2011 Proposal to AGFC SWG Program – Kresse, et al.

Characterization and Monitoring of Water Resources within the Gulf Mountain Wildlife Management Area to Assess Potential Impacts by Gas Exploration and Production

Project Summary: Activities related to gas exploration and production on land leased from the Arkansas Game and Fish Commission has the potential to impact water resources in the Gulf Mountain Wildlife Management Area (WMA). There is a paramount need to collect background water chemistry related to springs and associated hydrologic systems that comprise the sustained flows and relatively pristine water quality of streams within the WMA, prior to large scale drilling and production activities. We propose to (1) perform a reconnaissance of springs and associated hydrologic systems in the WMA (2) collect field temperature, pH, conductance, and dissolved oxygen at all sites, (3) analyze chloride concentrations in water samples from all sites, (4) analyze for a full inorganic suite of major cations and anions and trace metals at 8-10 selected sites based on results from the reconnaissance, and (5) investigate the rock/water, soil/water effects on geochemistry for future identification of effects of produced water on the hydrologic system in the WMA.

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Budget Summary: The total project cost is $75,412; this project requests $48,593 over a one-year period from the SWG Program and matching funds (i.e., 35% of the total budget) will be provided using the University of Arkansas ($26,819).

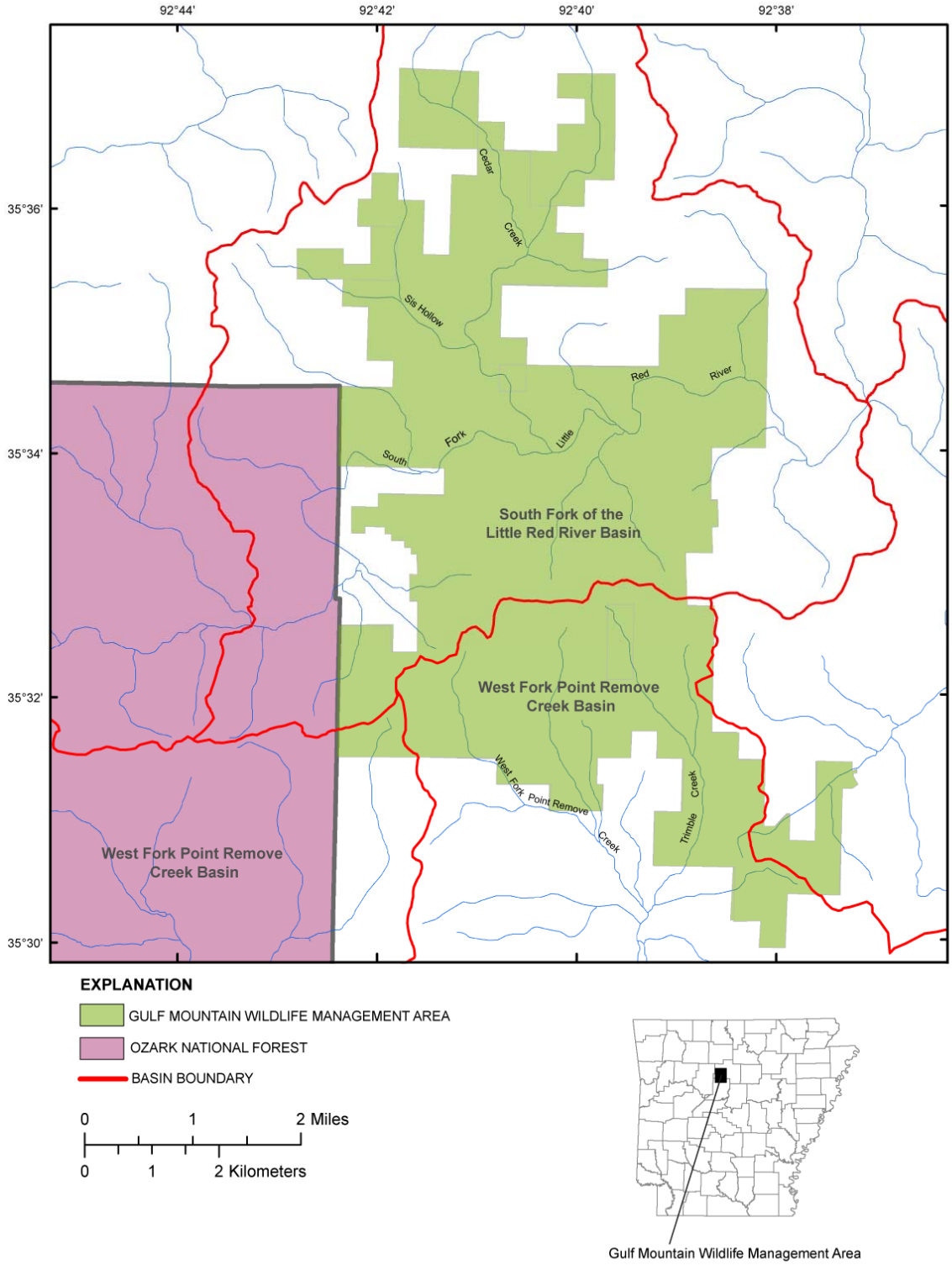
Project Need: Activities related to gas production associated with the Fayetteville shale play in and near the Gulf Mountain Wildlife Management Area (WMA) have the potential to impact the surface water hydrologic system. Direct runoff by overland flow and delayed runoff through the shallow subsurface in the form of seeps and springs

compose the major component of stream flow and define the unique chemistry of streams in the WMA. In assessing water-quality impacts to streams, it is imperative to define water quality of springs, seeps, and their associated hydrologic systems to assess sources and transport of contaminants from gas exploration and production activities.

Potential sources of impacts from gas drilling activities include fluids associated with the drilling operation and with the fracturing process used to enhance fracture permeability and gas yield. Constituent transport pathways include potential leakage from earthen pits used to store drilling mud and other process waters, leakage from pipes, and losses from overflows, spills, and other releases. The process of fracture enlargement through pressurizing the shale units with high-pressure fluid injection creates an additional concern for the shallow subsurface hydrology that provides baseflow to streams by creation of new fracture sets, enlargement of existing vertical fractures, loss of fluids through faulty casing, and migration of pressurized fluids across faults that extend downward from the shallow subsurface hydrologic systems into the zone of production. This project will complement existing work in the WMA, which focuses on flow and limited water-quality analyses in streams by defining water-quality in the overall hydrologic system, including shallow subsurface flow, which ultimately defines the chemistry and water quality of local streams in the WMA.

Project Objectives: The U.S. Geological Survey, working cooperatively with the University of Arkansas at Fayetteville and the Arkansas Water Resources Center (AWRC), proposes to characterize the quality of water feeding local streams in the WMA using springs and associated hydrologic systems, in addition to water in ephemeral drainages that contribute water to streams within and near to the WMA following storm events (fig. 1). The study is designed to describe existing (background) water quality and geochemistry for use in evaluating potential effects of waste streams associated with drilling and fracturing activities. Water quality will be correlated to geology and soil units to investigate water/rock and water/soil interactions, which will be used as a fingerprinting tool for assessing and differentiating anthropogenic and natural effects on water geochemistry. This data is paramount for identifying changes in water quality from gas drilling activities. The specific objectives of this project are to:

1. Perform a reconnaissance of springs and related hydrologic systems in the WMA,
2. Collect field parameters at all sites, including temperature, pH, conductance, and dissolved oxygen,
3. Analyze chloride concentration in water samples from all sites,



1. Figure 1. Location of Gulf Mountain Wildlife Management Area and associated streams.

4. Select sampling sites for full inorganic chemical analysis (major cations and anions, trace metals) based on distribution of conductance and chloride concentrations during the preliminary reconnaissance phase,
5. Import data into a geographical information system to investigate relation of water quality to geology and soils within WMA,
6. And, project management and reporting of results to Arkansas Game and Fish Commission (AGFC).

Project Timeline: This project is for one year from Nov. 1, 2011 through Oct. 31, 2012.

Project Approach: ***Objective 1*** *– Perform a reconnaissance to identify springs, seeps, and ephemeral headwater streams in the WMA.* A field reconnaissance of the entire WMA will be made to locate existing spring, seeps, and ephemeral stream headwaters, measure spring flow rates, and record site locations using a global positioning system instrument. All sites will be entered into an excel database, the USGS ground-water site inventory (GWSI) database, and a geographical information system database for producing maps. All shapefiles, maps, and associated databases will be shared with GIS personnel at AGFC.

Objective 2 *– Collect field water-quality parameters at all sites.* Temperature, pH, conductance, and dissolved oxygen will be measured at all sites with a YSI multiprobe meter. Probes will be calibrated according to manufacturer's instructions using USGS approved standard solutions.

Objective 3 *– Collect samples for chloride analysis at all sites.* Samples will be collected according to USGS protocol and delivered to the AWRC Water Quality Laboratory for analysis of chloride concentrations. Preliminary water-quality data gathering to date associated with water use by the gas industry has indicated that chloride is the most effective indicator parameter of choice because of its conservative nature in the environment, its elevated concentrations in the gas industry's waste streams, and its low cost and ease of sampling technique. As such, chloride data provide an inexpensive tool for rapidly assessing the general chemical characteristics and distribution of water type throughout the WMA and provide an excellent tool for selecting sites for full inorganic chemical analysis. This phased approach saves large expenditures of time and money, which are associated with analyzing many constituents at several sites without knowledge of the general geochemical distribution of water quality throughout the study area.

Objective 4 *– Select sampling sites for full inorganic suite of compounds.* Data collected during the field reconnaissance will be plotted in a geographical information system to assess the general distribution of conductance values and chloride concentrations. This

information will be used to select 8-10 sites for sampling and analysis of major ion and trace metal chemistry. By selecting sites based on field parameters and chloride analysis, the project will optimize funds for describing the range of full range of geochemistry of the water resources throughout the WMA without missing important and varied water types or duplicating analysis where not needed based on replicating (sampling water sources with similar chemistry) water types. Major ion and trace metal chemistry will be analyzed by the AWRC Water Quality Laboratory.

Objective 5 *– Import all water-quality data into geographical information system and compare to geology and soils within WMA.* Knowing the geospatial distribution of water chemistry throughout the WMA is imperative for assessing potential water-quality impacts from gas drilling operations. Water-quality variations are normal for differing geology and weathering products, and water geochemistry can also vary with residence time within similar geologic formations. Water emanating from shale formation commonly can be elevated with respect to chloride, sulfate, and iron, and it is important to understand these water/rock interactions and resulting geochemical evolution to differentiate between natural and anthropogenic effects on water quality. Eight to ten samples will be analyzed for major ions and trace metals to describe water type and range of inorganic constituents.

Objective 6 *– Project management and reporting of results to AGFC.* The USGS will provide oversight for the project and manage all objectives through every phase of the project. All data will be made available to the AGFC in excel format and geospatial layers will also be available if needed by AGFC or any other partner. Information will be shared through presentations at formal conferences and at meetings with AGFC.

Table 1. Timeline of the activities associated with each objective in the study.

	2011		2012									
Task	Nov	Dec	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct
Objective 1	*	*										
Objective 2	*	*										
Objective 3	*	*										
Objective 4			*	*								
Objective 5					*	*	*					
Objective 6			*	*	*	*	*	*	*	*	*	*

All data and related products will be made available to AGFC by September, 2012

Table 2. Budget summary by categories for the proposed study.

Budget Category	State Wildlife Grant Funds (Federal)	Cash Match (Non-federal)	In-Kind Match (Non-Federal)	Total Project Cost
A. Salaries	9,702$	7,441$		17143$
B. Fringe	378$	1,838$		2,216$
C. Travel	1,500$			1,500$
D. Equipment	0			
E. Supplies	0			
F. Consultants/Contracts	25,000$			25,000$
G. Other	8,055$			8,055$
Total Direct Costs	44,635$	9,279$		53,914$
H. Total Indirect Costs	3,958$	17,540$		21,498$
TOTAL	48,593$	17,540$		75,412$

Project Expected Outcomes and Benefits: Because extensive gas exploration and development has been delayed at the WMA at the present date, there is time to establish background data for springs and related/associated subsurface hydrologic systems at the site. Chemical reactions at the water/soil and water/rock interface in the WMA change the overall chemistry and water quality of percolating rainfall prior to reaching nearby streams. Changes in stream water quality can be misunderstood, when seeking sources through direct runoff at drilling sites. Predicting and preventing impacts to streams can occur only through a complete understanding of the water quality of springs and their associated hydrologic systems, which in most cases will be the first hydrologic system affected by leaks, spills, and other releases of drilling and fracturing fluids. This project will identify and map all springs and their associated hydrologic systems and establish background geochemistry throughout the WMA. The phased approach for the study, rather than spending large sums for complete chemical analyses at all sites, provides cost savings while providing needed information.

Project Team and Responsibilities: The project team includes extensive expertise by the University of Arkansas (Dr. Ralph Davis, Chair of the Geosciences Department, Dr. Brian Haggard, Director of the Arkansas Water Resources Center, and Dr. Phillip Hays, Associate Research Professor in the Department of Geosciences) and the U.S. Geological Survey (Tim Kresse, Arkansas Water Science Center). The University of Arkansas also will provide a Master's level student from the Geosciences Department to perform a majority of the field reconnaissance and water sampling. The U.S. Geological Survey will be responsible for technical oversight and overall project management and providing continual progress updates to the AGFC and all other partners.

Dr. Ralph Davis has managed large multi-disciplinary projects in several states throughout the United States, and currently oversees the multiple functions of the University of Arkansas, Department of Geosciences.

Dr. Brian Haggard oversees the Arkansas Water Resource Center, which includes a long-standing water quality laboratory accredited by the Arkansas Department of Environmental Quality, which will perform the chemical analysis for the project.

Tim Kresse has over 30 years in managing similar projects throughout Arkansas and other states. His broad experience includes private consulting, State, and Federal work in managing water-quality related projects similar to the proposed project.

Dr. Phillip Hays has a joint appointment as Associate Research Professor at the University of Arkansas at Fayetteville, Department of Geosciences and hydrologist with the U.S. Geological Survey. He has managed large multi-disciplinary projects nationally and internationally and is well suited for the proposed project.