

**NAME AND CONTACT INFORMATION**

*updated Aug 13, 2017*

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**EDUCATIONAL BACKGROUND**

Doctor of Philosophy, Geological Engineering, Minor: Computer Science Colorado School of Mines, Golden, CO	2003
Master of Science, Geological Sciences, Concentration: Hydrogeology Wright State University, Dayton, OH	1997
Bachelor of Arts, Geography/Environmental Studies Shippensburg University, Shippensburg, PA	1995 CUM LAUDE

**PROFESSIONAL EMPLOYMENT HISTORY**

<i>Hydrogeologist</i> <b>Oklahoma Geological Survey, The University of Oklahoma, Norman, OK</b>	2011–present
<i>Adjunct Professor</i> <b>School of Geology and Geophysics, The University of Oklahoma, Norman, OK</b>	2013–present
<i>Assistant Professor</i> <b>Department of Geological Sciences, The University of Texas at San Antonio, San Antonio, TX</b>	2004–2011
<i>Assistant Director for Undergraduate Research Development</i> <b>Honors College, The University of Texas at San Antonio, San Antonio, TX</b>	2006–2011
<i>Research Associate</i> <b>Department of Geology &amp; Geological Engineering, Colorado School of Mines, Golden, CO</b>	2003–2004
<i>GIS Specialist</i> <b>Earth Surface Processes Team, Geologic Division, U.S. Geological Survey, Denver, CO</b>	1999–2003
<i>Hydrogeologist</i> <b>Harding Lawson Associates, Engineering and Environmental Services, Denver, CO</b>	1997–2000
<i>Instructor</i> <b>Center for Ground Water Management, Wright State University, Dayton, OH</b>	1995–1997

## RESEARCH/SCHOLARLY/CREATIVE ACTIVITIES SUMMARY

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### Refereed Journal Articles

- Goebel, T.H.W., Walter, J.I., Murray, K., and Brodsky, E.E., 2017, Comment on “How will induced seismicity in Oklahoma respond to decreased saltwater injection rates?” by C. Langenbruch and M. D. Zoback: *Science Advances*, v. 3, no. 8. <http://dx.doi.org/10.1126/sciadv.1700441>
- Kroll, K. A., Cochran, E. S., and Murray, K. E., 2017. Poroelastic properties of the Arbuckle Group in Oklahoma derived from well fluid level response to the 3 September 2016 Mw5.8 Pawnee and 7 November 2016 Mw5.0 Cushing Earthquakes: *Seismological Research Letters*, v. 88, no. 4, p. 963-970. <http://dx.doi.org/10.1785/0220160228>
- Zhou, W., Minnick, M.D., Mattson, E.D., Geza, M., Murray, K.E., 2015. GIS-based geospatial infrastructure of water resource Assessment for supporting oil shale development in Piceance basin of northwestern Colorado. *Computers & Geosciences*, v. 77, p. 44-53. <http://dx.doi.org/10.1016/j.cageo.2015.01.007>
- Murray, K.E., Manitou-Alvarez, E.I., Inniss, E.C., Healy, F.G., and Bodour, A.A., 2015. Assessment of oxidative and UV-C treatments for inactivating bacterial biofilms from groundwater wells: *Frontiers of Environmental Science & Engineering*, v. 1, no. 1, p. 39-49. <http://dx.doi.org/10.1007/s11783-014-0699-0>
- Schweitzer H., Murray, K.E., and Healy, F.G., 2014. Evaluation of media and nitrogen:phosphorus ratios for optimal growth of biotechnologically important unicellular microalgae. *American Journal of Biomass and Bioenergy*, v. 3, no. 3, p. 139-150. <http://dx.doi.org/10.7726/ajbb.2014.1010>
- Murray, K.E., 2013. State-scale perspective on water use and production associated with oil and gas operations, Oklahoma, U.S.: *Environmental Science & Technology*, v. 47, no. 9, p. 4918-4925. <http://dx.doi.org/10.1021/es4000593>
- Murray, K.E., and Yosko, L.S., 2013. Multi-observation well aquifer test case study: is recovery coincident with the cessation of pumping?: *Environmental Earth Sciences*, v. 68, no. 7, p. 1955-1965. <http://dx.doi.org/10.1007/s12665-012-1883-9>
- Murray, K.E., Shields, J.A., Garcia, N.D., and Healy, F.G., 2012. Productivity, carbon utilization, and energy content of mass in scalable microalgae systems: *Bioresource Technology*, v. 114, p. 499-506. <http://dx.doi.org/10.1016/j.biortech.2012.03.012>
- Murray, K. E., Healy, F.G., McCord, R., and Shields, J.A., 2011. Biomass production and nutrient uptake by *Neochloris oleoabundans* in an open trough system: *Applied Microbiology and Biotechnology*, v. 90, no.1, p. 89-95. <http://dx.doi.org/10.1007/s00253-010-3054-9>
- Murray, K. E., Thomas, S. M., and Bodour, A. A., 2010. Prioritizing research for trace pollutants and emerging contaminants in the freshwater environment: *Environmental Pollution*, v. 158, p. 3462-3471. <http://dx.doi.org/10.1016/j.envpol.2010.08.009>
- Geza, M., McCray, J. E., and Murray, K. E., 2010. Model evaluation of the impacts of on-site wastewater systems on phosphorus in Turkey Creek watershed: *Journal of Environmental Quality*, v. 39, no. 5, p. 1636-1646. <http://dx.doi.org/10.2134/jeq2009.0354>
- Geza, M., Murray, K. E., and McCray, J. E., 2010. Watershed scale impacts of nitrogen from onsite wastewater systems: Parameter sensitivity and model calibration: *Journal of Environmental Engineering*, v. 136, no. 9, p. 926-938. [http://dx.doi.org/10.1061/\(ASCE\)EE.1943-7870.0000232](http://dx.doi.org/10.1061/(ASCE)EE.1943-7870.0000232)
- Thomas, S.M., Bodour, A.A., Murray, K.E., and Inniss, E.C., 2009. Sorption behavior of a synthetic antioxidant, polycyclic musk, and an organophosphate insecticide in wastewater sludge: *Water Science & Technology*, v. 60, no. 1, p. 145-154. <http://dx.doi.org/10.2166/wst.2009.284>

- Weissling, B.P., Xie, H., and Murray, K.E., 2009. Evaluation of NRCS curve number and MODIS time-series proxies for antecedent moisture condition: *Civil Engineering and Environmental Systems*, v. 26, no. 1, p. 85-101. <http://dx.doi.org/10.1080/10286600802005356>
- Murray, K.E., Straud, D.R., and Hammond, W.W., 2007. Characterizing groundwater flow in a faulted karst system using optical brighteners from septic systems as tracers: *Environmental Geology*, v. 53, p. 769-776. <http://dx.doi.org/10.1007/s00254-007-0689-7>
- Murray, K.E., and McCray, J.E., 2005. Development and application of a regional-scale pesticide transport and groundwater vulnerability model: *Environmental & Engineering Geoscience*, v. XI, no. 3, p. 271-284. <http://dx.doi.org/10.2113/11.3.271>
- Schlosser, S.A., McCray, J.E., Murray, K.E., and Austin, B., 2002. A subregional-scale method to assess aquifer vulnerability to pesticides: *Ground Water*, v. 40, no. 4, p. 361-367. <http://dx.doi.org/10.1111/j.1745-6584.2002.tb02514.x>

### **Refereed Book Chapters and Other Publications**

- McCray, J.E., Geza, M., Murray, K.E., Poeter, E.P., and Morgan, D.S., 2009. Modeling of onsite wastewater systems at the watershed scale: A user guide. IWA Publishing, London, U.K., ISBN 978-1-84339-528-7/1-84339-528-2, pp. 230.
- Daniele, L., Pulido-Bosch, A., Vallejos, A., Murray, K.E. and Molina-Sanchez, L., 2007. Relaciones entre la actividad extractiva y el agua subterránea en el humedal de la Cañada de Las Norias (Campo de Dalías, SE España). In: R.F. Rubio (Editor), *Activos ambientales de la minería Española*, Madrid, España, pp. 304-307.
- Turner, K.J., Hudson, M.R., Murray, K.E. and Mott, D.N., 2007. Three-dimensional geologic framework model for a karst aquifer system, Hasty and Western Grove Quadrangles, northern Arkansas, U.S. Geological Survey Scientific Investigations Report 2007-5095, Denver, CO, pp. 12.
- Blome, C.D., J.R. Faith, E.W. Collins, D.E. Pedraza, and K.E. Murray. 2004. Geologic map compilation of the Upper Seco Creek area, Medina and Uvalde Counties, south-central Texas, U.S. Geological Survey Open-File Report 2004-1430, Denver, CO., pp. 21.
- Colton, R.B., T.R. Brandt, D.W. Moore, and K.E. Murray. 2004. Geologic map of the Boulder--Fort Collins--Greeley area, Colorado, Version 1.1 ed. U.S. Geological Survey Geologic Investigations Series, GIS Database I-855-G, Denver, CO.
- Hudson, M. R. and K. E. Murray. 2004. Geologic map of the Hasty quadrangle, Boone and Newton Counties, Arkansas, Denver, CO, U.S. Geological Survey Scientific Investigations Map, SIM-2847.
- Trimble, D.E., M.N. Machette, T.R. Brandt, D.W. Moore, and K.E. Murray. 2004. Geologic map of the greater Denver area, front range urban corridor, Colorado, Version 1.1 ed. U.S. Geological Survey Geologic Investigations Series, GIS Database I-856-H, Denver, CO.
- Hudson, M. R. and K. E. Murray, 2003. Geologic map of the Ponca quadrangle, Newton, Boone and Carroll Counties, Arkansas, Denver, CO, U.S. Geological Survey Misc Field Studies, MF-2412.
- Brandt, T. R., D. W. Moore and K. E. Murray. 2003. A spatial database of bedding attitudes to accompany geologic map of the Boulder--Fort Collins--Greeley area, Colorado, by Roger B. Colton, U.S. Geological Survey Open-File Report, OFR-03-024, Denver, Colorado.
- Brandt, T. R., D. W. Moore and K. E. Murray. 2003. A spatial database of bedding attitudes to accompany geologic map of the greater Denver area, Front Range urban corridor, Colorado, by Donald E. Trimble and Michael N. Machette, Denver, Colorado, U.S. Geological Survey Open-File Report, OFR-03-025.
- Bryant, B., R. R. Shroba, A. E. Harding and K. E. Murray. 2002. Geologic map of the Storm King

Mountain quadrangle, Garfield County, Colorado (1:24,000). U.S. Geological Survey Miscellaneous Field Studies, MF-2389.

Hudson, M. R., K. E. Murray and D. Pezzutti. 2001. Geologic map of the Jasper quadrangle, Newton and Boone Counties, Arkansas (1:24,000). U.S. Geological Survey Miscellaneous Field Studies, MF-2356.

Scott, R. B., P. E. Carrara, W. C. Hood and K. E. Murray. 2001. Geologic map of the Grand Junction quadrangle, Mesa County, Colorado, (1:24,000). U.S. Geological Survey Miscellaneous Field Studies, MF-2363.

### **Refereed Conference Proceedings and Abstracts**

Daniele, L., A. Pulido-Bosch, K.E. Murray, and L. Molina-Sanchez. 2007. Estudio de la evolución de un humedal en una región semiárida mediante GIS. El caso de la Cañada de las Norias (Campo de Dalías, SE España). *Geogaceta* 41, p. 63-66.

<http://www.sociedadgeologica.es/archivos/geogacetas/Geo41/G41Art16.pdf>

Hudson, M.R., D.N. Mott, K.J. Turner, and K.E. Murray. 2005. Geologic controls on a transition between karst aquifers at Buffalo National River, northern Arkansas. In: E.L. Kuniandy (Editor), U.S. Geological Survey Scientific Investigations Report, SIR 2005-5160. Rapid City, SD, pp. 143.

Murray, K. E. and M. R. Hudson. 2002. Three-dimensional geologic framework modeling for a karst region in the Buffalo National River, Arkansas, In Proceedings of U.S. Geological Survey Karst Interest Group, E. Kuniandy (Editor), Shepherdstown, WV: Water Resources Investigations Report 02-4174. p. 51-58.

### **Non-Refereed Journal Articles**

Murray, K.E., and A.A. Holland. 2014. Inventory of Class II Underground Injection Control Volumes in the Midcontinent: Shale Shaker, v. 65, no. 2, p. 98-106.

Murray, K.E., 2012. Geologic controls on groundwater recharge to the central Oklahoma aquifer: Oklahoma Geology Notes, v. 72, no. 2, p. 1-8.

Weissling, B.P., Xie, H., and K.E. Murray. 2007. A multitemporal remote sensing approach to parsimonious streamflow modeling in a southcentral Texas watershed, USA: Hydrology and Earth System Sciences Discussions, v. 4, p. 33. <http://dx.doi.org/10.5194/hessd-4-1-2007>

Lin, Y.C., and K.E. Murray. 2006. Visual MODFLOW Pro 4.1 – Software Review, Southwest Hydrology v. 5, no. 6, p. 41.

### **Non-Refereed Book Chapters and Other Publications**

Murray, K.E., 2015. Class II Saltwater Disposal for 2009–2014 at the Annual-, State-, and County- Scales by Geologic Zones of Completion, Oklahoma, Oklahoma Geological Survey Open-File Report (OF5-2015), Norman, OK, pp. 18. <http://dx.doi.org/10.13140/RG.2.1.4841.7364>

Morgan, B.C., and Murray, K.E., 2015. Characterizing Small-Scale Permeability of the Arbuckle Group, Oklahoma. Oklahoma Geological Survey Open-File Report (OF2-2015), Norman, OK, pp. 12. <http://dx.doi.org/10.13140/2.1.3512.6569>

Murray, K.E., 2014. Class II Underground Injection Control Well Data for 2010–2013 by Geologic Zones of Completion, Oklahoma, Oklahoma Geological Survey Open-File Report (OF1-2014), Norman, OK, pp. 32. <http://dx.doi.org/10.13140/2.1.4309.7923>

Murray K.E., 2012. Oklahoma Rocks! Groundwater, Lesson 6: Climate versus Human Impact. In: The Oklahoman Newspapers in Education, Oklahoma City, OK, pp. 1.

- Murray K.E., 2012. Oklahoma Rocks! Groundwater, Lesson 5: What is in an aquifer's name? In: The Oklahoman Newspapers in Education, Oklahoma City, OK, pp. 1.
- Murray K.E., 2012. Oklahoma Rocks! Groundwater, Lesson 4: Groundwater Quality and Freshwater. In: The Oklahoman Newspapers in Education, Oklahoma City, OK, pp. 1.
- Murray K.E., 2012. Oklahoma Rocks! Groundwater, Lesson 3: Infiltration, Porosity, & Moisture Retention. In: The Oklahoman Newspapers in Education, Oklahoma City, OK, pp. 1.
- Murray K.E., 2012. Oklahoma Rocks! Groundwater, Lesson 2: Oklahoma Rocks! Groundwater Terminology. In: The Oklahoman Newspapers in Education, Oklahoma City, OK, pp. 1.
- Murray K.E., 2012. Oklahoma Rocks! Groundwater, Lesson 1: What is an aquifer? In: The Oklahoman Newspapers in Education, Oklahoma City, OK, pp. 1.
- Murray, K.E., 2012. Oklahoma Rocks! Groundwater. Newspapers In Education (NIE) for The Oklahoman, Oklahoma City, OK. pp. 16.
- Manitou-Alvarez, E.I., Bodour, A.A., and Murray, K.E., 2008, Laboratory-scale treatment of biofilms and recommendations for maintenance of Staggs Ranch wells: San Antonio, TX, Prepared for BexarMet Water District, Prepared by UTSA-Center for Water Research, San Antonio, TX. pp. 42.
- Murray, K.E., and Yosko, L.S., 2008, Water supply potential of existing wells, City of Kenedy, Texas: Prepared for City of Kenedy, Prepared by UTSA-Center for Water Research, San Antonio, TX. pp. 34.
- Murray, K.E., Bush, J.K., Haschenburger, J.K. and French, R.H., 2008. Technical and Field Guide: Management practices for natural waterways, Prepared for City of San Antonio, Prepared by UTSA-Center for Water Research, San Antonio, TX. pp. 80.
- Murray, K.E., and Yosko, L.S., 2007. Technical report: Assessment of water supply, water demand and water resources planning needs for the City of Kenedy, TX, Prepared for City of Kenedy, Prepared by UTSA-Center for Water Research, San Antonio, TX. pp. 13.
- Murray, K.E., Brumbelow, K., and Linthicum, C.L., 2006. Technical report: Audit of San Antonio Water System operations and infrastructure using International Water Association standards, Prepared for San Antonio Water System, Prepared by UTSA-Center for Water Research and TAMU-TEES, San Antonio, TX. pp. 75.
- Heatwole, K.K., McCray, J.E., Lowe, K.S., Murray, K.E. 2005. Technical report: Evaluation of potential impact of ISDS in a proposed development area near Todd Creek, Adams County, Colorado, Prepared for Adams County, Colorado Board of Commissioners, Prepared by Colorado School of Mines, Golden, CO. pp. 74.
- Murray, K.E. and N.J. Hawkins. 2005. Technical report: Hydrogeologic characterization and screening of alternatives for delivery of higher quality ground water, Prepared for Halff Brothers Ranch, Prepared by UTSA-Center for Water Research, San Antonio, TX. pp. 36.
- Murray, K. E. 2005. HydroGIS tools: MODFLOW input preparation. *International Ground Water Modeling Center Newsletter*, XXIII: 3.
- Murray, K.E. 2005. Technical report: Spatial evaluation of hydrogeologic data to support assessment of on-site wastewater treatment potential, Prepared for Colorado School of Mines, Prepared by UTSA-Center for Water Research, San Antonio, TX. pp. 13.
- Murray, K.E. 2004. Technical report: Design and Development of a National Groundwater Database Task 4 - Model Integration: Data Extraction and Insertion Technical Memorandum. Prepared for Kuwait Institute for Scientific Research, Prepared by Murray GeoConsulting, LLC, Lakewood, CO. pp. 36.

- Thyne, G.D., M. Dodds, K.K. Greaser, J. Miskimins, and K.E. Murray. 2003. Technical report: Hydrologic model for Grand Mesa watershed, Delta County, Colorado. Prepared for Delta County, CO, Prepared by Colorado School of Mines, Golden, CO. pp. 84.
- Murray, K. E. 2003. GIS-based modeling of ground water vulnerability to pesticide contamination in Colorado. *Colorado Ground-Water Association Newsletter* January-February: 6-10.
- Murray, K. E. 2003. Spatial analysis and modeling of water resource issues in Colorado utilizing Geographic Information Systems. Ph.D. thesis, Department of Geology and Geological Engineering, Colorado School of Mines, Golden, CO, pp. 111.
- McCray, J. E., K. E. Murray and S. A. Schlosser. 2003. Technical report: Aquifer vulnerability to agricultural contaminants in Colorado. Prepared for Colorado Department of Public Health and Environment, Prepared by Colorado School of Mines, Golden, CO. pp. 17.
- Murray, K. E. 2002. Validation of a GIS model used to predict the vulnerability of ground water in Colorado to pesticide contamination. *Colorado Ground-Water Association Newsletter* January-February: 7-9.
- Murray, K. E. 2001. Validation of a GIS model used to predict the vulnerability of ground water in Colorado to pesticide contamination. *Colorado Ground-Water Association Newsletter* September-October: 9.
- Murray, K. E. and J. E. McCray. 2001. Technical report: Recommendations for the installation of ground-water quality monitoring wells. Prepared for Colorado State University Water Center, Prepared by Colorado School of Mines, Golden, CO. pp. 17.
- Murray, K. E. and J. E. McCray. 2001. Technical report: Vulnerability assessment of Colorado ground water to agricultural pesticide contamination. Prepared for Colorado Department of Health and Environment - Water Quality Control Division, Prepared by Colorado School of Mines, Golden, CO. pp. 16.
- Murray, K. E. and K. L. Dalton. 1999. Technical memorandum: Recovery well operations testing. Prepared for Former Unocal Chemicals Distribution Facility, Wichita, KS, Prepared by Harding Lawson Associates, Denver, CO. pp. 4.
- Murray, K. E. 1997. A comparative study of the inorganic hydrogeochemistry of constructed and natural wetlands. M.S. thesis, Department of Geological Sciences, Wright State University, Dayton, OH, pp. 70.
- Murray, K. E. 1996. Horizontal wells: Environmental innovation. *Wisconsin Groundwater Association Newsletter* 10, no. 4: 10.

#### **Non-Refereed Conference Proceedings and Abstracts**

- Haffener, J., X. Chen, K. Murray, and T. Goebel. 2016. A robust, statistical identification and analysis of fluid disposal wells that cause earthquakes in central Oklahoma. In American Geophysical Union (AGU) Annual Fall Meeting. San Francisco, CA.
- Kroll, K.A., K.E. Murray, and E.S. Cochran. 2016. Using regional pore-fluid pressure response following the 3 Sep 2016 Mw5.8 Pawnee, Oklahoma earthquake to constrain far-field seismicity rate forecasts. In American Geophysical Union (AGU) Annual Fall Meeting. San Francisco, CA.
- Murray, K.E. 2016. Modeling Approach for Estimating Co-Produced Water Volumes and Saltwater Disposal Volumes in Oklahoma. In American Geophysical Union (AGU) Annual Fall Meeting. San Francisco, CA.
- Murray, K.E. 2016. Seismic Moment versus Water: A Study of Market Forces and Regulatory Actions. GSA Abstracts with Programs 48 no. 7: 95-11. <http://dx.doi.org/10.1130/abs/2016AM-286149>

- Perilla, P., and K.E. Murray. 2016. Pressure Prediction between Two Wells using the Laplacian Component in the Diffusion Equation: Analytical Solution in One Dimension. *GSA Abstracts with Programs* 48 no. 7: 120-10. <http://dx.doi.org/10.1130/abs/2016AM-284106>
- Williams, J., and K.E. Murray. 2016. Formation Level Characterization of the Arbuckle Group in Central Oklahoma: A Key to Understanding Induced Seismicity. *GSA Abstracts with Programs* 48 no. 7: 309-8. <http://dx.doi.org/10.1130/abs/2016AM-286782>
- Hernandez, R. J., and K.E. Murray, 2015. Field and laboratory characterization of the Antlers Formation and aquifer in south-central Oklahoma: *GSA Abstracts With Programs*, v. 47, no. 1, p. 57.
- Murray, K. E., 2015. Co-production and management of saltwater from petroleum resource plays in Oklahoma: *GSA Abstracts With Programs*, v. 47, no. 1, p. 48.
- Peng, X., and K.E. Murray, 2015. A tale of two cultures: Emerging pharmaceuticals and personal care products in fresh water: *GSA Abstracts With Programs*, v. 47, no. 1, p. 56.
- Holland, A., Keller, G., Darold, A., Murray, K., and S. Holloway. 2014. Multidisciplinary Approach to Identify and Mitigate the Hazard from Induced Seismicity in Oklahoma, American Geophysical Union Annual Fall Meeting. AGU, San Francisco, CA, pp. U34A-04.
- Murray, K.E. 2014. Re-examining Saltwater Management Practices in Oklahoma. *GSA Abstracts With Programs* 46 no. 6: 476.
- Murray, K.E., and A.A. Holland. 2014. Subsurface fluid injection in oil and gas reservoirs and wastewater disposal zones of the midcontinent: AAPG Extended Abstract No. 1840901.
- Carrell, J.R., and K.E. Murray. 2014. Groundwater flow model of fluid injection into the Arbuckle Group, Central Oklahoma: *GSA Abstracts With Programs*, v. 46, no. 1, p. 10.
- Murray, K.E., and J.R. Carrell. 2014. Spatial and temporal trends in underground injection control volumes, Oklahoma: *GSA Abstracts With Programs*, v. 46, no. 1, p. 10.
- Hernandez, R.J., and K.E. Murray. 2014. Sedimentological and hydrogeological characterization of the Antlers Formation and aquifer in south-central Oklahoma: *GSA Abstracts With Programs*, v. 46, no. 1, p. 8.
- Morgan, B.C., and K.E. Murray. 2014. Examining permeability of the Arbuckle Group: *AAPG Student Exposition*, Poster Presentation.
- Murray, K.E. 2014. Fluid injection inventory for class II UIC wells of Oklahoma, in *Underground Injection Control Conference, Aquifer Management & Underground Injection*, New Orleans, LA, Groundwater Protection Council, p. 17.
- Carrell J.R., and K.E. Murray. 2013. Fluid pressure distribution within the deep saline aquifer of the Arbuckle Group. Oklahoma Water Resources Research Institute (OWRRI) Water Research Symposium, Midwest City, OK.
- Hernandez, R.J., and K.E. Murray. 2013. Characterization of the Antlers aquifer based on surface and subsurface geology in south central Oklahoma. Oklahoma Water Resources Research Institute (OWRRI) Water Research Symposium, Midwest City, OK.
- Carrell, J.R., and K.E. Murray. 2012. Comparison of fertilizer, concentrated animal feeding operation, and septic tank effluent impacts on nitrate concentration of the Rush Springs aquifer. Oklahoma Water Resources Research Institute (OWRRI) Water Research Symposium, Tulsa, OK.
- Hernandez, R.J., and K.E. Murray. 2012. The geology and hydrogeology of the Antlers Formation in Love County, southern Oklahoma. Oklahoma Water Resources Research Institute (OWRRI) Water Research Symposium, Tulsa, OK.

- Irwinsky, M.J., and K.E. Murray. 2012. Total dissolved solids in produced water for the Mississippian Lime and other active plays in Oklahoma. Oklahoma Water Resources Research Institute (OWRRI) Water Research Symposium, Tulsa, OK.
- Johnson, M.D., Richardson, J.W., and K.E. Murray. 2012. Impact of alternative carbon sources on the economic success of microalgae farming for biofuels. Growing the BioEconomy Conference, Banff, Alberta, CA.
- Murray, K.E., Shields, J.A., Fisher D., and F.G. Healy. 2011. Enhancement of microalgae biomass production using alternative sources of carbon to achieve a sustainable energy production system. 1<sup>st</sup> International Conference on Algal Biomass, Biofuels & Bioproducts, St. Louis, MO.
- Schweitzer, H., Murray, K.E., and Healy, F.G. 2011. Evaluation of growth media for the cultivation of lipid-producing algae, American Society for Microbiology, Texas Branch Meeting: New Braunfels, TX.
- Zhou, W., Minnick, M., Geza, M., Murray, K.E., and E. Mattson. 2010. Development of a GIS-based water resource geospatial infrastructure for oil-shale development in the western U.S. 17<sup>th</sup> International Petroleum & Biofuels Environmental Conference, San Antonio, TX.
- Murray, K. E., and T.B. Le. 2010. Computing geovolumes for groundwater systems using GIS: *GSA Abstracts With Programs*, v. 42, no. 3, p. 6.
- Reyes, B., and K.E. Murray. 2008. Implementation of a Geographical Information System (GIS) for the Enhanced Oil Recovery Institute (EORI), Laramie WY: High Plains GIS, SouthWest Users Group Conference.
- Manitou-Alvarez, E.I., Murray, K.E., and A.A. Bodour. 2008. Laboratory-scale treatment of biofilms grown in situ in drinking water wells, in *Proceedings of National Association of Environmental Professionals*, San Diego, CA, 15 pp.
- Thomas, S.M., Bodour, A.A., and K.E. Murray. 2006. Optimization of an SPE and GC/MS method for analyzing endocrine disrupting compounds in water. American Geophysical Union Fall 2006 Meeting, 87(52), Abstract no. B53C-0367.
- Daniele, L., A. Pulido Bosch, K.E. Murray, and L. Molina. 2006. Estudio de la evolución de un humedal en una región semiárida mediante GIS. El caso del la balsa del sapo (Campo de Dalías, SE España). Meeting of the Geological Society of Spain. Barcelona, España.
- Daniele, L., K.E. Murray, A. Pulido Bosch, L. Molina, and A. Vallejos. 2006. Study of wetland evolution in a semiarid region using GIS. Case of Balsa del Sapo (Campo de Dalías, SE España). Integrated Water Resource Management and Challenges of Sustainable Development, International Congress CM-AIH. Marrakech, p. 147.
- Thomas, S.M. and K.E. Murray. 2006. Evaluation of water treatment methods for endocrine disrupting compounds, American Geophysical Union Joint Meeting, Baltimore, MD, May 22-25, 2006, Abstract no: 581.
- Brumbelow, K., C.L. Linthicum, S. Meyer, K.E. Murray, D. Nichols, G. Shelton, and L. Yosko. 2006. A comprehensive water audit of the San Antonio Water System, World Water and Environmental Resources Congress, Omaha, NE, American Society of Civil Engineers.
- Gayley, A.C. and K.E. Murray. 2006. LNAPL recoverability analysis of JP-4/JP-5 release at Kingsville Naval Air Station, *Ground Water Summit*. National Ground Water Association, San Antonio, TX, p. 21.



- Hawkins, N.J., K.E. Murray, A.A. Bodour. 2006. Water quality parameters and indicator organisms for early detection of biofouling in groundwater production wells, *Ground Water Summit*. National Ground Water Association, San Antonio, TX, p. 148-149.
- Murray, K.E., 2006. GIS-based modeling of groundwater resources in the Denver Basin Aquifer System. In: E.P. Poeter, C. Zheng, M.C. Hill and J. Doherty (Editors), *MODFLOW and More 2006: Managing Ground Water Systems*. International Ground Water Modeling Center, Golden, CO, p. 326-330.
- Murray, K.E., 2006. Visualizing hydraulic capture zones and assessing sustainability of water resources using GIS, *Ground Water Summit*. National Ground Water Association, San Antonio, TX, p. 39.
- Murray, K.E., 2006. Geospatial modeling of groundwater production scenarios using well hydraulics equations. In: D.R. Maidment (Editor), *GIS and Water Resources IV Specialty Conference*. American Water Resources Association, Houston, TX, pp. 6.
- Thomas, S.M., D. Paul, and K.E. Murray. 2005. Oxygen and hydrogen evolution of groundwater in the Edwards and Trinity aquifer system, south-central Texas. *GSA Abstracts With Programs* 37, no. 7. pp. 217.
- Daniele, L., K.E. Murray, and J. Gisbert. 2005. Análisis de recursos hídricos mediante SIG aplicación al Campo de Dalias: Third Conference of Young Researchers.
- Daniele, L., K.E. Murray, A. Pulido-Bosch, A. Vallejos, and L. Molina-Sanchez. 2005. GIS and geostatistic applied to complex coastal aquifers. Case of Campo de Dalias (SE, Spain), In: V European Congress on Regional Geoscientific Cartography and Information Systems, Barcelona, Spain.
- Murray, K.E. 2005. Critical production rates and quantities of recoverable water resources in the Denver basin aquifer system. *Ground Water Summit*. National Ground Water Association, San Antonio, TX, pp. 134-135.
- Daniele, L., K.E. Murray, A. Pulido-Bosch, A. Vallejos, and L. Molina-Sanchez. 2005. Study of wetland in a semiarid region using GIS. Case of Balsa del Sapo (Campo de Dalias, SE Spain), In: International Congress on Integrated Water Resources Management and Challenges of the Sustainable Development, Marrakech, International Association of Hydrogeologists.
- Murray, K.E. 2004. Stratigraphic framework modeling for constraining a hydrologic model of the Denver Basin Aquifer System. *GSA Abstracts With Programs* 36, no. 5: 104.
- Vanderbeek, G.A., E.P. Poeter and K.E. Murray. 2003. Estimating recharge and storage coefficient in a fractured rock aquifer using MODFLOW. In *Proceedings of MODFLOW and More 2003 Understanding through Modeling*, E.P. Poeter, C. Zheng, M.C. Hill and J. Doherty (Editors), International Ground-Water Modeling Center, Golden, CO, p. 510-514.
- Murray, K.E., E.P. Poeter and J.E. McCray. 2003. Estimating spatially variable ground-water recharge rates using GIS. In *Proceedings of MODFLOW and More 2003 Understanding through Modeling*, E.P. Poeter, C. Zheng, M.C. Hill and J. Doherty (Editors), International Ground-Water Modeling Center, Golden, CO, p. 475-479.
- Vanderbeek, G. A., E. P. Poeter, K. E. Murray, G. D. Thyne and J. E. McCray. 2003. Estimating recharge and storage coefficient in a fractured rock aquifer. *GSA Abstracts With Programs* 35, no. 5: 33.
- Murray, K. E. and M. R. Hudson. 2002. Three-dimensional geologic framework modeling in the Buffalo National River, Arkansas. *GSA Abstracts With Programs* 34, no. 6: p. 120.
- Murray, K. E. and J. E. McCray. 2002. Statistical evaluation of uncertainty in small-scale GIS-based soil property databases. *GSA Abstracts With Programs* 34, no. 4: 38.

- Murray, K. E., S. A. Schlosser and J. E. McCray. 2001. GIS comparison of methods for predicting pesticide contamination potential of ground water in Colorado. *GSA Abstracts With Programs* 33, no. 5: A-17.
- Schlosser, S. A., K. E. Murray and J. E. McCray. 2001. Selection and field test of a pesticide vulnerability assessment method for Colorado. *GSA Abstracts With Programs* 33, no. 5: A-52.
- Murray, K. E. 2001. Geographic information systems based approach for the assessment of ground water vulnerability to pesticide contamination, In *Proceedings of Colorado School of Mines Research Fair Competition*, eds. CSM-GSA, 22.
- Murray, K. E., S. A. Schlosser, J. E. McCray and B. Austin. 2000. Geographic information systems analysis of ground water vulnerability to pesticide contamination. *GSA Abstracts With Programs* 32, no. 7: A-374.
- Brandt, T. R. and K. E. Murray. 2000. Digital geologic map of the Fort Collins, Boulder, and Denver area, Colorado. In *Proceedings of GIS in the Rockies Conference 2000*, Denver, CO: GITA.
- Murray, K. E., J. E. McCray, R. M. Waskom and B. Austin. 2000. Sensitivity of ground water resources to agricultural contamination in the San Luis Valley, Colorado. *GSA Abstracts With Programs* 32, no. 5: A-34.
- Murray, K. E. and S. Cheng. 1997. A comparative study of the inorganic hydrogeochemistry of constructed and natural wetlands. *GSA Abstracts With Programs* 29, no. 4: 63.

### **Other Creative Activities**

Developed slug test laboratory and evaluated groundwater-flow and contaminant particle-flow modeling laboratory for: *Hydrogeology Laboratory Manual* (Lee, Fetter, and McCray, 2002)

### **SCHOLARLY PRESENTATIONS**

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#### **Invited Presentations**

- Jun 26, 2017 Washington, DC, Energy Information Association (EIA) 2017 Energy Conference: The Energy-Water Nexus and Induced Seismicity – Invited Lecture titled *Water-Energy Nexus, Pressure Monitoring & Produced Water Management Challenges*.
- May 24, 2017 Oklahoma City, OK, American Public Works Association of Oklahoma (APWAOK) and Oklahoma Water Environment Association (OWEA) Spring Technical Conference – Joint Presentation (with Freese & Nichols) titled *The Reality of Earthquakes and Municipal Infrastructure*.
- May 15, 2017 Beijing, China, U.S. Trade and Development Agency (USTDA): Accelerating Shale Gas Growth – Invited Lecture titled *Unconventional Challenges: Produced Water Treatment, Water Management, Faults, and Seismicity*.
- May 9, 2017 Tulsa, OK, Petroleum Technology Transfer Council (PTTC) Induced Seismicity: Industry Impact – Invited Lecture titled *Geologic Processes, Human Activities, and Mechanisms for Natural or Induced Seismicity*.
- Apr 7, 2017 Tulsa, OK, Leadership Oklahoma Session: Regulation, Conservation, Restoration Master Talks – Invited Lecture titled *Seismicity in Oklahoma: Our Scientific Understanding and Current Regulatory Response*.
- Mar 30, 2017 Oklahoma City, OK, University of Oklahoma (OU) 2017 Energy Symposium – Moderator and Presenter for *Challenges and Opportunities in the U.S.: Water*.

- Mar 28, 2017 Oklahoma City, OK, Society of Petroleum Engineers (SPE) Oklahoma City Oil & Gas Symposium – Invited Lecture titled *The Oklahoma Geologic Survey's Understanding of the Causes of Induced Seismicity*.
- Feb 17, 2017 Oklahoma City, OK, Association of Energy Service Companies (AESCC) Meeting – Invited Lecture titled *Seismicity and Related Research*.
- Feb 10, 2017 Pawhuska, OK, Osage Minerals Council Meeting – Invited Lecture titled *Fluid Production, Disposal, and Subsurface Pressure Monitoring*.
- Feb 9, 2017 Stillwater, OK, Oklahoma State University, Boone Pickens School of Geology – Guest Lecture titled *Water-Energy-Seismicity in Oklahoma*.
- Dec 2, 2016 Washington, DC: National Academy of Sciences (NAS), Onshore Unconventional Hydrocarbon Development: Legacy Issues, Induced Seismicity, and Innovations in Managing Risk – Invited Lecture titled *Subsurface Pressure Monitoring, Geologic Framework, and Rock Properties in Oklahoma*.
- Nov 30, 2016 Oklahoma City, OK: Oklahoma Produced Water Panel Discussion hosted by Baker Hughes – Invited Lecture titled *Recent Seismic Activity and Produced Water Management in Oklahoma*.
- Nov 16, 2016 Oklahoma City, OK: The Reality of Earthquakes – Municipal Infrastructure Workshop hosted by Freese and Nichols – Invited Lecture titled *Geologic and Hydrogeologic Insights Regarding Oklahoma's Seismicity*.
- Nov 10, 2016 Glenpool, OK: Natural Gas & Energy Association of Oklahoma – Luncheon Presentation titled *Interrelationships between Geology, Water Management, Seismicity, and Regulation*.
- Nov 9, 2016 Bartlesville, OK: Petroleum Environmental Research Forum (PERF) – Invited Lecture titled *Induced? Seismicity in Oklahoma: Putting the Pieces Together*.
- Oct 27, 2016 Golden, CO: American Geosciences Institute (AGI) Critical Issues Forum Addressing Changes in Regional Groundwater Resources: Lessons from the High Plains Aquifer – Invited Lecture titled *Perspectives (on High Plains Aquifer) from Oklahoma*.
- Oct 26, 2016 Tulsa, OK: United States Association for Energy Economics (USAEE) Workshop: The Cause and Consequence of Induced Seismicity – Invited Lecture titled *Market Trends, Produced Water, Saltwater Disposal, and Seismicity in Oklahoma*.
- Oct 7, 2016 Syracuse, NY: Central New York Association of Professional Geologists (CNYAPG) Emerging Contaminants Symposium – Invited Lecture titled *Planning for Emerging Contaminants and Wastewater Reuse in a Regional Water Supply System*.
- Sep 20, 2016 Tulsa, OK: Tulsa Geological Society (TGS) – Luncheon Presentation titled *Seismicity in Oklahoma: from a Hydrogeologist's Perspective*.
- Sep 14, 2016 Wichita, KS: Oil & Gas Breakout Session of Kansas Energy Conference – Invited Lecture titled *Produced Water Management in Oil & Gas Plays: Challenges & Opportunities*.
- Aug 18, 2016 Tulsa, OK: Water Management for Operators: Sourcing, Permitting, Disposal and Reuse with Sustaining Oklahoma's Energy Resources (SOER) – Oral Presentation titled *Geographic Significance of O&G Activity Relative to Produced Water (includes NORM data)*.
- Aug 15, 2016 Norman, OK: Oklahoma Emergency Management Association (OEMA) – Invited Lecture titled *Earthquake Awareness*.
- Jun 17, 2016 Oklahoma City, OK: General Counsels' Forum – Invited Lecture titled *Seismicity and Mitigation in Oklahoma*.

- Jun 14, 2016 Oklahoma City, OK: U.S. E.P.A. Region 6 Environmental Justice Training Workshop – Invited Lecture titled *Well Drilling, Hydraulic Fracturing, and Water Use*.
- Jun 7, 2016 Oklahoma City, OK: Water for 2060 Produced Water Working Group – Invited Lecture titled *Quantity and Quality of Produced Water in Oklahoma*.
- May 25, 2016 Washington, DC: National Academy of Sciences (NAS), Unconventional Hydrocarbon Roundtable Workshop on Use of Flowback and Produced Waters – Invited Lecture titled *Produced Water: The Oklahoma Perspective*.
- Apr 21, 2016 Oklahoma City, OK: Mid-Continent Exploration & Production Safety (MCEPS) Network Meeting – Invited Lecture titled *Resource Management and Seismicity in Oklahoma*.
- Apr 20, 2016 Norman, OK: Environmental Sustainability Symposium – Invited Lecture titled *Produced Water and Saltwater Management in the Oklahoma Oilfield*.
- Apr 14, 2016 Bartlesville, OK: Phillips 66 Safety Days Meeting – Invited Lecture titled *Earthquakes, Resource Management, and Related Safety Issues in Oklahoma*.
- Apr 12, 2016 Norman, OK: Oklahoma Rural Water Association (ORWA) Annual Meeting – Oral Presentation titled *GIS and Groundwater Modeling Technologies*.
- Apr 7, 2016 Norman, OK, University of Oklahoma, Energy in U.S. History in Honors College – Guest Lecture titled *Recent Petroleum Production and Related Water & Environmental Issues in Oklahoma*.
- Mar 29, 2016 Fort Worth, TX, Society of Petroleum Engineers (SPE) & Society of Exploration Geophysicists (SEG) Injection Induced Seismicity – Engineering Integration, Evaluation and Mitigation – Invited Lecture titled *Modeling of Subsurface Pressure Propagation from Arbuckle Saltwater Disposal Wells*
- Mar 24, 2016 Oklahoma City, OK, Legacy Investment Services, Inc. – Invited Lecture titled *Earthquakes, Oklahoma Fault Lines and Groundwater*.
- Feb 22, 2016 Norman, OK, University of Oklahoma, Presidential Dream Course: Water for a Thirsty World: Economics, Policy and Technology in Department of Geography and Environmental Sustainability – Invited Lecture titled *Water Use for Fossil Fuel Extraction*.
- Feb 18, 2016 Tulsa, OK, Oklahoma Energy Resources Board (OERB) – panelist for Mid-Continent Digital Oilfield Conference presentation titled *Produced Water and Saltwater Management*.
- Jan 12, 2016 Norman, OK: Oklahoma Ground Water Association (OGWA) Annual Meeting – Oral Presentation titled *Justifying Index Locations for a Ground-Water Monitoring Network in Oklahoma*.
- Dec 11, 2015 Norman, OK, American Geosciences Institute (AGI) – panelist for Critical Issues Webinar: Making Produced Water More Productive presentation titled *Geoscientific Perspective on Produced Water and Saltwater Disposal Practices*.
- Dec 2, 2015 Golden, CO, Colorado School of Mines, WE2ST Speaker Series – Guest Lecture titled *Synthesizing Petroleum and Water Management Trends with Market Forces and Seismic Activity in Oklahoma*.
- Nov 19, 2015 Norman, OK, University of Oklahoma, Energy in U.S. History in Honors College – Guest Lecture titled *Oil Field Fluid Extraction, Injection and Potential Relationships to Seismicity: Oklahoma*.
- Nov 5, 2015 Tulsa, OK: Osage Oil and Gas Summit – Oral Presentation titled *Produced Water Budget for Oklahoma*.

- Oct 29, 2015 Norman, OK, University of Oklahoma, Natural Resource Economics Class in Department of Geography and Environmental Sustainability – Guest Lecture titled *Market Forces and Relationships to Water Management in the OilField: Oklahoma*.
- Oct 9, 2015 Norman, OK: Society of Environmental Journalists Conference – Panelist for *What's Shaking: Earthquakes Linked to Drilling in Oklahoma and Beyond*.
- Oct 8, 2015 Norman, OK: Society of Environmental Journalists Conference – Speaker for field tour *Drilling, Fracking, Disposal and Earthquakes? Oh My!*
- Sep 28, 2015 Oklahoma City, OK: Ground Water Protection Council (GWPC) Meeting – Oral Presentation titled *Modeling of Pressure Propagation from Saltwater Disposal Wells Completed in the Arbuckle Group, northern Oklahoma*.
- Sep 23, 2015 Oklahoma City, OK: AAPG Reality-Based Reservoir Development Workshop – Oral Presentation titled *Relationships between Geologic Zones, Produced Water, Saltwater Management, and Seismicity in Oklahoma*.
- Aug 27, 2015 Woodward, OK: Water Transfer, Treatment and Reuse Workshop with Sustaining Oklahoma's Energy Resources (SOER) – Oral Presentation titled *Water Use and Permitting in Oklahoma Produced Water, UIC and SWD*.
- Aug 15, 2015 Chicago, IL: National Association of Insurance Commissioners (NAIC) Earthquake Study Group Meeting – Oral Presentation titled *Overview of Earthquake Activity in the Contiguous States*.
- Aug 14, 2015 Chicago, IL: National Association of Insurance Commissioners (NAIC) Center for Insurance and Policy Research (CIPR) Event – Oral Presentation titled *State of the Science: Triggered Seismicity in Oklahoma*.
- Jul 23, 2015 Oklahoma City, OK: Mid-Continent Seismicity Panel Discussion at the Oklahoma City Geological Society (OCGS) – Oral Presentation titled *Mid-Continental Seismicity and Related Research at OGS and OU*.
- Jun 11, 2015 Norman, OK: Water Transfer, Treatment and Reuse Workshop with Sustaining Oklahoma's Energy Resources (SOER) – Oral Presentation titled *Water Use and Permitting in Oklahoma Produced Water, UIC and SWD*.
- Apr 28, 2015 Tulsa, OK: Water Transfer, Treatment and Reuse Workshop with Sustaining Oklahoma's Energy Resources (SOER) – Oral Presentation titled *Water Use and Permitting in Oklahoma Produced Water, UIC and SWD*.
- Apr 17, 2015 Conway, SC: Natural Gas Symposium at Coastal Carolina University – Oral Presentation titled *Water and Natural Gas Production*.
- Jan 28, 2015 Stillwater, OK, Oklahoma State University, Boone Pickens School of Geology – Guest Lecture titled *Integrated Petroleum Water Resource Management*.
- Oct 28, 2014 Edmond, OK: National Association of Retired Federal Employees (NARFE) Meeting – Oral Presentation titled *Overview of Seismicity and Saltwater Management in Oklahoma*.
- Oct 7, 2014 Oklahoma City, OK: Association of Energy Service Companies (AESCC) Meeting – Oral Presentation titled *Earthquake and Other Activity in Oklahoma*.
- Sep 24, 2014 Tulsa, OK: Osage Oil and Gas Summit – Oral Presentation titled *Co-Produced Saltwater and Underground Injection Control in Osage County, Oklahoma*.
- Sep 17, 2014 Oklahoma City, OK: Instructor for Foxmoor Continuing Education Seminar titled *Environmental Issues in Natural Gas Production*.

- Jul 30, 2014 Catoosa, OK: Inter Tribal Environmental Council Conference – Oral Presentation titled *Measuring the Potential for Wastewater Reuse to Augment Existing Water Supplies*.
- Jul 22, 2014 Oklahoma City, OK: Produced Water: Treatment & Reuse Workshop with Sustaining Oklahoma’s Energy Resources (SOER) – Oral Presentation titled *Water in Oil & Gas Operations*.
- Jul 10, 2014 McAlester, OK: Pioneer Library System of Oklahoma, McAlester Branch – Oral Presentation titled *Confounding Interplay of Petroleum Production, Water Injection, and Seismicity*.
- Jun 25, 2014 Oklahoma City, OK: Mississippi Lime Congress – Oral Presentation titled *Examining Water Production Volumes and Produced Water Quality in the Mississippi Lime to Optimize Oil Production Vs. Water and Minimize Water Disposal Costs*.
- May 27, 2014 Woodward, OK: Produced Water: Treatment & Reuse Workshop with Sustaining Oklahoma’s Energy Resources (SOER) – Oral Presentation titled *Water in Oil & Gas Operations*.
- May 20, 2014 Tahlequah, OK: Tahlequah Rock and Mineral Society Meeting – Oral Presentation titled *Co-Produced Water and Underground Fluid Injection in Oklahoma*.
- Apr 29, 2014 Tulsa, OK: Produced Water: Treatment & Reuse Workshop with Sustaining Oklahoma’s Energy Resources (SOER) – Oral Presentation titled *Water in Oil & Gas Operations*.
- Apr 16, 2014 Wichita, KS: Kansas Induced Seismicity State Task Force Meeting – Oral Presentation titled *An Ounce of Understanding is Worth a Pound of Cure*.
- Mar 26, 2014 Norman, OK, University of Oklahoma, Natural Hazards Class in Department of Geography and Environmental Sustainability – Guest Lecture titled *Three C’s of Seismicity in Oklahoma*.
- Mar 25, 2014 Ardmore, OK: Produced Water: Treatment & Reuse Workshop with Sustaining Oklahoma’s Energy Resources (SOER) – Oral Presentation titled *Water in Oil & Gas Operations*.
- Mar 20, 2014 Oklahoma City, OK: Mid-Continent Exploration & Production Safety (MCEPS) Network Annual Meeting – Oral Presentation titled *Seismically Inspired Opportunity Cost*.
- Jan 23, 2014 New Orleans, LA: Ground Water Protection Council 2014 Underground Injection Control Conference – Oral Presentation titled *Fluid Injection Inventory for Class II UIC Wells of Oklahoma*.
- Jan 15, 2014 Norman, OK: Oklahoma Ground Water Association (OGWA) Annual Meeting – Oral Presentation titled *Groundwater Issues/Data*.
- Nov 21, 2013 Edmond, OK: Edmond Neighborhood Alliance Annual Meeting – Oral Presentation titled *Earthquake Frequency and Fluid Stress Trends in Central Oklahoma*.
- Nov 5, 2013 Catoosa, OK: Osage Oil and Gas Summit – Oral Presentation titled *Water Associated with Oil & Gas Operations of the Mid-Continent*.
- Oct 29, 2013 Oklahoma City, OK: Mississippi Lime & Chert Drilling & Completions Congress – Oral Presentation titled *Evaluating Recent Geological Trends In The Mississippi Lime To Guide Continued Drilling And Completions Development In The Mississippi Lime*.
- Oct 25, 2013 Manhattan, KS: Kansas Governor’s Conference on the Future of Water in Kansas – Oral Presentation titled *Fate of Injected Fluids in the MidContinent*.
- Oct 3, 2013 New Wilmington, PA: Westminster College Environmental Science Program – Oral Presentation titled *Interplay between water, energy and the environment: Tales from the Mid-Continent*.
- Oct 1, 2013 Pittsburgh, PA: Water Management for Shale Plays – Oral Presentation titled *Regulatory Landscape for the Midcontinent: Mississippi Lime and Anadarko/Granite Wash*.
- Sep 24, 2013 Oklahoma City, OK: Oklahoma Environmental Education Coordinating Committee

- Quarterly Meeting – Oral Presentation titled *Cycling of Water through Oil & Gas Operations in the Midcontinent*.
- Aug 15, 2013 McAlester, OK: Pioneer Library System of Oklahoma, McAlester Branch – Oral Presentation titled *Drought and Other Issues Affecting Water Availability and Quality in Oklahoma*
- Jun 26, 2013 Oklahoma City, OK: Mississippi Lime Production and Produced Water Congress – Oral Presentation titled *Examining Water Production Volumes and Produced Water Quality in the Mississippi Lime to Develop Appropriate Management Strategies*.
- Jun 11, 2013 Tulsa, OK: 2<sup>nd</sup> Mississippi Formation Summit – Oral Presentation titled *Produced Water from the Mississippi Lime Formation, Reported Quantity and Salinity*.
- Jan 23, 2013 Oklahoma City, OK: Oklahoma Aggregates Association Annual Meeting – Oral Presentation titled *Long-term Trends in Oklahoma Groundwater Systems: Climatic Variability Versus Human Impact?*
- Nov 28, 2012 Oklahoma City, OK: Mississippi Lime Congress – Oral Presentation titled *Examining Historic Water Production and Water Use Trends in the Mississippi Lime Formation*.
- Nov 1, 2012 Antlers, OK: Annual Meeting of Oklahomans for Responsible Water Policy – Oral Presentation titled *Groundwater Recharge, Storage, and Demand – The Importance of a Balanced Water Budget*.
- Oct 31, 2012 Norman, OK: Mississippian Arbuckle Workshop – Oral Presentation titled *Anticipating Water Production, Reuse, and Disposal Volumes*.
- Oct 25, 2012 Norman, OK: Oklahoma Water Survey Workshop on Oil and Gas Operations and the Protection of Water Resources – Oral Presentation titled *State-Scale Perspective on Water Use in Oil and Gas Operations*.
- Oct 16, 2012 Tahlequah, OK: Tahlequah Rock and Mineral Society Meeting – Oral Presentation titled *Overview of Aquifers and Groundwater Issues in Oklahoma*.
- Oct 10, 2012 Oklahoma City, OK: Public Hearing on Cedar Encroachment SB1539 Hosted by Rep. Richard Morrisette – Oral Presentation titled *Perspectives on Hydrology and Water Use in Oklahoma*.
- Mar 8, 2012 Norman, OK: School of Geology and Geophysics Colloquium at the University of Oklahoma – Oral Presentation titled *Arsenic and chromium in groundwater: Case of the central Oklahoma aquifer*.
- Jan 12, 2012 Oklahoma City, OK: U.S. Geological Survey Water Science Center – Oral Presentation titled *Agenda for Hydrogeologic Research at the Oklahoma Geological Survey*.
- Feb 16, 2010 San Antonio, TX: San Antonio Peace Center’s New Ways of Looking at Water Symposium hosted at Trinity University – Oral Presentation titled *Energy & Water: New Ways of Deriving Energy from Water*.
- Apr 27, 2009 San Antonio, TX: Trinity University Biology Seminar – Oral Presentation titled *Algae-based Biofuels: The Next Frontier in Alternative Energy*.
- Mar 25, 2009 San Antonio, TX: St. Mary’s University President’s Peace Commission – Oral Presentation titled *At Last Growing Alternative Energy*.
- Oct 3, 2008 San Antonio, TX: Environmental Science and Engineering Seminar Series at UTSA – Oral Presentation titled *Energy, Water and GIS – New Research Directions*.
- Mar 28, 2008 Waco, TX: Baylor University Department of Geology Colloquium – Oral Presentation titled *Hydrogeologic Characterization and GIS Analysis of the Oakville/Jasper Aquifer*.

- Feb 29, 2008 San Antonio, TX: Environmental Science and Engineering Seminar Series at UTSA – Oral Presentation titled *Microbial Profiling and Laboratory-Scale Treatment of Groundwater Well Biofilms from the Carrizo Aquifer, Texas*.
- Mar 13, 2007 Kenedy, TX: City Council Meeting – Oral Presentation titled *Assessment of Water Resources Needs City of Kenedy, TX*.
- Nov 28, 2006 San Antonio, TX: City of San Antonio’s Linear Creekway Parks Advisory Board – Oral Presentation titled *Management Practices for Natural Waterways: Guidelines for the San Antonio, TX Area*.
- Nov 14, 2006 San Antonio, TX: GIS Day hosted at UTSA – Oral Presentation titled *GIS-based Study of the Potential Economic Impact of the Ports-to-Plains Transportation Corridor*.
- Jul 24, 2006 San Antonio, TX: Texas Bahia Karst Workshop at UTSA – Oral Presentation titled *Water Balance of San Antonio Water System: 2004 Operations*.
- Jul 12, 2006 San Antonio, TX: San Antonio Water System – Oral Presentation titled *Water Balance of San Antonio Water System Operations 2004*.
- Mar 7, 2006 San Antonio, TX: MORE Science Program at UTSA – Oral Presentation titled *3-D Geospatial Applications in Geology and Hydrology*.
- Nov 30, 2005 Almería, España: Research Exchange – Oral Presentation titled *Hydrogeology and Related Research at the University of Texas at San Antonio*
- Apr 8, 2005 Austin, TX: UT-Austin Hydrogeology Brown Bag Seminar Series – Oral Presentation titled *A Spatial Volumetrics Approach to Understanding Critical Production Rates and Recoverable Quantities of Ground Water*.
- Mar 23, 2005 San Antonio, TX: American Society of Civil Engineers (ASCE) Student Chapter at UTSA – Oral Presentation titled *Overview of the Capabilities and Engineering Applications of GIS*.
- Oct 22, 2004 San Antonio, TX: Environmental Science and Engineering Seminar Series at UTSA – Oral Presentation titled *Three-Dimensional Stratigraphic Framework Modeling for Understanding the Hydrology of the Denver Basin Aquifer System*.
- Jul 13-14, 2004 Englewood, CO: Ground Water Institute for Teachers Program – Oral Presentation titled *Ground-water modeling and Geographic Information Systems*

### **Conference Presentations**

- Dec 13, 2016 San Francisco, CA: American Geophysical Union (AGU) Annual Meeting, Session H24E Water Issues Related to Conventional and Unconventional Produced Water Management: Water Quality, Salinity Mapping, Underground Injection Control, and Induced Seismicity I – Oral Presentation titled *Modeling Approach for Estimating Co-Produced Water Volumes and Saltwater Disposal Volumes in Oklahoma*.
- Sep 26, 2016 Denver, CO: Geological Society of America (GSA) Annual Meeting, Session T64. Injection-Induced Earthquakes: Geologic and Operational Constraints, Seismic Hazard, Mitigation, and Societal Impact – Oral Presentation titled *Seismic Moment versus Water: A Study of Market Forces and Regulatory Actions*.
- Sep 7, 2016 Norman, OK: Oklahoma Geological Survey Workshop: Seismicity in Oklahoma – Oral Presentation titled *Monitoring of Fluid Levels and Pressures in the Arbuckle Group*.
- Mar 20, 2015 Stillwater, OK: Geological Society of America, South-Central Section Meeting – Oral Presentation titled *Co-production and management of saltwater from petroleum resource plays in Oklahoma*.



- Mar 20, 2015 Stillwater, OK: Geological Society of America, South-Central Section Meeting – Oral Presentation titled *A tale of two cultures: Emerging pharmaceuticals and personal care products in fresh water.*
- Oct 22, 2014 Vancouver, BC Canada: Geological Society of America (GSA) Annual Meeting, Session: Joint Sustainability of Water Resources and Petroleum Energy Production – Oral Presentation titled *Re-Examining Saltwater Management Practices in Oklahoma.*
- May 6, 2014 Denver, CO: National Ground Water Association (NGWA) Summit, Session: Water and Energy – Oral Presentation titled *Natural Hydraulic Fracturing, Fluid Pressure and Saltwater Disposal in the Arbuckle: Implications for Induced Seismicity.*
- Apr 7, 2014 Houston, TX: AAPG Annual Convention & Exhibition, Session: Water Management and Induced Seismicity – Oral Presentation titled *Subsurface Fluid Injection in Oil and Gas Reservoirs and Wastewater Disposal Zones of the Midcontinent.*
- Mar 17, 2014 Fayetteville, AR: Geological Society of America, South-Central Section Meeting – Oral Presentation titled *Spatial and Temporal Trends in Underground Injection Control Volumes, Oklahoma.*
- Oct 22, 2013 Midwest City, OK: OWRRI Water Research Symposium – Oral Presentation titled *Sustainability of Oklahoma Groundwater Systems? Climate versus Human Impact.*
- Nov 14, 2012 Tulsa, OK: OWRRI Water Research Symposium – Oral Presentation titled *Estimating Freshwater and Saline Water Volumes Associated with Oil and Gas Production in Oklahoma, 2000 to present.*
- Jul 18, 2011 St. Louis, MO: 1st International Conference on Algal Biomass, Biofuels & Bioproducts – Poster Presentation titled *Enhancement of Microalgae Biomass Production Using Alternative Sources of Carbon to Achieve a Sustainable Energy Production System.*
- Apr 29, 2010 Houston, TX: National Algae Association Quarterly Meeting for Algae Commercialization, Research and Business Networking Forum - Oral Presentation titled *Upscaling a Microalgae Growth System and Assessing Biomass Production, Lipid Production, Nutrient and Carbon Removal.*
- Apr 21, 2010 Rapid City, SD: Geological Society of America Meeting – Oral Presentation titled *Computing GeoVolumes for Groundwater Systems using GIS.*
- May 22, 2006 Golden, CO: International Ground Water Modeling Center MODFLOW and More 2006 Conference – Oral Presentation titled *GIS-based Modeling of Groundwater Resources in the Denver Basin Aquifer System.*
- May 9, 2006 Houston, TX: American Water Resources Association GIS and Water Resources IV Specialty Conference – Oral Presentation titled *Geospatial Modeling of Groundwater Production Scenarios Using Well Hydraulics Equations.*
- Apr 24, 2006 San Antonio, TX: National Ground Water Association Meeting – Oral Presentation titled *Visualizing Hydraulic Capture Zones and Assessing Sustainability of Water Resources using GIS.*
- Apr 19, 2005 San Antonio, TX: National Ground-Water Association Meeting – Oral Presentation titled *Critical Production Rates and Quantities of Recoverable Water Resources in the Denver Basin Aquifer System.*
- Nov 7, 2004 Denver, CO: Geological Society of America National Meeting – Oral Presentation titled *Geologic Framework Modeling for Constraining a Hydrologic Model of the Denver Basin Aquifer System.*
- May 9, 2003 Golden, CO: International Ground Water Modeling Center MODFLOW and More 2003 Conference – Oral Presentation titled *Estimating Spatially Variable Ground-Water Recharge Rates*

*Using GIS.*

## **TEACHING ACTIVITIES**

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### **University Teaching**

2017, University of Oklahoma, Norman, OK

CEES 5853: Groundwater and Seepage

2005–2011, Universidad de Almería, Spain

Aplicaciones de los SIG a la Hidrogeología (Applications of GIS to Hydrogeology): 5-day short course for working professionals and graduate students

2004–2011, The University of Texas at San Antonio, San Antonio, TX

GEO 1103: Introduction to Earth Systems

HON 3501: Honors Thesis Exploration Seminar

GEO 4023: Engineering Geology

GEO 5033: Geographic Information Systems

GEO 5483: Environmental Hydrogeology

GEO 6523: GIS for Water Resources

GEO 6543: Internet Served GIS

ES 6941: Biofuel Colloquium

1999–2004, Colorado School of Mines, Golden, CO

SYGN 201: Earth Systems Engineering

EPICS 251: Engineering Practices Introductory Course Sequence

GEGN 466/467: Ground-Water Engineering

GEGN 475/575: Applications of Geographic Information Systems

Introduction to ArcGIS: 3-day short-course for Colorado School of Mines faculty

### **K-12 Teaching Experience**

Jun 17, 2013 Westville, OK, Westville Branch of Pioneer Library System of Oklahoma, Activity – Oklahoma Rocks, grades K-12

May 30, 2013 Oklahoma City, OK, South Oklahoma City Branch of Pioneer Library System of Oklahoma, Activity – Rocking Out at the Library, grades K-5

Apr, 2013 Norman, OK, Terra Verde Discovery School, Guest Instructor for Earth Science Education, grades 1&2

Nov 15, 2012, Norman, OK, Norman High School, Guest Lecturer for Advanced Placement (AP) Environmental Science, grades 10-12

### **Undergraduate/Graduate Theses and Dissertations Supervised**

Perilla-Castillo, P.J. 2017. Rock properties derived from analysis of solid earth tide strain observed in continuous pressure monitoring of the Arbuckle Group of Oklahoma. M.S. Thesis in Geology, University of Oklahoma, Norman, OK. 65 pp.

Hernandez, R.J. 2015. Hydrogeological characterization of the Antlers Formation and Aquifer in southern

- and southeastern Oklahoma. M.S. Thesis in Geology, University of Oklahoma, Norman, OK. 74 pp.
- Hildebrant, B. 2015. Historical fluid extraction volumes for the Arbuckle Group of Oklahoma. B.S. Thesis in Environmental Geology, University of Oklahoma, Norman, OK. 37 pp.
- Carrell, J.R. 2014. Field-scale hydrogeologic modeling of water injection into the Arbuckle Zone of the midcontinent. M.S. Thesis in Geology, University of Oklahoma, Norman, OK. 89 pp.
- Morgan, B.C. 2014. Characterizing permeability of small-scale features in the Arbuckle Group. B.S. Thesis in Environmental Geology, University of Oklahoma, Norman, OK. 42 pp.
- Irwinsky, M.J. 2013. Dissolved solids and naturally occurring radioactive material in water produced from oil and gas wells of Oklahoma. B.S. Honors Thesis in Environmental Geology, University of Oklahoma, Norman, OK. 16 pp.
- Muhlestein, K.N. 2012. Detecting thermal infrared radiation from cave openings using thermography. Ph.D. Thesis in Environmental Science and Engineering, University of Texas at San Antonio. 80 pp.
- Garcia, N.D. 2011. Carbon source efficiency and aerial productivity of *Neochloris oleoabundans* in an open trough system. B.S. Honors Thesis in Biology. University of Texas at San Antonio. 19 pp.
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## **PROFESSIONAL SERVICE ACTIVITIES**

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Associate Editor: *Hydrogeology Journal* (three-year appointment 2016–2018),

Peer Reviewer for International Journals: *Environmental Science & Technology* (Apr 2015, Jan 2014, Oct 2013, May 2013), *Journal of Contaminant Hydrology* (Jan 2014, Jul 2013, Apr 2013), *Frontiers of Environmental Science and Engineering* (Jan 2014), *Environmental and Engineering GeoScience* (Aug 2013, Feb 2012, Dec 2010, Feb 2005), *CLEAN-Soil, Air, Water* (Sep 2012), *Environmental Earth Sciences* (May 2012), *Journal of Biobased Materials and Bioenergy* (Oct 2011), *Water Resources Management* (Feb 2011, Mar 2009, Aug 2008), *Water* (Aug 2010), *Science of the Total Environment* (Aug 2010), *Computers & Geosciences* (Jun 2010), *Soil and Sediment Contamination An International Journal* (Aug 2009, 2004), *Journal of Human and Ecological Risk Assessment* (Jul 2009), *American Society of Agricultural and Biological Engineers* (Dec 2007), *Applied Geochemistry* (Mar 2007), *Journal of Environmental Management* (Sep 2006), *Environmental Geology* (Aug 2006), *Ground Water* (Aug 2006), *Journal of Hydrologic Engineering* (Aug 2006), *International Journal of Environment and Pollution* (Oct 2005), *Journal of Environmental Quality*, *Ground Water Monitoring and Remediation*, *Soil Science Society of America Journal*

Peer Reviewer for Proposals: National Institute of Health Loan Repayment Program (Apr 2013, Apr 2009), National Institutes for Water Resources (Jun 2011, Jan 2008, Apr 2007), Louisiana Sea Grant Program (May 2009), Southwest Consortium for Environmental Research & Policy (Jan 2007, Jan 2006), American Chemical Society (Apr 2006)

Invited Participant: Consortium of Universities for the Advancement of Hydrologic Science, Incorporated (CUAHSI), Data-Driven Cyberlearning for Geoscience and Hydrology Education Workshop, Boulder, CO (Jul 22, 2010).

Member: American Society of Civil Engineers-Environmental and Water Resources Institute (ASCE-EWRI) Watershed Modeling, Onsite Systems Task Committee (2007–2008)

Invited Participant: Environmental Systems Research Institute (ESRI) ArcHydro Groundwater Data Model Workshop, Redlands, CA (Dec 2006).

Conference Session Convener/Moderator for: Session H24E Water Issues Related to Conventional and Unconventional Produced Water Management: Water Quality, Salinity Mapping, Underground Injection Control, and Induced Seismicity I at American Geophysical Union (AGU) Annual Meeting (Dec 2016); Session 5: Geological and Reservoir Characterization at OGS Workshop: Seismicity in Oklahoma (Sep 2016); Energy-Water Nexus: Fluids, Induced Seismicity, and Environment & Managed Aquifer Recharge Session at National Ground Water Association (NGWA) Summit (May 2014); and Ground Water Recharge Session at the International Ground Water Modeling Center hosted MODFLOW and More 2003: Understanding Through Modeling Conference, Golden, CO (May 2003).