Climate Issues Committee Meeting
Wyoming Water Development Office (WWDO) Report
May 19th, 2011

New Water Planning Projects

The 2011 Legislature approved the Omnibus Water Planning Bill which included $2,860,000 for 20 new and ongoing Level I and II water projects. The following is a brief description of each project, appropriated amount, and the WWDO Project Manager assigned to the project (for additional information).

Project	Budget	Manager	Description
Level I Reconnaissance Studies – New Development			
Farson MP	$118,000	Tavelli	Municipal Master Plan
Hanna MP	$123,000	Tavelli	Municipal Master Plan
Little Snake WS	$245,000	Vore	Watershed Study
Lower Nowood Rural Water	$68,000	Pavlica	Rural Water Supply Study
Rawlins Operations	$198,000	Besson	System Ops Review
Snake/Salt Basin Groundwater	$300,000	Ogle	River Basin Planning: Groundwater Study
Sweetwater River Watershed	$100,000	Vore	Watershed Study (ongoing)
Level II Feasibility Studies – New Development			
Boulder Flats WS	$270,000	Boyce	Groundwater Exploration
Burns Well	$348,000	Clarey	Well Construction/Testing
Cambria/Sweetwater Water Supply	$115,000	Vore	Tank Evaluation & Connection Study
Green River West Water Supply	$82,000	Tavelli	Transmission / Storage Study
Jeffrey City Water Supply	$98,000	Boyce	Master Plan for Operational Improvements
Lance Creek Well	$258,000	Clarey	Well Construction/Testing
Manville Well	$448,000	Clarey	Well Construction/Testing
Pavillion Area Water Supply	$100,000	Clarey	Groundwater Supply Study (ongoing)
Level II Feasibility Studies - Storage			
Big Sandy Enlargement	$298,000	Besson	Fatal Flaw Analysis
Clear Creek Storage	$247,000	Mead	Hydrologic Site Analysis
Cottonwood/Grass Creek Storage	$130,000	Muth	Hydrologic Site Analysis (ongoing)
Sublette Creek Reservoir	$325,000	Muth	Hydrologic Site Analysis (ongoing)
Probable Maximum Precipitation Study	$547,000	Besson	Development of WY specific PMP estimates statewide.

New Construction Projects

Twenty-two new Level III construction projects were approved by the legislature as part of the Omnibus Water Bill - Construction. There were 12 new projects funded from the New Development Program, Water Account I, and 10 projects funded from the Rehabilitation Program, Water Account II. Appropriations for Water Account I totaled $24,587,910 and appropriations for Water Account II totaled $5,628,700. There was also additional funding provided for ongoing projects. The following is a list of the new construction projects, appropriated amount, and the WWDO Project Manager assigned to the project (for additional information).

Project	Appropriation	Manager
New Development Program – Account I		
33 Mile Pump Station	$125,960	Coyer
Central Wyoming Regional Zone IIB	$1,959,750	Coyer
Cheyenne Southern Pipeline	$14,029,800	Clerkin
Douglas Box Elder Spring - Phase I	$1,487,400	Coyer
GR/RS/SC Raw Water Reservoir - Phase I	$900,000	Hackett
LaBarge Water Supply	$370,000	Hackett
Poison Spider Pipelines	$1,036,000	Coyer
Reliance Water Supply	$1,742,000	Hackett
South Circle Estates Water Supply	$480,000	Clerkin
Ten Sleep Storage Tank	$1,540,000	Clerkin
Wright Water Supply 2011 - Phase I	$737,000	Clerkin
Yoder Water Supply	$180,000	Hendon
Rehabilitation Program - Account II		
Cody ID Canal Chute	$223,000	Anderson
Cody ID Canal Drop Structure	$50,000	Anderson
Eden Valley ID Rehabilitation 2011	$1,713,000	Hackett
Goshen ID Rehabilitation 2011	$1,100,000	Hendon
Kirby ID Rehabilitation 2011	$420,000	Anderson
Little Snake Rehabilitation	$154,100	Muth
Midvale ID Rehabilitation 2011	$450,000	Verplancke
Shoshone ID Rehabilitation 2011	$585,000	Anderson
Wheatland ID Rehabilitation 2011	$723,600	Hendon
Willwood ID Dam Rehabilitation - Phase I	$210,000	Anderson

Wyoming Weather Modification Pilot Program
Winter 2010/2011

<u>Medicine Bow/Sierra Madre Ranges Target Areas</u> (randomized program)

Images courtesy of WMI

An above normal snowpack in the Medicine Bow Range forced the early termination of the randomized statistical experiment for the season. Shown are WMI personnel attempting to access the Turpin Reservoir ground generator (left); and Mountain Meadows Cabin #9, site of the surface-based INC measurements and snow sampling in the Medicine Bow Range (right).

Randomized operations in the Medicine Bow and Sierra Madre Range target areas for winter 2010-2011 realized 24, 4-hour seeding events (13 Medicine Bows; 11 Sierra Madres), bringing the total number of cases achieved under the program since its implementation to that of 108 cases. **It should be noted that research operations in these target areas came to an abrupt halt when established suspension criteria were reached on March 6th, 2011.**

The WWDO Project Manager, WMI Director of Meteorology, and the Operations Criteria Team (subset of the Technical Advisory Team) began meeting regularly starting on January 18th, 2011 to closely monitor the ever changing situation. Numerous conference calls were held during the period, and a significant amount of information was distributed out to the group including current snow water equivalent (SWE) amounts with departures from normal at individual Snotel sites, average SWE amounts for each of the target areas, and reservoir contents information.

Participating in the conference calls were representatives from the USDA Natural Resources Conservation Service, US Bureau of Reclamation, US Forest Service (Medicine Bow and Shoshone National Forests), Wyoming State Engineer's Office, and the Wyoming Department of Transportation.

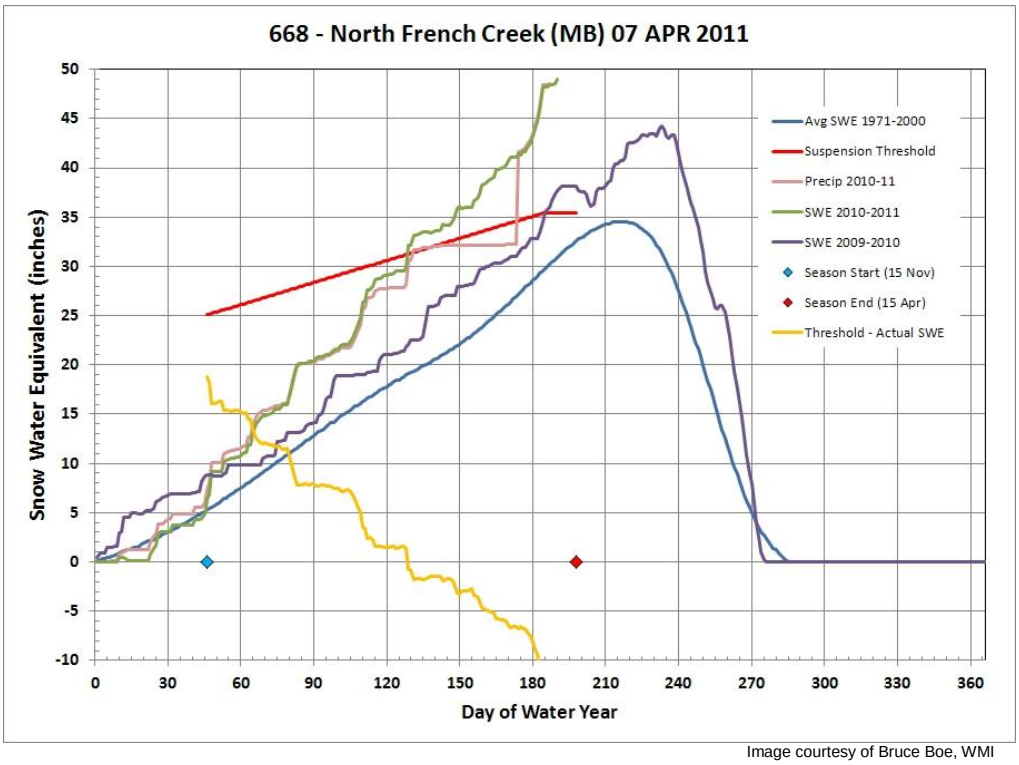

Image courtesy of Bruce Boe, WMI

Snow water equivalent (SWE) amounts as measured by the Natural Resources Conservation Service at the North French Creek Snotel site in the Medicine Bow Range evaluation target area during winter 2010-11. The blue line marks the 30-year average for SWE at the site, while the green line shows SWE amounts for the current winter. The suspension threshold for this target area was reached on March 6, 2011. The date of the actual last seeding event in the Medicine Bow Range was February 25th, and in the Sierra Madres, February 26th.

Even though the randomized statistical experiment in the Medicine Bow and Sierra Madre Ranges was suspended, scientists at NCAR asked that there be no changes in the calling of cases, releasing of weather balloons, INC sampling, snow chemistry sampling, etc. from what would have been done had the program not been under suspension. These individuals believed that program consistency was key to the success of the project. Additionally, the collected information would provide good background data for seedable conditions and would further the modeling efforts. To that end, five suspended cases have been called since suspension went into effect on March 6th, 2011. A ground generator operations summary for the target area follows:

Medicine Bow/Sierra Madre Ranges Target Area
2010-2011 Ground-Generator Operations Summary

	November	December	January	February	March	April	*Total*
# of RSE Case Pairs**	4	6	5	9	0	0	24
# of Clear Air Cases***	0	0	0	8	1	0	9
Total GGEN Seed Hours	105	146	92	315	44	0	702

** Due to the blind nature of the independent evaluation, only general summary information is shown
*** Cases called in "clear air" non-seedable conditions to support airborne INC measurements as part of the IOP

<u>Wind River Range Target Area</u> (non-randomized study)

Image courtesy of WMI

WMI personnel service the Block & Tackle ground generator in the Wind River Range.

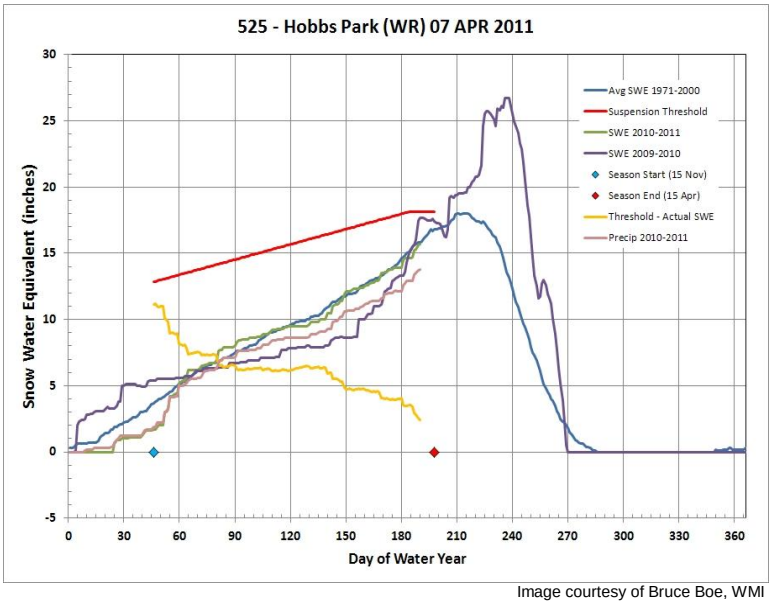

Image courtesy of Bruce Boe, WMI

SWE amounts were near normal at Hobbs Park Snotel, Wind River Range.

Snow water equivalent amounts in the Wind River Range as measured at NRCS Snotel sites were at or near normal and below set suspension criteria such that operations could continue throughout the operational season for this target area:

Wind River Range Target Area
2010-2011 Ground-Generator Operations Summary

	November	December	January	February	March	April	*Total*
# of Seeding Events	2	3	3	6	4	0	18
Total GGEN Seed Hours	229	205	139	403	212	0	1188

Project 26, Geerts: Detecting the signature of glaciogenic cloud seeding in orographic snowstorms in Wyoming II: Further airborne cloud radar and lidar measurements

This proposal is linked both to the five-year Wyoming Weather Modification Pilot Program (WWMPP), and to the current WWDC/USGS grant ("Detecting the signature of glaciogenic cloud seeding in orographic snowstorms in Wyoming using the Wyoming Cloud Radar", Geerts, PI), which will be entering its 3rd and final year in March 2009. We refer to the present grant as WKA-Seed I.

Federal support for weather modification research dried up about 25 years ago, yet new measurement techniques have been developed to more rigorously address the question of cloud seeding efficacy. As mentioned in a recent article in *Nature* (Qiu and Cressey 2008), the WWMPP is "the type of targeted and rigorous study that needs to be done in weather modification, but it took Wyoming to do it." Clearly the stakes are high, as effective cloud seeding can have an immediate and obvious benefit for society. This is especially true for Wyoming, as much of its water supply originates as snow, accumulating each winter on the state's mountain ranges.

Under WKA-Seed I, the University of Wyoming King Air (WKA) research aircraft has conducted two flights so far over the Medicine Bow Range in February 2008. These flights took the aircraft repeatedly along fixed tracks over and incrementally downstream of select WWMPP silver iodide generators on the ground, both during on (seeding) and off (no seeding) conditions in equal proportions. Detailed Wyoming Cloud radar (WCR) transects and flight-level data were collected along each flight leg. WKA-Seed-I supports a total of 20 flight hours, and, if Year 3 is funded, then we plan to fly the remaining flight hours (11.8 hours) between 1 Feb and 31 March 2009, while the WKA is fully instrumented for a local NSF-funded project, called WAICO. This proposal requests some additional WKA flight time (9.2 hours) in order to conduct a total of five full flights during WAICO. This will significantly enhance our chances to detect the signature of glaciogenic seeding of orographic clouds.

Project 31, Fan: Development of a Contaminant Leaching Model for Aquifer Storage and Recovery Technology

Wyoming is lack in water resources. Aquifer storage and recovery (ASR) through water injection could be an important method to solve the water problem in Wyoming. However water injection could lead to contamination of ASR due to the leaching of heavy metals and other elements. Therefore prediction of the potential of leaching of contaminants with a model is critically important to the successes of the application of ASR technology in Wyoming and other states in the U.S.

The proposed project is designed to provide a solution to the universal issue facing many potential ASR technology customers, which is based on the physical and chemical properties of rocks and waters to be used and chemical engineering's kinetic theories. Both batch leaching and continuous flow leaching models are going to be developed. The purpose of developing batching model is to obtain necessary kinetic parameters for development of continuous flow leaching model. The continuous flow models (for multi species) will not only be developed but also be tested under various contaminant leaching conditions.

Project 32, Park: Development of GIS-based Tools and High-Resolution Mapping for Consumptive Water Use for the State of Wyoming

Accurate estimation of crop consumptive water use in the State of Wyoming is a key component for making decisions in irrigational policy and allocations of water and administration of water rights. State water resources managers utilize crop consumptive water use data to monitor and guide farmers and make a sustainable future plan and decision. The proposed project will utilize the best available local weather station data (102 stations for precipitation and temperature in Wyoming) along with Parameter-elevation Regressions on Independent Slopes Model (PRISM) data to accurately represent spatial variation of weather pattern for the three major river basins, i.e. North Platte, Green, and Bear River basins in the State of Wyoming (Figure 1). GIS-based ET calculation tools (ArcInfo reference ET tool and ArcGIS ET calculation tool) and a web - based analysis tool will be developed to help water resources managers as well as local water users to make operational decisions in an easier and faster fashion than before. The ArcInfo reference ET tool will use historical and real-time daily data to calculate the daily, monthly and seasonal reference ET at 1 km x 1 km spatial resolution. ArcGIS ET calculation tool will be installed in a PC or laptop and will provide user-interface to define parameters (area of interest, gridded crop coefficient, time step, ET method, effective precipitation, and water supply condition) for the calculation of crop ET, Consumptive Irrigational Requirement (CIR), Consumptive Water Use (CU) for the area of interest within the three major basins (N. Platte, Green, and Bear) in Wyoming. We will produce gridded daily, monthly and seasonal weather data using historical from NCDC and gridded real-time daily weather data from SEO and ACIS, and archive them in SEO's data server. SEO data server will supply data required for GIS-based ET calculator.

Project 33, Cammack: Treatment of High-Sulfate Water used for Livestock Production Systems

Reliable drinking water sources that meet minimum quality standards are essential for successful livestock production. Recent surveys have shown that water sources throughout the semi-arid rangelands of the U.S. are not of sufficient quality to support optimum herd/flock health and performance. Water sources high in sulfur (S) concentrations, usually in the form of sulfate (SO_4^{2-}), are problematic in many western regions. High SO_4^{2-} concentrations in water sources can arise from several factors. First, water sources can be naturally high in SO_4^{2-}. Second, drought conditions can cause SO_4^{2-} to be concentrated within the water source. Third, conventional oil and gas production can also increase SO_4^{2-} content within the water source. Many of these water sources are used for livestock production systems, especially throughout the western states. High-SO_4^{2-} water has been shown to reduce performance and cause secondary health and immunity complications in exposed livestock. Additionally, high SO_4^{2-} levels in drinking water are a primary cause of polioencephalomalacia (PEM) in ruminant livestock. Sulfur-induced PEM (sPEM) is a disease state in ruminant animals that can cause 25% morbidity and 25-50% mortality in affected populations, resulting in substantial economic losses to the livestock producer. Currently, there are no available treatments for affected livestock, and frequent and stringent testing of drinking water sources for levels of SO_4^{2-} and other S compounds, a costly and time-consuming process, is the best prevention strategy. In addition, methods for SO_4^{2-} removal from the water source are neither cost-effective nor practical. Ferrous carbonate ($FeCO_3$) is a soluble iron salt that is routinely used in water treatment plants to bind S. We hypothesize that treatment of high-SO_4^{2-} water with $FeCO_3$ will bind excess S, enabling such sources to be used for livestock production. Our objectives are to 1) determine the effectiveness of $FeCO_3$ treatment in binding S in high-SO_4^{2-} water, and 2) determine if treatment of high-SO_4^{2-} water with $FeCO_3$ prevents the reduced performance and poor health normally observed in livestock consuming high-SO_4^{2-} water.

Project 34, Shuman: Multi-Century Droughts in Wyoming's Headwaters: Evidence from Lake Sediments

Wyoming has historically experienced extended periods of drought, which have had significant economic and social impacts. Tree-ring records and archeological evidence indicate that past centuries have contained multi-decadal megadroughts far more severe than any drought of the past 150 years. Here, we propose to study the extent and controls on past dry periods in the Bighorn and Green River watersheds that exceeded even the severity of multi-decadal megadroughts. In doing so, we will build upon results from our previous Wyoming Water Research Program grant, which enabled us to measure the prehistoric shoreline elevations of a lake, Lake of the Woods, at the point where the watersheds of the Green and Bighorn Rivers meet with the watershed of the Snake River. Our results showed that climatic shifts can rapidly generate new hydrologic regimes that persist for centuries to millennia. Aridity at least as severe and extensive as during the CE 1930s Dust Bowl prevailed from 9.1-3.4 ka (thousand years before CE 1950), and was most extensive across the watersheds from ca. 5-3 ka. Regional aridity was also bounded by abrupt shifts at >11.3 and 1.8-1.2 ka. Similar results from lakes in the North Platte River drainage indicate that the river probably had ephemeral flows for several millennia. These centennial-to-millennial variations in the availability of water are important because they occurred when the world's climate was similar to today, and represent part of the natural climate variability that preceded historic time. Such persistent drought may well represent an analogy for periods in Wyomings future, and should be studied. Proposed and ongoing work includes 1) an extensive survey of lakes in the Green and Bighorn drainage basins, using sub-surface radar, to determine the extensiveness of past periods of low lake levels, 2) sediment core analysis, including radiocarbon dating and fossil pollen analyses, of a few representative lakes to date and quantify past climate conditions, and 3) hydroclimatic analysis, comparing paleoclimate estimates with modern climatic data and climate model output, to examine the factors that contributed to the periods of prolonged drought. Improved data would provide direct measurements of regional water levels during extremely dry periods and, thus, could provide important data for considering future drought impacts and the development of contingency plans.

Project 35, Ewers: Impact of bark beetle outbreaks on forest water yield in southern Wyoming

A Rocky Mountain Region outbreak of bark beetles and their associated fungi from British Columbia to New Mexico is having profound impacts on forest function and ecosystem services. These forests are key components of major river watersheds which could magnify any impacts on downstream users of water including those in Wyoming. Current and ongoing research is documenting the potential extent, causes and impacts on carbon exchange and evapotranspiration but less is known about how water yields will be impacted on short to long time scales. This project will enhance preliminary measurements on evapotranspiration and soil moisture from a mid-elevation lodgepole pine forest undergoing infestation by 1) reasonably closing stand water budgets to better quantify and thus predict water yield and 2) extending replicate measurements and analyses to post-infection management to facilitate future scaling to landscape water yield. New stands will be established in mid elevation former lodgepole pine that has been clearcut after infestation. We will provide complete water budgets that are closed on a stand basis by measuring 1) spatially explicit snow accumulation and loss, 2) detailed liquid canopy interception and stem flow, 3) appropriately scaled transpiration from living, dying and dead trees' water use (or lack thereof) through sap flow and leaf gas exchange, 4) soil hydraulic characteristics and modeling and runoff for water yield and 5) stable isotopes of soil, plant and atmospheric water as a further test of water budget component closure. Our proposed data collection and analysis will provide highly probable predictions of water yield during the first 5 to 10 years of the outbreak and provide the basis for first order predictions of the next 10 to 100 years of impact. The results of this project will be communicated with State and Federal agency personnel, providing data necessary for future water management decisions in all areas of Wyoming impacted by the bark beetle outbreak.

Project 36, Kelleners: FATE OF COALBED METHANE PRODUCED WATER IN DISPOSAL PONDS IN THE POWDER RIVER BASIN

The Powder River basin (PRB) in Wyoming has seen a rapid increase in coalbed methane (CBM) production over the past decade. Product water from the ~20,000 active CBM wells is mostly released in surface ponds. The product water may be high in total dissolved solids (TDS), be sodium dominated, and may contain trace elements that are toxic to humans, livestock, and wildlife. To date, about 4,000 such ponds have been permitted. The ponds can be either on-channel or off-channel. The fate of the pond water is generally unknown. Infiltration of pond water could lead to the contamination of shallow groundwater and surface water. Concentration of pond water due to evaporation could lead to unacceptable high trace element concentrations. Recent reports suggest that pond water infiltration reduces with time because of soil dispersion related to the high sodium content of the CBM water. We propose to examine the relationship between soil type, CBM water quality, and infiltration rate for a variety of unlined ponds across the PRB. We are particularly interested in determining the time frame over which the infiltration rate reduces as compared to the total lifetime of the ponds. This type of information is currently lacking for the PRB and would greatly benefit pond operators, landowners, and agencies in assessing the environmental impact of the ponds (i.e. groundwater contamination versus concentration of pond water constituents). Infiltration experiments conducted in the laboratory will be supplemented with numerical modeling of subsurface water flow and solute transport to assess the practical implications of the measured infiltration rates.

Project 37, Snider: Instrumentation for Improved Precipitation Measurement in Wintertime Snowstorms

It is widely recognized that precipitation measurements (rain and snow) can be biased by wind-induced errors. Measurement of snowfall is especially confounded by wind occurring at forested measurement sites. Negative bias occurs if a precipitation gauge is shadowed by trees, and positive bias occurs if a secondary flux occurs due to wind resuspension of antecedent snowfall. In addition, a negative wind-induced bias occurs because the downward vertical speed of a snow particle is decreased by the airflow distortion near a precipitation gauge. Because the fall speed of a rain drop is much larger than that of a snow particle the flow distortion bias is largest for the snow particle. Fall speeds for these two particle types are about 1 m/s (snow) and 10 m/s (drop) assuming a 4 milligram particle mass (liquid equivalent particle diameter = 2 mm).

These complications are evident in many studies of snowfall, even when using a wind shield to slow down the horizontal air velocity (and thus the vertical velocity distortion) near a gauge orifice. We propose to use a new type of precipitation sensor (the “hotplate”) in an intercomparison with conventional gauges. Both the hotplate and the conventional gauges will be deployed at a wintertime cloud seeding target site. The primary objective of the work is the development of a correction for the hotplate’s report of the precipitation rate. One M.S. student will be supported by the project and a hotplate snow sensor will be upgraded with visible and infrared radiometers reporting measurements necessary for the correction. It is anticipated that the research will advance the hotplate as a device superior to conventional gauges for measurement of snowfall.

UW Office of Water Programs
Water Research Program FY11 Projects

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1. "Detecting the Signature of Glaciogenic Cloud Seeding in Orographic Snowstorms in Wyoming II: Further Airborne Cloud Radar and Lidar Measurements", Bart Geerts, Associate. Prof., Dept of Atmospheric Science, UW, Mar 09 – Feb 12.
2. "Development of a Contaminant Leaching Model for Aquifer Storage and Recovery Technology", Maohong Fan, SER Associate Professor, Dept. of Chemical & Petroleum Engineering, UW, Mar 10 – Feb 12.
3. "Development of GIS-based Tools and High-Resolution Mapping for Consumptive Water Use for the State of Wyoming", Gi-Hyeon Park, Assistant Prof. and Mohan Reddy Junna, Prof., Dept. of Civil and Architectural Engineering, UW, Mar 10 – Feb 12.
4. "Treatment of High-Sulfate Water used for Livestock Production Systems", Kristi M. Cammack, Ph.D., Assistant Professor, and Kathy J. Austin, M.S., Senior Research Scientist, Dept. of Animal Science, UW, and Ken C. Olson, Associate Professor, West River Ag Center, South Dakota State University, Rapid City, SD, and Cody L. Wright, Associate Prof., Dept. of Animal and Range Sciences, South Dakota State University, Brookings, SD, Mar 10 – Feb 12.
5. "Multi-Century Droughts in Wyoming's Headwaters: Evidence from Lake Sediments", Bryan N. Shuman, Associate Prof., Dept. of Geology & Geophysics, Jacqueline J. Shinker, Assistant Prof., Dept. of Geography, Thomas A. Minckley, Assistant Prof., Dept. of Botany, UW, Mar 10 – Feb 13.
6. "Impact of Bark Beetle Outbreaks on Forest Water Yield in Southern Wyoming", Brent E. Ewers, Assoc. Prof., Dept. of Botany, Elise Pendall, Assoc. Prof., Dept. of Botany, and David G. Williams, Prof., Dept. of Renewable Resources, UW, Mar 10 – Feb 13.
7. "Fate of Coalbed Methane Produced Water in Disposal Ponds in the Powder River Basin", T.J. Kelleners, Assistant Prof., Department of Renewable Resources, K.J. Reddy, Prof., Dept. of Renewable Resources, UW, Mar 11 – Feb 13.
8. "Instrumentation for Improved Precipitation Measurement in Wintertime Snowstorms", Jefferson Snider, Prof., Dept. of Atmospheric Science, UW, Mar 11 – Feb 13.