CHARLES FRANKLIN HARVEY

Department of Civil and Environmental Engineering
Building 48, MIT
Cambridge, MA 02139

phone: (617)258-0392
email: charvey@mit.edu
web.mit.edu/harvey-lab

EXPERTISE

Hydrogeology and Hydrology. Twenty years of experience in assessment of water resources and analysis of groundwater systems.

Groundwater Contamination. Extensive background in field measurement, analysis, and modeling of groundwater contamination.

Biogeochemistry and Carbon Fluxes. Leader of research teams investigating: (1) Arsenic contamination of groundwater in Bangladesh; (2) Water and chemical exchanges between aquifers and the coastal ocean on Cape Cod; (3) Carbon fluxes to and from Southeast Asian rainforests; (4) Geologic sequestration of carbon dioxide.

EMPLOYMENT

MIT, Civil and Environmental Engineering, 1998 - present.
Assistant Professor, Tenured Associate Professor (2005), to Full Professor (2010)
National Science Foundation Career Award.

Harvard University, 1996 - 1998.
Gordon McKay Assistant Professor of Environmental Engineering (tenure track),
Division of Applied Sciences with joint appointment in Earth and Planetary Science.

U. S. Geological Survey, 1988 - 1990. Menlo Park, CA. Hydrologist.

U. S. Geological Survey, 1987 - 1988. Richmond, VA. Hydrologist.

EDUCATION

Stanford, Ph.D., 1996, Geological and Environmental Sciences. Advisor: Steven Gorelick
National Science Foundation Graduate Fellowship

Stanford, M.S., 1992, Applied Earth Science.
Student Appointment, U.S. Geological Survey, Menlo Park.

Ohio State University, 1987-88, School of Medicine.
Completed the first year of medical school (MD) with honors.

Oberlin College, B.A., 1986, Mathematics.

SELECTED AWARDS, ACTIVITIES, SERVICES and CONSULTING

- M. King Hubbert Award, 2008, National Groundwater Association (NGWA) prize for major science or engineering contributions to the groundwater industry.
- Wonking-Class Hero, Miller-McCune (http://www.miller-mccune.com/science/charles-harvey-water-detective-20153)
- Scientific Advisor for C12, a second-stage venture-capital-funded startup to develop geologic carbon sequestration.
- Oliver Lectureship, Jackson School of Geosciences, University of Texas
- Member of Hydrology Expert Facility (HEF) for the World Bank.

- Science Prize for Online Resources for Education, American Association of the Advancement of Sciences (AAAS). Member of Harvard-Smithsonian team that produced the environmental science curriculum, *The Habitable Planet*, funded by the Annenberg Foundation. www.learner.org/channel/courses/envsci.
- AAAS expert panel to evaluate and guide the Vermont Experimental Program to Stimulate Competitive Environmental Research (EPSCOR).
- Member of National Science Foundation expert panel to assess the effects of the 2004 tsunami on Sri Lanka's groundwater.
- Board of Directors: *The Arsenic Foundation* (residing at Harvard University), and *Sea Change* (a not-for-profit institution mediating environmental disputes).
- Panel member for the Department of Energy's workshop *Basic Research for Geosciences; Facilitating 21st Century Energy Systems.*
- Technical Outreach in Service to Communities (TOSC) appointed by EPA for Cape Cod.
- Organizer of National Science Foundation sponsored Workshop on the future of the Ganges-Brahmaputra Delta, held in Bangladesh, 2003.
- Associate Editor for *Water Resources Research* and *Hydrogeology.*
- Reviewer for *Nature, Science, Proceedings of the National Academy of Science*, and many journals.
- Scientific Advisory Committees for Conferences including: Chapman Conference, *Arsenic in Asian Environments*, 2009; *Bringing Groundwater Quality Research to the Watershed Scale*, IAH/AIH, IAHS/AISH, Ontario, 2004; *International Conference on Finite Element Models, Solving Groundwater Problems*, Czech Republic, 2004; *Reactive Transport in Groundwater*, AGU/EGU/HIS *International Workshop on Groundwater Hydrology*, Berkeley, 2002; Gordon Conference on *Flow in Porous Media*, 2002.
- Consulting including: Shell Oil, Assessment and optimization of carbon sequestration strategies in sediments off the coast of New York. Industrial Economics, Cambridge, (i) Evaluation of proposed EPA regulations for the paint industry, (ii) Evaluation of proposed EPA regulations for fly ash disposal, and; (iii) Evaluation of proposed EPA regulations for use of waste foundry sands. MacGillifrey Films, Technical Consultant for IMAX films; Kleiner Perkins Caufield & Byers, Evaluation of novel Water Treatment Systems; Arthur D. Little, Groundwater Clean-up of Belarusian Military Bases; Meehan Engineering, Evaluation of a Levee Failure.

PUBLICATIONS SINCE 2000

Rice Field Geochemistry and Hydrology: An Explanation for Why Groundwater Irrigated Fields in Bangladesh are Net Sinks of Arsenic from Groundwater, **Environmental Science and Technology**, 2011, (Neumann, R.B., A.P. St. Vincent, L. C. Roberts,|| A. B. M. Badruzzaman, A. Ali, and C. F. Harvey)

The Immobility of CO_2 in Marine Sediments Beneath 1500 Meters of Water", **ChemSusChem**, 2010, (House, K.Z., A. Bilgin. C. F. Harvey, D. P. Schrag)

Anthropogenic Influences on Groundwater Arsenic Concentrations in Bangladesh, **Nature Geoscience**, 2010, (R. B. Neumann, K. N. Ashfaque, A. B. M. Badruzzaman, M. Ashraf Ali, J. K. Shoemaker and C. F. Harvey)

Marine Electrical Resistivity Imaging of Submarine Ground-Water Discharge: Sensitivity Analysis and Application in Waquoit Bay, Massachusetts, USA, **Hydrogeology**, 2010, (R. D. Henderson, F. D. Day-Lewis, E. Abarca, C. F. Harvey, H. N. Karam, L. Liu, J.W. Lane, Jr.)

Using Performance Reference Compounds in Polyethylene Passive Samplers to Deduce Sediment Porewater Concentrations for Numerous Target Chemicals, **Environmental Science and Technology**, 2009, (L. Fernandez, C.F. Harvey, P.M. Gschwend)

The Hydrology of a Groundwater-Irrigated Rice Field in Bangladesh: Seasonal and Daily Mechanisms of Infiltration, **Water Resources Research**, 2009, (R. B. Neumann, M. L. Polizzotto, A. B. M. Badruzzaman, M. Ashraf Ali, Z. Zhang, C. F. Harvey)

Investigation of Aquifer-Estuary Interaction Using Wavelet Analysis of Fiber-Optic Temperature Data, **Geophysical Research Letters**, 2009, (R.D. Henderson, F.D. Day-Lewis, C.F. Harvey)

Acceptance of M. King Hubbert Award, **Groundwater**, 2009, (C. F. Harvey)

A Differential Pressure Instrument with Wireless Telemetry for In-Situ Measurement of Fluid Flow across Sediment-Water Boundaries, **Sensors**, 2009, (A. Gardner, H. Karam, A. Mulligan, C.F. Harvey, T. Hammar, and H. F. Hemond)

The Energy Penalty of Post-Combustion CO_2 Capture & Storage and Implications for Retrofitting the Installed Base, **Energy & Environmental Science**, 2009, (K. House, C. F. Harvey, M. Aziz, D. Schrag)

Environmental Science: Poisoned Waters Traced to Source, **Nature**, 2008, (C. F. Harvey)

The Effects of Dual-Domain Mass Transfer on the Tritium-Helium-3 Groundwater Dating Method, **Environmental Science and Technology**, 2008, (R. Neumann, E. LaBolle and C. F. Harvey)

A Colorimetric Reaction to Quantify Fluid Mixing, **Experiments in Fluids**, 2006, (P. M. Oates and C. F. Harvey).

Permanent Carbon Dioxide Storage in Deep-Sea Sediments, **Proceedings of the National Academy of Science**, 2006, (K. House, D. Schrag, C. F. Harvey, K. Lackner).

Groundwater Dynamics and Arsenic Contamination in Bangladesh, **Chemical Geology**, 228, 112-136, April, 2006, (Harvey, C. F., K. N. Ashfaque, W. Yu, A.B.M. Badruzzaman, M. Ashraf Ali, P. M. Oates, H. A. Michael, R. B. Neumann, R. Beckie, S. Islam and M. F. Ahmed).

Solid-Phases and Desorption Processes of Arsenic within Bangladesh Sediments, **Chemical Geology**, 228, 97-111, 2006, (M. L. Polizzotto, C. F. Harvey, G. Li, B. Badruzzman, A. Ali, M. Newville, S. Sutton and S. Fendorf).

Groundwater Dynamics and Arsenic Mobilization in Bangladesh Assessed Using Noble Gases and Tritium, **Environmental Science and Technology**, 40(1), 2006, (S. Klump, R. Kipfer, O. Cirpka, C. F. Harvey, K. Ashfaque, A.B.M. Badruzzaman, S. Hug and D. Imboden).

Comment on *Investigating the Macrodispersion Experiment (MADE) site in Columbus, Mississippi, using a three-dimensional inverse flow and transport model*, **Water Resources Research**, 2006, (Molz, F. J., C. Zheng, S. M. Gorelick, and C. F. Harvey).

Processes Conducive to the Release and Transport of Arsenic into Aquifers of Bangladesh, **Proceedings of the National Academy of Science**, 102(52), 18819-18823, 2005, (M. L. Polizzotto, C. F. Harvey, S. R. Sutton and S. Fendorf).

Shedding Light on Reactive Microbial Transport in Porous Media: Experimental Visualization and Numerical Modeling of Pseudomonas Fluorescens 5RL Bioluminescence, **Contaminant Hydrology**, May, 2005, (P. M. Oates, C. Castenson, C. F. Harvey, M. Polz, and P. Culligan).

Arsenic. Its Biogeochemistry and Transport in Groundwater, in "Biogeochemical Cycles of the Elements", Vol. 43 of Met. Ions Biol. Syst. , A. Sigel, H. Sigel, and R. K. O. Sigel, eds., M.

Dekker, New York, 2005, (C.F. Harvey, and R. Beckie).

Seasonal Water Exchange between Aquifers and the Coastal Ocean, **Nature**, 436, 1145-1149, 2005, (H. Michael, A. Mulligan and C. F. Harvey).

Groundwater Arsenic Contamination on the Ganges Delta: Biogeochemistry, Hydrology, Human Perturbations, and Human Suffering on a Large Scale, **Comptes-Rendus: Geoscience**, 337(1-2), 2005, (Harvey, C. F., C. Swartz, B. Badruzzman, N. Keon, W. Yu, A. Ali, J. Jay, R. Beckie, V. Niedan, D. Brabander, P. Oates, K. Ahsfaque, D. Islam, H. Hemond, F. Ahmed).

Subsurface Geochemistry And arsenic Mobility in Bangladesh, **Geochemica Acta,** 4539-4557, 2004, (Swartz, C.H., Keon, N.E., Badruzzman, B., Ali, A., Brabander, D, Jay, J., Islam, S., Hemond, H.F., Harvey, C.F.).

Experimental Visualization of Solute Transport and Mass Transfer Processes in Spatially Heterogeneous Porous Media, **Environmental Science and Technology**, 38(14), 2004, (Zinn, B., C. F. Harvey, L. Meigs, R. Haggerty, W. Peplinski, and C.Freiherr von Schwerin).

What Controls the Apparent Timescale of Solute Mass Transfer in Aquifers and Soils? A Comparison of Diverse Experimental Results, **Water Resources Research**, 2004, (Haggerty, R., Harvey, C.F., Freiherr von Schwerin, C., Meigs, L.).

Bromide Transport Before, During, and After Colloid Mobilization in Push-Pull Tests and the Implications for Changes in Aquifer Properties, **Water Resources Research**, 39(10), 2003, (Hellerich, L., Oates, P., Johnson, C., Nikolaidis, N., Harvey, C. F., and Gschwend, P.).

Arsenic in Groundwater in Bangladesh: A Geostatistical and Epidemiological Framework for Evaluating Health Effects and Potential Remedies, **Water Resources Research**, 39(6), 2003, (Yu, W., Harvey, C. F., and Harvey, C.M.).

Arsenic Mobility and Groundwater Extraction in Bangladesh, Response to Technical Comment, **Science**, 300, 584d, April, 2003, (Harvey, C. F., Swartz, C.H., Badruzzman, B., Keon, N., Yu. W., Ali, A., Jay, J., Beckie, R., Niedan, V., Brabander, D, Oates, P., Ahsfaque, K., Islam, S., Hemond, H.F., Ahmed, F.).

Characterizing Submarine Groundwater Discharge, **Geophysical Research Letters**, 30(6), 1297, 2003, (Michael, H., Lubetsky, J., 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 Conductivity Fields, **Water Resources Research**, 39(3), 1051, 2003, (B. Zinn, and Harvey, C. F.).

What Does a Slug Test Measure: An Investigation of Instrument Response and the Effects of Heterogeneity, **Water Resources Research**, 38(12), 2003, (Beckie, R., and Harvey, C. F.).

Arsenic Mobility and Groundwater Extraction in Bangladesh, **Science** , 298, p. 1602-1606, November, 2002, (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.).

Reactive Transport in Porous Media: A Comparison of Model Prediction with Laboratory Visualization, **Environmental Science and Technology**, 36, 2002, (Gramling, C., Harvey, C.F., Meigs, L.).

Groundwater Flow in the Ganges Delta, **Science**, Technical Comment, May, 2002, (Harvey, C. F.).

Possible Causes of High Arsenic Concentrations in the Well Water of Bangladesh, **Environmental Sciences**, 8(5), 491, 2001, (Harvey, C.F.).

Evaluation of an Arsenic Sequential Extraction Method for Evaluating Mobility in Sediments, **Environmental Science and Technology**, 35, 2778, 2001, (Keon, N. E., Swartz, C. H., Brabander, D. J., Harvey, C. F., Hemond, H. F.).

The Global Flux of CO_2 into Groundwater, **Geophyisical Research Letters**, 28(2), 279-282, 2001, (Kessler, T. and Harvey, C.F.).

Rate-limited Mass Transfer or Macrodispersion: Which Dominates Plume Evolution at the MAcroDispersion Experiment (MADE) Site?, **Water Resources Research**, 36(3), 637, March 2000, (Harvey, C.F. and Gorelick, S.).

SELECTED TALKS (of more than 80)

Oliver Lecturer, 2010, Univ. Texas, a sequence of lectures
Origins and Solutions of the Arsenic Crisis in South Asia
Coastal Groundwater Dynamics and Biogeochemistry
Geologic Carbon Sequestration: Comparing Terrestrial and Submarine Injection

Keynote lectures at Marie Curie Symposium (European Union), "*Flow and Transport in Porous and Fractured Media*", Corsica, 2010

The Cause of Severe Arsenic Contamination in Bangladesh, Chapman Conference, *Arsenic in Asian Environments*, 2009

Hydrogeology is the Key to Understanding the Arsenic Crisis on the Ganges Delta, Consortium of Universities for the Advancement of Hydrologic Science, Cyberseminars (on-line live seminar archived at: http://www.cuahsi.org/sem-archive.html) February 2008.

The Hydrology and Biogeochemistry of the Arsenic Crisis in Bangladesh, Dartmouth, April, 2008.

Consequences of Toxics in Groundwater, Harvard School of Public Health, October 2008.

Chemical Spreading, Mixing and Reaction in Groundwater, Gordon Research Conference on Flow in Porous Media, 2006.

The Hydrology and Biogeochemistry of the Arsenic Crisis in Bangladesh, Harvard University, Series on the Global Environment, 2006.

The Arsenic Crisis in Bangladesh, U.S. Geological Survey, Reston VA, 2006.

Reactive Transport in Porous Media, Harvard Geophysics and Rock Mechanics Series, 2006.

Solute Mixing and Chemical Reaction in Porous Media, DFG-NSF Workshop on Geochemical Gradients, sponsored by the Deutsche Forschungsgemeinschaft, 2004.

The Crisis of Arsenic Contamination in Bangladesh, Future of World Water Symposium, U. Cal. Davis, 2004.

Water Quality and Human Health: Bangladesh as a Case Study, Public and Private Sector Collaboration in Addressing the UN Millennium Water and Sanitation Goals, American Academy of Arts and Sciences Cambridge, MA, 2003.

The Arsenic Crisis on the Ganges Delta: Hydrology, Biogeochemistry, Human Perturbations, and Human Suffering on a Large Scale, Colloque sur l'EAU, French Academy of Science, Paris, 2003.

The Arsenic Crisis in Bangladesh, ETH (EAWAG), Dubendorf, Switzerland, 2003.

Solute Transport And Reaction In Groundwater, Henry Darcy's 200th Birthday: Fundamental Advancements Through Observation and Analysis, Geological Society of America, Seattle, 2003.

Direct Visualization of Reactive Transport: Mixing at the Pore-Scale and at the Darcy-Scale, Conceptual Model Development for Subsurface Reactive Transport Modeling of Inorganic

Contaminants, Radionuclides, and Nutrients, Federal Interagency Steering Committee on Multimedia Environmental Modeling Workshop, Albuquerque, NM, 2003.

GRANTS AND FELLOWSHIPS

National Institute for Environmental Health, (2010-2015), Providing Safe Water in Bangladesh $925,000

National Science Foundation, (2009–2012), Collaborative Research: Enhancing the sustainability of groundwater pumping from low-arsenic aquifers in southern Asia - a case-study in Vietnam south of Hanoi, $60,000

Singapore National Research Foundation, (2008–2013), Center for Environmental Modeling and Sensing (CENSAM), Carbon Fluxes in and out of Tropical Forests, $1,350,000.

Kuwait-MIT Center for Natural Resources and the Environment, (2009 – 2011), $110,000

National Science Foundation, (2006–2009), Deployment of Environmental Sensor Networks in Asian Rice Fields, $120,000

National Science Foundation, (2006–2009), Saltwater and Freshwater Fluxes through Coastal Aquifers: Multiple Time Scales of Terrestrial and Oceanic Forcing, $360,000.

Department of Energy, (2006 –2007), CO_2 Sequestration Beneath the Deep Sea Floor, $40,000.

Sea Grant, Woods Hole Oceanographic Institute, (2006 –2008), Freshwater/Saltwater Interaction at the Coast, $100,000.

National Science Foundation, (2005 –2009), Groundwater Dynamics and Arsenic Contamination in the Ganges Delta: Irrigated Agriculture, Subsurface Chemical Transport, and Aquifer Flushing, $460,000.

National Science Foundation, (10/2003 –10/2006), *Collaborative Research: CMG: Mathematical and Experimental Analysis of Transport Phenomena in Highly Heterogeneous Porous Media*, $78,000.

City of Boston, (2003), *Rotting Foundations and Groundwater Dynamics Beneath Boston*, $30,000.

National Institute of Health, (11/2002 – 11/2003), *Seed Grant: Tracking Arsenic through the Food Chain in Bangladesh*, $30,000.

National Science Foundation, (7/2000 - 7/2003), *Arsenic Contaminated Groundwater in Bangladesh: Characterizing the Source, Mobilization, and Transport*, $400,000.

Alliance for Global Sustainability, (4/2000 - 4/2002), *A Sustainable Water Supply System in an Arsenic-Contaminated Asian Environments*, $125,000.

National Science Foundation CAREER Award, (7/99 - 7/04) *Revisiting two Basic Processes in Hydrogeology: Solute Transport in Heterogeneous Formations and Chemical Mixing in Porous Media*, $270,000.

Department of Energy (Basic Energy Science), (1/2000 - 1/2003), *Transport Visualization for Studying Mass Transfer and Solute Transport in Permeable Media Upscaling the Effects of Diffusion in Natural Soils and Aquifers*, $105,000.

Office of Naval Research (1/1/99 – 12/30/01) *Investigating Contaminant inputs via Submarine Groundwater Discharge to Coastal Waters using Radium Isotopes*, $160,000.

Environmental Protection Agency (NCERQA), (10/97 - 10/00) *A Decision Analysis Framework for Groundwater Remediation*, $210,000.

National Institute of Health, (5/98, 5/00) *Modeling Arsenic Transport through Heterogeneous Sediments*, $120,000.

Department of Energy, (3/98 – 3/01) *Upscaling Diffusion in Natural Soils and Aquifers*, $45,000.

Merck Foundation Grant, (1/96-1/97) $85,000 from the George Merck Fund in Community Funds.

TEACHING and MENTORING

Co-Director of Terrascope, began Fall 2008. Terrascope is an undergraduate learning community at MIT built on a sequence of classes that investigate a global environmental issue each year. The topic is carbon sequestration during the 2009/2010 year.

Courses Taught

- Graduate Level: *Hydrology, Hydrogeology, Stochastic Hydrology, Geostatistics*
  Doctoral Seminars -- *Terrestrial Carbon Fluxes, Reactive Transport, Coastal Hydrology, Mass-Transfer Processes in Groundwater and Soils*
- Undergraduate: *Introduction to Operations Research, Ecology II: Engineering for Sustainability, Mission 2009: Solving Water Crises*
- Short Courses: Technical University of Denmark, *Mass Transfer in Groundwater and Soil.*
  University of Florence, *Advanced Groundwater Hydrology*

Doctoral Advisees

- Current PhD students: Rebecca Neumann, Hanan Karam, Mason Stahl
- Completed PhD's: Kaeo Duarte, Winston Yu (Harvard), Brendan Zinn, Holly Michael, Peter Oates, Khandaker Ashfaque, Kurt House (Harvard).
- Post-Doctoral Researchers: Christopher Swartz, Jenny Jay, Elena Abarca, Alex Cobb, Kurt House, Jiabang Li.