DEPARTMENT OF NATURAL RESOURCES

DIVISION OF WATER RESOURCES

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December 10, 2012

Oil & Gas Conservation Commission
1120 Lincoln St., Suite 801
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Subject: Statewide Water Sampling and Monitoring Rulemaking, Rule 609 --- Specifically regarding monitoring of existing groundwater sources (water-supply wells or springs) in the vicinity of oil and gas development and the determination of upgradient and downgradient directions within the aquifer(s).

This written testimony of Matthew A. Sares, Hydrogeological Services Manager, Colorado Division of Water Resource (DWR), was developed at the request of the Department of Natural Resources – Executive Director's Office to help answer questions about the requirement of upgradient and downgradient water sources for monitoring of oil and gas well sites (including multi-well sites).

Groundwater gradient and groundwater maps

Groundwater flows from higher elevation to lower elevation or from higher pressure to lower pressure. The difference in water elevation or pressure between two points within the same aquifer constitutes a hydraulic gradient between the points. A simple plane of hydraulic gradient can be established with three data points. With many data points a map of the groundwater surface elevation (or potentiometric surface) can be constructed. Contour lines of equal groundwater elevation can be drawn defining a "potentiometric surface," much like a topographic map has contour lines defining the slope of the ground surface. The groundwater flow direction is perpendicular to groundwater equipotential lines in a down gradient direction.

Types of aquifers

The shallowest aquifer is termed the water-table or unconfined aquifer and often occurs within unconsolidated material (soil, sand, gravel, alluvium) near the earth's surface. Water-table aquifers can also occur within near-surface permeable bedrock such as sandstones or limestones. In these aquifers, the water is unconfined and the groundwater surface (potentiometric surface) generally follows the surface topography. Therefore, upgradient and downgradient in this shallow unconfined water-table aquifer can generally be assumed to mimic the ground surface, but there are exceptions. The base of the unconfined water-table aquifer extends to the depth of the first relatively impermeable layer of clay or consolidated bedrock.

Water-bearing strata below the first significant impermeable clay or bedrock unit are generally confined aquifers under hydrostatic pressure. In these aquifers the water is under pressure such that the potentiometric surface rises above the top of the physical aquifer. Groundwater flow within confined aquifers is governed by differences in pressure within the aquifer and is disconnected from surface topography. Hydraulic gradient and groundwater flow direction in a confined aquifer can be very different than in an unconfined water-table aquifer in the same geographic location.

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<u>Use of existing water supply wells to determine hydraulic gradient</u>
Obtaining valid water level data from existing water supply wells to determine an aquifer's hydraulic gradient using can be problematic for reasons outlined below:

- To obtain valid water-level data on which to determine hydraulic gradient, wells used for monitoring must be completed within the same aquifer. The water supply wells close to a proposed drill site may be completed in different aquifers. If this is the case, a valid hydraulic gradient cannot be established. Moreover, within certain regulation-defined aquifers, (such as the Dawson, Denver, and Arapahoe aquifers of the Denver Basin) there can be several water bearing strata, with slightly different potentiometric surfaces. Where this happens, obtaining valid hydraulic gradients even within the same regulatory aquifer can be difficult.
- Existing water supply wells are generally pumping wells, which is problematic for obtaining valid water levels. A pumping well modifies the aquifer's potentiometric surface by lowering it within a "cone of depression" surrounding the pumping well. The magnitude of the cone of depression depends on the magnitude of pumping. Irrigation and municipal wells create large depressions in the aquifer's potentiometric surface, domestic wells less so. By pumping water, existing water supply wells change water levels in the aquifer at diurnal and seasonal time scales depending on the well's use. Valid hydraulic gradients cannot be obtained where water levels are transient. Even if well owners were asked to turn off their pumps prior to a monitoring event, it can take days or months for water levels to equilibrate to an approximate static water level. This certainly would be onerous to both the water well owner and the oil and gas operator.

<u>Regional vs. local scale in determining hydraulic gradient at a specific well site or multi-well site</u>
Regional-scale potentiometric surface maps have been published for various Colorado aquifers, including unconfined alluvial aquifers and confined bedrock aquifers. Regional groundwater gradients and groundwater flow direction can be determined from these maps. Local groundwater gradients and flow directions can be different than those identified on regional maps primarily because of the difference in scale. Local groundwater movement in unconfined, water-table aquifers is strongly influenced by local topography. While groundwater in a regional sense (several square miles) is moving to the north in an unconfined aquifer, locally groundwater may be moving in many different directions. Furthermore, groundwater pumping in both unconfined and confined aquifers can drastically affect local groundwater gradients and flow direction.

This points out that prevalent Colorado groundwater literature containing maps of aquifer potentiometric surfaces, are reliable at the regional level, but should not be relied upon for determining local groundwater gradients on the scale of one-mile or less.

<u>Rules and practical matters pertaining to accessing wells for water-level measurements</u>
Gaining access to existing water supply wells is not a simple matter. According to Colorado's Water Well Construction Rules (2 CCR 402-2) wells must be hydraulically sealed to prevent potential aquifer contamination from surface spills, floods, etc. (Rules 10.1.3, 10.4.8, 10.4.10, 11.5). Some wells have an access port for measuring water levels, others do not. If an access port is not available, the well's hydraulic seal must be broken to allow water level measurement. Per Rule 13.3, "Only a licensed well construction contractor, licensed pump installation contractor, authorized individual[1], or the well owner may remove a well seal." This limits the personnel who can legally open a well seal.

[1] An "authorized individual" means a professional engineer registered in Colorado or a professional geologist as defined in section 34-1-201(3), C.R.S., who is qualified to do the work, or anyone directly employed by or under the supervision of a registered professional engineer or professional geologist.

When a well seal is broken for water level measurement, the measuring equipment must be disinfected prior to being used in the well unless the entire well will be disinfected after completion of the testing operations.

Liability is an issue when accessing a water supply well and lowering equipment into it. Damage to the well pump, well casing, and electrical lines can occur by directly harming the well's construction or by inadvertently dropping monitoring equipment in the well. Damage to a water well can be expensive, costing thousands of dollars to repair. Any entity required to do this work should have specific liability coverage for this activity.

Conclusion

Requiring a determination of the local groundwater gradient for freshwater aquifers by means of existing water-supply wells at a proposed oil and gas well site or multi-well site is impractical. Nearby water-supply wells may be completed in different aquifers, not allowing a valid determination of hydraulic gradient. Water-supply wells pump groundwater at varying timescales and with different flow rates, thereby creating transient water levels. Therefore, hydraulic gradients on the local-scale can change diurnally and seasonally. Static water levels are necessary to obtain valid hydraulic gradients, but the process of shutting down pumping wells can be onerous to well owners. Accessing existing water supply wells to obtain water-level data requires important logistical planning to comply with Colorado Water Well Construction Rules. For the reasons explained in this testimony, I recommend against requiring oil and gas operators to determine the local hydraulic gradient at proposed drilling sites in the promulgation of Rule 609.

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Education

Colorado School of Mines, 1/1990 – 5/1991
Professional Degree, Hydrogeology, May 1991

University of Toledo, 1/1978 – 12/1981
B.S., Geology, December 1981

Professional experience

Colorado Division of Water Resources, Denver, CO, 6/2011-present

Hydrogeological Services Manager (PSR/S V)

- Assure that geologic, hydrogeologic, and geotechnical factors are properly and professionally evaluated, interpreted, and applied to the implementation and application of the laws and policies governing the extraction and use of ground water within the state of Colorado.
- Manage the Ground Water Monitoring Program that collects critical water-level data on various aquifers statewide. Data are used for evaluating development impacts, water management practices, and conjunctive use alternatives.
- Act on behalf of the Board of Examiners of Water Well Construction and Pump Installation Contractors to ensure proper licensing of drillers and pump installation contractors, and that the Board's rules, policies, and procedures are implemented.
- Oversee the Well Inspection Program that enforces minimum well construction standards to protect ground water from contamination.

Colorado Geological Survey, Denver, CO, 12/2005 – 6/2011

Deputy Director (PSR/S V)

- Assist State Geologist/Director in strategic planning, budgetary planning, funding requests, personnel work plans and reviews of the Science Section staff.
- Lead new geothermal resource assessment of Colorado. Includes compilation of new heat flow and geothermal gradient maps of the state, geothermometry, and other studies.
- Participate in department-level discussions and analysis of oil shale development and environmental, water resource, and water quality implications.
- Guided agency's assessment of coalbed methane production impacts on stream depletion in the San Juan, Raton, Piceance, and Sand Wash basins of Colorado.
- Continued duties identified below.

Professional experience (continued)

<u>Colorado Geological Survey</u>, Denver, CO 4/2005 – 12/2005

Chief, Engineering and Environmental Geology (PSR/S V)

- Strategically plan, design, and manage day-to-day operations of the Engineering and Environmental Geology Sections. Responsible for the Critical Geological Hazards Program, Land Use Review Program, Subsidence Information Center, Water Resource Data Program, Underground Storage Tank and Environmental Site Assessment Program, Abandoned Mine Land Program, and Uranium and Special Projects Program.
- Liaison with Local, State, and Federal agency personnel to develop and initiate cooperative projects addressing engineering and environmental geology issues in Colorado.
- Plan current and future work; budget funds; interview, hire, train, and review performance of employees, contractors, and interns.
- Present results of investigations to advisory groups, constituents, the professional community, and the public

<u>Colorado Geological Survey</u>, Denver, CO 9/1998 – 4/2005

Chief, Environmental Geology Section (PSR/S III & IV)

- Strategically plan, design, and manage operations of Environmental Geology Section. Responsible for the Water Quality Data Program, Underground Storage Tank / Environmental Site Assessment Program, Abandoned Mine Land Program, and Uranium and Special Projects Program.
- Plan the section's current and future work; budget funds; interview, hire, train, and review performance of employees, contractors, and interns.
- Present results of investigations to advisory groups, constituents, the professional community, and the public

<u>Colorado Geological Survey</u>, Denver, CO 7/1995 – 9/1998

Program Geologist (PSR/S II & III)

- Lead and managed the scientific endeavors, budget, and day-to-day operations of the Water Quality Data Program (WQDP) and the Abandoned Mine Lands Program. The WQDP, through multiple projects, studies the interaction of geology and water quality throughout the state and makes existing water quality data accessible to all interested parties.

<u>Colorado Geological Survey</u>, Denver, CO 6/1991 – 7/1995

Project Geologist (PSR/S II)

- Managed the U.S. Forest Service Abandoned Mine Land Inventory Project. This project located and gathered environmental and physical hazard information on all abandoned mines on National Forest System Lands in Colorado.
- Devised and managed yearly project budgets totaling $1.4 million over seven-year project. Supervised up to eight permanent and temporary geologists.

<u>Colorado Geological Survey</u>, Denver, CO 6/1990 – 11/1990

Staff Geologist (PSR/S I)

- Performed site assessments and remediation of hydrocarbon contamination at underground storage tank (UST) sites. Supervised tank removal, test-hole drilling, and monitor well installation. Prepared reports on all activities.

<u>RPI International, Inc.</u>, Boulder, CO 7/1982 – 1/1990

Staff Geologist

- Delineation of geologic stratigraphy, detailed well-log interpretation, contour and edit maps, well core description, field work, write and edit text. Participated in numerous studies of strata in Wyoming, Texas, North Dakota, and Canada.
- Leader of regional correlation teams for Siluro-Devonian study of West Texas and Paleozoic-Mesozoic study of the Powder River Basin, Wyoming. Managed geotechnical personnel.

Certification/ Professional Training

- OSHA 40-hour HAZWOPER Training with annual 8-hour refresher courses 1990 through present
- Geothermal Exploration Technologies Short Course, 2006
- EPA Introductory Preliminary Assessment Training, 1999
- EPA Introductory Site Inspection Training, 1999
- EPA STORET 2000 Database Training, 1999
- State of Colorado Supervisory Certificate Program, 1996

Previous Expert Testimony

None

Professional memberships

National Ground Water Association, Colorado Ground Water Association, Geological Society of America, Rocky Mountain Association of Geologists, Colorado Scientific Society,

Awards

- **John C. Frye Award for Environmental Geology, 2012**
  Awarded to the best paper on environmental geology published by the Geological Society of America or by one of the State geological surveys. (*paper: Natural Acid Rock Drainage Associated with Hydrothermally Altered Terrane in Colorado, Bulletin 54, Colorado Geological Survey, 2011, by John T. Neubert, Jeffrey P. Kurtz, Dana J. Bove, and Matthew A. Sares)*
- **President's Certificate for Excellence in Presentation Award**
  American Assoc. of Petroleum Geologists - Energy Minerals Division, Annual Convention & Exhibition, Denver, 2009.
  (*presentation: Geothermal Resources of Colorado and the Potential for Electrical Power Generation*)
- **Best Presentation Award**
  Resource Assessment Session, Geothermal Resource Council Annual Meeting Reno, NV, 2009. (*presentation*: *Statewide Geothermal Resource Mapping in Colorado*)
- **U.S. Forest Service Leadership Award**, 1999
- **Best Undergraduate Award – Geology**, 1982, University of Toledo

Publications

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