STATE OF SOUTH DAKOTA
DEPARTMENT OF ENVIRONMENT AND NATURAL RESOURCES

BEFORE THE WATER MANAGEMENT BOARD

IN THE MATTER OF WATER PERMIT APPLICATION #2730-2, UNITED ORDER OF SOUTH DAKOTA	))))	**United Order of South Dakota's Disclosure of Expert Witness**

Pursuant to the Court's May 18, 2015 Scheduling Order, United Order of South Dakota hereby discloses the name of any expert that it intends to call as an expert witness as follows:

1. Arden D. Davis, Ph.D., P.E., 1014 Milwaukee Street, Rapid City, South Dakota 57701. A copy of Mr. Davis' March 27, 2015 expert report and his curriculum vitae is attached.

Dated this 15 day of June, 2015.

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CERTIFICATE OF SERVICE

I hereby certify on this 16 day of June, 2015, I mailed by first-class U.S. mail, a true and correct copy of a United Order of South Dakota's Designation of Expert Witness to the following:

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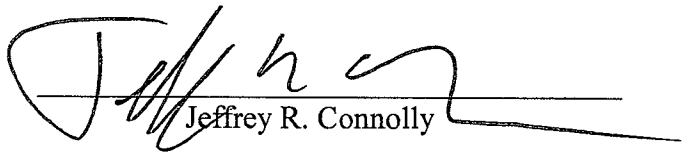

Jeffrey R. Connolly

Groundwater in the Madison Aquifer

With Regard to Water Permit Application No. 2730-2

Arden D. Davis, Ph.D., P.E.
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March 27, 2015

Introduction

This report was prepared in regard to Water Permit Application No. 2730-2, which under the Applicant's revised application requests 0.23 cubic feet per second (cfs) of water from the Madison aquifer. The request for 0.46 cfs was modified to 0.23 cfs by the applicant in a letter of February 18, 2015. A new Madison well would be constructed to augment production from two existing wells that were authorized in a previous permit (Water Permit 2610-2). The wells are in the NW ¼ SE ¼ of Section 10, T. 6 S., R. 3 E., in Custer County, South Dakota. The new well would be about 900 feet from the existing wells at the site.

The Madison aquifer underlies much of the southern Black Hills area and contains abundant groundwater supplies. The Madison aquifer, at the site of Water Permit Application No. 2730-2, is understood by current scientific literature to be fully saturated (Carter et al., 2002), as shown on Figure 1. Groundwater in the Madison aquifer is an under-utilized and almost undeveloped resource in the vicinity of the requested withdrawals. In the S.D. DENR review of Water Permit Application No. 2730-2, Mr. Buhler

(2014) noted no other existing water rights/permits for the Madison aquifer within ten miles or more of the applicant site. Additional evidence of the under-utilized nature of the Madison aquifer, in the area of the requested permit, is available in reports of the U.S. Geological Survey. A potentiometric map of the Madison aquifer in the Black Hills (Strobel et al., 2000) showed no Madison wells for water-level contours in the entire 36 square mile area of T. 6 S., R. 3 E. (Figure 2). Therefore there are no other water permit demands for the aquifer within the 36 square miles.

Concerns Raised by the National Park Service

The National Park Service filed a petition in 2014 to intervene in the matter of Application No. 2730-2. In its petition letter, the National Park Service cited a concern about water levels in the Madison aquifer within Wind Cave National Park. The letter showed calculated values of predicted drawdown at a distance of 13 miles from the site of the requested Water Permit Application No. 2730-2. Assumptions underlying the use of the equations appear to be faulty. The petitioner's assumed values of the aquifer properties used in the calculations are quite variable. For example, the calculations used a storage coefficient value of 0.0002 in trying to predict drawdown at a distance of thirteen miles, from the site of the requested water permit to Wind Cave, even though the outcrop of the Madison Limestone (i.e., part of its recharge area) is exposed between Wind Cave and the site of Water Permit Application No. 2730-2. The aquifer would receive recharge at its outcrop area, but the Theis equation assumes that no recharge occurs during drawdown calculations. Recharge to the aquifer would reduce any drawdown from pumping.

At the outcrop area and eastward toward Wind Cave, the aquifer would be under water-table (unconfined) conditions. It is not appropriate to use a small storage coefficient value such as 0.0002 (which is typical of a confined aquifer) in such an area. The groundwater in Wind Cave and its lakes is under atmospheric pressure and is not confined by the overlying weight of rocks, because the cave is open to the atmosphere. Therefore, the Madison aquifer is not a confined (artesian) aquifer at the cave, and the water is not under pressure by an overlying confining layer. A very small storage coefficient of 0.0002 implies confined conditions (Freeze and Cherry, 1979) and is not suitable for predicting drawdowns at the Wind Cave lakes. A storage coefficient value of 0.0002 would give inappropriately large calculated values of drawdown at Wind Cave, compared to values of drawdown calculated with a storage coefficient value that would be typical of an unconfined (water-table) aquifer at the cave. For areas where an aquifer is unconfined, a storage value much larger than 0.0002 normally should be used. Accordingly, calculated drawdowns from pumping would be less.

The deep lakes at Wind Cave are mainly at the eastern and southeastern side of the cave, approximately 13 miles or more from the site of Water Permit Application No. 2730-2. This is a long distance (more than 68,000 feet) for extrapolating drawdowns; it is noted that in his review of the application, Mr. Buhler (2014) extended his extrapolated drawdowns to a distance of 2000 feet away, which is much more reasonable than a longer distance, because of variability of aquifer properties and uncertainty about hydrologic conditions.

The transmissivity and storage coefficient values of the Madison aquifer are not known with certainty in the Black Hills and can be quite

variable. It is at best speculative to assert that drawdowns of 6 to 9 feet or more would occur at Wind Cave because of pumping occurring about 13 miles away at the site from Water Permit Application No. 2730-2.

It is also important to report that the site of requested applicant withdrawals does not appear to be upgradient from Wind Cave and therefore would be less likely to result in an adverse effect at the cave.

Concerns Raised by the Black Hills National Forest

The United States Department of Agriculture, Black Hills National Forest, in January of 2015 filed a petition to intervene in the matter of Application No. 2730-2. In its letter, the National Forest expressed concern that withdrawals could over time affect the warm water spring ecosystem at Cascade Springs. However, Cascade Springs are approximately 17 miles from the site of requested applicant withdrawals from the Madison aquifer, which is a very long distance for extrapolating effects of pumping. In addition, water at the site of Water Permit Application No. 2730-2 is approximately 54° F, which is much cooler than the warm spring water at Cascade Springs (about 68° F). There is no close hydraulic connection between the applicant's site and Cascade Springs.

The Forest Service letter petition states that there are no known structural features between the area of the well and Cascade Springs that would be expected to isolate the effects of well pumping from the springs. However, U.S. Geological Survey maps by Driscoll et al. (2002) and Strobel et al. (2000) show a long, synclinal fold between the well site and Cascade Springs, which limits any hydraulic connection across this distance (see Figure 3). The axis of a synclinal fold normally is an area of compression in which fractures tend to remain closed, which would limit permeability and

thus limit hydraulic connection between the applicant's well site and Cascade Springs.

Evans Plunge is a warm-springs swimming pool (approximately 87° F) that is fed by springs along the Fall River in Hot Springs (see Figure 3). The springs at Evans Plunge are more than 15 miles from the area of the applicant's site. The source of the springs is believed to be the Madison aquifer (Carter and others, 2002). According to research by Back et al. (1983) the calculated age of water at Evans Plunge was 1,900 years before present. Back et al. (1983) did not calculate an age for the water at Cascade Springs, because of problems with possible mixing of water from the Minnelusa or other aquifers, and Cascade Springs is farther south than Evans Plunge. We can conclude that a very long travel time would be involved for water that emerges at Cascade Springs, indicating that it is extremely unlikely that pumping at the applicant's site would affect the springs.

Conclusions

Groundwater in the Madison aquifer is an under-utilized and almost undeveloped resource in the vicinity of the requested withdrawal for Water Permit Application No. 2730-2. The Madison aquifer is generally understood to be fully saturated at the site. No existing water rights for Madison aquifer wells appear to be within approximately ten miles of the applicant's site. The requested additional diversion of 0.23 cubic feet per second is not expected to have any adverse effect on other Madison wells, or the water at Wind Cave, or Cascade Springs, because of the distances (12 miles or more) that are involved. The requested withdrawals from the Madison aquifer are reasonable for their intended use.

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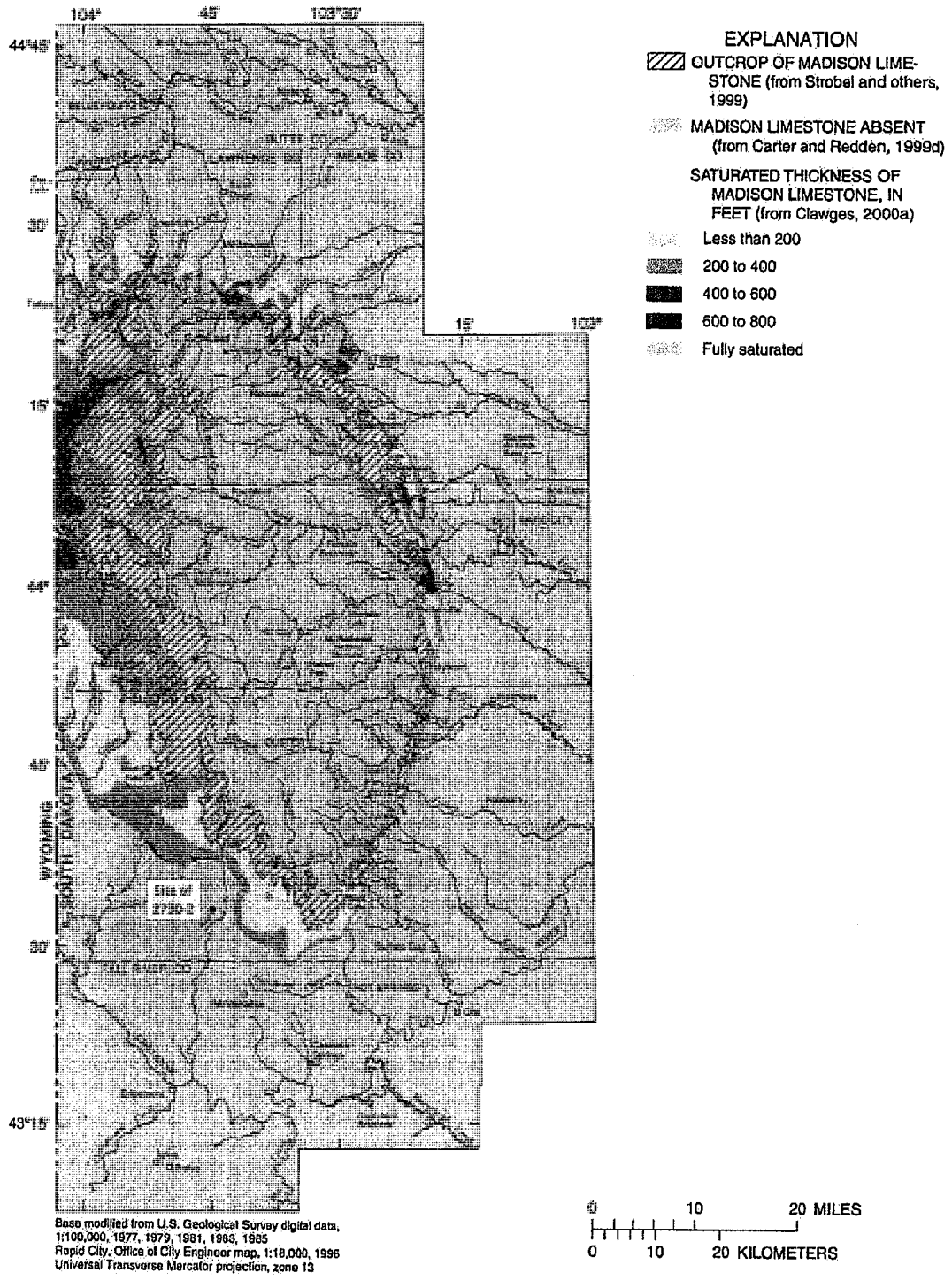

Figure 1. Saturated thickness of the Madison aquifer in the Black Hills (from Driscoll et al., 2002).

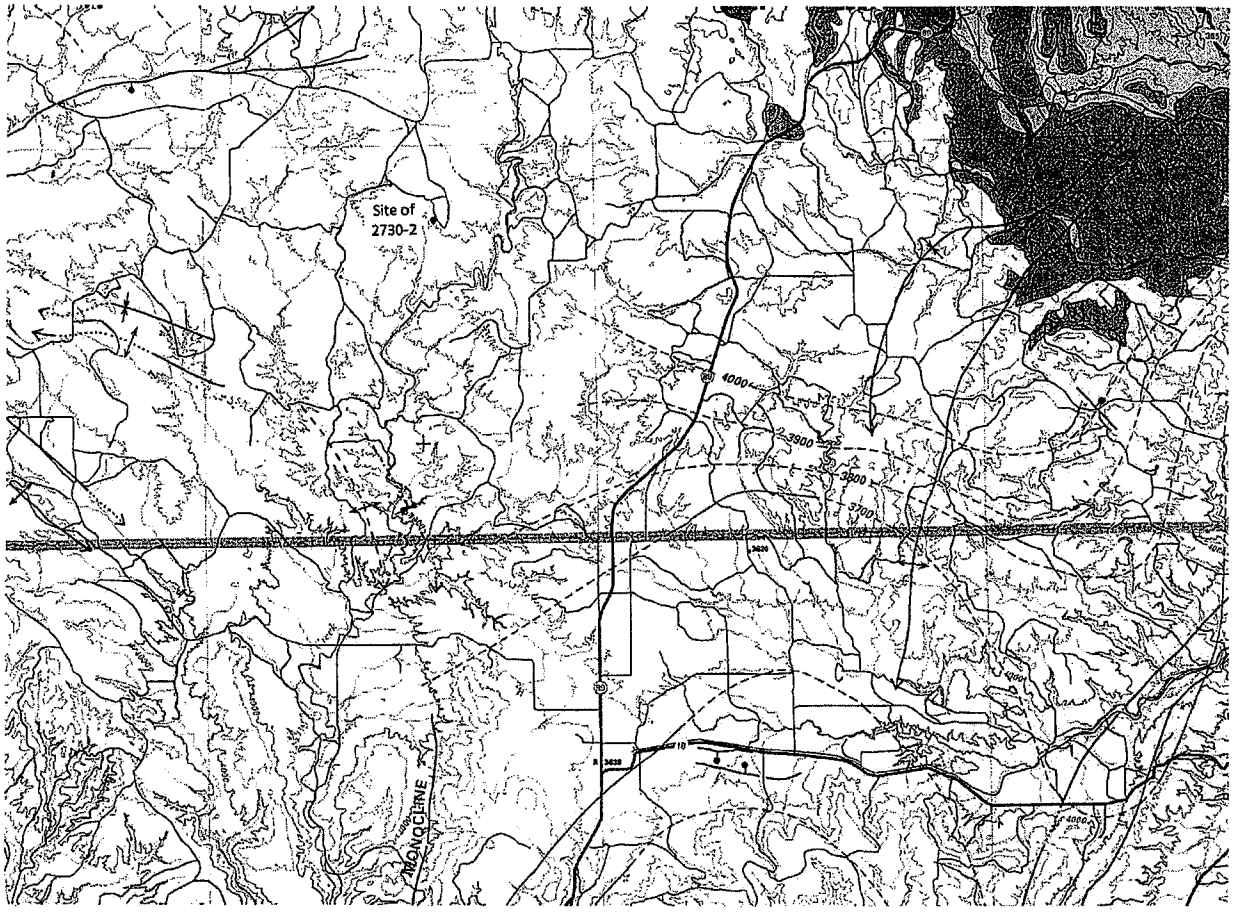

Figure 2. Potentiometric map of the Madison aquifer (from Strobel et al., 2000) showing few or no Madison wells near the site of Water Permit Application 2730-2.

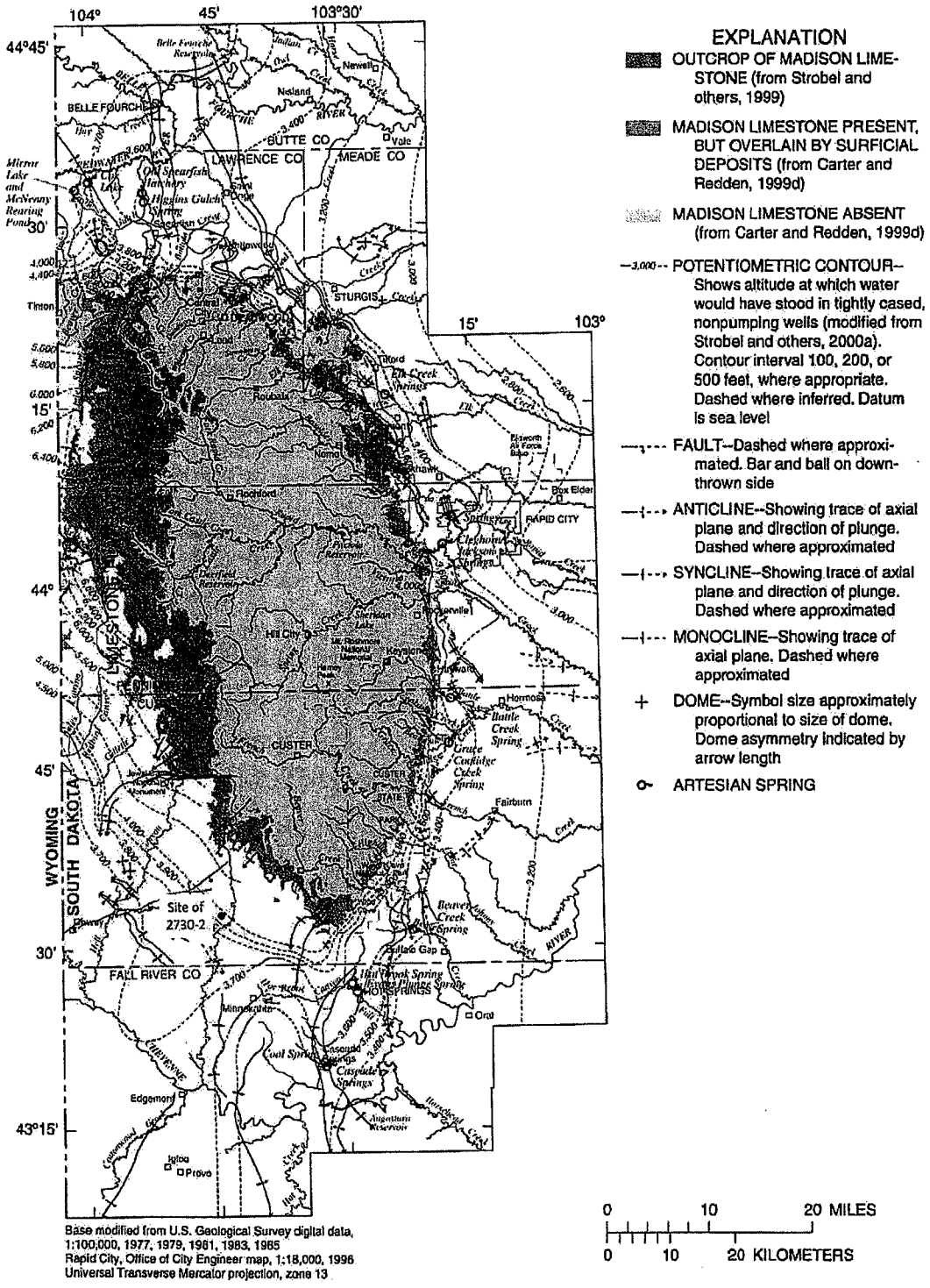

Figure 3. Madison aquifer in the Black Hills area (from Driscoll et al., 2002).

Arden D. Davis

Arden Davis received a B.A. degree in geology from the University of Minnesota and M.S. and Ph.D. degrees in geological engineering from South Dakota School of Mines and Technology.

Dr. Davis currently is Professor in the Department of Geology and Geological Engineering at South Dakota School of Mines and Technology. Since 1982 he has served as Instructor, Assistant Professor, Associate Professor, Professor, and Chairman of the Department of Geology and Geological Engineering. During that time he has worked on digital modeling of ground-water flow as well as transport and dispersion of subsurface contaminants. He teaches courses in ground water, digital modeling of ground-water flow and contaminant transport, ground-water geochemistry, analytical methods in ground water, and geological engineering design.

Dr. Davis is a Registered Professional Engineer in South Dakota. He also is a member of the Society for Mining, Metallurgy, and Exploration (SME). He has served as associate editor and reviewer for the journal of Ground Water, and as a book reviewer for the Bulletin of the Association of Engineering Geologists. He has served as chairman of the Council of Education and the Accreditation and Curricular Issues Committee of the Society for Mining, Metallurgy, and Exploration. From 2002 to 2007, Dr. Davis served on the Engineering Accreditation Commission of ABET. In 2007, he was appointed to the ABET Board of Directors and served a three-year term. In 2010, he was re-appointed to the ABET Board of Directors.

During his career at South Dakota School of Mines and Technology, Dr. Davis has worked extensively on ground-water projects and geological engineering site evaluations. He has been an investigator in more than fifty funded research projects. As a consultant he has provided expert witness testimony in cases involving environmental contamination and disposal of waste. He also has given technical assistance to the South Dakota Department of Environment and Natural Resources in the review of mining plans and ground-water contamination problems, including Superfund sites. He and his co-researchers hold a U.S. patent for removal of arsenic from water, and they have applied for a second patent for removal of metals from water.

In his service to South Dakota School of Mines and Technology, Dr. Davis has acted as Geological Engineering Program Coordinator and ABET Coordinator for geological engineering accreditation. This included revision of the geological engineering curriculum, origination and teaching of new engineering design courses, and preparation of ABET reports. He also is active in ground-water protection efforts, and in 1998 received the Virginia Simpson Award for community service in the Rapid City area. In 2007, he received the Ennenga Award for Excellence in Teaching. In 2014 he received the Ivan Rahn Education Award from SME, and in 2015 he was presented with the Distinguished Service Award of the Environmental Division of SME.

Arden D. Davis

Academic rank:	Professor, Department of Geology and Geological Engineering	
Education:	B.A. - 1971	University of Minnesota (Geology)
	M.S. - 1979	South Dakota School of Mines and Technology (Geological Engineering)
	Ph.D.- 1983	South Dakota School of Mines and Technology (Geological Engineering)

Registered Professional Engineer (South Dakota; No. 4663)

Experience:	2006 - present	Professor S.D. School of Mines and Technology
	2002 - 2006	Chairman Dept. of Geology and Geological Engineering S.D. School of Mines and Technology
	1995 - 2002	Professor S.D. School of Mines and Technology
	1989 - 1994	Associate Professor S.D. School of Mines and Technology
	1984 - 1989	Assistant Professor S.D. School of Mines and Technology
	1982	Instructor
	1976-1982	Teaching and Research Assistant
	1978	Shell Development (Shell Oil Company)

Teaching:	Digital Modeling of Ground-Water Flow Systems, Ground Water, Ground-Water Geochemistry, Geochemistry, Analytical Methods in Ground Water, Advanced Ground Water, Engineering Field Geology, Geological Engineering Design Project I
Consulting:	Ground-water hydrologist and geological engineering consultant for numerous projects over past thirty years involving ground-water contamination, aquifer evaluation, low-level radioactive waste site evaluation, spring-flow measurements, and mine site development.
Funded research:	Projects involving ground-water contamination, ground-water resource evaluation, aquifer vulnerability, water quality, and mine waste.
Community service:	Ground-water protection efforts (see following pages).
Theses:	Forty eight M.S. theses and twelve Ph.D. dissertations supervised.

Consulting:

2015 Siting of pipeline; water rights application
2014 Spring discharges
2013 Spring discharges
2012 Expert witness testimony – proposed pipeline
2011 Spring discharges
2010 Madison aquifer well for municipal water supply.
2009 Expert witness testimony: springs and potential effects of nearby wells.
2008 Ground-water model for permit application.
2007 Siting of new Madison wells for public water supplies in the Black Hills.
2006 Modeling of ground-water flow and biodegradation of benzene.
2005 Modeling of ground-water flow and gasoline contamination.
2004 Ethylene dibromide contamination; expert witness.
2003 Alliance of Architects and Engineers; expert witness.
2002 Alliance of Architects and Engineers; expert witness.
2001 Consolidated Engineers & Materials Testing; GeoTek; expert witness.
2000 Hillcrest Spring Water; Rapid City Landfill; expert witness.
1999 Boyd County LLW Monitoring Committee; Gill Landfill modeling.
1998 Boyd County LLW Monitoring Committee; Rapid City Landfill.
1997 Boyd County LLW Monitoring Committee; Terra, Inc., modeling.
1996 Terra, Inc., modeling; Boyd County LLW Monitoring Committee.
1995 Terra, Inc.; modeling for City of Ida Grove, Iowa; Vogel Paint and Wax.
1994 Keystone Gold Project, Keystone, South Dakota.
Dunbar Resort: proposed railroad grade, Deadwood, South Dakota.
Vogel Paint and Wax Superfund Site, Maurice, Iowa.
1993 Keystone Gold Project, Keystone, South Dakota.
Vogel Paint and Wax Superfund Site, Maurice, Iowa.
Low-level radioactive waste site evaluation and modeling.
1992 City of Rapid City: criteria for private wastewater disposal facilities.
Nitrate contamination from mine waste.
1991 Corrosion problems during geothermal heating.
1990 Low-level radioactive waste site evaluation.
South Dakota Department of Environment and Natural Resources: cyanide contamination.
1989 Wastewater facility site evaluation.
South Dakota Department of Environment and Natural Resources: review of mine plan, northern Black Hills.
1988 Expert witness: gasoline contamination of ground water.
1987 South Dakota Department of Environment and Natural Resources: modeling of gasoline contamination.
Utility Engineering Company: aquifer test evaluation.
Gasoline contamination of ground water.
1986 South Dakota Department of Environment and Natural Resources.
1985 South Dakota Department of Environment and Natural Resources: ground-water contamination.

1983 Rosebud Sioux Tribe: aquifer evaluation.
1981 Save Wyoming Water: drawdown calculations.
South Dakota Public Utilities Commission: aquifer evaluation.
1981 Evans Plunge, Hot Springs, South Dakota: spring discharges.
1979 U.S. Environmental Protection Agency; Engineering Science, Inc.

Community Service:

Assisted City of Rapid City and Pennington County in determining aquifer vulnerability in the Rapid City area. Assisted U.S. Environmental Protection Agency and South Dakota Department of Environment and Natural Resources as member of Technical Advisory Team, Gilt Edge Superfund Site.

Selected Publications:

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Related research:

Grainger Prize for Sustainability: HydroTech Engineering and Rohm & Haas (collaboration): Limestone-based arsenic-removal method; selected for Round II of competition.

Recent Research Funding:

National Science Foundation: SGER: Characterization of the Precambrian Aquifer at the Homestake DUSEL: Dr. Larry D. Stetler, Dr. Arden D. Davis, and Dr. Rohit Salve (Lawrence Berkeley Laboratory), $75,000.

U.S. Geological Survey 104b Grant Program / South Dakota Water Resources Institute: Acidic Leaching Tests to Determine Arsenic Mobility from Concrete-Encapsulated Limestone Waste: Dr. Arden D. Davis, Dr. M.R. Hansen, and Dr. David J. Dixon, $12,131.

U.S. Geological Survey 104b Grant Program / South Dakota Water Resources Institute: Investigation of Arsenic Removal from Water by Microbiologically Induced Calcite Precipitation: Dr. Arden D. Davis, Dr. Sookie S. Bang, and Dr. David J. Dixon, $13,983.

U.S. Bureau of Land Management: Belle Eldridge Mine Sampling and Monitoring, Phase III, $4,500 (additional); Arden D. Davis, Principal Investigator.

U.S. Geological Survey 104b Grant Program / South Dakota Water Resources Institute: Development of an agglomeration process to increase the efficiency of limestone-based material to remove metals from drinking water: Dr. Arden D. Davis and Dr. David J. Dixon, $10,897.

U.S. Geological Survey 104b Grant Program / South Dakota Water Resources Institute: Fixed-bed adsorption column studies and engineering scale-up design of a limestone-based metals removal technology for small water supply systems: Dr. Arden D. Davis and Dr. David J. Dixon, $12,918.

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U.S. Department of the Interior, National Park Service; Jewel Cave Pumping Test; Dr. Arden D. Davis, Principal Investigator; $8,800.

U.S. Bureau of Land Management: Belle Eldridge Mine Sampling and Monitoring, Phase III, $4,500 (additional); Arden D. Davis, Principal Investigator.

West Dakota Water Development District: Determination of historic ground water pollution problems, Part II: Pactola Dam, Rapid City West, and the North One-Half of Rockerville quadrangles; $9,162; Dr. Alvis L. Lisenbee, Principal Investigator; Dr. Arden D. Davis, Co-Principal Investigator.

West Dakota Water Development District: Aquifer susceptibility study of the Pactola Dam quadrangle, South Dakota: Part II – Precambrian: $9,112; Dr. Alvis L. Lisenbee, Principal Investigator; Dr. Arden D. Davis, Co-Principal Investigator.

West Dakota Water Development District: Aquifer mapping (1:24,000) of the Hermosa NW quadrangle; $13,538; Dr. Alvis L. Lisenbee, Principal Investigator; Dr. Arden D. Davis and Dr. Larry Dr. Stetler, Co-Principal Investigators.

West Dakota Water Development District: Preliminary aquifer vulnerability and susceptibility study of the Blackhawk quadrangle; $15,988; Dr. Alvis Lisenbee, Principal Investigator; Dr. Arden D. Davis, Co-Principal Investigator.

West Dakota Water Development District: Geologic mapping of the Mt. Rushmore quadrangle, South Dakota; $14,970; Dr. Alvis Lisenbee, Principal Investigator; Dr. Arden D. Davis, Co-Principal Investigator.

West Dakota Water Development District: Aquifer vulnerability study of the Rockerville quadrangle, South Dakota; $14,763; Dr. Alvis Lisenbee, Principal Investigator; Dr. Arden D. Davis, Co-Principal Investigator.

Phase I Small Business Innovation Research Grant, U.S. Environmental Protection Agency, Limestone-Based Material for Arsenic Removal from Drinking Water: Dr. Cathleen J. Webb, Dr. Arden D. Davis, Dr. David J. Dixon, and Dr. Terrence L. Williamson; $100,000.

Phase II Small Business Innovation Research Grant, U.S. Environmental Protection Agency, Limestone-Based Material for Arsenic Removal from Drinking Water: Dr. Cathleen J. Webb, Dr. Arden D. Davis, Dr. David J. Dixon, and Dr. Terrence L. Williamson; $225,000.

National Science Foundation, Statewide Partnership to Support Technology Innovation and Entrepreneurship in South Dakota (PFI), University of South Dakota: Arsenic Removal from Drinking Water; John C. Lofberg, Dr. Arden D. Davis, and Dr. David J. Dixon; $35,826.

West Dakota Water Development District: Crystalline Aquifers of the Central Black Hills, South Dakota: Phase IV: Dr. Alvis L. Lisenbee, Dr. Arden D. Davis, and Dr. Maribeth Price; $44,000.

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U.S. Geological Survey 104b Grant Program / South Dakota Water Resources Institute: Investigation of the Contribution of Coliform Contamination in Runoff from Scoured Bed Sediments: Dr. Jennifer L. Benning, Dr. Scott J. Kenner, and Dr. Arden Davis, $14,913.

West Dakota Water Development District: Crystalline Aquifers of the Central Black Hills, South Dakota: Phase II; Dr. Laurie Anderson, Principal Investigator; Dr. Alvis L. Lisenbee, Dr. Arden D. Davis, and Dr. Maribeth H. Price, Co-Principal Investigators; $33, 020.

Pete Lien and Sons, Inc: Optimization and characterization of iron-loaded limestone as a medium for the removal of arsenic from drinking water; Dr. Arden D. Davis, Principal Investigator; Dr. David J. Dixon, Co-Principal Investigator; $8,800.

City of Custer, South Dakota: Water Sampling of Crystalline and Alluvial Aquifers at Custer, South Dakota: Dr. Arden D. Davis, Principal Investigator; Dr. J. Foster Sawyer, Dr. Alvis L. Lisenbee, and Dr. Maribeth H. Price, Co-Principal Investigators; $25,000.

U.S. Department of the Interior, Bureau of Land Management: Environmental Monitoring of the Belle Eldridge Mine: Dr. Arden D. Davis, Principal Investigator; $5,000.