2006

WESTERN SOUTH DAKOTA HYDROLOGY CONFERENCE

Program and Abstracts

April 18, 2006
Rushmore Plaza Civic Center
Rapid City, South Dakota

TABLE OF CONTENTS

2006 Western South Dakota Hydrology Conference

This program and abstracts book has been produced in conjunction with the 2006 Western South Dakota Hydrology Conference, held at the Rushmore Plaza Civic Center on April 18, 2006. The purpose of this book is to provide summaries of the presentations made during the conference.

The purpose of the 2006 Western South Dakota Hydrology Conference is to bring together researchers from Federal, State, University, local government, and private organizations and provide a forum to discuss topics dealing with hydrology in western South Dakota. This conference provides an opportunity for hydrologists, geologists, engineers, scientists, students, and other interested individuals to meet and exchange ideas, discuss mutual problems, and summarize results of studies. The conference consists of four technical sessions and a keynote luncheon speaker. The topics of the technical sessions include surface-water quality and ecology; contaminants and aquifer vulnerability; surface-water modeling; and water supply, resources, and management.

Acknowledgments

Many people have contributed to this conference. The many presenters are thanked for their contributions. The moderators are thanked for their help in streamlining the technical sessions. The help by many students from the South Dakota School of Mines and Technology with presentations and lights is greatly appreciated. Keynote speaker, Dr. James Fox, is thanked for his time and perspectives.

Registration help by Sheri Meier (USGS) is greatly appreciated. Brenda Athow (USGS) provided computer support for the conference. Connie Ross (USGS) designed the conference Web site.

The sponsoring organizations are thanked for support: South Dakota Department of Environment and Natural Resources, South Dakota Engineering Society, South Dakota School of Mines and Technology, U.S. Geological Survey, and West Dakota Water Development District. The chairpersons for this conference were J. Foster Sawyer (South Dakota Department of Environment and Natural Resources), Arden D. Davis (South Dakota School of Mines and Technology), Scott J. Kenner (South Dakota School of Mines and Technology), Janet M. Carter (U.S. Geological Survey), Daniel G. Driscoll (U.S. Geological Survey), Van A. Lindquist (West Dakota Water Development District), and Jenifer Sorensen (South Dakota Engineering Society).

CONFERENCE PROGRAM

Tuesday, April 18, 2006
Alpine/Ponderosa Rooms
Rushmore Plaza Civic Center

7:15 - 8:00 a.m. .... Registration
8:00 - 8:10 a.m. .... Welcome, general information

Session 1 – Surface-Water Quality and Ecology (1.5 PDH)
8:10 - 9:50 a.m.
Alpine/Ponderosa Rooms

Moderator: **Dan Driscoll,** Chief of Hydrologic Studies, U.S. Geological Survey South Dakota Water Science Center, Rapid City, South Dakota

Presentations

8:10 – 8:30 a.m. - [1-1] M. Anderson and Woosley, *Water availability for the Western United States—Key scientific challenges*

8:30 – 8:50 a.m. - [1-2] Hoyer and Schwickerath, *Belle Fourche River watershed restoration implementation, Belle Fourche River, South Dakota*

8:50 – 9:10 a.m. - [1-3] Erickson and Shearer, *Appearance of Didymosphenia geminata in the Black Hills of South Dakota*

9:10 – 9:30 a.m. - [1-4] Foreman and Hoyer, *Historic data analysis for the lower Cheyenne River watershed*

9:30 – 9:50 a.m. - [1-5] Patceg, Dababneh, Foreman, and Kenner, *Physical habitat assessment classification of the Cheyenne River below Angostura Dam*

9:50 – 10:15 a.m. .... Refreshment break

Session 2 – Contamination and Aquifer Vulnerability (1.0 PDH)
10:15 a.m. - 11:35 a.m.
Alpine/Ponderosa Rooms

Moderator: **Derric Iles,** State Geologist, South Dakota Department of Environment and Natural Resources, Geological Survey Program, Vermillion, South Dakota

Presentations

10:15 – 10:35 a.m. - [2-1] Stone, Stetler, Schwalm, Wintergerst, Walters-Clark, *Soil, water and air investigation concerning abandoned uranium mines in North Cave Hills Region, Custer National Forest*

10:35 – 10:55 a.m. - [2-2] Rahn, *Nitrate in Rapid City's water supply*

10:55 – 11:15 a.m. - [2-3] Long, Putnam, and Sawyer, *Environmental tracers as indicators of fast ground-water flowpaths and potential anthropogenic influence in the karstic Madison aquifer*

11:15 – 11:35 a.m. - [2-4] Sorensen, Davis, Dixon, and Webb, *Controlling factors on arsenic removal from water by limestone-based materials*

11:35 a.m. – 1:05 p.m. .... Luncheon

Rushmore H Room

Keynote speaker: Dr. James Fox (1.0 PDH)

South Dakota School of Mines and Technology

james.fox@sdsmt.edu

Title: ***New Orleans, the Next Atlantis?***

Session 3 – Concurrent Session in Alpine Room
Hydrology Potpourri (1.5 PDH)
1:05 – 2:45 p.m.

Moderator: **Dr. Arden Davis**, Professor and Chairman, Geology and Geological Engineering Department, South Dakota School of Mines and Technology, Rapid City, South Dakota

Presentations

1:05 – 1:25 p.m. - [3-1A] Huq, *Mni Wiconi Rural Water that supplies water to one-sixth of South Dakota including Three Indian Reservations*

1:25 – 1:45 p.m. - [3-2A] Olson, Kenner, and Hoyer, *Operational model of the Belle Fourche Irrigation District*

1:45 – 2:05 p.m. - [3-3A] Shmagin and Chen, *Understanding and mapping water resources by multidimensional statistics and fuzzy logic: Missouri River Basin case*

2:05 – 2:25 p.m. - [3-4A] Doubková and Henebry, *Sensitivity of the AMSR-E Vegetation Water Content product to precipitation events and mid-season dry spells*

2:25 – 2:45 p.m. - [3-5A] Wiles, *The potential extent of the Jewel Cave System*

Session 3 – Concurrent Session in Ponderosa Room
Surface-Water Modeling (1.5 PDH)
1:05 - 2:45 p.m.

Moderator: **Jenifer Sorensen,** South Dakota Engineering Society, Rapid City, South Dakota

Presentations

1:05 – 1:25 p.m. - [3-1P] Love and Donigian, *Complex watershed modeling in a semi-arid region with irrigation applications and channel losses*

1:25 – 1:45 p.m. - [3-2P] Love and Donigian, *The Unnamed River watershed model: model sensitivity and uncertainty analyses*

1:45 – 2:05 p.m. - [3-3P] Brich and Nelson, *An AnnAGNPS Non-Point Source Pollution Model ArcGIS interface*

2:05 – 2:25 p.m. - [3-4P] Wood, Wylie, Brown, Meyer, Maxwell, Reed, Kruger, and Brich, *Range condition as input to water-quality monitoring*

2:25 – 2:45 p.m. - [3-5P] Schoenfelder, Kenner, and Hoyer, *Hydraulic model of the Belle Fourche Irrigation District using EPA SWMM 5.0*

2:45 - 3:10 p.m. ....Refreshment break

Session 4 – Water Supply, Resources, and Management (1.5 PDH)
3:10 - 4:50 p.m.
Alpine/Ponderosa Rooms

Moderator: **Van Lindquist,** Administrative Manager, West Dakota Water Development District, Rapid City, South Dakota

Presentations

3:10 – 3:30 p.m. - [4-1] Everett, *South Dakota Forestry best management practices—Field audit and training project*

3:30 – 3:50 p.m. - [4-2] Driscoll and Sando, *Complicating factors for flood-frequency analysis for the Black Hills area of western South Dakota*

3:50 – 4:10 p.m. - [4-3] Patrick, Wegleitner, and Martin, *New methods in stratigraphic correlation: Pierre Shale, South Dakota*

4:10 – 4:30 p.m. - [4-4] Smith, *The National Weather Service's Hydrology Program*

4:30 – 4:50 p.m. - [4-5] C. Anderson, *Sedimentation in Reclamation's South Dakota Reservoirs*

4:50 - 5:00 p.m. ....Closing remarks

TUESDAY, APRIL 18, 2006
SESSION 1
8:10 - 9:50 A.M.

SURFACE-WATER QUALITY AND ECOLOGY

Water Availability for the Western United States—Key Scientific Challenges

Mark T. Anderson
U.S. Geological Survey South Dakota Water Science Center, 1608 Mt. View Road, Rapid City, SD 57702, manders@usgs.gov

Lloyd H. Woosley, Jr.
U.S. Geological Survey, Office of Water Information, 440 National Center, Reston, VA 20192, lwoosley@usgs.gov

In the Western United States, the availability of water has become a serious concern for many communities and rural areas. Near population centers, surface-water supplies are fully appropriated, and many communities are dependent upon ground water drawn from storage, which is an unsustainable strategy. Water of acceptable quality is increasingly hard to find because local sources are allocated to prior uses, depleted by overpumping, or diminished by drought stress. Some of the inherent characteristics of the West add complexity to the task of securing water supplies. The Western States, including the arid Southwest, have the most rapid population growth in the United States. The climate varies widely in the West, but it is best known for its low precipitation, aridity, and drought. There is evidence that the climate is warming, which will have consequences for Western water supplies, such as increased minimum streamflow and earlier snowmelt events in snow-dominated basins. The hydrologic sciences have defined the interconnectedness of ground water and surface water, yet these resources are still administered separately by most States. The definition of water availability has been expanded to include sustaining riparian ecosystems and individual endangered species, which are disproportionately represented in the Western States. The minimum amount of water required, however, to sustain native peoples, a riparian system, or an endangered species eventually will need to be known in order to manage the available water supply. Periodic inventory and assessment of the amounts and trends of water available in surface water and ground water are needed to support water management. There is a widespread perception that the amount of available water is diminishing with time. This and other perceptions about water availability should be replaced by objective data and analysis. Some data are presented here for the major Western rivers that show that flows are not decreasing in most streams and rivers in the West. Systematic information is lacking to make broad assessments of ground-water availability, but available data for specific aquifers indicate that these aquifers are being depleted, especially near population centers.

Belle Fourche River Watershed Restoration Implementation, Belle Fourche River, South Dakota

Dr. Dan P. Hoyer, Vice President
RESPEC Water and Natural Resources, P.O. Box 725, Rapid City, SD 57709,
Dan.Hoyer@respec.com

Patrick D. Schwickerath, Engineer
RESPEC Water Resources, P.O. Box 725, Rapid City, SD 57709, pdschwi@respec.com

The Belle Fourche River Watershed, located in western South Dakota, drains approximately 3,300 square miles. The river flows to the Cheyenne River in Meade County and ultimately to the Missouri River. The watershed receives an annual precipitation of 14–28 inches.

The Belle Fourche River is identified in the 2004 Integrated Report for Surface Water Quality Assessment by the South Dakota Department of Environment and Natural Resources as impaired due to elevated total suspended solids (TSS) and fecal coliform concentrations. The Total Maximum Daily Load (TMDL) report for TSS for this watershed has been completed and approved by Environmental Protection Agency (EPA). The TMDL for fecal coliform has been completed and submitted to EPA. Beginning in 2004, the Belle Fourche River Watershed Partnership began the Belle Fourche River Watershed Management and Project Implementation Plan to improve TSS. The goal of the implementation plan is to bring the Belle Fourche River into compliance for TSS within 10 years and to implement additional Best Management Practice (BMP) recommendations from other TMDLs for waterbodies within the watershed as they become available.

Approximately 10 types of BMPs have been installed during implementation including flow automation units, irrigation pipeline, lining open irrigation ditches, installation of irrigation sprinkler systems, off-stream water supplies, and managed grazing. The implementation of these BMPs will reduce TSS concentrations an estimated 24 mg/L by the end of 2006. Other products of the implementation plan included a Ten-Year Belle Fourche River Watershed Strategic Implementation Plan and the Belle Fourche Irrigation District Water Conservation Plan.

The fecal TMDL for the Belle Fourche River from the Wyoming/South Dakota state line was written due to fecal coliform concentrations exceeding the immersion recreation beneficial use. Bacteria source tracking sampling completed during the associated watershed assessment showed no human or cattle contamination.

Appearance of *Didymosphenia geminata* in the Black Hills of South Dakota

Jack W. Erickson
South Dakota Department of Game, Fish and Parks, 20641 South Dakota Highway 1806, Ft. Pierre, SD 57532, Jack.Erickson@state.sd.us

Jeff S. Shearer
South Dakota Department of Game, Fish and Parks, 3305 West South Street, Rapid City, SD 57702, Jeff.Shearer@state.sd.us

Rapid Creek (Black Hills, South Dakota) from Pactola Reservoir downstream through Rapid City has traditionally been one of the two best brown trout *Salmo trutta* fisheries in the state of South Dakota. Trout productivity has averaged 25.0 g / m^2 within the city of Rapid City making Rapid Creek one of the most productive trout waters in the western United States. But in recent years the number of adult ($\geq$ 8-inch) brown trout has experienced sharp declines. Several environmental variables can be associated with the reduction in brown trout numbers. Of particular concern is the presence of a diatom, *Didymosphenia geminata*. This diatom was first reported in Rapid Creek in 2002 and has displayed characteristics of an aquatic invasive species, spreading throughout a 20-mile reach of Rapid Creek between Pactola Dam and Rapid City. *Didymosphenia geminata* mats have exceeded 95% coverage of the stream substrate in some locations. To date, no direct links have been made between *Didymosphenia geminata* and a decline in trout fisheries. Low flows from a 6-year drought coupled with controlled water releases out of Pactola Reservoir have also contributed to the recent decline in the Rapid Creek brown trout fishery. South Dakota Game, Fish and Parks stocked catchable rainbow trout in 2005 to provide anglers with a short-term recreational fishery. Long-term solutions include research into the interactions between *Didymosphenia geminata*, aquatic insects, and the fish population and working with water users on Rapid Creek to provide for more stable flows during drought conditions.

Historic Data Analysis for the Lower Cheyenne River Watershed

Cory S. Foreman, Engineer
RESPEC Water & Natural Resources, P.O. Box 725, Rapid City, SD 57709,
Cory.Foreman@respec.com

Dr. Dan P. Hoyer, Vice President
RESPEC Water & Natural Resources, P.O. Box 725, Rapid City, SD 57709,
Dan.Hoyer@respec.com

A Phase I Total Maximum Daily Load (TMDL) assessment project for the Cheyenne River Watershed in western South Dakota was initiated in the spring of 2005. The focus area of this project is the Cheyenne River Watershed below Angostura Reservoir, near Hot Springs, South Dakota, to the mouth of the river where it meets Oahe Reservoir. A key component of this project is a historical data analysis of discharge and water quality data available for the watershed.

A total of 93 gaging stations for water quality and discharge data are located in the Cheyenne River Watershed below Angostura Reservoir (excluding the Belle Fourche River Watershed). From these 93 gages, key stations with large data sets were selected for a more detailed data analysis. Types of analysis included annual and monthly descriptive statistics of water quality parameters, trilinear diagrams of cation/anion relationships, flow and load duration curves, and **FLUX** annual loading estimates. Much of this analysis was used for development of spatial data layers representing water quality conditions in the watershed. The spatial data layers for water quality were statistically correlated with physical habitat data collected at 48 sites.

The combination of water quality analysis and physical habitat data analysis will give insight to the source areas of impairment in the watershed. The results of the analysis will be used for widespread public outreach to gather additional insight to the workings of the watershed. This will ultimately lead to a detailed sampling plan for further TMDL development, with participation and guidance from an active stakeholders group for the Cheyenne River Watershed. Phase I of this project will be complete by October 2006.

Physical Habitat Assessment Classification of the Cheyenne River below Angostura Dam

Andrew J. Pacteg, Graduate Engineering Student
South Dakota School of Mines and Technology, 501 East St. Joseph Street, Rapid City, SD 57701, Patceg@gmail.com

Alumed Dababneh, Doctoral Engineering Student
South Dakota School of Mines and Technology, 501 East St. Joseph Street, Rapid City, SD 57701, Jemie77@hotmail.com

Cory S. Foreman, Engineer
RESPEC Water & Natural Resources, P.O. Box 725, Rapid City, SD 57709, Cory.Foreman@respec.com

Dr. Scott Kenner, Professor of Civil Engineering
Department of Civil and Environmental Engineering, South Dakota School of Mines and Technology, 501 East St. Joseph Street, Rapid City, SD 57701, Scott.Kenner@sdsmt.edu

The Cheyenne River discharges into the Missouri River at Oahe Reservoir. The watershed is approximately 24,240 square miles and is located in western South Dakota and eastern Wyoming. The Cheyenne River Watershed has several lakes and stream segments listed as impaired due to exceedences of water quality standards for various water quality parameters.

Forty-eight sites were established for classification and assessment of physical habitat following the South Dakota Department of Environment and Natural Resources standard operating procedures as well as data requirements from the Environmental Protection Agency's Environmental Monitoring and Assessment Program (EMAP). The sites ranged in location from Angostura Dam on the Cheyenne River to a few miles upstream of Oahe Reservoir. Several sites were located on tributaries to the Cheyenne River. Sites were spaced to efficiently characterize the stream gradient from the upper portions of the basin down to the outlet of the river.

Rosgen's geomorphic classification and Schumm's five-stage channel evolution model were used to classify each site. Metrics were calculated from physical habitat measurements taken at each site. Kruskal-Wallis statistical test was used to find metrics with greatest variability among the sites. Sites were categorized based on channel types, vegetation types, and classifications, allowing the sites to be "lumped" together into groups of similar habitats.

Characterization of stream types based upon physical habitat metrics aided the watershed analysis, calling attention to areas of rapid change within a particular stream segment in the Cheyenne River Watershed. A spatial description of the watershed was used to identify areas recommended for further monitoring, laying the foundation for a detailed and focused sampling plan focused on areas identified as contributing to impairment, for development of Total Maximum Daily Load (TMDL) reports for impaired stream segments.

TUESDAY, APRIL 18, 2006
SESSION 2
10:15 A.M. - 11:35 A.M.

CONTAMINATION AND AQUIFER VULNERABILITY

Soil, Water and Air Investigation Concerning Abandoned Uranium Mines in North Cave Hills Region, Custer National Forest

Dr. James Stone, P.E., Assistant Professor
Department of Civil and Environmental Engineering, South Dakota School of Mines and Technology, 501 E. Saint Joseph St., Rapid City, SD 57701, james.stone@sdsmt.edu

Dr. Larry Stetler, Associate Professor
Department of Geology and Geological Engineering, South Dakota School of Mines and Technology, 501 E. Saint Joseph St., Rapid City, SD 57701, Larry.Stetler@sdsmt.edu

Dr. Albrecht Schwalm
Oglala Lakota College, 490 Piya Wiconi, Kyle, SD 67752, aschwalm@olc.edu

Robert Wintergerst
USFS Northern Regional Office, P.O. Box 7669, Missoula, MT 59807, rwintergerst@fs.fed.us

Laurie Walters-Clark
USFS Sioux Ranger District, P.O. Box 37, Camp Crook, SD 57724, lwaltersclark@fs.fed.us

During the late 1950s and early 1960s a substantial amount of prospecting and mining of uranium resources occurred in western South Dakota, southeastern Montana, and northeast Wyoming. As a result of these historic activities, degradation of both land and water resources have occurred as a result of the migration of the contaminated material by water and wind erosion. Through US-EPA CERCLA funding, a Joint Venture Agreement between the USDA-Forest Service Northern Region Office and the South Dakota School of Mines and Technology (SDSM&T) has been established to evaluate impacts to soil, water, and air resources, as well as, potential impacts to human health stemming from the migration of contaminated material from past mining activities on or adjacent to lands that administered by the USFS Sioux Ranger District. The initial phase of this Joint Venture, in collaboration with Oglala Lakota College, will be the assessment of off-site soil, water, and air contamination from abandoned mines located in the North Cave Hills region (Riley Pass mines) within Harding County, SD. The presentation will discuss environmental impacts from regional historical uranium mining operations, summarize current knowledge regarding on-site contamination, and outline the methodology of the "air and watershed" approaches developed to assess off-site contamination.

Nitrate in Rapid City's Water Supply

Dr. Perry H. Rahn
Department of Geology & Geological Engineering, South Dakota School of Mines and Technology, Rapid City, SD 57701, perry.rahn@sdsmt.edu

Nitrate concentration is increasing in Rapid City's municipal wells. Wells #5, #6, #8, #9, #10, and #11 were drilled to the Madison Limestone in 1991-92, and yearly samples for 1993-2005 show nitrate (as nitrogen) concentration in these wells fairly consistently increasing from roughly 0.15 to 0.35 mg/L. Well #8 is furthest from the Madison outcrops and has the lowest concentration. The nitrate concentration is still below the EPA drinking water limit of 10 mg/L. Nevertheless, the increasing concentration is disconcerting because it is clearly anthropogenic but its cause is not known.

Meadowbrook Gallery and Girl Scout Gallery obtain water from alluvium, and by induced infiltration from Rapid Creek. These two water sources show slightly declining nitrate concentration, roughly from about 1.3 mg/L in 1993 to 1.0 mg/L in 2005. These relatively high values probably reflect fertilizers used in the Meadowbrook golf course and other places and/or high nitrate in Rapid Creek.

Jackson Spring shows nitrate concentration increasing from roughly 0.25 to 0.35 mg/L. This water originates from a resurgent spring (as part of the "Jackson Spring/Cleghorn Springs complex"); the nitrate probably reflects the general composition of the ground water in the Madison aquifer as well as Rapid Creek.

The nitrate could come from a number of sources: (1) Streams recharging the Madison aquifer at the sinkhole "loss zones" along Rapid, Boxelder, and Spring Creeks. (2) On-site wastewater systems upgradient from the city wells. Over 1,000 upgradient on-site wastewater systems exist within three miles of the city wells. (3) Fertilizers from home sites and/or agricultural areas. Commercial agriculture is probably not the main reason for increasing nitrate in the city wells because there are no feedlots and practically no farmlands (where fertilizers may be used) on the recharge areas of the Madison aquifer. (4) Explosives used for mining. This is probably not the cause of nitrate in Rapid City's water supply.

Environmental Tracers as Indicators of Fast Ground-Water Flowpaths and Potential Anthropogenic Influence in the Karstic Madison Aquifer

Andrew J. Long
U.S. Geological Survey South Dakota Water Science Center, 1608 Mt. View Road, Rapid City, SD 57702, ajlong@usgs.gov

Larry D. Putnam
U.S. Geological Survey South Dakota Water Science Center, 1608 Mt. View Road, Rapid City, SD 57702, ldputnam@usgs.gov

J. Foster Sawyer
South Dakota Geological Survey, 2050 West Main Street, Suite #1, Rapid City, SD 57702, foster.sawyer@state.sd.us

Fast ground-water flowpaths within the karstic Madison aquifer result in vulnerability to potential contaminants for many public water supplies located on or near the eastern flank of the Black Hills of South Dakota. Environmental tracers were used to better define these flowpaths and to assess early indications of anthropogenic influence. Forty wells open to the Madison aquifer, most of which were public supply wells, were sampled once during October 2005 to assess the spatial distribution of environmental tracers. Chlorofluorocarbons and tritium were used to estimate ground-water age, and specific conductance was used as an indicator of relative residence time, which is possible because of the time-dependent dissolution of carbonate rocks. Anomalies of young ground-water age and low specific conductance indicated the location and orientation of probable fast flowpaths, which originate where streams sink into the outcrop of the Madison Limestone. Stable isotopes were used to better define source-water recharge areas for these flowpaths, and nitrogen and phosphorous were used as indicators of potential anthropogenic influence. The highest nitrogen and phosphorous concentrations generally occurred within or near these flowpaths, which may indicate the influence of population growth and development on and upgradient from recharge areas in recent years. The estimated flowpath from the Boxelder Creek recharge area is initially to the southeast, then turns toward the northeast. The estimated flowpath from the Spring Creek recharge area bifurcates: one branch flows to the north toward Jackson-Cleghorn Springs and one to the east or southeast. The ground-water flowpaths from Boxelder Creek and the north branch of Spring Creek coincide with the results of previous dye tracing. For Rapid Creek recharge, the ground-water flowpath is not distinguishable based on environmental tracers.

Controlling Factors on Arsenic Removal from Water by Limestone-Based Materials

Jenifer L. Sorensen, P.E.
South Dakota School of Mines and Technology, 501 East St. Joseph St., Rapid City, SD 57701, jensorensen@rushmore.com

Arden D. Davis, P.E., Ph.D.
South Dakota School of Mines and Technology, 501 East St. Joseph St., Rapid City, SD 57701, arden.davis@sdsmt.edu

David J. Dixon, Ph.D.
South Dakota School of Mines and Technology, 501 East St. Joseph St., Rapid City, SD 57701, david.dixon@sdsmt.edu

Cathleen J. Webb, Ph.D.
Western Kentucky University, 1 Big Red Way, Bowling Green, KY, cathleen.webb@wku.edu

With the recent lowering of the drinking water maximum contaminant level for arsenic from 50 to 10 parts per billion (ppb), there is a renewed interest in the development of lower-cost innovative treatment technologies that can be applied to smaller drinking water systems. A thorough understanding of the process of arsenic removal by limestone-based material requires both macroscopic and microscopic investigations that provide information on the removal process at different scales.

Methods used during this research to characterize the arsenic removal process by limestone-based material include physical characterization of the material, quantification of the removal rate and capacity of the material, and definition of the chemical reactions driving the removal process. Materials characterization included analyses to determine and quantify physical properties including size, surface area, porosity, and mineralogy. Equilibrium, kinetic, and temperature adsorption studies provided information on the adsorption capacity of the material under different conditions, including changes in temperature, pH, adsorbent dosage, particle size, initial arsenic concentration, interference ions, and real water quality conditions.

Adsorption studies are limited in scope – they can only monitor changes in solution chemistry and provide indirect information on the nature of the adsorption process. To better understand the molecular-level interactions between arsenic and limestone-based material, an existing surface complexation model of the calcite-water interface was extended to include arsenic surface complexes.

Efforts were also made to improve the arsenic removal efficiency of the limestone-based material through the use of additives and the process of agglomeration. The process of agglomeration involved mechanically forming limestone powder into larger, spherical granules. This process successfully took advantage of the increase in material surface area acquired through agglomeration (as compared to crushed limestone of equal diameter) while not compromising water flow through rates of the material.

TUESDAY, APRIL 18, 2006
LUNCHEON
11:35 A.M. - 1:05 P.M.

NEW ORLEANS, THE NEXT ATLANTIS?

(RUSHMORE H ROOM)

TUESDAY, APRIL 18, 2006
SESSION 3A
1:05 - 2:45 P.M.

HYDROLOGY POTPOURRI
(ALPINE ROOM)

Mni Wiconi Rural Water that Supplies Water to One-Sixth of South Dakota including Three Indian Reservations

Syed Y. Huq, Director
Mni Wiconi – Rosebud Rural Water System, Box 910, Rosebud SD 57570, shuq@sicangu.com

A combination of ground water from the Ogallala Aquifer and surface water from the Missouri River, serves as the source of safe drinking water for a design population of 51,635 in 12 counties including three Indian Reservations over 12,500 square miles of south central South Dakota. The Mni Wiconi Rural Project was authorized by Congress to ensure that adequate water supplies are available to meet the economic, environmental, municipal, and public health needs of the design population. It is the largest rural water project in the country.

Of 3,911 homes on Pine Ridge Reservation, 1,551 homes relied on hauled water or wells producing insufficient water with total dissolved solids (TDS) exceeding 500 mg/L. TDS and sulfates in the West River and Lyman Jones service area averaged 1577 mg/L and 836 mg/L respectively. The Ogallala Aquifer provides good quality water to the southern part of Rosebud Reservation but in the north, water availability is poor in quality and quantity. Also, some portion of the Ogallala Aquifer is contaminated by arsenic, nitrate and hydrocarbons. Water quality is poor in rural homes on the Lower Brule Reservation. Water-borne diseases such as gastroenteritis, shigellosis, dysentery, impetigo, and hepatitis-A were high in the design area as compared to the rest of the State and Nation. Mni Wiconi is already having an impact to bring the numbers of water borne diseases down.

The paucity of good quality water on three Indian Reservations and neighboring non- Indian counties and the resulting hardship suffered by the impoverished population, played out extremely well for our congressional delegation to secure authorization and funding for Mni Wiconi from U.S. Congress, to the tune of 440 million dollars (indexed) for completion by 2008.

The total design flow rate is 13,886 gpm that includes water for 274,811 livestock. Of the total annual usage of 12,474 acre- feet, 8,591 acre- feet will be diverted from the Missouri River and 3,883 acre- feet will be pumped from the Aquifers. Seventy-two percent of the Project has been completed at a cost of 300 million dollars. The project completion includes the intake, treatment plant, pipelines, pumping stations, reservoirs, SCADA, wells development, electrical transmission and secondary service area. Finally, Mni Wiconi is a Lakota term meaning "Water is Life" and it is believed that safe drinking water is a birthright. The Project has generated large number of jobs, economic opportunities and most of all it is reconciliation at its best between Indians and non- Indians.

Operational Model of the Belle Fourche Irrigation District

Tim Olson, Engineering Student
South Dakota School of Mines and Technology, 501 East St. Joseph Street, Rapid City, SD 57701, tjolson@gmail.com

Dr. Scott Kenner, Professor of Civil Engineering
Department of Civil and Environmental Engineering, South Dakota School of Mines and Technology, 501 East St. Joseph Street, Rapid City, SD 57701, Scott.Kenner@sdsmt.edu

Dr. Dan P. Hoyer, Vice President
RESPEC Water and Natural Resources, P.O. Box 725, Rapid City, SD 57709, Dan.Hoyer@respec.com

Operational and transportation efficiency contributes greatly to the amount of non-used water produced in the Belle Fourche Irrigation District (BFID), which, in turn, contributes to the excessive total suspended solids (TSS) load in the Belle Fourche River. An operational model linked with a hydraulic model is being created to improve the operational efficiency of the BFID and to reduce amount of non-used water discharged into adjacent waterways. The operational model is comprised of three main objectives. The first objective is to ensure the correct amount of water is delivered to the Vale Flume, which represents the beginning of a problematic area of the BFID. The model will also eliminate the need for large surges of water to be released from the dam. Surges tend to increase the head at lateral gates and if the additional head is not accounted for, an unknown increase in water is discharged into the lateral. Finally, the operational model will provide operating procedures and rating curves for control check structures. Further, the operational plan for the 2006 irrigation season is discussed.

Understanding and Mapping Water Resources by Multidimensional Statistics and Fuzzy Logic: Missouri River Basin Case

Dr. Boris A Shmagin, Research Associate
Water Resources Institute SDSU, Ag Engineering 211, Box 2120, Brookings, SD 57007,
Boris.Shmagin@sdstate.edu

Dr. Din Chen, Associate Professor
Department of Mathematics and Statistics SDSU, Harding Hall 118, Brookings, SD 57007,
Din.Chen@sdstate.edu

Time series from 46 gauging station with drainage areas from 113 to 398 sq mi in the Upper Missouri River basin with mutual period of observation from 1963 to 1991 were used for analysis. Factor analysis of average annual flow revealed five patterns of river runoff within four distinct subregions of the territory (east, two carbonate karsts areas, uplands). This factor model reflected 62% variance of initial matrix. Each of four groups of watersheds obtained as a factor was presented by one gauging station with time series of annual and monthly discharges (I-06218500, II- 06478690, III- 06412500, and IV- 06323000). Streams represented by patterns I, II and IV have increase of values and those represented by III have a decrease. The positive trend for pattern II is statistically significant. For four typical flow records, monthly average values were obtained from three to four seasons composed of different ensembles of months. The trends for seasonal components were analyzed for four typical watersheds and a significant increase was obtained for fall-winter season for type IV. Stream runoff is the most appropriate regional indicator for hydroclimatological processes. With multidimensional statistics this process can be considered as spatiotemporal structure of different scale of landscape properties and dynamics. Uncertainties of process originating stream runoff based on dynamic of regional meteorological system and diversity of local landscapes. Boundaries for domains with different annul and seasonal regimes of stream runoff were defined with factor loadings and fuzzy logic rules. With case of Missouri River basin presented that more complete decryption of real events in nature requires use probability and fuzzy logic together.

Sensitivity of the AMSR-E Vegetation Water Content Product to Precipitation Events and Mid-Season Dry Spells

Marcela Doubková, M.A. Student
Center for Advanced Land Management Information Technologies (CALMIT), Graduate Program in Geography, University of Nebraska-Lincoln, Lincoln, NE 68588-0517, mdoubkova@calmit.unl.edu

Geoffrey M. Henebry, Ph.D., Professor and Senior Research Scientist
Geographic Information Science Center of Excellence (GIScCE), South Dakota State University, Brookings, SD 57007, Geoffrey.Henebry@sdstate.edu

A key factor in land-atmosphere interactions is the response of vegetation to meteorological conditions. Land surface phenologies are the seasonal spatio-temporal patterns of the vegetated land surface as observed by synoptic sensors at spatial resolutions and extents relevant to meteorological processes in the atmospheric boundary layer. In order to study these complex interactions, synoptic observations are needed at a high temporal frequency. The Vegetation Water Content (VWC) product from Advanced Microwave Scanning Radiometer (AMSR-E) onboard the Aqua satellite provides an important new window onto vegetation responses to recent weather. A multifrequency passive microwave radiometer, AMSR-E has sensitivity to changes in the moisture bound in the canopy and in the uppermost 2 cm of the soil. While the spatial resolution of the AMSR-E Level 3 data products is relatively coarse (25 km), there are twice daily acquisitions at 1:30 and 13:30, thus enabling the study of diel variations in canopy water content.

In this study we analyzed the relationship between VWC and extreme precipitation events and mid-season dry spells in north central Great Plains. In order to characterize the variety of land surface phenologies observed at finer spatial resolution that are contained within the coarser spatial resolution AMSR-E pixel, we employed classification techniques to MODIS image time series data. To track precipitation events, we used data from ground stations and from NEXRAD weather radar.

The results indicate a reduced sensitivity of AMSR-E to changes in VWC in more densely vegetated areas. However, in sparsely vegetated areas, we observed strong responses of VWC to the intense precipitation events. The rapidity of the response and the subsequent drydown were both modulated by the land cover type. We also found a correspondence between the diel difference of VWC (pre-dawn minus afternoon values) and total precipitation. These results suggest the possible utilization of the VWC standard data product in flood and drought monitoring.

The Potential Extent of the Jewel Cave System

Michael E. Wiles
Jewel Cave National Monument, 11149 US Highway 16, Custer, SD 57730,
Mike_Wiles@nps.gov

Purpose

With over 135 miles mapped, Jewel Cave is currently the second longest cave in the world. Research has shown a direct relationship between airflow at the entrance and the prevailing atmospheric pressure. Herb Conn used this barometric airflow to estimate a total minimum volume of four billion cubic feet, or 4,000 average-sized cave miles, only 3-4% of what is presently documented.

This study refines earlier estimates of geospatial parameters and includes the additional cave volume represented by other entrances and blowholes exhibiting barometric airflow. It estimates the extent of still-undiscovered portions of the cave system based on the following existing information: 1) thickness and distribution of the Madison limestone, 2) potentiometric surface of the Madison aquifer, 3) location and extent of potential geological obstacles, 4) the three-dimensional distribution of Wind Cave and Jewel Cave within the host rock, and 5) the "cave density" at Wind Cave and Jewel Cave.

Results

The resulting geospatial model delineates the maximum geographic extents of the two caves. Most of Jewel Cave's volume extends toward Wind Cave, and vice versa. The overall cave-to-limestone ratio is well within the range of known "cave density" values for each cave. This data supports the possibility that the two volumes could meet.

General Conclusions

Wind Cave and Jewel Cave could be portions of a single large cave system, but a physical air trace is needed to prove an air connection. Although it is *unlikely* that most of the cave volume is too small for human entry, the continuity of human-sized passages was not evaluated.

Outlining the potential extent of the proposed Wind/Jewel cave system serves as a valuable tool for resource protection. It strengthens the rationale for adaptive surface use, pursuit of land purchases and exchanges, and good-neighbor relationships.

TUESDAY, APRIL 18, 2006
SESSION 3P
1:05 – 2:45 P.M.

SURFACE-WATER MODELING
(PONDEROSA ROOM)

Complex Watershed Modeling in a Semi-Arid Region with Irrigation Applications and Channel Losses

Jason T. Love, Project Engineer
RESPEC Consulting and Services, Rapid City, SD 57709-0725, Jason.Love@respec.com

A. S. Donigian, Jr., President & Principal Engineer
AQUA TERRA Consultants, Mountain View, CA 94043-1115

In this study, a comprehensive watershed hydrologic model of the Calleguas Creek Watershed in Southern California was developed for use as a tool for watershed planning, resource assessment, and water quality management purposes. This study was jointly funded by the Calleguas Creek Watershed Management Plan and the Ventura County Watershed Protection District (VCWPD). The modeling package selected for this application is the U.S. EPA Hydrological Simulation Program-FORTRAN (HSPF). HSPF is a comprehensive watershed model of hydrology and water quality that includes modeling of both land surface and subsurface hydrologic and water quality processes, linked and closely integrated with corresponding stream and reservoir processes. It is considered a ***premier***, high-level model among those currently available for comprehensive watershed assessments.

This model application presented significant modeling and technical challenges, including extensive irrigation applications for agriculture and urban uses, water importation, channel and groundwater losses, groundwater-surface water interactions, and alluvial channel beds with dynamically changing cross sections and rating curves. The combination of the semiarid climate and extensive irrigation applications produces dramatic impacts on the watershed water balance, potentially changing historically ephemeral streams into perennial ones.

This paper presents a summary of the model results and focuses on the technical challenges noted above presented by this watershed. The current HSPF application to the Calleguas Creek Watershed produced a sound, calibrated and validated hydrologic watershed model that provides a framework for watershed management analyses and needs for flood assessments, water quality issues, and impact evaluation of mitigation alternatives. The calibration and validation results, based on the weight-of-evidence approach described in the Study report and summarized herein, demonstrate a **good to very good** representation of the observed data. This is the outcome of a wide range of graphical and statistical comparisons and measures of the model performance for both calibration and validation time periods.

The Unnamed River Watershed Model: Model Sensitivity and Uncertainty Analyses

Jason T. Love, Project Engineer
RESPEC Consulting and Services, Rapid City, SD 57709-0725, Jason.Love@respec.com

A. S. Donigian, Jr., President & Principal Engineer
AQUA TERRA Consultants, Mountain View, CA 94043-1115

The Unnamed River, its sediment, and associated floodplain have been contaminated with polychlorinated biphenyls (PCBs) and other hazardous substances released from the General Electric Company (GE) facility in Western MA. The GE/ Unnamed River site has been subject to regulatory investigations dating back to the early 1980s. The Consent Decree entered by U. S. District Court in October 2000 provides for, among other things, the cleanup and environmental restoration of Unnamed River and its floodplains extending downstream of the GE facility.

Evaluation of risks posed to human health and the environment from contaminated sediment often requires the application of watershed/hydrodynamic/water quality models and contaminant fate and bioaccumulation models to address the range of environmental migration pathways and potential exposures. For this study a linked modeling system was developed and applied to the Unnamed site and surrounding watershed using the following modeling components:

- Watershed Model (Hydrological Simulation Program – FORTRAN [HSPF])
- Hydrodynamic and Sediment/Contaminant Transport and Fate Model (Environmental Fluid Dynamics Code [EFDC])
- Bioaccumulation Model (Food Chain Model [FCM]), derived from QEAFDCHN Version 1.0

This paper describes the sensitivity and uncertainty analyses that were performed for the Watershed Model component using HSPF, and is a companion to the model development, calibration, and validation paper also submitted to this conference. Although sensitivity and uncertainty are important elements in any model effort, they are not often performed for complex, dynamic continuous simulation models like HSPF; both technical and computing resource issues often limit the extent to which these issues are addressed. This project provided a unique opportunity to investigate these issues because of their importance in the regulatory arena.

Sensitivity was addressed by identifying critical model input and parameters, performing 25-year simulations with perturbations to both meteorologic inputs and parameters, and displaying the results as 'tornado' diagrams that demonstrate both absolute and relative sensitivity. Uncertainty was addressed by performing Monte Carlo analyses with 600 model runs, with model parameter values randomly selected from assigned probability distributions; model results were analyzed to generate uncertainty estimates as the 90% confidence intervals on calibrated results.

An AnnAGNPS Non-point Source Pollution Model ArcGIS Interface

Sol J. Brich
South Dakota Department of Environment and Natural Resources, PMB 2020, Joe Foss Building, 523 East Capitol, Pierre, SD 57501-3182, sol.brich@state.sd.us

Erik R. Nelson
South Dakota Bureau of Information and Telecommunications, Joe Foss Building, 523 East Capitol, Pierre, SD 57501-3182, erik.nelson@state.sd.us

The South Dakota Department of Environment and Natural Resources (DENR) uses the Annualized Agricultural NonPoint Source Pollution Model (AnnAGNPS) to estimate factors affecting water quality in South Dakota Watersheds. The model accounts for climate, topography, soils, and landuse in its computations for runoff, sediment, and nutrients. The model is used to estimate non-point source pollutant loadings to South Dakota waters, and determine the origins of the pollutants.

Originally, AnnAGNPS used an Arcview 3.2 interface to derive input parameters. DENR and Bureau of Information and Telecommunications (BIT) staff have developed an interface utilizing ArcGIS. The new interface generates topographic input for AnnAGNPS, which the model uses to delineate the watershed into cells. The interface then determines the primary soil and land use for each cell, and stores them in a format usable by AnnAGNPS. These improvements have allowed users to model larger watersheds much faster, and increased the ability of the user to analyze the model input spatially.

Range Condition as Input to Water-Quality Monitoring

Eric C. Wood
SAIC, USGS/EROS; Sioux Falls, SD, 57198, woodec@usgs.gov

Bruce K. Wylie
SAIC, USGS/EROS; Sioux Falls, SD 57198, wylie@usgs.gov

Jesslyn F. Brown
SAIC, USGS/EROS; Sioux Falls, SD, jfbrown@usgs.gov

David J. Meyer
SAIC, USGS/EROS; Sioux Falls, SD, dmeyer@usgs.gov

Susan Maxwell
SAIC, USGS/EROS; Sioux Falls, SD, maxwell@usgs.gov

Bradley C. Reed
USGS Flagstaff Science Center, 2255 North Gemini Drive, Flagstaff, AZ 86001,
reed@usgs.gov

Sean Kruger
South Dakota Department of Environment and Natural Resources, Pierre, SD 57501,
Sean.Kruger@state.sd.us

Sol J. Brich
South Dakota Department of Environment and Natural Resources, Pierre, SD 57501,
sol.brich@state.sd.us

Federal Clean Water Act requires that states develop Total Maximum Daily Loads (TMDLs) for water bodies. Once the state has developed an inventory of TMDLs, it is required to provide public notice of the report and have it approved by the Environmental Protection Agency. The South Dakota Department of Environment and Natural Resources (DENR) is using the USDA's annualized Agricultural Non-Point Source Pollution (AnnAGNPS) Model to determine what land use changes are required to meet TMDL goals. Of the approximately 450 parameters required for running the model, several are related to the condition of range and pasture sites and their respective management practices. Range condition is highly correlated with the nature of runoff occurring in a site. USGS is assisting the DENR to better characterize range conditions in the state utilizing datasets and methodologies being addressed by its Drought Monitoring, Carbon Cycle Research, Phenological Trends and other projects. It is understood than no one project can develop tools that adequately characterize the dynamics of the state's rangelands, but by developing a suite of tools brought together from a number of projects there exists the opportunity to provide state, regional, and tribal land managers with the ability to address their particular needs.

Hydraulic Model of the Belle Fourche Irrigation District Using EPA SWMM 5.0

Curtis Schoenfelder, Student
South Dakota School of Mines and Technology, 501 East Saint Joseph Street, Rapid City, SD 57701, Curtis.Schoenfelder@gold.sdsmt.edu

Dr. Scott Kenner, Professor of Civil Engineering
Department of Civil and Environmental Engineering, South Dakota School of Mines and Technology, 501 East St. Joseph Street, Rapid City, SD 57701, Scott.Kenner@sdsmt.edu

Dr. Dan P. Hoyer, Vice President
RESPEC Water and Natural Resources, P.O. Box 725, Rapid City, SD 57709, Dan.Hoyer@respec.com

The Belle Fourche River Watershed Partnership is sponsoring a project with the overall goal of bringing the Belle Fourche River into compliance for TSS within 10 years through the implementation of several best management practices (BMPs). One of the recommended BMPs is the development and implementation of an operational model for the Belle Fourche Irrigation District (BFID). The model will help to improve the operational efficiency in the BFID, which will in turn reduce the amount of non-used irrigation flows. Non-used return flows are responsible for approximately 20 percent of the TSS load in the Belle Fourche River system.

A hydraulic model of the BFID South Canal was developed using Environmental Protection Agency Storm Water Management Model (EPA SWMM 5.0), which is used in conjunction with the operational model to provide the BFID with a useful tool and resource. The model was developed using U.S. Bureau of Reclamation survey data, contract drawings, and field measurements. Stage, flow, and structure setting data throughout the BFID were collected during the 2005 irrigation season (approximately June 20th – September 20th). This set of data and measurements was used to calibrate the model. An immediate underlying goal of the model is check structure operation procedures for specified flow condition scenarios. Thus, the calibration was focused on check structures. Observed flows at key structures in the system are modeled within approximately 5% and observed depths at check structures are modeled within approximately $\pm$ 0.15 feet. The model is fully capable of modeling the irrigation system and its structures, including automated check structure gates, which are being installed at various locations to improve operational efficiency. The model will assist BFID personnel in making adjustments to the system, which will aid in improving operational efficiency.

TUESDAY, APRIL 18, 2006
SESSION 4
3:10 - 4:50 P.M.

WATER SUPPLY, RESOURCES, AND MANAGEMENT

South Dakota Forestry Best Management Practices
Field Audit and Training Project

Aaron M. Everett, Forest Programs Manager
Black Hills Resource Association, 2218 Jackson Blvd., Suite 10, Rapid City, SD 57702,
aeverett@hills.net

Purpose: Best Management Practices (BMPs) for the protection of water and soil resources during forestry and timber harvest activities were established by the State of South Dakota in 1980. BMPs were revised by the State of South Dakota in 1993, and again in 2003, and have been adopted in the South Dakota Nonpoint Source Pollution Management Plan with approval by the US Environmental Protection Agency (EPA) under a provision of the Clean Water Act. Compliance with BMPs is not mandated by statute or regulation in South Dakota. Timber harvest operators, wood products companies, and land management agencies implement BMPs on a voluntary basis.

Training for foresters, logging professionals, and resource specialists, as well as field audits of timber sales for BMP compliance, have been conducted through a partnership between the Black Hills Forest Resource Association (BHFRA) and the South Dakota Department of Environment and Natural Resources (DENR) under a Pollution Prevention program grant.

Results: Seven timber sales were audited in 2004; two on private land, two on state land or under state administration, and three on federal land. Averaged across all timber sales, BMP standards for application were met or exceeded on 92 percent of the total rated items. Ratings for BMP effectiveness confirmed adequate or improved protection of soil and water resources on 95 percent of the total rated items. In comparison, audits in 2001 showed 82 and 84 percent compliance for application and effectiveness, respectively.

Conclusions: The most common mistakes in BMP application pertained to stream crossing and culvert design and installation, and ensuring adequate design and installation of road surface drainage features. These issues were focal to the 2004 BMP training workshops, so continued improvement in compliance can be anticipated.

The audit and steering committees recommend continuing the system of audits and training on a three-year cycle, simplifying the current audit rating criteria, and evaluating the development of new BMPs for salvage timber sales and “legacy road” considerations.

Complicating Factors for Flood-Frequency Analysis for the Black Hills Area of Western South Dakota

Daniel G. Driscoll
U.S. Geological Survey, 1608 Mt. View Road, Rapid City, SD 57702, dgdrisco@usgs.gov

Steven K. Sando
U.S. Geological Survey, 3162 Bozeman Ave., Helena, MT, 59601, sksando@usgs.gov

Flood-frequency analyses for the Black Hills area have extremely large uncertainty because of several complicating factors, including: (1) flood flows resulting from the extreme 1972 storm near Rapid City; (2) geologic influences; and (3) potential influences of topography on precipitation patterns. An overview of complicating factors and effects on frequency analyses is discussed.

The large floods that occurred at numerous streamflow-gaging locations on June 9-10, 1972, are a primary complicating factor. The 1972 storm produced as much as 10-15 inches of rainfall in about 6 hours over an area of about 60 square miles along the eastern flank of the Black Hills, with rainfall totals exceeding 6 inches over about 300 square miles. Resulting flood flows for many gaging stations affected by this storm constitute high outliers (as defined by the Grubbs-Beck outlier test) when using the log-Pearson Type III frequency analysis suggested by the 1982 Water Resources Councils Bulletin 17B. Results of frequency analyses for affected gages also are highly inconsistent with frequency analyses for other area gages that were unaffected by the 1972 storm, but may be subject to similar extreme events.

A second complicating factor is the influence of extensive outcrops of the Madison Limestone and Minnelusa Formation, which dominate the geology of the "Limestone Plateau" area of the western Black Hills. High infiltration capacity for these formations results in peak-flow characteristics that are distinctively suppressed for small recurrence-interval flood events for gages in this geologic setting.

A third complicating factor is the possible influence of topography on precipitation patterns for the Black Hills area. Decreasing potential with increasing altitude for prolonged rainstorms of high intensity has been well documented for other mountainous areas (generally above about 7,500 feet); however, documentation for the Black Hills area is not available. Thus, it currently is not known whether differences in precipitation patterns contribute substantially to suppression of peak-flow characteristics for large recurrence-interval flood events in the Limestone Plateau area, which occurs at altitudes of about 6,000 feet and higher.

New Methods in Stratigraphic Correlation: Pierre Shale, South Dakota

Doreena Patrick
Department of Earth and Environmental Science, University of Pennsylvania, Philadelphia, PA 19104, doreena@sas.upenn.edu

Paul N. Wegleitner
GeoChemical Solutions, LLC, Fort Pierre, SD 57532

James E. Martin
Museum of Geology, South Dakota School of Mines and Technology, 501 E. St. Joseph, Rapid City, SD 57701

Physical characteristics of rocks and fossils can be used to identify changes that occurred in the environment over time. The study of these physical characteristics can be the basis for understanding the evolution of events for both the earth and its life forms. Techniques such as lithostratigraphy, biostratigraphy, and geophysical properties of strata provide frameworks for stratigraphic correlation. Stratigraphy has great economic importance by providing markers in the geological record that proves invaluable for ventures such as oil exploration, mining, and hydrology.

Our recent research has involved new methods for stratigraphic correlation including Rare Earth Element (REE) analysis and unit cell dimension analysis (UCDA) of fossil bioapatites. REE analysis and UCDA use variations in REE signatures and unit cell dimensions (UCD) within bioapatite from different stratigraphic units. The REE composition and UCD of fossil bioapatite are dependent upon the conditions of diagenesis and thus dependent upon availability of REE and other elements for substitution during bioapatite per mineralization. REE signature and UCD variations identify distinct intervals within lithologic formations. Because these intervals represent an averaging of periods of certain depositional environments, these distinct intervals can be correlated over significant areas.

Fossil vertebrate samples were obtained from the Pierre Shale, at localities between Chamberlain and Pierre, South Dakota, in Brule, Buffalo, Hughes, and Hyde counties. Samples were collected from the lower, middle and upper Sharon Springs, Gregory, Crow Creek, lower and upper DeGrey and Verendrye members. REE signatures and UCD variations were found to be consistent within individual lithostratigraphic units but are significantly different between these units. Therefore, REE signatures and UCD act as markers for their units and are used to discriminate between units for purposes of stratigraphic correlation. Results of our research indicate that REE analyses and UCDA provide for a finer scale of resolution for stratigraphic correlation.

The National Weather Service's Hydrology Program

Melissa Smith
NOAA/National Weather Service, 300 E. Signal Dr., Rapid City, SD 57701,
melissa.smith@noaa.gov

As the nation grows, more segments of society are becoming increasingly vulnerable to an excess or lack of water. Timely and accurate river and flood forecasts and warnings spanning minutes out to months in the future are thus becoming more critical to decision making processes which affect all citizens. The objective of the National Oceanic and Atmospheric Administration (NOAA) National Weather Service's (NWSs) Hydrologic Services Program is to provide river and flood forecasts and warnings for the protection of life and property and to provide hydrologic information for the nation's economic well-being. This presentation will provide an overview of the NWS hydrologic services available from the Rapid City Weather Forecast Office.

Sedimentation in Reclamation's South Dakota Reservoirs

Curt Anderson, Civil Engineer
Bureau of Reclamation, 501 9th Street, Rapid City, SD 57701, canderson@gp.usbr.gov

Sedimentation has occurred at the reservoirs that are operated out of the Bureau of Reclamation's Rapid City Field Office. The main discussion will be on the recent sedimentation survey reports published in 2005 for Angostura and Keyhole. These surveys show that loss of reservoir storage due to sedimentation is a lot less than originally anticipated. Information on sedimentation that has occurred for the period of record at Shadehill and Belle Fourche Reservoirs also will be presented. Current sediment problems at Belle Fourche Reservoir are aggravated by the current drought.