

**Recently-completed and ongoing USGS investigations in the Williston Basin
August, 2016**

USGS Office Abbreviations:

CERC, Columbia Environmental Research Center; **CERSC**, Central Energy Resources Science Center; **CGGSC**, Crustal Geophysics and Geochemistry Science Center; **CMERSC**, Central Mineral and Environmental Resources Science Center; **COWSC**, Colorado Water Science Center; **DSC**, Dakota Science Center; **EROS**, Earth Resources Observation and Science Center; **ERP**, Energy Resources Program; **GECS**, Geosciences and Environmental Change Science Center; **IDWSC**, Idaho Water Science Center; **NPWRC**, Northern Prairie Wildlife Research Center; **NRMSC**, Northern Rocky Mountain Science Center; **ORWSC**, Oregon Water Science Center; **WY-MTWSC**, Wyoming-Montana Water Science Center

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Topic 1. Understanding the Scale and Nature of UOG Resources											
1.1	Energy and Minerals	2013	present	Isotope geochemistry and provenance of the Bakken Formation	Leonid Neymark, CMERSC; Chris Holm-Denoma, CMERSC; Wayne Premo, GECS; Rick Moscati, CGGSC; Zell Peterman, CGGSC	Analytical work completed. Report writing next.	Determine the provenance of the Devonian-Mississippian Bakken Formation by dating of detrital zircon using LAICPMS and analyzing Sr and Nd isotopes in whole-rock samples.	Bakken, Provenance, Detrital Zircon, Rb-Sr and Sm-Nd isotope geochemistry, U-Pb zircon geochronology	2.5.1 and 2.5.2		
Topic 2. Water Quality											
Topic 2.1. Multi-Research Topic - overarching studies with multiple sub-components											
Topic 2.2. Groundwater											
2.2.1	Water	2013	2014	Williston Basin Baseline Groundwater-Quality Assessment - Upper Fort Union	Peter McMahon, COWSC; Rod Caldwell, WY-MTWSC; Joel Galloway, DSC; Greg Delzer, DSC	Journal article published.	Characterize baseline water-quality conditions in the Upper Fort Union aquifer within the Williston Basin, Montana and North Dakota.	Energy Development, Williston Basin, Water Quality, Baseline	3		http://pubs.er.usgs.gov/publication/70141030
2.2.2	Water	2014	2015	Groundwater Quality Assessment of the Standing Rock Reservation in North and South Dakota	Joel Galloway, DSC; Josh Valder, DSC	Data collected.	The primary purpose is to provide an initial assessment of the groundwater quality on the Standing Rock Reservation, particularly to develop baseline information related to future energy development activities in the area. A secondary purpose of this study is to establish selected wells for an ambient water-quality sampling program on the Standing Rock Reservation.	Baseline, Water Quality, Tribal, Groundwater, Williston Basin, Energy Development, Hydraulic Fracturing	3		
Topic 2.3. Surface Water											
Topic 2.4. Groundwater and Surface Water											
2.4.1	Water	2003	2014	Delineation of brine contamination in and near the East Poplar oil field, Fort Peck Indian Reservation, northeastern Montana	Joanna Thamke, WY-MTWSC; Zell Peterman, CGGSC; Bruce Smith, CGGSC; Todd Preston, NRMSC	USGS OFR 2006-1216; USGS OFR 2010-1326, USGS SIR 2014-5024.	Assessment of brine contamination to the shallow aquifers and surface water. Uses combination of hydrology, geochemistry, and geophysics to delineate areas of groundwater contamination.	Energy Development, Williston Basin, Brine Contamination, Groundwater, Surface Water, East Poplar oil field, Fort Peck Indian Reservation	3, 6	http://wy-mt.water.usgs.gov/projects/east_poplar/in dex.html	http://pubs.er.usgs.gov/publication/wri034214 http://pubs.usgs.gov/of/2006/1216/ http://pubs.usgs.gov/

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											gov/of/2010/1326/ http://pubs.usgs.gov/sir/2014/5024/
2.4.2	Water	2010	present	Delineation of brine contamination in and near the City of Poplar and East Poplar oil field, Fort Peck Indian Reservation, northeastern Montana	Joanna Thamke, WY-MTWSC; Zell Peterman, CGGSC; Bruce Smith, CGGSC; Todd Preston, NRMSC	One journal article in preparation. Second journal article has been accepted by American Association of Petroleum Geologists for July 2016 publication.	Delineation of brine contamination to shallow aquifers in and near the City of Poplar and East Poplar oil field. Uses combination of hydrology, geochemistry, and geophysics to define extent of contamination.	Energy Development, Williston Basin, Brine Contamination, Groundwater, City of Poplar, East Poplar oil field, Fort Peck Indian Reservation	3, 6	http://wy-mt.water.usgs.gov/projects/east_poplar/in dex.html	
2.4.3	Water	2013	present	Analyses of water-quality data and resources on the Fort Berthold Reservation, North Dakota	Joel Galloway, DSC	Publication in preparation	Analyses of water-quality data and resources on the Fort Berthold Reservation, North Dakota.	Fort Berthold, Water Quality	3, 6		

Topic 2.5. Produced Water

2.5.1	Energy and Minerals, Water	2012	present	Baseline Chemical and Isotopic Data for Produced Water from the Bakken Formation, Williston Basin	Zell Peterman, CGGSC; Rod Caldwell, WY-MTWSC; Joel Galloway, DSC	Data available at http://mt.water.usgs.gov/	Characterize Bakken Formation water.	Energy Development, Williston Basin, Bakken Formation, Strontium Isotopes	3, 6		http://energy.usgs.gov/EnvironmentalAspects/EnvironmentalAspectsofEnergyProductionandUse/ProducedWaters.aspx#3822349-data
2.5.2	Energy And Minerals, Water	2013	present	Isotopic Indications of Fluid Flow in the Bakken Formation, Williston Basin	Zell Peterman and Kiyoto Futa, CGGSC; Thomas Oliver, CERSC		Sr isotopic characterization of pore salts in members of the Bakken Formation to evaluate flow amount units.	Energy Development, Williston Basin, Bakken Formation Flow	3, 6		http://www.aapg.org/publications/news/explorer/emphasis/articleid/10195/saline-water-in-bakken-where-did-it-come-from

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2.5.3	Energy And Minerals, Water	2014	2015	Refined Methodology and Safety Analysis for the Collection of Produced Waters: Field Evaluation in the Williston Basin	Rod Caldwell, WY-MTWSC; Tanya Gallegos, ERP; Greg Delzer, DSC		Characterization of produced waters from the Bakken and Three Forks fm. Comparison of waters sampled from wells and separator.	Produced Water, Field Protocol Evaluation, Bakken Formation, Three Forks Formation		Workplan methods eval v 3-21	

Topic 3. Water Availability

Topic 3.1. Multi-Research Topic Proposal(s)

Topic 3.2. Groundwater

3.2.1	Water	2012	2015	Williston and Powder River basins groundwater availability	Joanna Thamke and Tim Bartos, WY-MTWSC; Andrew Long and Kyle Davis, DSC	Bednar, 2013, South Dakota School of Mines Thesis; Aurand, 2013, South Dakota School of Mines Thesis; USGS SIR 2014-5047; USGS SIR 2014-5055	Groundwater budget, hydrogeologic framework, conceptual model prepared. Groundwater availability determined for current and projected energy development.	Energy Development, Williston Basin, Powder River Basin, Groundwater Availability	2	http://mt.water.usgs.gov/projects/Water/PR/	http://pubs.er.usgs.gov/publication/sir20145047 http://pubs.er.usgs.gov/publication/sir20145055
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Topic 3.3. Surface Water

Topic 3.4 Groundwater and Surface Water

3.4.1	Ecosystems, Water	2010	present	Water Balances for Energy Resource Production	Seth Haines, CERSC; Joanna Thamke, WY-MTWSC	USGS Fact Sheet 2014-3010; USGS OFR 2015-1117	Water availability, resource assessment methods, water and proppant (sand) quantities.	Energy Development, Williston Basin, Groundwater, Surface Water	2, 6	http://energy.usgs.gov/Environment/Aspects/EnvironmentalAspectsofEnergyProductionandUse/ProducedWaters.aspx	http://pubs.usgs.gov/fs/2014/3010/ https://pubs.er.usgs.gov/publication/ofr20151117
3.4.2	Water	2013	2014	Quantifying water-use requirements for the variable conditions and processes associated with hydraulic fracturing within North Dakota, South Dakota, and Montana	Kyle Blasch, IDWSC; Roy Sando, WY-MTWSC	Information presented at Feb 2016 National Groundwater Association meeting.	Quantifying water-use requirements for the variable conditions and processes associated with hydraulic fracturing within North Dakota, South Dakota, and Montana	Energy development, Williston Basin, Bakken Formation, Three Forks Formation, Hydraulic Fracturing, Water-Use Requirements	2, 6		

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3.4.3	Water	2014	2018	Method Development to Estimate National Water Use Associated with Unconventional Oil and Gas – Phase 1	Kathleen Rowland, DSC; Joanna Thamke, WY-MT WSC; Janet Carter, DSC; Greg Delzer, DSC	USGS Fact Sheet 2016-3032	Obtain and analyze water use data for direct (e.g., well drilling, hydraulic fracturing, dust suppression) and indirect uses (e.g., municipalities and crew camps) related to UOG development in the Williston Basin from 2005-2015. Develop water- use coefficients and consumptive-use coefficients for UOG processes for broader application. Assist stakeholders in projecting water use requirements and availability associated with future UOG development.	Water use, Williston Basin, Direct Use, Indirect Use, National Water-Use Assessment	2, 6	http://sd.water.usgs.gov/projects/UOG/UOG.html	https://pubs.er.usgs.gov/publication/fs20163032
Topic 4. Air Quality and Greenhouse Gas Emissions											
Topic 5. Effects on Human Health and Communities											
Topic 6. Ecological Effects											
6.1.1	Ecosystems	2008	2014	Brine Contamination to Prairie Potholes from Energy Development in the Williston Basin	Robert Gleason, NPWRC; Joanna Thamke, WY-MTWSC; Brian Tangen, NPWRC; Todd Preston, NRMSC; Bruce Smith, CGGSC	USGS SIR 2014-5017; USGS FS 2011-3047; Applied Geochemistry, August 24, 2012; USGS OFR 2012-1149; Preston, 2011, Montana State University Thesis	Water-quality impacts of brine spills, spatial data on wells, decision analysis findings.	Energy Development, Williston Basin, Brine Contamination, Prairie Potholes, Wetlands, Groundwater	2		http://pubs.usgs.gov/sir/2014/5017/ http://pubs.usgs.gov/fs/2011/3047/ http://pubs.usgs.gov/ofr/2012/1149/
6.1.2	Environmental Health	2015	present	Understanding Potential Risks to Water Resources and Environmental Health Associated with Wastes from Unconventional Oil and Gas Development	Isabelle Cozzarelli, NRP; Katie Skalak, NRP; Joanna Thamke, WY- MTWSC	Engle, M.A., Cozzarelli, I.M., and Smith, B.D., 2014, USGS investigations of water produced during hydrocarbon reservoir development: U.S. Geological Survey Fact Sheet 2014-3104, 4 p.	Characterizing source materials from active drilling sites, study historical and recent leaks and spills of brine wastewaters in the Williston Basin.	Brine spills, wastewater, surface water quality, biological effects, water quality methods development, radium,	2	http://toxics.usgs.gov/investigations/uog/	http://pubs.usgs.gov/fs/2014/3104/

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Topic 6.2. Spatial Data Sets and GIS											
6.2.1	Ecosystems	2011	2012	A GIS-Based Vulnerability Assessment of Brine Contamination to Aquatic Resources from Oil and Gas Development in Eastern Sheridan County, MT	Todd M. Preston, NRMSC; Joanna N. Thamke, WY-MTWSC	Article published in Science of the Total Environment	Vulnerability assessment methods.	Energy Development, Williston Basin, Vulnerability Assessment, Brine Contamination, Aquatic Resources	2		http://dx.doi.org/10.1016/j.scitotenv.2013.09.027
6.2.2	Ecosystems	2014	2015	A Web-Based Tool to Evaluate Potential Saline Contamination to Aquatic Resources in the Williston Basin from Energy Development	Todd M. Preston, NRMSC	Article published in Science of the Total Environment	Integrate several datasets into a cohesive data product allowing federal, state, tribal, and others to visualize the spatial distribution of factors relevant to brine contamination and determine potential vulnerability.	Energy Development, Williston Basin, Vulnerability Assessment, Brine Contamination, Aquatic Resources	2		http://dx.doi.org/10.1016/j.scitotenv.2014.11.054
6.2.3	Ecosystems	2012	2015	Monitoring and modeling wetland chloride concentrations	Max Post van der Burg, NPWRC; Brian Tangen, NPWRC; Robert Gleason, NPWRC; Jill Frankforter, WY-MTWSC	Article published in the Journal of Environmental Management	Impacts of brines on wetland surface water chemistry.	Energy Development, Williston Basin, Brine Contamination, Prairie Potholes, Wetlands	2		http://dx.doi.org/10.1016/j.jenvman.2014.10.028
6.2.4	Ecosystems	2013	2015	Presence and Abundance of Non-Native Species Related to Energy Development in Montana and North Dakota	Todd M. Preston, NRMSC; Rick Sojda, NRMSC	Article published in Environmental Monitoring and Assessment	The effects of energy development on the presence and abundance of noxious weeds.	Energy Development, Williston Basin, Invasive Species, Noxious Weeds			http://www.ncbi.nlm.nih.gov/pubmed/25797884
6.2.5	Ecosystems	2012	present	Investigating the biological impacts of brine contamination on wetlands of the Prairie Pothole Region: Developing maps depicting conditions in the ecosystems	Todd M. Preston, NRMSC	Article in Review with the Journal of Freshwater Ecology	Biological impacts of brine contamination.	Energy Development, Williston Basin, Brine Contamination, Biological Impacts, Prairie Potholes, Wetlands	2		

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6.2.6	Ecosystems	2014	present	Updating, gathering, and serving datasets relevant to oil and gas development and fish and wildlife management within the Williston Basin and Bakken Formation	Todd M. Preston, NRMSC		Updating, gathering, and serving datasets relevant to energy development and natural resources to ScienceBase and a NRMSC server.	Energy development, Williston Basin, Bakken Formation, Water Quality, Hydraulic Fracturing, GIS, Data Server, Webman	2, 3		
6.2.7	Ecosystems	2014	2016	Evaluating recent and future land-use changes related to energy development in the Williston Basin and Bakken Formation	Todd M. Preston, NRMSC	Article has been published in Science of the Total Environment	Determine the acreage of different land-use classifications converted to current and future oil and gas development	Energy Development, Williston Basin, Bakken Formation, Land Use	2, 3		
6.2.8	Ecosystems	2013	2016	Comprehensive Wetland Assessment and Monitoring Program within the Lostwood Complex of Northeast Montana and Northwest North Dakota	Todd M. Preston, NRMSC; Rick Sojda, NRMSC	Phase 1. Internal final report submitted to U.S. Fish & Wildlife Service. Phase 2. Sampling	Use previously determined vulnerability assessment methods for Waterfowl Production Areas in the Lostwood National Wildlife Refuge Complex.	Energy Development, Williston Basin, Waterfowl Production Areas, Brine Contamination, Vulnerability Assessment	2		
6.2.9	Ecosystems	2012	2015	Effects of oil and gas development on grassland birds	Doug Johnson, NPWRC	Article has been published in Biological Conservation	Biological impacts of energy development	Grassland birds, Oil and Gas Development			https://pubs.er.usgs.gov/publication/70157525
6.2.10	Ecosystems	2014	present	Modeling avian abundance or occupancy	Max Post van der Burg, NPWRC		Develop a Bayesian hierarchical model to assess relationships between bird abundance and patterns of oil development. More specifically, relate cumulative oil development to population growth rates of various migratory birds using Breeding Bird Survey data, and then using those trends to predict future changes.	Energy Development, Williston Basin, Avian, Migratory Birds			

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6.2.11	Ecosystems	2013	2015	Landcover change and water permanence algorithms	Marty Goldhaber, CGGSC; Jennifer Rover, EROS	Developing code.	Develop and implement improved algorithms for detecting and characterizing land cover change and water permanence from Landsat data.	Land cover, water availability, change detection, information products, energy development			
6.2.12	Ecosystems	2016	2017	Develop grassland bird habitat suitability models in relation to energy development in the Williston Basin	Todd Preston, NRMSC Rachel Bolus, NRMSC	Developing code and acquiring land cover changes	Develop grassland bird habitat suitability models using USGS GAP species and habitat data in conjunction with land cover data derived from 6.2.7	Grassland birds, habitat suitability, energy development, land cover change			
Topic 6.3. Toxicity Studies											
6.3.1	Ecosystems	2013	2015	Effects of salinity on aquatic resources, acute	Aida Farag, CERC; Dave Harper, CERC		Potential effects of saline waters from energy activities on aquatic resources.	Saline, Brine, Toxicity, Lethal, Sublethal, Energy Development, Williston Basin, Water Quality, Baseline	2, 3, 5		
6.3.2	Ecosystems	2014	2015	Effects of salinity on aquatic resources, chronic	Aida Farag, CERC; Dave Harper, CERC		Potential effects of saline waters from energy activities on aquatic resources.	Saline, Brine, Toxicity, Lethal, Sublethal, Energy Development, Williston Basin, Water Quality, Baseline	2, 3, 5		
6.3.3	Ecosystems	2015	2017	Field and laboratory assessments of toxicity to multiple species	Aida Farag, CERC; Dave Harper, CERC; Chris Ingersoll, CERC		This work evaluates the toxicity of major ions of concern (including and beyond chloride) to a range of taxa of interest, including the influence of the base water on the toxicity of major ion mixtures. The project is building upon the above listed 6.3.1 projects and additional major ion toxicity projects being conducted at CERC. We have begun with laboratory experiments that simulate various background waters and will work to expand and generate information for a range of taxa using a combination of (1) laboratory toxicity experiments of field-collected waters or field-	Saline, Brine, Toxicity, Lethal, Sublethal, Energy Development, Williston Basin, Water Quality, Baseline	2,3,5		

