterization and measurement of the hydraulic properties of unsaturated porous media; use of inverse methods for estimating vadose zone flow and transport parameters; crop salt tolerance; root water uptake; reclamation of salt-affected soils; preferential flow of water and solutes in structured media; pesticide transport; colloid and colloid-facilitated transport.

List of 5 Publications Most Closely Related to the Proposal:

- Schaap, M. G., F. J. Leij and M. Th. van Genuchten. 2001. Rosetta: A computer program for estimating soil hydraulic parameters with hierarchical pedotransfer functions. *J. Hydrol.* 251: 163-176.
- Silliman, S. E., B. Berkowitz, J. Simunek, and M. Th. van Genuchten. 2002. Fluid flow and solute migration in the capillary fringe. *Ground Water* 40(1):76-84.
- Bradford, S. A., M. Bettahar, J. Simunek, and M. Th. van Genuchten. 2004. Straining and attachment of colloids in physically heterogeneous porous media. *Vadose Zone J.* 3: 384-394.
- Rassam, D., J. Simunek and M. Th. van Genuchten. 2003. *Modelling Variably-Saturated Flow with HYDRUS-2D*. ND Consult, Brisbane, Australia, 275 p.
- Steppuhn, H., M. Th. van Genuchten, and C. M. Grieve. Root-zone salinity: I. Selecting a product-yield index and response function for crop tolerance. *Crop Science* (in press).

List of 5 Other Significant Publications:

- van Genuchten M. Th., and D. R. Nielsen. 1985. On describing and predicting the hydraulic properties of unsaturated soils. *Annales Geophysicae*, 3(5): 615-628.
- van Genuchten, M. Th., and R. J. Wagenet. 1989. Two-site/two-region models for pesticide transport and degradation: Theoretical development and analytical solutions. *Soil Sci. Soc. Am. J.*, 53(5): 1303-1310.
- Šimunek, J., K. Huang, M. Šejna, and M. Th. van Genuchten. 1999. The HYDRUS-2D Software Package for Simulating Two-Dimensional Movement of Water, Heat and Multiple Solutes in Variably-Saturated Media. Version 2.0. *IGWMC-TPS-53*, Int. Ground Water Modeling Center, Colorado School of Mines, Golden, CO., 251 p.
- van Genuchten, M. Th., and J. Simunek. 2004. Integrated modeling of vadose-zone flow and transport processes. *In*: R.A. Feddes, G. H. de Rooij and J. C. van Dam (eds.), *Unsaturated-Zone Modeling; Progress, Challenges and Applications*, Wageningen UR Frontis Series, Vol. 6, Chapter 2, pp. 37- 69, x-xi, Kluwer Academic Publishers, Dordrecht, The Netherlands.
- Simunek, J., N. J. Jarvis, M. Th. van Genuchten, and A. Gärdenäs. 2003. Review and comparison of models for describing non-equilibrium and preferential flow and transport in the vadose zone. *J. Hydrol.* 272 (1-4):14-35.

Collaborators:

Jiri Simunek and Marcel Schaap, University of California, Riverside; Karim Abbaspour, EAWAG, Duebendorf, Switzerland; Yakov Pachepsky, USDA-ARS, Beltsville, MD; Peter Shouse and Scott Bradford, USDA-ARS, Riverside, CA; Harold Steppuhn, Agriculture and Agri-Food Canada, Swift Current, Saskatoon, Canada; Yves Coquet, UMR-INRA, Grignon, France; Paolo Castiglione, Montana State University, Bozeman, MT; David Rassam, CSIRO, Indooroopilly, Australia; Viliam Novak, Slovak Academy of Sciences, Bratislava.

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E-mail: williamy@seas.ucla.edu

Education:

B.S., C.E., National Chen-Kung University, Taiwan	1961
M.S., C.E., New Mexico State University	1964
Ph.D., C.E., Stanford University	1967

Positions:

Distinguished Professor and Chair	2002-Present
Distinguished Professor (Above-Scale), UCLA	1996-Present
Professor and Chair, UCLA	1985-1988
Professor and Vice Chair, UCLA	1979-1982
Professor, UCLA	1977-1996
Associate Professor and Vice Chair, UCLA	1975-1976
Associate Professor, UCLA	1973-1977
Assistant Professor, UCLA	1969-1973
Assistant Research Engineer, UCLA	1967-1969
Acting Assistant Professor, Stanford	1967

Honors and Awards:

Received the 1975 UCLA Engineering Alumni Association Distinguished Faculty Award for excellence in teaching.

Received the 1981 Engineering Foundation Fellowship Award on behalf of ASCE.

Received the 1989 American Geophysical Union's Robert E. Horton Award.

Elected to Fellow, American Geophysical Union, 1993.

Received the 1994 American Society of Civil Engineers' Julian Hinds Award.

Received the 1994 ASCE Water Resources Planning and Management Division's Outstanding Journal Paper Award.

Elected to Fellow, American Society of Civil Engineers, 1994.

Elected to Honorary Member, American Society of Civil Engineers, 1996.

Received the 1999 Warren A. Hall Medal, Universities Council on Water Resources.

Professional Societies:

American Society of Civil Engineers, Fellow and Honorary Member

American Geophysical Union, Fellow

American Water Resources Association, Member

Associate Editor, *Water Resources Research*, AGU, 1984-1988

Associate Editor, *Journal of Water Resources Planning and Management*, ASCE, 1984-1988

Editor, *Journal of Water Resources Planning and Management*, ASCE, 1988-1993

List of 5 Publications Most Closely Related to the Proposed

Yeh, W.W-G. "Review of Parameter Identification Procedures in Groundwater Hydrology: The Inverse Problem," *Water Resources Research*, 22(1):95-108, 1986.

Sun, N-Z., Yeh, W. W-G., "Coupled Inverse Problems in Groundwater Modeling 2. Identifiability and Experimental Design," *Water Resources Research*, 26(10):2527-2540, 1990.

Cleveland, T.G., Yeh, W. W-G., "Sampling Network Design for Transport Parameter Identification," *Journal of Water Resources Planning and Management*, ASCE, 116(6):764-783, November/December 1990.

Cleveland, T.G., Yeh, W. W-G., "Optimal Configuration and Scheduling of Ground-Water Tracer Test," *Journal of Water Resources Planning and Management*, ASCE, 117(1):37-51, January/February 1991.

Tsai, F.T-C., Sun, N-Z., Yeh, W.W-G., "Global-Local Optimization for Parameter Structure Identification in Three-Dimensional Groundwater Modeling,' to appear in *Water Resources Research*, 2003.

List of 5 Other Significant Publications:

Yeh, W.W-G., Yoon, Y.S. "Aquifer Parameter Identification with Optimum Dimension in Parameterization," *Water Resources Research*, 17(3), 664-672, 1981.

Yeh, W.W-G. "Reservoir Management and Operation Models: A State-of-the-Art Review," *Water Resources Research*, 21-12:1797-1818, December 1985.

Willis, R., Yeh, W.W-G. *Groundwater Systems Planning and Management*, Prentice-Hall, Englewood Cliffs, New Jersey, 1987.

Yeh, W.W-G., "Systems Analysis in Ground-Water Planning and Management, " *Journal of Water Resources Planning and Management*, ASCE, 118(3): 224-237, 1992.

Sun, N-Z., Yang, S., Yeh, W.W-G. "A Proposed Stepwise Regression Method for Model Structure Identification," *Water Resources Research*, 34(10): 2561-2572, 1998.

Collaborators: Prof. T.C. Harmon, UCLA; Prof. N-Z. Sun, UCLA; Prof. B.P.F. Braga, USP, Brazil; Prof. Mario Barros, USP, Brazil
Names of Graduate Advisor: Prof. J.B. Franzini, Stanford University, Ph.D. Advisor
Prof. N. Gunaji, New Mexico State University, M.S. Advisor
Doctoral Advisees (last 5 years): Pam Emch; Angelina Tong; Ali T-Diba; Hugh Wong; Antonella Sciotino; Eleni Hailu; Frank Tsai; Ming-Yen Tu; James McPhee

Total Number of PhD Students Chaired: 45