Kansas Field Conference

Northwest Kansas

Water Conservation and Consumption, Energy and Transportation, and the Agricultural Economy

2012 Field Conference
June 6–8

Kansas Geological Survey

Kansas Water Office

Kansas Department of Transportation

Kansas Department of Wildlife, Parks and Tourism

2012 Kansas Field Conference

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Northwest Kansas

Water Conservation and Consumption, Energy and Transportation, and the Agricultural Economy

Field Guide

Edited by

Shane A. Lyle
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This project is operated by the Kansas Geological Survey and funded, in part, by the Kansas Water Office, the Kansas Department of Transportation, and the Kansas Department of Wildlife, Parks and Tourism

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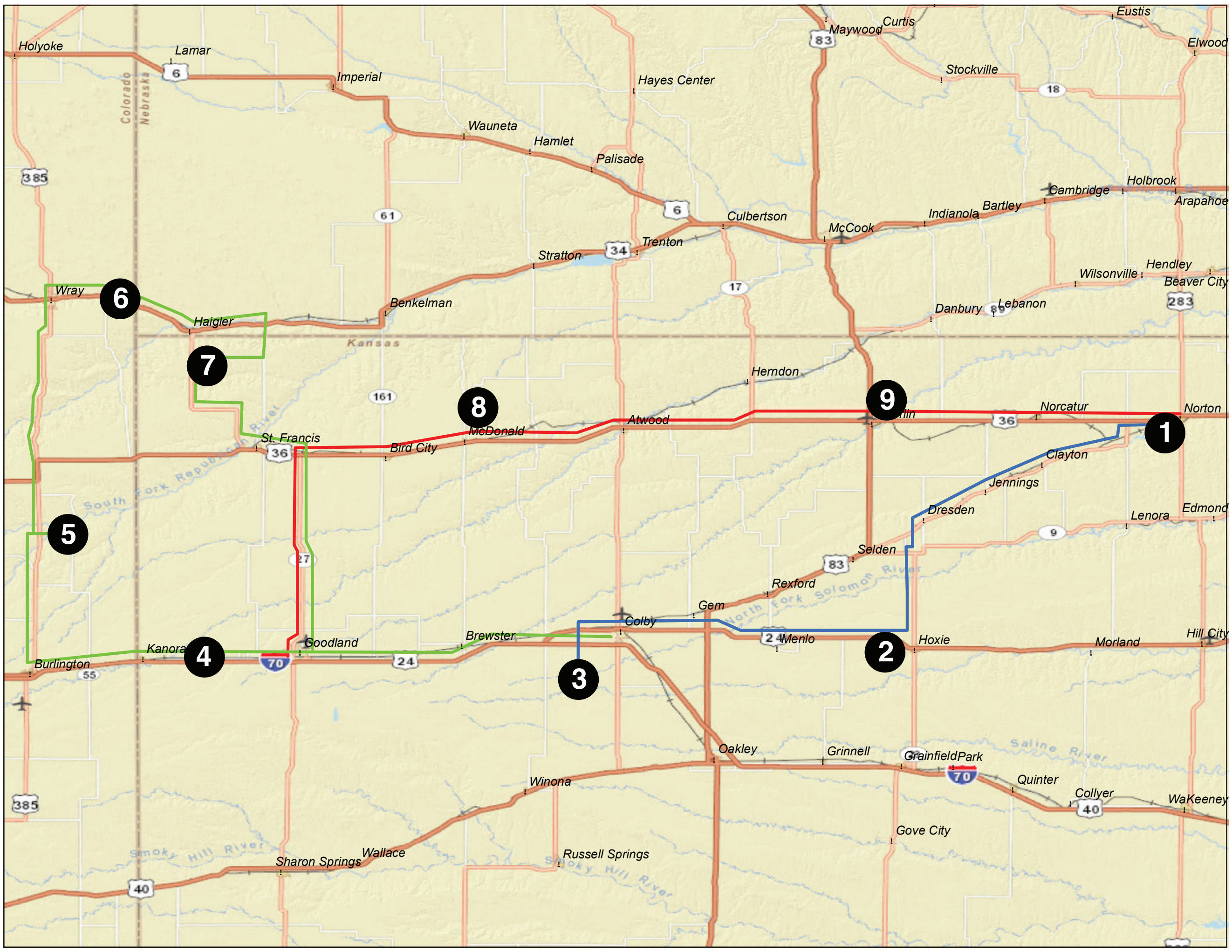
KGS Open-file
Report 2012–4



Day 1
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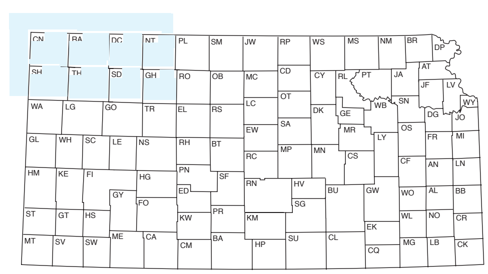

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Acknowledgments

Thanks to Cathy Evans for preparation of the field conference brochure and to Marla Adkins–Heljeson for editing and preparation of this field guide.

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Water Conservation and Consumption, Energy and Transportation, and the Agricultural Economy

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PARTICIPANTS

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Mark Sievers, Chairman, Kansas Corporation Commission
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Biographical Information

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Kansas Department of Wildlife, Parks and Tourism
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Topeka KS 66612
785–296–2281
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Responsibilities and Experience
KDWPT, 1989–present
Previous: Fisheries biologist, Florida Game and Freshwater Fish Commission, 1986–89
Northeastern Oklahoma State University – BS, 1980
Oklahoma State University – MS, 1983

Mitchell Baalman
Owner and Manager, FDK Partnership
Northwest Groundwater Management District #4 Board Member
1433 Pine Street
P.O. Box 295
Hoxie KS 67740
785–675–8581
fdkest-tel.net
Responsibilities and Experience
Owner and manager of FDK Partnership, a diversified farm growing corn, soybeans, wheat, alfalfa, and sunflowers, 100% no-till for 15 years
Fort Hays State University – Agronomy, BS, 1997

Larry Biles
State Forester
Kansas Forest Service
2610 Claflin Road
Manhattan KS 66502
785–532–3309
lbiles@ksu.edu
Responsibilities and Experience
Leadership for agency's rural, community, fire management, conservation, trees, forest health, and wood utilization programs.
Previous: Director–Southern Forest Research Partnership, Athens, GA: USDA–Community Forestry and Multiple Use Forestry Specialist, Atlanta, GA; USDA–Extension Service Program Leader, Washington, D.C.; U.S. Army in Missouri, Georgia, North Carolina, and Belgium
University of Missouri – Forestry, 1967
Kansas State University – Ornamental Horticulture, 1974

Wayne Bossert
Manager, Northwest Kansas Groundwater Management District #4
P.O. Box 905
Colby KS 67701
785–462–3915
wab@gmd4.org
Responsibilities and Experience
Manager, Northwest Kansas GMD4, Colby; responsible for all programs and activities of the District as specified by the 11-member elected Board of Directors
Previous: Oklahoma Water Resources Board, ground-water hydrologist, 1975–77
University of Oklahoma – Geology, 1975

Pete DeGraaf
Kansas House of Representatives, 81st District
1545 E 119th Street
Mulvane KS 67110
316–777–1414
KDeGraaf4U@att.net or petedegraaf@att.net
Responsibilities and Experience
Appropriations Committee member, vice chairman of General Government Budget and Government Efficiency, chairman of legislature south-central delegation; Financial Counselor, Wichita Area Director Crown Ministries; Pastor and President, Shepherd's Staff Ministries
U.S. Air Force Academy – BS, Behavioral Science, 1979
Helicopter Training – Pilot, 1980

Greg Foley
Executive Director
Division of Conservation, Kansas Department of Agriculture
109 SW 9th Street, 2A
Topeka KS 66612
785–296–3600
greg.foley@kda.ks.gov
Responsibilities and Experience
Oversee multiple cost-share programs that protect or restore Kansas natural resources; responsible for handling environmental isues for the agency
Previous: Executive Director, State Conservation Commission; Assistant Secretary of Agriculture for two administrators; section chief of the Livestock Waste Management Unit, Kansas Department of Health and Environment
Kansas State University – BS, 1989

Lon Frahm
Frahm Farmland Inc.
375 S. Range Avenue
Colby KS 67701
785–460–6719
lfrahm@st-tel.net
Responsibilities and Experience
Owner and manager of 20,000-acre irrigated and dryland cash grain production farm in Thomas County
Previous: Kansas Geological Survey Advisory Council; board chairman, Midwest Energy; GMD4; Kansas Water Authority; Kansas Arts Commission
Kansas State University – BS, 1980
Kansas State University – MAB, 2002

Marci Francisco
Senator, 2nd District
1101 Ohio Street
Lawrence KS 66044
785–842–6402
maf@sunflower.com
Responsibilities and Experience
Ranking minority member on Senate Agriculture, and Natural Resources committees; member of Senate Utilities, and Ways and Means committees; staff member, KU Center for Sustainability
Previous: Mayor of Lawrence, 1981–83; member of Lawrence City Commission, 1979–1983
University of Kansas – B.E.D., 1974
University of Kansas – B.Arch, 1977

Margaret Gabelmann
District Representative for Senator Jerry Moran
1200 Main Street, Suite 402
P.O. Box 249
Hays KS 67601
785–628–6401
margaret_gabelmann@moran.senate.gov
Responsibilities and Experience
Assist constituents with agricultural, immigration, and State Department issues with the Federal government; provide outreach for Senator Jerry Moran in the northwest part of the state.
Barton County Community College – AS, 2008
Kansas State University – BS, 2010

Raney Gilliland
Interim Director, Kansas Legislative Research Department
300 SW 10th Street, Rm. 68–W
Topeka KS 66612
785–273–3181
Raney.Gilliland@klrd.ks.gov
Responsibilities and Experience
Interim Director; Staff – Agriculture and Natural Resources, Commerce and Economic Development, Administrative Rules and Regulations, Interstate Cooperation, and Energy and Environment Policy; Kansas Legislative Research Department – 34 sessions
Kansas State University – BS, 1975
Kansas State University – MS, 1978

Bob Grant
Kansas House of Representatives, 2nd District
202 S. Appleton
Frontenac KS 66763
620–308–5518
Responsibilities and Experience
State Representative, 20 years; Agriculture and Natural Resources committees
Previous: 1967–1992, Kansas Army Ammunition Plant; Catering business, bar and grill owner, 1985–2005
Southeast High School – 1966
Labette Community College – AA, 1971
Pittsburg State University

Burke Griggs
Legal Counsel
Division of Water Resources, Kansas Department of Agriculture
109 SW 9th Street, 4th Floor
Topeka KS 66612
785–296–4616
burke.griggs@kda.ks.gov
Responsibilities and Experience
Represents DWR and Kansas in interstate water litigation and interstate river compacts; represents DWR in state court; advises KDA and DWR on water policy and legislation
Previous: Assistant Professor of history, Boston College, 1997–2003; Attorney, Stevens and Brand, LLP, Lawrence, 2006–08
Stanford University – BA, 1990
Yale University – PhD, 1998
University of Kansas Law School – JD, 2006

Dave Heinemann
Chair, Kansas Geological Survey Advisory Council
3826 SW Cambridge Court
Topeka KS 66610
785–213–9895
daveh123@cox.net

Responsibilities and Experience

Legislative representative for American Cancer Society, American Heart Association, High Plains Public Radio, Schools for Quality Education, Smoky Hills Public Television, and Stand Up For Kansas

Previous: Special Assistant to the Secretary of Revenue, 5 years; Executive Director, KCC, 2 years; General Counsel, KCC, 2 years; State Representative, 27 years; Speaker Pro Tem, Kansas House of Representatives, 2 terms; U.S. Commissioner, Kansas–Oklahoma Arkansas River Commission, 11 years

Augustana College – BA, 1967

University of Kansas – 1967–68

Washburn Law School – JD, 1973

Kyle Hoffman

Kansas House of Representatives, 116th District

1318 Avenue T

Coldwater KS 67029

620–635–5844

kyle@KyleHoffman.net

Responsibilities and Experience

Owner operator of Central Fuel & Service (gas and service station in Coldwater); assistant manager of family farm; serve on County Conservation Board (14 years); Area II Board Member for Kansas Association of Conservation Districts

Previous: Served on Farm Bureau County Board

Coldwater High School – 1990

Kansas State University – BS, 1994

Carl D. Holmes

Kansas House of Representatives, 125th District

PO Box 2288

Liberal KS 67905

785–608–9555

repcarl@aol.com

Responsibilities and Experience

Chairman, Energy and Utilities Committee; chairman, Kansas Electric Transmission Authority; vice-chairman, Joint Committee Administrative Rules and Regulations; member, Agriculture and Natural Resources Committee; member, several national committees concerning energy

Previous: Farm-ranch manager, 50 years; past president, League of Municipalities; past president, Kansas Mayors Association; past member, Groundwater Management District #3 Board of Directors; past chairman, NCSL Advisory Council on Energy

University of Kansas – 1958–1960

Colorado State University, BS, BA – 1962

Mitch Holmes

Kansas House of Representatives, 114th District

211 SE 20th Ave

St. John KS 67576

620–234–7667

mimi.holmes@juno.com

Responsibilities and Experience

Federal and State Affairs; Veterans, Military, and Homeland Security; Judiciary; Joint Special Claims Against the State; Joint Environment and Energy; and Joint Pensions, Investments, and Benefits committees

Previous: Military service, ethanol production worker, computer programmer, college instructor, sales

Hutchinson Community College – AA, 1984

Friends University– BS, 1988

DePaul University – Post-graduate certificate, 1995

Robin Jennison

Secretary, Kansas Department of Wildlife, Parks & Tourism

1020 S. Kansas Avenue, Room 200

Topeka KS 66612

785–296–2281

robin.jennison@ksoutdoors.com

Responsibilities and Experience

Secretary, Kansas Department of Wildlife, Parks & Tourism, 2011–present; partner, Jennison Ranch

Previous: Representative, 117th District; Assistant Majority leader, chairman of the House Appropriations Committee, House Majority Leader, Speaker of the House; president, Jennison Government Services; anchor, Kansas Outdoors Radio Show

Fort Hays State University, animal science

Mike King

Secretary, Kansas Department of Transportation

700 SW Harrison Street

Topeka KS 66603

785–296–3285

peggyh@ksdot.org

Responsibilities and Experience

Secretary, Kansas Department of Transportation, 2012

Previous: President and majority owner of King Enterprise Group in McPherson, 1991–present; Martin K. Eby Construction Co., 1981–1991;

vice president of business development, Hutton Construction Corp., 2004–09; owner, Assured Occupational Solutions, 2011–present.
John Brown University – BS, 1981

Rick Kreider
Chief, Bureau of Materials and Research
Kansas Department of Transportation
700 SW Harrison Street
Topeka KS 66603
785–296–1195
rickk@ksdot.org
Responsibilities and Experience
Responsible for all materials that are incorporated into KDOT projects, all research completed by KDOT, all geotechnical investigations, and all metal fabrication inspection for KDOT projects
Previous: Welder, 1980–84; engineer of special assignments, materials quality control engineer, assistant Bureau chief, and Bureau chief, KDOT
Kansas State University – BSCE, 1991

Annie Kuether
Kansas House of Representatives, 55th District
1346 SW Wayne Avenue
Topeka KS 66604
785–232–0717
kuet@aol.com
Responsibilities and Experience
Ranking Member, Energy and Utilities Committee; Joint Committee on Energy and Environment; KETA; Judiciary 911 Commission
Webster Groves High School – 1970
Bowling Green State University, Ohio

Cindy Lash
Principal Analyst
Kansas Legislative Research Department
300 SW 10th Street, Room 68–W
Topeka KS 66612
785–296–3923
cindy.lash@klrd.ks.gov
Responsibilities and Experience
Staff, House Energy and Utilities, Senate Utilities, Joint Committee on Energy and Environmental Policy, Kansas Electric Transmission Authority, Claims Against the State
Previous: Kansas Legislative Post Audit, 1983–2007
Rutgers – BA, 1975
University of Kansas – graduate studies

Tamera Lawrence
Assistant Revisor of Statutes
Kansas Office of Revisor of Statutes
2326 Surrey Drive
Lawrence KS 66046
785–296–5243
tamera.lawrence@rs.ks.gov
Responsibilities and Experience
Staff, Senate Agriculture and Natural Resources committees, House Energy and Utilities committee, Joint Comittee on Energy and Environmental Policy
University of Kansas – BS, 2006
University of Kansas – JD, 2010

Wayne Lebsack
President
Lebsack Oil Production, Inc.
603 S. Douglas Street
Lyons KS 67554
620–938–2396
Responsibilities and Experience
Manager exploration and production, Lebsack Oil Production, Inc.; Board Member, The Nature Conservancy, Kansas Chapter, and stewardship committee
Colorado School of Mines – GE, 1949
Colorado School of Mines – graduate studies, 1951

Janis K. Lee
Chief Hearing Officer
Kansas Court of Tax Appeals
1008 SW Fleming Court #101
Topeka KS 66604
785–296–2388
jlee@ruraltel.net
Responsibilities and Experience
Chief Hearing Officer, Judge pro tempore, and acting Executive Director, Kansas Court of Tax Appeals
Previous: Served 22+ years in Kansas Senate; served on Utilities, Ways and Means, Natural Resources, Agriculture, Education, and Tax committees; served on Kansas Electric Transmission Authority
Kansas State University – BS, Education, 1970

Lane Letourneau
Program Manager, Water Appropriation Program
Kansas Department of Agriculture, Division of Water Resources
109 SW 9th Street
Topeka KS 66612
785–296–0757
lane.letourneau@kda.ks.gov

Responsibilities and Experience

Oversee administration and enforcement of Kansas statutes related to the beneficial use of water resources, including new applications, changes certificates, water use reporting, compliance and enforcement; water rights administration; supervise staff in Topeka headquarters and in field offices in Garden City, Stafford, Stockton, and Parsons satellite office

Previous: Open-hole and case-hole engineer in the oil field, 1983–87; work with Kansas Department of Agriculture, Division of Water Resources, 1987–present

Fort Hays State University – BS, 1983

Earl Lewis

Assistant Director
Kansas Water Office
901 S. Kansas Avenue
Topeka KS 66612
785–296–0867
earl.lewis@kwo.ks.gov

Responsibilities and Experience

Oversee agency operations, including State Water Plan and coordinating planning, reservoir operations, and budget development

Previous: Seven years with DWR in water-use compliance, subbasin management, and interstate water issues

University of Kansas – BS, 1992

Judith Loganbill

Kansas House of Representatives, 86th District
215 S. Erie Street
Wichita KS 67211
316–990–6884
judithloganbill@msn.com

Responsibilities and Experience

Ranking member of Federal and State Affairs Committee and Joint House and Senate Security Committee

Previous: Elementary teacher

Bethel College – BS, 1975

Northern Arizona University – MA Ed, 1981

Brad Loveless

Director, Biology & Conservation Programs
Westar Energy
818 S. Kansas Avenue
Topeka KS 66451
785–575–8115
brad.loveless@westarenergy.com

Responsibilities and Experience

Manages environmental siting for generation and line construction, carbon planning, endangered species, avian protection, and environmental stewardship programs; member of Kansas Forest Service Advisory Council and board member of Kansas Alliance for Wetlands and Streams (KAWS)

The Ohio State University – BS, 1981

University of Kansas – MS, 1985

Ed Martinko

Director
Kansas Biological Survey
Higuchi Hall
2101 Constant Avenue
University of Kansas
Lawrence KS 66047–3759
785–864–1505
martinko@ku.edu

Responsibilities and Experience

State Biologist and Director, Kansas Biological Survey; Professor of ecology and environmental studies; Ex-officio Kansas Water Authority

College of Emporia – BS, 1967

University of Colorado – MA, 1970

University of Kansas – PhD, 1976

Carolyn McGinn

Kansas Senate, 31st District
P.O. Box A
Sedgwick KS 67135
316–772–0147
mcginn1@pixius.net

Responsibilities and Experience

Chair of Senate Ways and Means Committee, vice chair of Natural Resources Committee

Previous: Agriculture producer, Sedgwick County Commissioner

Wichita State University – BBA, 1983

Friends University – MSES, 1998

Ray Merrick

Kansas Senate, 37th District
6874 West 164th Terrace
Stilwell KS 66085
913–669–8586
merrickrf@sbcglobal.net

Responsibilities and Experience

Member Commerce, Financial Institutions, and Utilities committee

Previous: Sales management, Proctor & Gamble (Folgers Coffee Division); vice president and general manager, Cline Enterprises; owner, MJM Management

University of Kansas, 1958–1960
Washburn University, BBA - 1965

Ralph Ostmeyer
Kansas Senate, 40th District
P.O. Box 97
Grinnell KS 67738
785–824–3773
rostmey@ink.org
Responsibilities and Experience
Chair, Natural Resources Committee; farmer and rancher
Previous: Kansas House member; member, Agriculture Committee; Federal and State Affairs, Local Government, and Joint Administrative Rules and Regulations committees; county commission; school board member; Soil Conservation Board; FLBA board
Grinnell High School – 1961
Fort Hays State University

Don Paxson
Vice Chair
Kansas Water Authority
2046 U.S. Highway 24
Penokee KS 67659
785–421–2480
dpaxson@ruraltel.net
Responsibilities and Experience
Vice Chair, Kansas Water Authority and Chair of KWA Budget Committee
Previous: Owned Paxson Electric and Irrigation for 37 years; farming 1,600 acres dryland and center pivot irrigation; licensed in electrical and plumbing; well and pump design and center pivot sales, design, and installation
Hill City High School – 1956
Licensed electrician and licensed pump designer

Arlen Siegfreid
Kansas House of Representatives, 15th District
1403 W. Prairie Terrace
Olathe KS 66061
913–406–4093
siegfreid@comcast.net
Responsibilities and Experience
Majority leader of the Kansas House of Representatives
Mid-American Nazarene University – BS, 1987

Mark Sievers
Chairman, Kansas Corporation Commission
1500 SW Arrowhead Road
Topeka KS 66604
785–271–3350
m.sievers@kcc.ks.gov
Responsibilities and Experience
Act as agency head with input from commissioners; act independently with authority to render judgments and decisions on regulated utilities. Regulate motor carriers, gas conservation, telegraph/telephone companies, pipeline companies, common carriers, water, electric, gas, and power companies not owned by municipalities
Previous: Sievers & Sievers, 2002–11; Verizon Communications, 2000–02; GTE Communications, 1997–2000; Swidler & Berlin Chtd, 1996–97; Sprint Communications, 1988–1996; Southwestern Bell Telephone, 1986–88; Utah Attorney General, 1985–86; University of Utah, 1984–85; Utah State University, 1983–84; University of California, Davis, 1981–82; California Department of Water Resources, 1980–82; United Pacific/Reliance Ins., 1979; Colorado Springs Police Department, 1975–79
University of Colorado – BA, 1978
University of California – MA, ABD, 1982
University of Utah – JD, 1986

Tracy Streeter
Director
Kansas Water Office
901 S. Kansas Avenue
Topeka KS 66612
785–296–3185
tracy.streeter@kwo.ks.gov
Responsibilities and Experience
KWO Director 2004–present; Development of Kansas Water Plan, drought management, water marketing in 13 Kansas reservoirs, and staff to Kansas Water Authority. Serve on Missouri River Association of States and Tribes (MORAST) and Western States Water Council. Chair GIS Policy Board
Previous: Executive Director of SCC, 1995–2004
Highland Community College – AA, 1983
Missouri Western State University – BS, 1985
University of Kansas – MPA, 1993

John K. Strickler
Trustee, The Nature Conservancy, Kansas Chapter
1523 University Drive
Manhattan KS 66502

785–565–9731
jstrickl@ksu.edu
Responsibilities and Experience
Trustee, The Nature Conservancy, Kansas Chapter; Chair, Kansas Forest Service Advisory Council
Previous: Special Assistant for Environment and Natural Resources to Gov. Hayden, 2 years; Acting Secretary, Kansas Department of Wildlife and Parks, 1987 and 1995; Kansas Forest Service, KSU, 33 years; U.S. Forest Service, 4 years; Kansas Association for Conservation and Environmental Education, 5 years
University of Missouri – BS, 1957
Kansas State University – MS, 1968

Josh Svaty
Senior Adviser to the Regional Administrator
U.S. EPA Region 7
901 N. 5th Street
Kansas City KS 66101
913–551–7202
svaty.josh@epa.gov
Responsibilities and Experience
Senior adviser to the regional EPA administrator
Previous: Administrator for KDA regulations and policies; Secretary of Agriculture, 2010; advocate for agriculture; work with legislature for agriculture; family farming; seven years as Kansas State Representative, 108th District
Sterling College – BA, 2002

Vern Swanson
Kansas House of Representatives, 64th District
1422 5th Street
Clay Center KS 67432
785–632–5322
svswan@twinvalley.net
Responsibilities and Experience
Vice-chair, House Vision 20–20 Committee; Energy and Utility and Transportation committees
Previous: Food sales for 31 years
Emporia State University – BS, 1966

Julie Westhoff, R.G.
Senior Project Manager
Kennedy/Jenks Consultants
5800 Foxridge Drive, Suite 304
Mission KS 66202
913–385–7299
juliewesthoff@kennedyjenks.com
Responsibilities and Experience
Manage a number of environmental projects and tasked with marketing of office, an engineering and environmental consulting company with headquarters in San Francisco, CA
Previous: Worked in environmental consulting field as a geologist for 27 years; owned Prairie Environmental for six years; served on local AEG board as chair, 2007–09; registered geologist in Kansas and Missouri
University of Kansas – BS (biology), BS (geology), 1983

Vincent Wetta
Kansas House of Representatives, 80th District
1204 N. Poplar Street
Wellington KS 67152
620–399–3339
vmwetta@sutv.com
Responsibilities and Experience
State Representative
Previous: Engineer, BNSF Railway Co., 41 years
Wichita State University – BA, 1996

David Wiese
Assistant Revisor, Office of Revisor of Statutes
1017 SE 30th Street
Topeka KS 66605
785–296–0364
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Responsibilities and Experience
Staff, Senate Committee on Agriculture
University of Kansas – BA, 2007
Washburn University – JD, 2010

Jerry Williams
Kansas House of Representatives, 8th District
21225 Kiowa Road
Chanute KS 66720
620–431–0172
jerry.williams@house.ks.gov
Responsibilities and Experience
State Representative
Previous: Teacher, school administrator, executive director – health care, hospital/nursing home administrator, city commissioner, county commissioner, small business owner, farmer/rancher
Southeastern State University – BS, 1964
Southeastern State University – MSE, 1966
Emporia State University – EDS, 1971

Kansas Geological Survey Staff

Rex Buchanan
Interim Director
Kansas Geological Survey
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Responsibilities and Experience
Responsible for operations and direction of the Kansas Geological Survey; Kansas Geological Survey, 34 years
Previous: University-Industry Research, University of Wisconsin, 3 years; Salina Journal, 4 years
Kansas Wesleyan University – BA, 1975
University of Wisconsin–Madison – MA, 1978
University of Wisconsin–Madison – MS, 1982

Cathy Evans
Information Writer and Editor
Outreach and Public Service
Kansas Geological Survey
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Responsibilities and Experience
Write news releases and educational materials; edit publications; assist with field conference and guidebook
Previous: University Press of Kansas; Spencer Museum of Art
University of Kansas – BA, 1978
University of Kansas – MS, 1990

Shane Lyle
Senior Research Assistant
Geology Extension
Kansas Geological Survey
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Responsibilities and Experience
Geology Extension Coordinator; Kansas Field Conference; Kansas Geological Survey, 6 years
Previous: Environmental and Engineering Geology, 12 years
Kansas State University – BS, 1993
University of Kansas – MS, 2011

Bob Sawin
Senior Research Associate
Geology Extension/Stratigraphic Research
Kansas Geological Survey
1930 Constant Avenue
University of Kansas
Lawrence KS 66047–3724
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bsawin@kgs.ku.edu
Responsibilities and Experience
Geology Extension, Kansas Field Conference; Stratigraphic Research, geologic mapping, stratigraphic nomenclature committee chair; Kansas Geological Survey, 20 years
Previous: Petroleum Geology, 15 years; Engineering Geology, 6 years
Kansas State University – BS, 1972
Kansas State University – MS, 1977

Northwest Kansas
Water Conservation and Consumption, Energy and Transportation, and the Agricultural Economy

June 6–8, 2012

Welcome to the 2012 Kansas Field Conference, co-sponsored by the Kansas Geological Survey (a division of the University of Kansas), the Kansas Water Office, the Kansas Department of Transportation, and the Kansas Department of Wildlife, Parks and Tourism. Previous Field Conferences have focused on specific topics, such as energy or water. This year's Field Conference aims at a better understanding of a range of natural-resource issues in one part of the state: northwestern Kansas. This area is heavily agricultural and rural, dependent on ground water, reliant on a high-quality highway network, and is experiencing a growth in energy exploration. It also is an area of scenic surprises and holds evidence of some of the earliest movement of people onto the Great Plains. We'll look at all these things.

Water is an inescapable issue out here, and over the next three days, we'll look at both surface water —at Keith Sebelius Lake, Bonny Reservoir in Colorado, and the Republican River—and ground water, especially the Ogallala aquifer. We'll examine the basics of irrigation-based agriculture in northwestern Kansas, learn about ways that the aquifer is studied and monitored, and talk about some of the very latest management methods of dealing with those declines. We'll discuss other economic drivers in this part of Kansas, including oil and gas exploration, horizontal drilling, and hydraulic fracturing. And we've allowed time to see some of the natural features, including the scenic Arikaree Breaks in Cheyenne County, and visit an archeological site in a natural shelter formed in the Ogallala Formation in Rawlins County.

Just a word of geologic background. All of this trip will be in the High Plains physiographic region of Kansas, Colorado, and Nebraska. Most of the geologic materials you'll see at the surface were eroded off the face of the Rocky Mountains and carried out onto the High Plains by streams or wind over the past few million years of geologic history. Probably the most notable rock unit out here is the Ogallala Formation, a layer of sand and gravel, silt, clay, and other rock debris. In the subsurface it holds considerable amounts of water, thus forming the Ogallala aquifer that is the source of much of the ground water in this area. It also crops out at the surface in the form of "mortar beds," or naturally cemented sand and gravel, which will be readily apparent at the Burntwood Creek rockshelter stop. Another notable visible component of the landscape is loess, a finely ground rock flour or silt that mantles much of the surface. You'll see it in the highly eroded draws and canyons of the Arikaree Breaks.

The High Plains get their name because of their elevation and because they are relatively flat (except in places where the loess has been heavily dissected by erosion). All of western Kansas was raised up by the uplift of the Rockies to the west, but the high point in Kansas, topographically speaking, is Mount Sunflower in Wallace County, where the elevation is 4,039 feet. Much of the area where we'll travel is above 3,000 feet in elevation. Because of that elevation, and because this area is in the rain shadow of the Rocky Mountains, the climate here is different from much of the rest of the state. Average annual precipitation is low, generally less than 20 inches per year, and overall temperatures are generally cooler. The natural vegetation is different as well, much of it dominated by short-grass prairie. In the Arikaree Breaks, which are largely uncultivated, you'll see that buffalo grass and yucca dominate the landscape.

Day 1

Our first day begins with a trip to Keith Sebelius Lake, named after a long-time Kansas Congressman from Norton and the father-in-law of former governor Kathleen Sebelius. Because of the lack of precipitation, surface water is rare all across northwestern Kansas, which makes impoundments, like this one, important places for recreation. Then we'll switch from surface water to ground water, with the first of several discussions of the Ogallala aquifer. Outside of Hoxie, we'll see how the aquifer is monitored and studied, both on the regional scale and at a much more local level, and we'll learn about LEMAs, or Local Enhanced Management Areas, a new tool for attempting to deal with Ogallala declines. Moving on to the Lon Frahm farm south of Colby, we'll cover some of the basics of irrigated agriculture out here, learning more about large-scale farming, the economics of agriculture and land prices, and the development of drought-tolerant crops, which could play a role in helping conserve water supplies. We'll also take on a controversial topic, the black-footed ferret, an animal that had disappeared from much of the west, but has been reintroduced to parts of northwestern Kansas. We'll close the night at Lon Frahm's residence on the north edge of Colby.

Day 2

We'll begin the day by heading west for a discussion of roads and highways. Because of the rural nature of this part of the state, highways form a critical connecting link between residents and towns. Finding the material to build those roads, however, poses its own challenges. Then we'll move on west into Colorado (our first step into that state in the 18-year history of the Field Conference). We'll go to Bonny Reservoir to learn about the efforts there, and in other parts of eastern Colorado, to satisfy Colorado's responsibilities as part of the Republican River Compact. Before returning to Kansas through the steep-sided canyons of the Arikaree Breaks of Cheyenne County, we'll briefly detour into Nebraska (previous attendees may remember our last foray into the Cornhusker State, in 2008, when we got the Nebraska perspective on Republican River Compact issues to the east of here). Then, on the way to Goodland, we'll shift gears and move the conversation toward energy with a discussion on water usage for hydraulic fracturing, a clear example of the intersection of water and energy issues. Supper will be at the High Plains Museum in Goodland (although it's located in the Mountain time zone, our schedule will remain on Central time).

Day 3

North of McDonald, near the Nebraska border, is an overhang of the Ogallala mortar beds, a spot that once sheltered Native Americans. Kansas Geological Survey geoarcheologist Rolfe Mandel will describe an archeological study of this location, including a place nearby where Paleoindians herded bison over a sharp drop in the landscape, and the injured animals were then killed and butchered, their bones still visible today. Then we'll head to the Gateway Civic Center in Oberlin for a conversation about oil exploration and hydraulic fracturing. A recent oil play in the Mississippian along the southern border of Kansas has led to increased drilling and leasing for mineral rights. The extent of that play remains to be seen, however, and one company, SandRidge Energy Corporation, has done extensive leasing in west-central Kansas, into northwestern Kansas. They'll describe their exploration program and answer some of the questions surrounding it.

About the Kansas Field Conference

Some issues are best understood by seeing them firsthand. The 2012 Field Conference marks the 18th year the Kansas Geological Survey (KGS) has worked with co-sponsors to give policymakers the opportunity to see and experience some of the natural-resource issues with which they grapple. Participants have been selected to provide a range of legislative, government, education, and private-business expertise. Local and regional experts in natural-resource issues will meet us at each site and describe the location and the issues related to it. The objective is to let participants see the results of their decisions and to talk with local, State, and Federal governmental officials, environmental groups, business people, and citizens' organizations. The result should give participants a broader, more-informed perspective useful in formulating policies. In addition, the Field Guide you are holding provides background on sites and issues and serves as a handy reference long after the Field Conference is over.

During the Field Conference, participants are expected to be just that—participants. We want you to contribute to the discussion, to ask questions, and to otherwise join in on deliberations. **The bus microphone is open to everyone, and we encourage everyone to participate.**

Please remember that in the course of the Field Conference, we do not seek to resolve policy or regulatory conflicts. We do try to provide opportunities to familiarize policymakers with resource problems. By bringing together experts on energy and water, we hope to go beyond merely identifying issues. We want this combination of first-hand experience and interaction among participants to result in a new level of understanding of the state's natural-resource issues.

In doing this, we attempt to present, as nearly as possible, all sides of contentious issues. Please know that the opinions presented during the Field Conference are not necessarily those of the KGS or Field Conference co-sponsors. Nonetheless, we do believe it is important for participants to hear various viewpoints on complex issues.

The Field Conference is an outreach program of the KGS, administered through its Geology Extension program. Its mission is to provide educational opportunities to individuals who make and influence policy about natural-resource and related social, economic, and environmental issues in Kansas. The KGS's Geology Extension program is designed to develop materials, projects, and services that communicate information about the geology of Kansas, the state's natural resources, and the products of the KGS to the people of the state.

The Field Conference was begun in 1995 with the support of Lee Gerhard, then the Survey's director and State geologist. The Field Conference is modeled after a similar program of national scope, the Energy and Minerals Field Institute, operated by the Colorado School of Mines. The KGS appreciates the support of Erling Brostuen, retired Director of the Energy and Minerals Field Institute, in helping develop the Kansas project.

The Field Conference has been recognized by

- The National Institute of Standards and Technology as among 50 Best Practices for Communication of Science and Technology for the Public, 2001; and
- The Division of Environmental Geosciences of the American Association of Petroleum Geologists, which presented the Field Conference with its Public Outreach Award in 1998.

The KGS appreciates your attendance at this year's Field Conference and your willingness to share your insights for its improvements. Your input has helped make the Field Conference a model that has been adopted by other state geological surveys.

Sponsors

Kansas Geological Survey

Since 1889, the Kansas Geological Survey (KGS) has studied and reported on the state's geology. Today the KGS mission is to study and provide information about the state's geologic resources and hazards, particularly ground water, oil, natural gas, and other minerals. In many cases, the KGS's work coincides with the state's most pressing natural-resource issues.

By statutory charge, the KGS role is strictly one of research and reporting. The KGS has no regulatory function. It is a division of the University of Kansas. The KGS employs more than 65 scientific researchers and technical staff and 40 graduate research assistants and hourly student employees. It is administratively divided into research and research-support sections. KGS programs can be divided by subject into water, energy, geology, and information dissemination.

Water—Water issues affect the life of every Kansan. Western Kansas agriculture and industry rely heavily on ground water; in eastern Kansas, growing populations and industry generally use surface water. KGS water research and service include an annual water-level-measurement program (in cooperation with the Kansas Department of Agriculture, Division of Water Resources), modeling the impact of regulatory decisions, studies of recharge rates, water quality in the Arkansas River, depletion of the Ogallala aquifer, the interaction between streams and aquifers, and other topics. Much of that work is done with funding from the Kansas Water Plan, the National Science Foundation, and the state's groundwater management districts. The KGS also collects, archives, and disseminates water-well logs in cooperation with the Kansas Department of Health and Environment.

Energy—Kansas produced more than $4.7 billion worth of oil and natural gas last year. Because much of the state has long been explored for oil and gas, maintaining that production takes research and information. The KGS does research on the state's petroleum reservoirs, new methods of providing information, and new methods of exploring for and producing oil and gas. The KGS recently completed a multi-year study of the resources of the Hugoton Natural Gas Area, a study that resulted in the drilling of a substantial number of additional wells. Researchers are also characterizing the subsurface for possible sequestration of carbon dioxide. Unconventional natural gas, such as coalbed methane or low-BTU gas, and horizontal-drilling techniques are also a focus of ongoing research. The KGS works with the Kansas Corporation Commission to enable online reporting of oil and gas information, and has a branch office in Wichita, the Wichita Well Sample Library, that stores and loans rock samples collected during the drilling of oil and gas wells in the state. Much of the KGS energy research is funded by the U.S. Department of Energy.

Geology—Much of the KGS's work is aimed at producing basic information about the state's geology, information that can be applied to a variety of resource and environmental issues. The KGS develops and applies methods to study the subsurface, such as high-resolution seismic reflection; undertakes mapping of the surficial geology of the state's counties; and studies specific resources, such as road and highway materials. The KGS reports on nonfuel minerals (such as salt, gypsum, aggregates, etc.) and is charged with studying geologic hazards, including subsidence, earthquakes, and landslides. Much of this work is funded through the U.S. Geological Survey, the U.S. Army Corps of Engineers, the Kansas Department of Transportation, and the Department of Defense. The KGS also maintains a program in geoarcheology, studying the early peopling of the Great Plains.

Geologic Information—To be useful, geologic information must be disseminated in a form that is most appropriate to the people who need it. The KGS provides information to the general public, policymakers, oil and gas explorationists, water specialists, other governmental agencies, and academic researchers. Information is disseminated through a publication sales office, cartographic services, the state's Data Access and Support Center (DASC, located at the KGS), a data library, electronic publication, and Geology Extension.

KGS staff participating in the 2012 Field Conference include the following:

Shane Lyle, Senior Research Assistant, Geology Extension
Cathy Evans, Writer/Editor, Public Outreach
Bob Sawin, Senior Research Associate, Public Outreach/Section Chief, Stratigraphic Research
Rex Buchanan, Interim Director
Jim Butler, Senior Scientist and Section Chief, Geohydrology Section
Rolfe Mandel, Senior Scientist, Stratigraphic Research Section, and Professor, KU Department of Anthropology

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Kansas Department of Transportation

The Kansas Department of Transportation (KDOT) was founded in 1917. It is charged with providing a statewide transportation system to meet the needs of Kansans. Its primary activities are road and bridge maintenance; transportation planning, data collection, and evaluation; project scoping, designing, and letting; contract compliance inspection of material and labor; Federal program funding administration; and administrative support. In addition to dealing with roadways for automobile traffic, KDOT is responsible for other modes of transportation, including aviation, rail, and bicycles/pedestrians. KDOT has more than 3,000 employees. KDOT's headquarters are in Topeka with six district offices, 26 area offices, and 112 sub-area offices across the state. KDOT is responsible for maintenance of about 9,600 miles of State highway.

The agency is organized into divisions of public affairs, administration, aviation, engineering and design, operations, and planning and development. Within the Division of Operations is the Bureau of Materials and Research. This Bureau is responsible for approved materials, pavement management, testing, and research. Within that Bureau is a geotechnical unit that includes a geology section. That section supplies information and recommendations regarding surface and foundation geology, hydrology, and bridge-deck conditions to the Bureau of Design for project-plan preparation; conducts special surveys on selected subjects such as soil shrinkage, rock expansion, and pile-foundation requirements; and constructs new water wells in rest areas and rehabilitates and maintains existing wells for all KDOT facilities. Robert Henthorne is the chief geologist within the unit.

KDOT's current transportation program, called T-Works, will undertake about $1.7 billion worth of highway improvements. Work scheduled for fiscal years 2012–13 include 336 highway projects, 93 bridges/interchages, and 1,404 miles of roads, costing an estimated $677 million.

Mike King is the Secretary of Transportation.

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Kansas Department of Wildlife, Parks and Tourism

The Kansas Department of Wildlife, Parks and Tourism (KDWPT) is responsible for management of the state's living natural resources. Its mission is to conserve and enhance Kansas' natural heritage, its wildlife, and its habitats. The KDWPT works to assure future generations the benefits of the state's diverse living resources; to provide the public with opportunities for the use and appreciation of the natural resources of Kansas, consistent with the conservation of those resources; and to inform the public of the status of the natural resources of Kansas to promote understanding and gain assistance in achieving this mission.

The KDWPT's responsibility includes protecting and conserving fish and wildlife and their associated habitats while providing for the wise use of these resources, and providing associated recreational opportunities. The KDWPT is also responsible for providing public outdoor-recreation opportunities through the system of State parks, State fishing lakes, wildlife-management areas, and recreational boating on all public waters of the state.

In 1987, two State agencies, the Kansas Fish and Game Commission and the Kansas Park and Resources Authority, were combined into a single, cabinet-level agency operated under separate comprehensive planning systems. Then, in 2011, the state's Division of Travel and Tourism was moved from the Department of Commerce to the Department of Wildlife and Parks by executive order of Governor Sam Brownback. The KDWPT operates from offices in Pratt, Topeka, five regional offices, and a number of State park and wildlife area offices. The KDWPT employs about 420 people in five divisions: Executive Services, Administrative Services, Fisheries and Wildlife, Law Enforcement, and Parks. It operates 24 state parks, four nature centers, four fish hatcheries, and 63 wildlife areas.

The cabinet-level agency is administered by a Secretary of Wildlife, Parks and Tourism and is advised by a seven-member Wildlife and Parks Commission. The Governor appoints all positions, and Commissioners serve staggered four-year terms. As a regulatory body for the KDWPT, the Commission is a nonpartisan board, made up of no more than four members of any one political party, that advises the Secretary on planning and policy issues regarding administration of the KDWPT. Regulations approved by the Commission are adopted and administered by the Secretary.

Robin Jennison is the Secretary of Wildlife, Parks and Tourism.

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Kansas Water Office

The mission of the Kansas Water Office (KWO) is to provide the leadership to ensure that water policies and programs address the needs of all Kansans. The KWO evaluates and develops public policies, coordinating the water-resource operations of agencies at all levels of government. The KWO administers the Kansas Water Plan Storage Act, the Kansas Weather Modification Act, and the Water Assurance Act. It also reviews plans of any State or local agency for the management of water and related land resources in the state. The KWO advises the Governor on drought conditions and coordinates the Governor's drought-response team. The Drought Monitoring Program collects climate data from a variety of sources, monitors drought activities, and publishes a weekly Drought Report during periods of drought.

The KWO develops the Kansas Water Plan, which is revised periodically and addresses the management, conservation, and development of water resources in the state. Numerous water-related public and private entities, as well as the general public, are involved in its preparation and planning. The Water Plan is approved by the Kansas Water Authority, a 13-member board whose members are appointed, along with 11 nonvoting *ex officio* members who represent various State water-related agencies. Besides approving the Water Plan, the Authority approves water-storage sales, Federal contracts, administrative regulations, and legislation proposed by the KWO. Much of the input for the Water Plan comes from 12 Basin Advisory committees composed of volunteer members from each of the state's drainage basins.

The KWO is currently providing support for an Ogallala Aquifer Advisory Committee, holds annual water forums in Wichita and Hays, and is providing support for a Governor's Water Conference to be held in Manhattan October 30–31, 2012. During this year's Field Conference, we will be in the Upper Republican and Solomon river basins.

Tracy Streeter is the Director of the KWO.

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Schedule and Itinerary

Wednesday, June 6, 2012

6:00 a.m.	Breakfast at Norton Sleep Inn (starting time is informal)
7:15 a.m.	Conference Overview *Rex Buchanan*, Interim Director, Kansas Geological Survey
8:00 a.m.	**Bus leaves Sleep Inn for Site 1**
8:15 a.m.	**SITE 1** – Keith Sebelius Lake, Norton Lake Recreation and Local Economy *Robin Jennison,* Secretary, KS Dept. of Wildlife, Parks and Tourism *Scott Sproul,* Norton City/County Economic Development *Mike Nyhoff,* Region 1 Public Land Supervisor, KS Dept. of Wildlife, Parks and Tourism
9:00 a.m.	Bus to restroom break – Hoxie
	Bus Session – Update on the Governor's 2012 Water Policy Legislation *Tracy Streeter*, Director, Kansas Water Office
10:00 a.m.	Restroom break – Hoxie
10:30 a.m.	Bus to Site 2
10:45 a.m.	**SITE 2** – Mitch Baalman Farm, Hoxie
	High Plains Aquifer Ground-Water Level Monitoring *Rex Buchanan*, Interim Director, Kansas Geological Survey
	High Plains Aquifer Calibration Monitoring Well Program *Jim Butler,* Kansas Geological Survey
11:30 a.m.	Local Enhanced Management Areas (LEMA) *Wayne Bossert*, GMD 4 Manager *Mitch Baalman*, Ogallala Aquifer Advisory Committee
12:15 p.m.	Lunch – Mitch Baalman Farm, Hoxie
1:15 p.m.	Bus to Site 3
2:00 p.m.	**SITE 3** – Lon Frahm Farm, Colby

	Black-footed Ferret Reintroduction Program *Mike LeValley,* U.S. Fish and Wildlife Service
2:45 p.m.	Commercial Farming *Lon Frahm,* Frahm Farmland Inc.
3:45 p.m.	Agricultural Economics and the Future of Farming *Terry Kastens*, *PhD,* K-State Emeritus Agricultural Economist
4:15 p.m.	Drought Tolerant Corn Development *Cory Mills,* Research Scientist, Pioneer Hi-Bred International, Garden City, Kansas *Cole Randol*, Technical Production Manager, Pioneer Hi-Bred International, Greeley, Colorado
4:45 p.m.	Bus to Comfort Inn, Colby
5:00 p.m.	Arrive at Comfort Inn, Colby
6:00 p.m.	Bus to Social Gathering and Dinner at Lon Frahm's
6:15 p.m.	Arrive at Lon Frahm's
7:45 p.m.	Return to Comfort Inn, Colby

Keith Sebelius Lake

In the aftermath of the region's deadly 1935 flash flood, the Republican River and its tributaries were included in the U.S. Bureau of Reclamation's and U.S. Army Corps of Engineers' project planning for flood control and irrigation. Federal flood control and irrigation projects in the Republican drainage today include a system of seven Bureau of Reclamation reservoirs, two Corps of Engineers' reservoirs, and six irrigation districts (fig. 1).

Keith Sebelius Lake, formerly Norton Reservoir (fig. 2), and Norton Dam are part the Bureau of Reclamation Almena Unit located along the valley of Prairie Dog Creek in north-central Kansas. The unit consists of Norton Dam and Keith Sebelius Lake, Almena Diversion Dam, Almena Main and South canals, and a system of laterals and drains to serve 5,763 acres of project lands. In addition to storing water for irrigation, the unit provides water for use in the city of Norton; protects the valley downstream from floods; and offers opportunities for recreation, conservation, and the development of fish and wildlife resources.

Water Storage

Norton Dam and Keith Sebelius Lake on Prairie Dog Creek provide storage for the Almena Unit. The dam is about 2.5 miles upstream from Norton, Kansas. Water is released from Norton Dam for the municipal needs of Norton. Releases for irrigation purposes are diverted by Almena Diversion Dam, about 11 miles downstream from Norton Dam. Water diverted from Prairie Dog Creek by the diversion

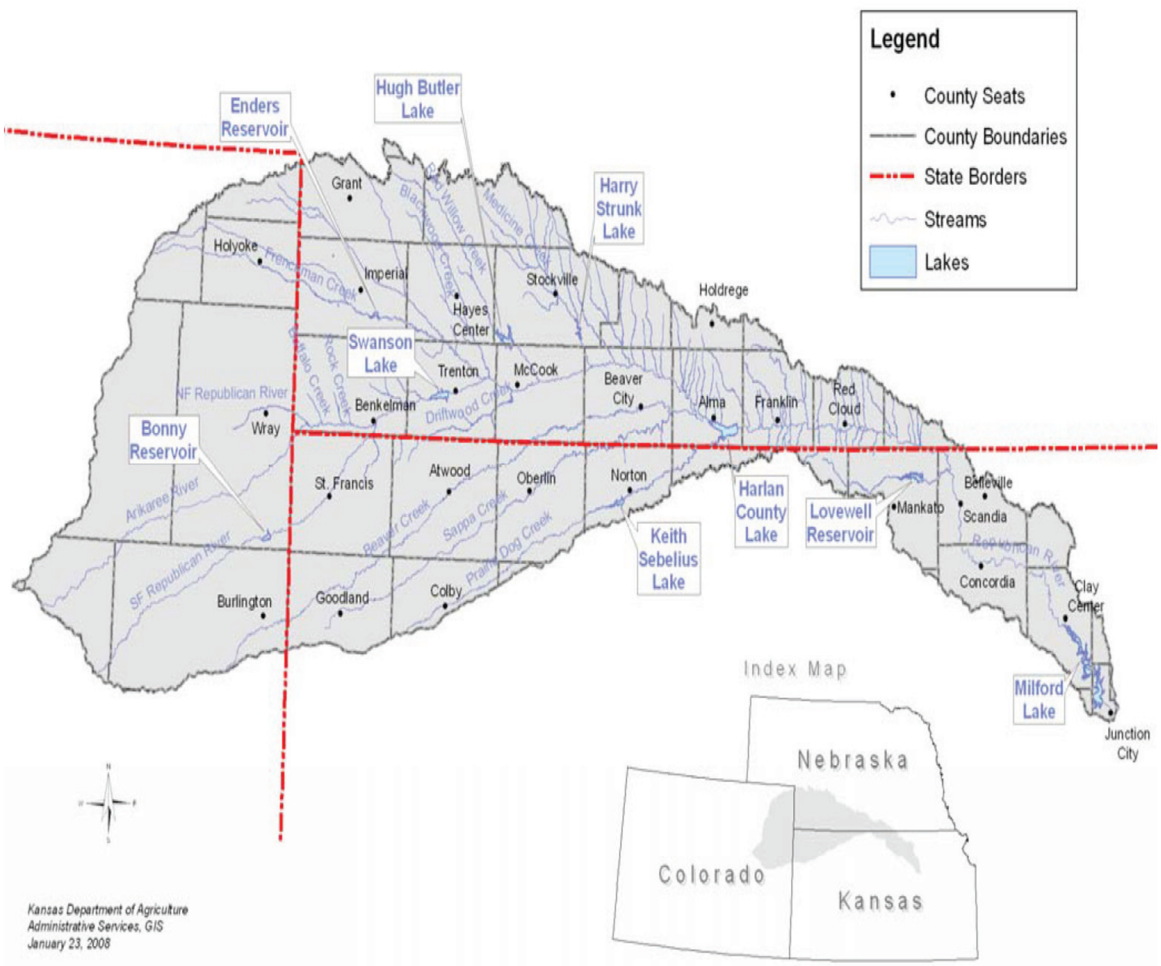

Figure 1 – Republican River basin (Division of Water Resources, Kansas Department of Agriculture).

structure is carried by the main and south canals and a system of laterals to farmland in the Almena Irrigation District No. 5. These lands are in Prairie Dog Creek valley and extend from about 2 miles southwest of Almena to 3 miles east of Long Island.

Norton Dam is a zoned earth fill structure with rock riprap on its upstream face. It has a height of 101 feet above the streambed and a crest length of 6,450 feet. Almena Diversion Dam consists of a concrete ogee overflow weir about 150 feet long, 19 feet high above the streambed, and includes earth dikes 310 feet long and 31 feet high above the streambed.

The capacity of Keith Sebelius Lake is 134,738 acre-feet. Of this amount, 2,718 acre-feet are allocated for dead storage, 30,651 acre-feet are allocated for irrigation and municipal supply, 98,803 acre-feet are for flood control, and 2,566 acre-feet are inactive capacity.

Project Authorization

The Almena Unit was approved under the Flood Control Act of 1944 as a unit of the Pick–Sloan Missouri Basin Program development plan. The Army Corps of Engineers' plan for the region, designated the "Pick Plan" after Colonel Lewis A. Pick, emphasized flood control and navigation. The Bureau of Reclamation's William G. Sloan headed a study that stressed irrigation and hydroelectric power. The two proposals were reconciled in the 1944 act, hence the name, "Pick–Sloan." The Flood Control Act of 1946 authorized construction of the Almena Unit.

The contract for the construction of the Norton Dam and Reservoir was awarded in 1962, and initial water storage started in 1964. The contract for the construction of the Almena Diversion Dam was awarded in 1965, and the dam was completed in 1967.

Figure 2 – Keith Sebelius Lake, Norton County, Kansas (Kansas Geological Survey).

KDWPT Keith Sebelius Lake/Norton Wildlife Area

The Norton Wildlife Area is owned by the Bureau of Reclamation but managed under a long-term agreement by Kansas Department of Wildlife, Parks and Tourism for fish, wildlife, and recreation. The Norton Wildlife Area borders Keith Sebelius Lake, which was created in 1964 when the Bureau of Reclamation completed construction of the Norton Dam.

Norton Wildlife Area, located 3 miles southwest of Norton, comprises Keith Sebelius Lake and adjacent lands, excluding the State Park and Federal Operation Areas. At the current water elevation, the wildlife area has 900 water acres and 6,900 land acres. At full capacity of 2,181 water acres, the area provides the best natural resource opportunities. As water levels decline, tradeoffs occur between maximizing aquatic and land species habitats and maintaining recreational opportunities. To alleviate that problem, the managing agencies are always considering ways to keep water levels as high as possible in the reservoir.

The area provides exceptional hunting, fishing, and boating opportunities. Walk-in access is nearly unlimited, and a system of seasonal and permanent roads provides good vehicular access. The only required fees are for fishing, hunting, and boating licenses, which support management of the area. Camping, hiking, and wildlife-watching activities provide limited or no financial support for the area.

Sources

Kansas Department of Wildlife, Parks and Tourism, 2012, Keith Sebelius Reservoir/Norton Wildlife Area: Kansas Department of Wildlife, Parks and Tourism, http://kdwpt.state.ks.us/news/KDWPT-Info/Locations/Wildlife-Areas/Region-1/Keith-Sebelius-Reservoir-Norton

Norton, Kansas, History. Http://us36.net/nortonkansas/history1.htm

Rucker, K. E., 2009, Almena Unit—Pick–Sloan Missouri Basin Program: U.S. Bureau of Reclamation, 31 p., available online at http://www.usbr.gov/projects/ImageServer?imgName=Doc_1261497067636.pdf

U.S. Bureau of Reclamation, 1985, Keith Sebelius Lake/Almena Diversion Dam Reservoir Area Management Plan, 86 p.

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Measuring Water Levels in the High Plains Aquifer

The High Plains aquifer (fig. 1) is the primary source of water for the High Plains region of western and south-central Kansas. Each year the Kansas Geological Survey (KGS) and the Kansas Department of Agriculture's Division of Water Resources (DWR) measure water levels in approximately 1,400 representative wells in 47 counties to provide an accurate but cost-effective snapshot of water levels in the High Plains aquifer. For consistency the same wells are measured each year. Wells were selected for the project based on the screened interval and construction, spatial location, historical data, and well use. In general, one well in every 16-square-mile area is measured (fig. 2). A representative water level is the most fundamental and unequivocal measuring stick to assess an aquifer management strategy. Measurements in this program are largely obtained in early January when irrigation wells, which cause levels to fluctuate, are not in use.

The High Plains Aquifer

The High Plains aquifer system lies beneath parts of eight states in the Great Plains and all or part of 54 western and central Kansas counties. The aquifer has various sub-aquifer units, and water is also sometimes withdrawn from underlying bedrock units in this region. Comprising the well-known Ogallala aquifer, shallow alluvial deposits, and other units, the High Plains aquifer supports the region's cities, industry, and agriculture. It is the main water source for much of western and central Kansas and provides 70% of the water used by Kansans each day.

Aquifers are underground deposits containing permeable rock or sediments (clay, silts, sands, and gravels) from which water can be pumped in usable quantities. The High Plains aquifer is composed mainly of silt, sand, gravel, and clay sediment eroded

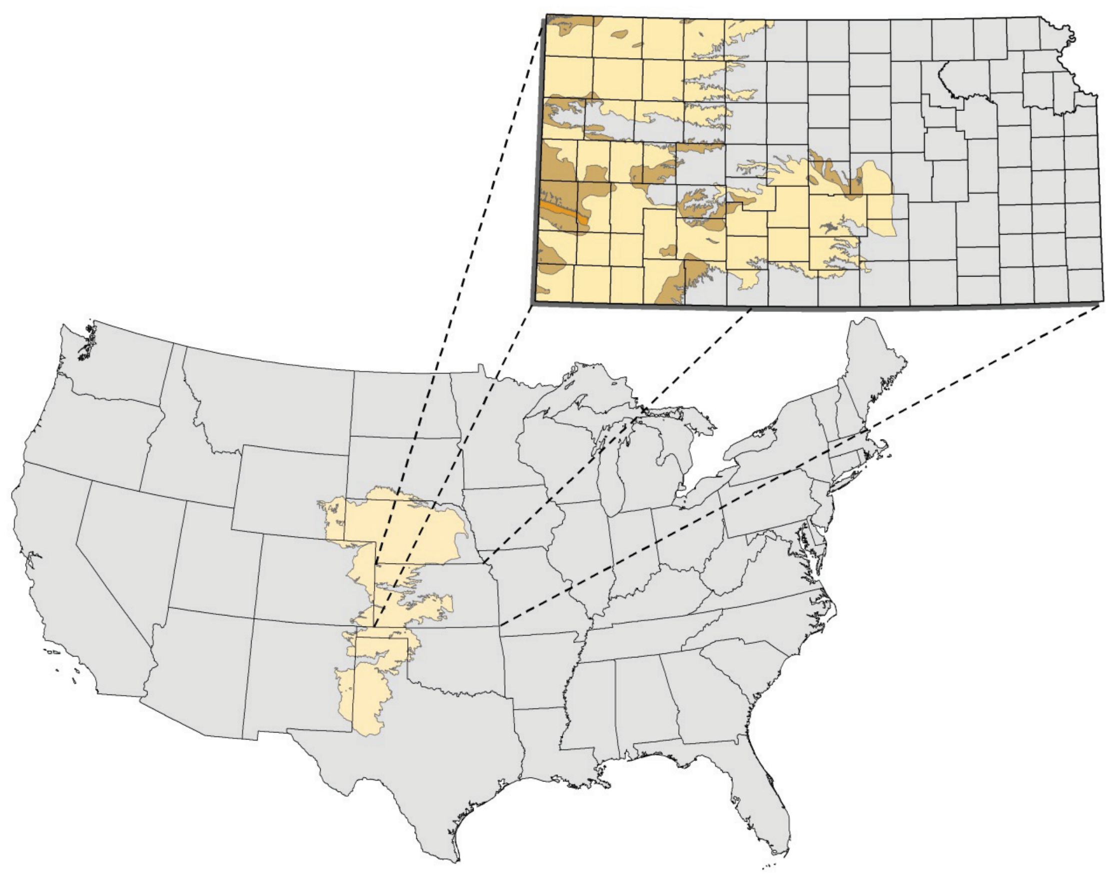

Figure 1–Saturated extent of the High Plains aquifer in Kansas (Kansas Geological Survey).

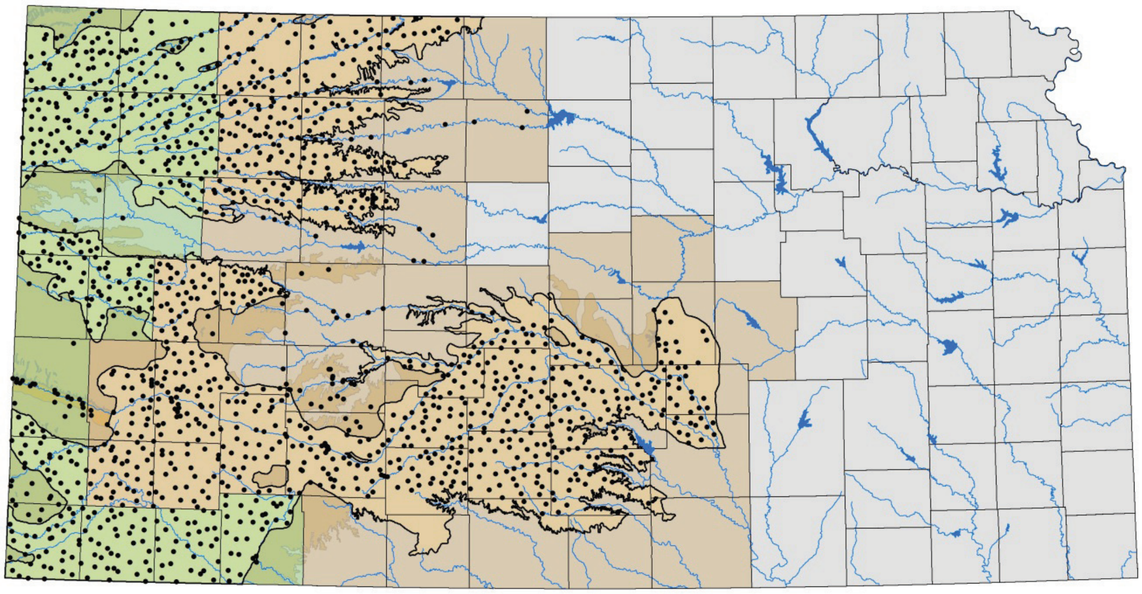

Figure 2–High Plains aquifer (solid black outline) annual well locations (Kansas Geological Survey).

from the Rocky Mountains. In Kansas, the High Plains aquifer is made up of several sub-regional aquifers—the Ogallala, Great Bend Prairie, and Equus Beds (fig. 3).

The Ogallala Formation, present throughout much of the western half of Kansas, is the High Plains aquifer's principal geologic unit. The Ogallala was deposited by eastward-flowing braided streams that carried sediments onto an aggrading outwash plain that covered the land surface and buried existing valleys. Where the Ogallala crops out at the surface, it is typically cemented by calcium carbonate and forms resistant rock known as mortar beds. Unconsolidated alluvium of the Great Bend Prairie and Equus Beds aquifers in south-central Kansas are within the great bend of the Arkansas River and north of Wichita, respectively. This portion of the High Plains aquifer is mostly reworked Ogallala sediment. Large areas south of the Arkansas River are covered in dune sand. In southwestern Kansas, the water table is generally below the surficial dune-sand deposits, but it is an important recharge area for the aquifer. Relatively recent valley-fill alluvium in modern stream valleys, such as the Republican and Arkansas rivers, are the youngest deposits of the High Plains aquifer and represent the surface expression of the aquifer.

Aquifer Characteristics

Aquifer characteristics are determined in large part by geology. As is suggested by the sediment deposition from braided or meandering streams, the aquifer varies greatly from place to place. It is thick in some places, thin in others, permeable (able to transmit water easily) in some places, less so in others. In general, available water in storage is the fraction of water that will drain by gravity and can be withdrawn by wells. About 50 to 100 ft of saturated thickness is required to sustain high-volume irrigation pumping under most aquifer and water-use conditions (fig. 4). Where the deposits are thick and permeable, water is easily removed and the aquifer can support large volumes of pumping for long periods. In most areas this water is of good quality.

Long-term water-level changes in the aquifer result from an imbalance between discharge and recharge. Discharge is primarily ground water

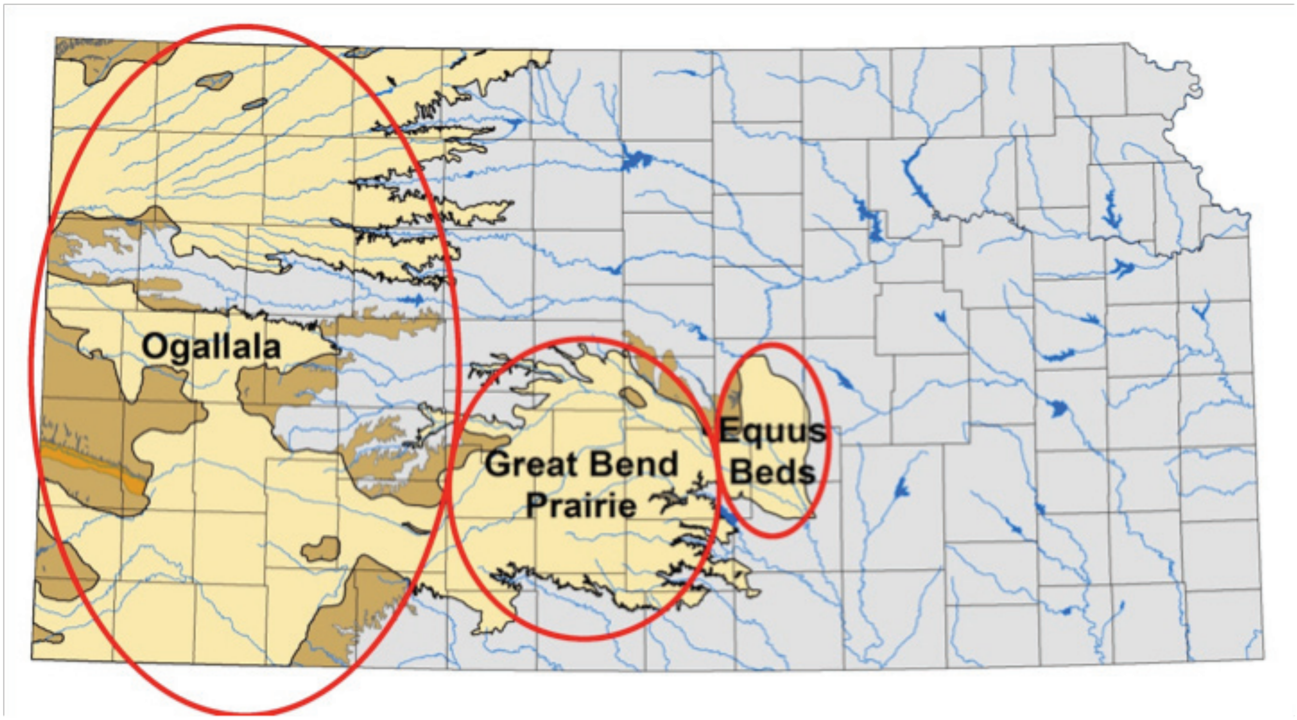

Figure 3–Sub-regional High Plains aquifers in Kansas—the Ogallala, Great Bend Prairie, and Equus Beds (Kansas Geological Survey).

withdrawn for irrigation, although it may also be pumped for public water supply and other uses. Water is also discharged through evapotranspiration, and seepage to streams, springs, and other surface-water bodies where the water table intersects the land surface. Recharge comes primarily from precipitation. Other sources of recharge include seepage from streams, canals, reservoirs, and irrigation return flows. In general, the Great Bend Prairie and Equus Beds are closer to the surface and in wetter areas of Kansas than the Ogallala, so these aquifers receive more recharge and are relatively sustainable with safe yield practices. The Ogallala is much deeper and mainly in semi-arid parts of Kansas. It receives, on average, a little less than one inch of recharge per year, which is an unsustainable amount in the long term when high-volume irrigation is practiced. Water-level declines can increase pumping costs due to increased pumping lift and decreased well yields, and also affect ground-water and surface-water availability.

Data Storage and Analysis

Once data from the annual water-level measurement program are recorded and checked, they are entered into the Water Information Storage and Retrieval Database (WIZARD) and made electronically available to the public. The current year's measurements and historical water-level data are archived and maintained at the KGS in a large, statewide computer database. Information on Kansas ground-water resources can be obtained for areas as small as a section or as large as the entire state. Data analyses, reports, and general queries also are available. The annual data are used to complete various kinds of scientific analyses, including determinations of saturated thickness, depth to water, depletion trends, and water-resource predictions.

Data gathered from well measurements are used for a variety of purposes, both public and private. Organizations and governmental agencies use the data, especially in mapped form (fig. 5), to develop an understanding of trends in regional water levels. That understanding is then used in making decisions about water and in taking regulatory actions. Groundwater management districts use the results to plan for localized enhanced management. The DWR uses the data in making decisions about applications for new water rights and in declaring and regulating intensive ground-water use control areas, where new ground-water pumping is extremely limited. Private

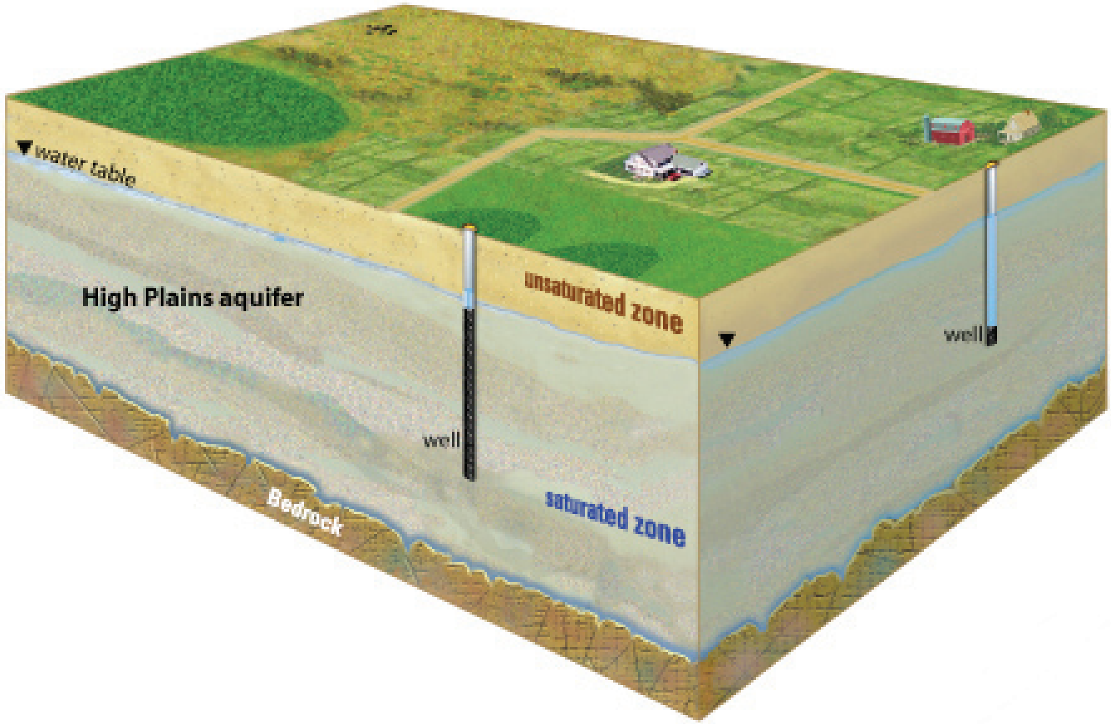

Figure 4–Generalized cross section of the High Plains aquifer. Different layers of sediment will vary laterally in thickness and extent (U.S. Geological Survey, 2008).

institutions use the measurements to appraise the value of land and make lending decisions. Private landowners use the data to monitor water levels in their own and nearby wells. All these uses require high-quality data.

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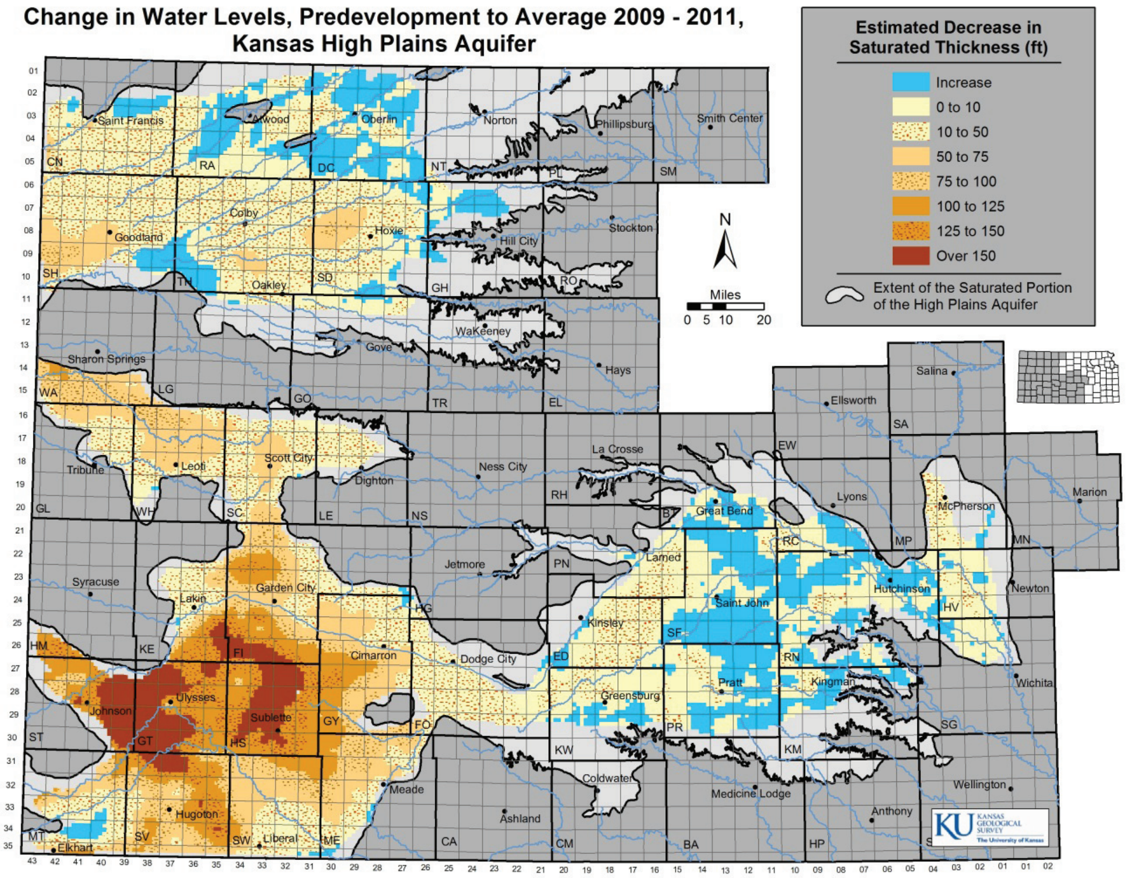

Figure 5–Change in predevelopment water levels in the High Plains aquifer. The differences in geology, recharge, and aquifer management techniques are apparent when comparing the Great Bend Prairie and Equus Bed aquifers to the Ogallala aquifer (Kansas Geological Survey).

High Plains Aquifer Calibration Monitoring Well Program (Index Well)

The Kansas Geological Survey (KGS) High Plains Aquifer Calibration Monitoring Well Program (also called the index well program) is directed at developing improved approaches for measuring and interpreting water-level responses at the local level. The study is supported by the Kansas Water Office (KWO) with Water Plan funding as a result of KWO's interest in and responsibility for long-term planning of ground-water resources in western Kansas. The Kansas Department of Agriculture, Division of Water Resources (DWR), is providing assistance, as are Groundwater Management Districts (GMDs) 1, 3, and 4.

Assessing aquifers on a local scale helps prioritize and determine aquifer sub-units of High Priority Areas (HPAs) and local enhanced management areas (LEMAs). Changes in water level are considered the most direct and unequivocal measure of the impact of aquifer management strategies. The index well program, which supplements the annual regional ground-water-level monitoring program, is making a significant contribution to understanding the High Plains aquifer at a scale appropriate to define and manage aquifer subunits. This understanding should lead to cost-effective improvements for long-term aquifer management. A subsidiary goal of the program is to directly examine issues and areas of particular interest to the GMDs, DWR, and KWO.

In the summer of 2007, the KGS installed three index wells in the Ogallala portion of the High Plains aquifer, one in each of the three western Kansas GMDs. The sites, in Haskell (GMD 3), Scott (GMD 1), and Thomas (GMD 4) counties (fig. 1), are being continuously monitored.

Index Well Overview

The three index wells are in areas of economic importance and where other supporting ground-water studies have been pursued. The Haskell County site is near a location that was subject to a water-right impairment complaint. The Scott County site has the only well that directly monitors the water level in the northern portion of the Scott–Finney depression, the major water supply source for Scott City. In addition, the Scott County monitoring well is co-located with a project in which drillers' logs are being analyzed to map aquifer intervals that readily yield water and to relate aquifer lithology to well response characteristics. The Thomas County site has been the subject of previous water-budget analyses. It is also of interest because of its position near the edge of a

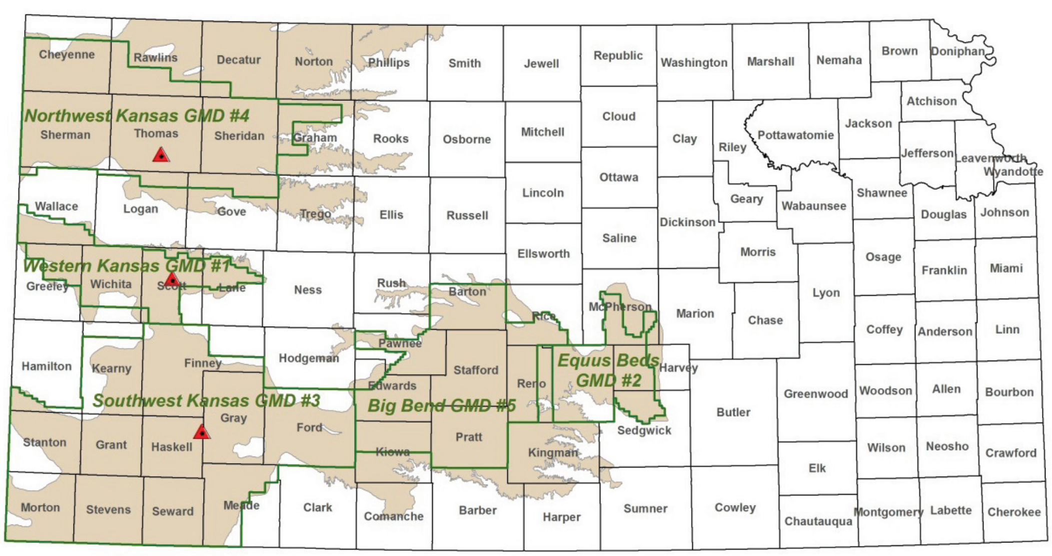

Figure 1—Index well locations relative to the Ogallala–High Plains aquifer in Haskell, Scott, and Thomas counties (Kansas Geological Survey).

productive portion of the High Plains aquifer and the potential there for surface-water recharge.

Each index well location has a monitoring well equipped with an automated pressure transducer and data logger that provide an almost continuous water level-record (fig. 2). The monitoring wells are designed to monitor the effects of high-volume irrigation wells and to supplement the region-wide, annual water-level data sets. Water-level measurements recorded every January for the annual water-level project include data collected from irrigation wells that typically do not completely recover between pumping seasons, are uncorrected for barometric pressure, and do not consider local hydrogeology variations associated with aquifer recharge, thickness, sorting, and depth to bedrock. These hydrologic uncertainties may produce water-level numbers that are of limited use for managers in terms of assessing the impact of conservation programs such as LEMAs. Interpretation of the near-continuous data provided by an index well (fig. 3) can help managers assess aquifer trends and local hydrologic uncertainties due to geology and, in some instances, ground-water recharge.

Aquifer Conditions

The commonly held view of the High Plains aquifer as a single unconfined aquifer appears appropriate in some instances, such as at the Thomas and Scott county sites. Contrary to that assumption, however, data from the Haskell County site show that the aquifer is more complex there than the two other index well sites. Although the saturated thickness at the Haskell County site is about 160 ft, productive zones that easily yield water are actually not nearly that thick. It appears that there is a two-zone aquifer system with an upper unconfined aquifer zone and a thin lower confined aquifer zone on top of bedrock. A thick clay layer separates the two aquifer zones. These zones also vary laterally, which leads to a more rapid rate of water-level and well-yield decline.

The Scott and Thomas sites are both unconfined aquifers located in areas where the saturated thickness is generally 100 ft or less, with some areas of less than 50 ft. Since 50–100 ft of saturated thickness is generally required to sustain high-volume irrigation pumping, these sites are vulnerable to resource exhaustion.

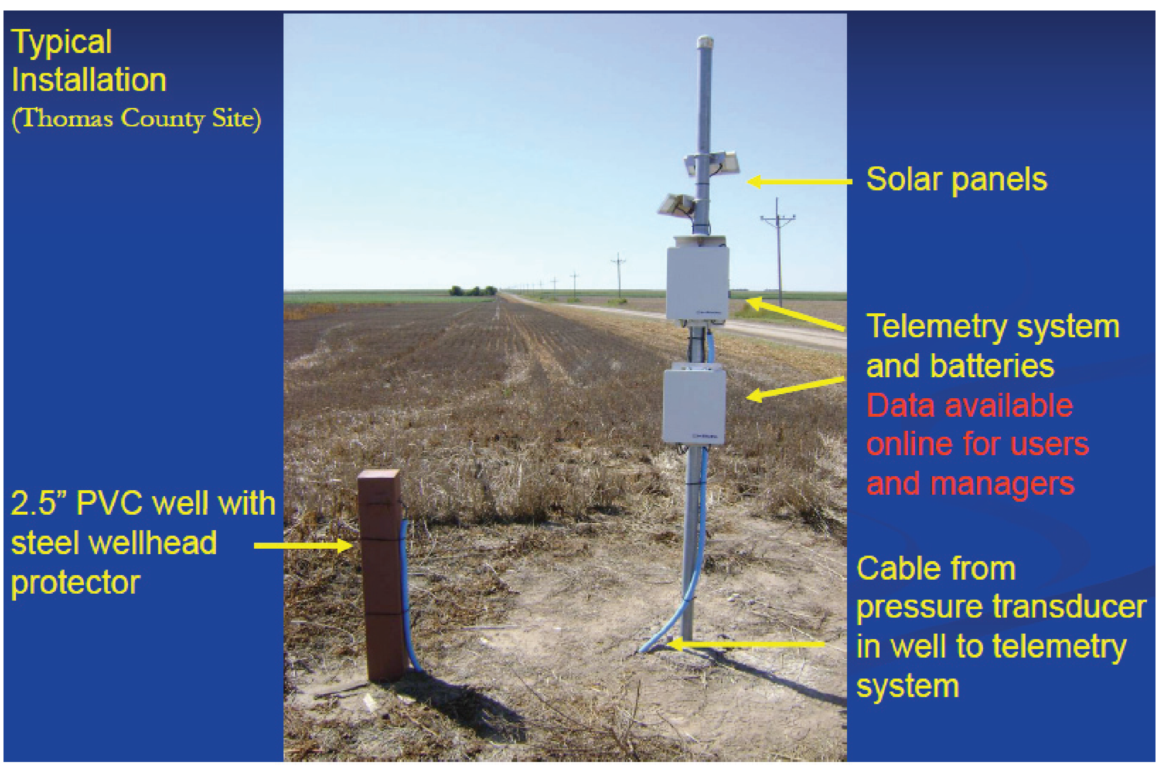

Figure 2–Thomas County (GMD 4) index well. The telemetry system allows for online data analysis and downloads (Kansas Geological Survey).

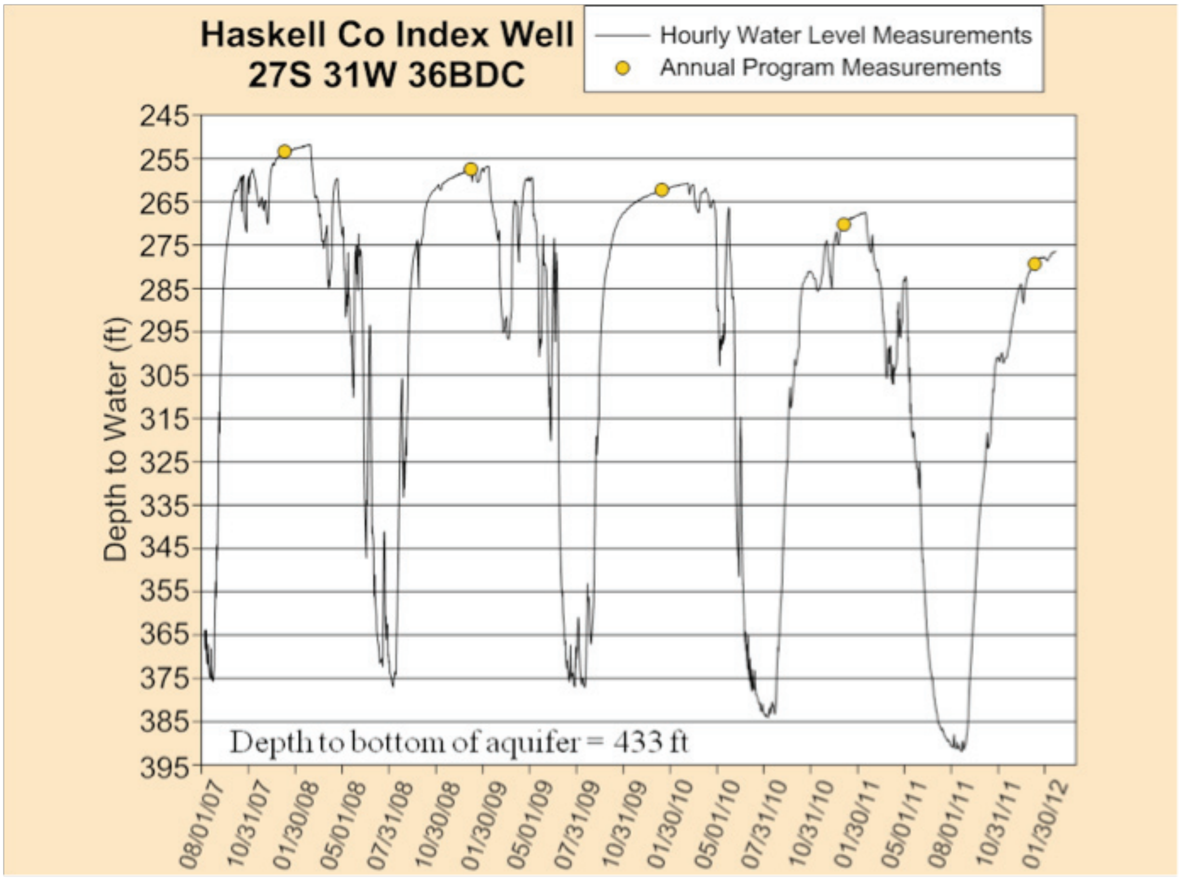

Figure 3–The Haskell County index well hydrograph depicting water-level drawdown during the pumping season and the incomplete winter recovery. The bottom of the aquifer is 433 ft below land surface (Butler et al., 2012).

Interpretation of Water-level Changes

A detailed examination of the water-level records from the Haskell County index well (fig. 3) and DWR-monitored wells in that vicinity reveals that, despite the relatively thick saturated interval, it is likely that large-scale irrigation withdrawals will not be sustainable beyond the current decade in the vicinity of the Haskell site, except, possibly, in those wells that are also completed in the discontinuous sandstones of the underlying Dakota Formation.

A detailed examination of the water-level records from the Thomas County index well and nearby wells monitored with the assistance of DWR and GMD4 reveals that a significant amount of water flows into the High Plains aquifer in that vicinity. This inflow, which is revealed by the near-coincidence of recovery rates between years, is independent of conditions in the previous pumping season (e.g., amount and duration of pumping). Determination of the origins of this inflow at the Thomas County index well is critical for assessing the continued viability of that portion of the aquifer as a water source for irrigated agriculture.

Interpretation of water-level records from the Scott County site is in its early phases. Monitoring of additional wells in that vicinity started earlier this year.

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Local Enhanced Management Areas (LEMAs)

Recent passage of Kansas Senate Bill 310 provides a significant change to the Groundwater Management District Act, allowing Groundwater Management Districts (GMDs) in Kansas to develop Local Enhanced Management Areas (LEMAs) to reduce water level decline rates within the Ogallala aquifer. LEMAs permit GMDs and local stakeholders to have greater control over conservation practices within their management areas than were previously allowed under the Intensive Groundwater Use Control Area (IGUCA) policy. LEMAs provide an alternate method for GMDs to ask the Chief Engineer for corrective controls in certain areas, without asking for an IGUCA, a process that may result in unintended consequences for stakeholders. Under the IGUCA process, the Chief Engineer could implement corrective control beyond what the stakeholders had asked for or even desire. Using the LEMA approach, stakeholders are not guaranteed their plan will be accepted, but they are guaranteed they will not be forced to accept an alternate plan.

The LEMA process allows local communities of producers to collectively decide their future by initiating the implementation of conservation plans that meet their local goals. LEMAs are a high-priority component of Governor Brownback's Legislative agenda to promote water conservation, grow the economy, and create jobs in western Kansas.

History

In 2008 the Northwest Kansas GMD No. 4 (GMD 4; fig. 1), in cooperation with stakeholders and the Kansas Department of Agriculture, Division of Water Resources, started a process that would lead to the establishment of LEMAs. At that time GMD 4 began working with irrigators to reduce water usage in six high-priority areas (HPAs; fig. 2) where ground-water levels had declined as a result of excessive pumping. In 2010 a group of irrigators in Sheridan County (SD-6) agreed to shared reduction in water usage to prolong their water supply and avoid impairment claims from holders of junior water rights. GMD 4 asked the Kansas Department of Agriculture Division of Water Resources (DWR) for regulations allowing a shared reduction in quantity based on 55 acre-inches over a five-year allocation. At that time, however, reductions could only be administrated through the established IGUCA policy,

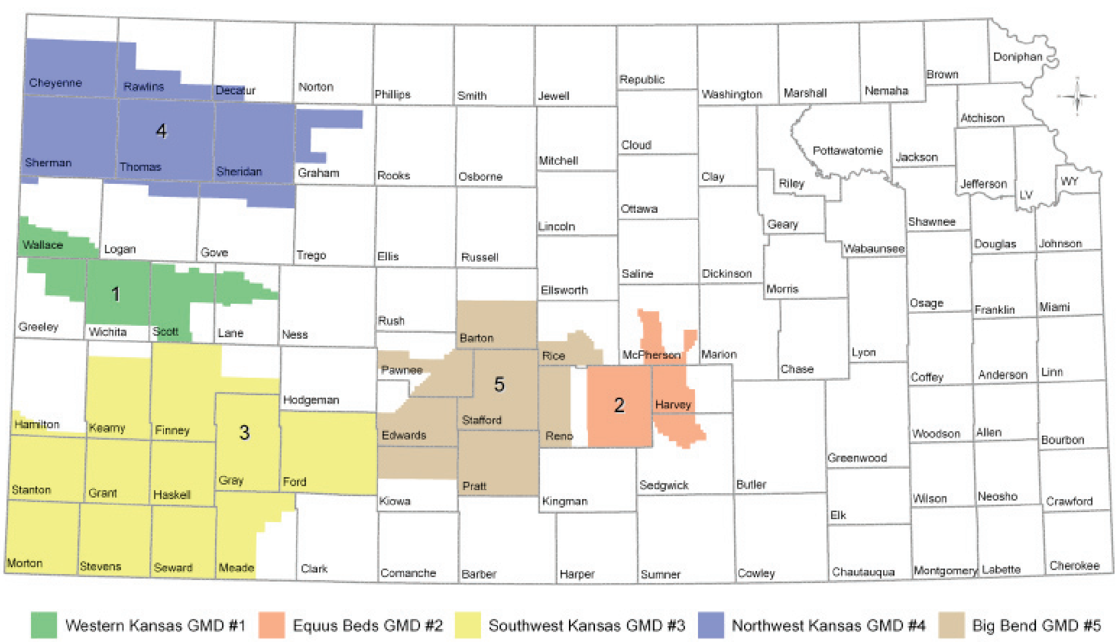

Figure 1–The five Groundwater Management Districts in Kansas were organized to establish the right of local water users in accordance with basic laws and policies of the state (DWR, 2012).

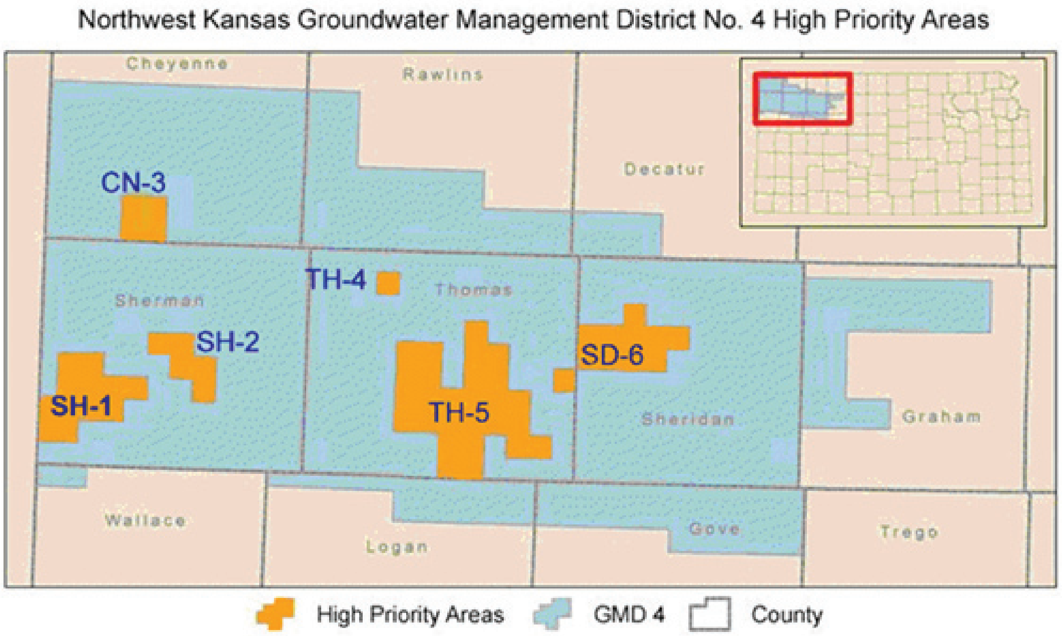

Figure 2–High Priority Areas in Northwest Kansas GMD No. 4. The first LEMA initiatives will begin in SD-6 (GMD 4, 2012).

and there was concern that the IGUCA process could result in unintended controls beyond the intent of local stakeholders.

Using the LEMA framework, GMDs and stakeholders can propose to the Chief Engineer their own local corrective controls without invoking an IGUCA. In GMD 4, any proposed LEMA plan is expected first to be incorporated into the GMD's Revised Management Program before being submitted as a LEMA request. The Chief Engineer then holds a hearing or hearings solely on the proposed local plan to accept, reject, or send that plan back for modification. In essence, if the plan is rejected by the Chief Engineer, it will not be replaced with a different plan without local approval.

As of April 2012, GMD 4 and stakeholders in SD-6 affirmed their intent to move forward and establish local controls and shared reduction in the HPA to conserve and extend the useful life of the Ogallala aquifer. GMD 4 proposed a draft revised management plan to the Chief Engineer for comments. The Chief Engineer's comments were incorporated, approved by GMD 4, and submitted again for the Chief Engineer review and approval.

SD-6 LEMA Management Plan

Enhanced controls in the SD-6 will cover 99 sections of ground and 194 distinct non-domestic ground-water wells, with a total annual authorized quantity of 61,164 acre-feet of water. Of this authorized quantity, an average of 28,800 acre-feet had already been pumped annually over the preceding 10 years and applied to approximately 24,803 irrigated acres (fig. 3). The stakeholders have proposed reductions of about 20% in actual historical use (i.e., not a 20% reduction of total authorized quantity). Review and implementation of the GMD 4 revised management plan is ongoing, and specific details will be developed in accordance with the new LEMA statutes.

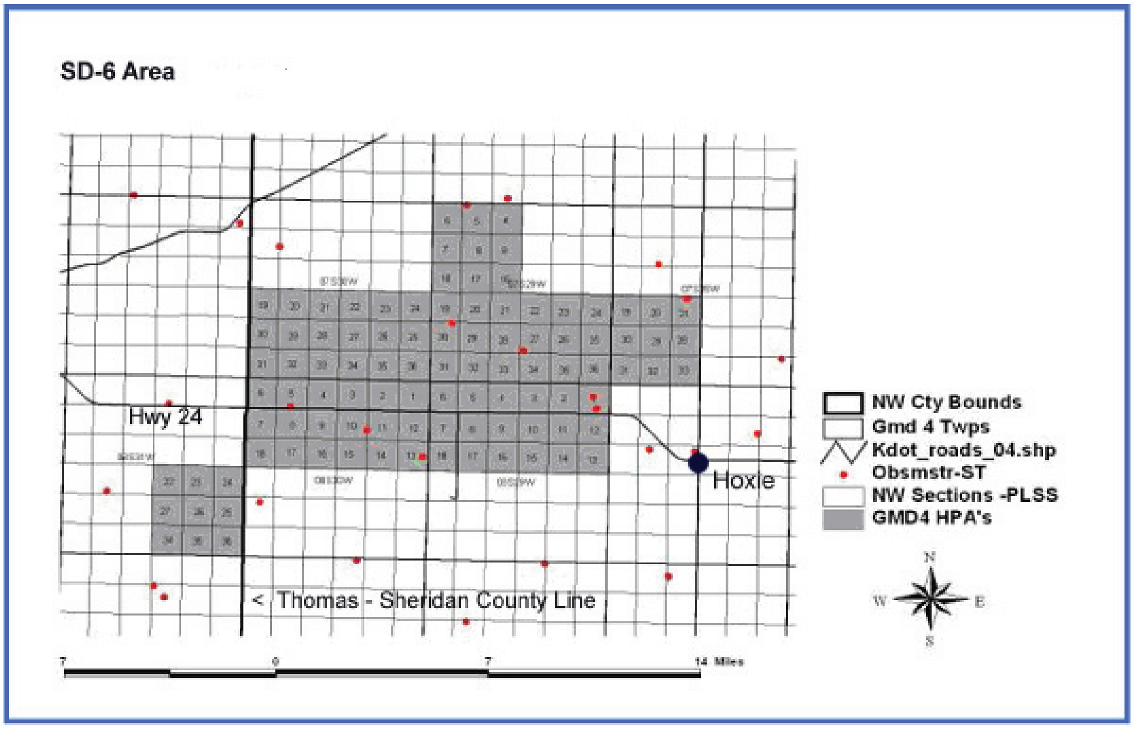

Figure 3–Detail of High Priority Area SD-6 located in Sheridan and part of Thomas counties (GMD 4, 2012).

Summary

The new LEMA law is a procedure to implement local aquifer conservation efforts, and use of the LEMA process is considered only for a specific area upon request of a local GMD and stakeholders. LEMA conservation efforts are limited only by the goals and creativity of local stakeholders within a framework of sufficient State and local checks and balances that ensure the LEMA approach is consistent with State law and GMD management programs. The IGUCA process is still retained if needed or preferred. A LEMA request does not guarantee that local stakeholders and the GMD board will receive approval, but it ensures that an alternative plan will not be implemented without local approval.

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Black-footed Ferret Reintroduction Program

Twice since the late 1950s, speculation spread about the likely demise of the black-footed ferret (fig. 1). None had been seen in Kansas since a sighting near the Sheridan County town of Studley in 1957, and by the end of that decade many thought the elusive mammal might be extinct altogether. But in 1964, a small population was discovered in South Dakota, and the black-footed ferret was included on the first U.S. endangered species list in 1967. After the South Dakota ferrets still in the wild disappeared by 1974, and an attempted captive breeding program failed by 1979, extinction was again surmised. Then in 1981 a Wyoming ranch dog brought a dead black-footed ferret home, leading to the discovery of a new ferret population. Another—this time, successful—captive breeding program was activated, and in 1991 the first black-footed ferrets bred in captivity were reintroduced in Wyoming.

In 2007, black-footed ferrets were successfully reintroduced in Kansas—in Logan County–but the venture has not been without controversy. A handful of ranchers support the effort but many, who are already contending with prairie dogs they fear will destroy their grasslands, oppose it. In 2010, a State judge ruled against Logan County, which had sought to exterminate the prairie dog population on a private ranch where the ferrets had been reintroduced. The county argued its case based on a 1901 statute that called for the eradication of all prairie dogs in the state. However, the Federal Endangered Species Act protecting the black-footed ferrets, who live alongside the prairie dogs, superseded the State law and the county lost its case. The black-footed ferret issue remains contentious in the region.

Characteristics and Habitat

Black-footed ferrets, like badger, skunk, and mink, are members of the weasel family. They are a pale buff color, becoming nearly white on the face, throat, and lower half of the body. Their heads and saddle areas of the back are brown. A distinctive black mask, black feet, and black tail characterize the species. They have large rounded ears and short legs with long front claws developed for digging. The average life span of a ferret is one to three years in the wild and four to six years in captivity.

Ferrets are totally dependent upon prairie dog burrows for cover and food. The micro-ecosystem created within a prairie dog colony is incredibly complex and diverse, allowing such creatures as burrowing owls and swift foxes to thrive. Scientific research has verified that myriad plants and animals occur in higher densities and numbers in a prairie dog colony than on similar habitats in the absence of prairie dogs.

Figure 1—Black-footed ferret (photo by M. Lockhart/USFWS; Black-footed Ferret Recovery Implementation Team, 2011).

Black-footed ferrets once ranged throughout the Great Plains from southern Saskatchewan to Mexico, including portions of 12 states. This historic range coincides with the occurrence of several different prairie dogs species (fig. 2). In Kansas, ferrets had inhabited over approximately the western two-thirds of the state in association with black-tailed prairie dogs. Extensive conversion of rangeland to cropland, along with widespread poisoning of prairie dogs, has destroyed most of the state's ferret habitat, although some of the larger areas of short-grass prairie in western Kansas may still have isolated prairie dog towns capable of supporting black-footed ferrets (fig. 3).

Reintroduction

The captive breeding program instigated in the 1980s has been successful, and captive ferret populations now live in special facilities in six states and one Canadian province. Facilities that house black-footed ferrets with viable breeding populations are not open to the public due to disease and disturbance concerns. Keeping captive ferrets in a variety of locations eliminates the possibility of losing the entire population to natural disasters or a disease outbreak, such as canine distemper virus and plague. Since 1986, over 7,100 kits have been produced at the captive breeding facilities.

Since 1991, State and Federal agencies, in cooperation with Native American tribes, private landowners, non-profit organizations, and the North American zoo community have reintroduced thousands of black-footed ferrets into the wild. Beginning in Wyoming, release efforts have expanded to a total of 19 reintroduction sites in Wyoming, South Dakota, Montana, Arizona, Colorado, Utah, Kansas, New Mexico, Canada, and Mexico. Approximately 1,000 black-footed ferrets now live in the wild.

In Kansas, experimental populations of black-footed ferrets have been released on a voluntary basis by private property landowners in Logan County and The Nature Conservancy's Smoky Valley Ranch (fig. 4). The ferrets were placed by using an experimental recovery permit, with U.S. Fish and Wildlife Service (USFWS) assuming liability for any ferrets accidentally killed. Prairie dog maintenance is provided by a mix of private and agency money to assist with prairie dog control for landowners surrounding the ferret release sites.

Species Protection and Critical Habitats

Black-footed ferrets are protected by the Kansas Nongame and Endangered Species Conservation Act, the Federal Endangered Species Act, and State and Federal regulations applicable to those acts. Any time

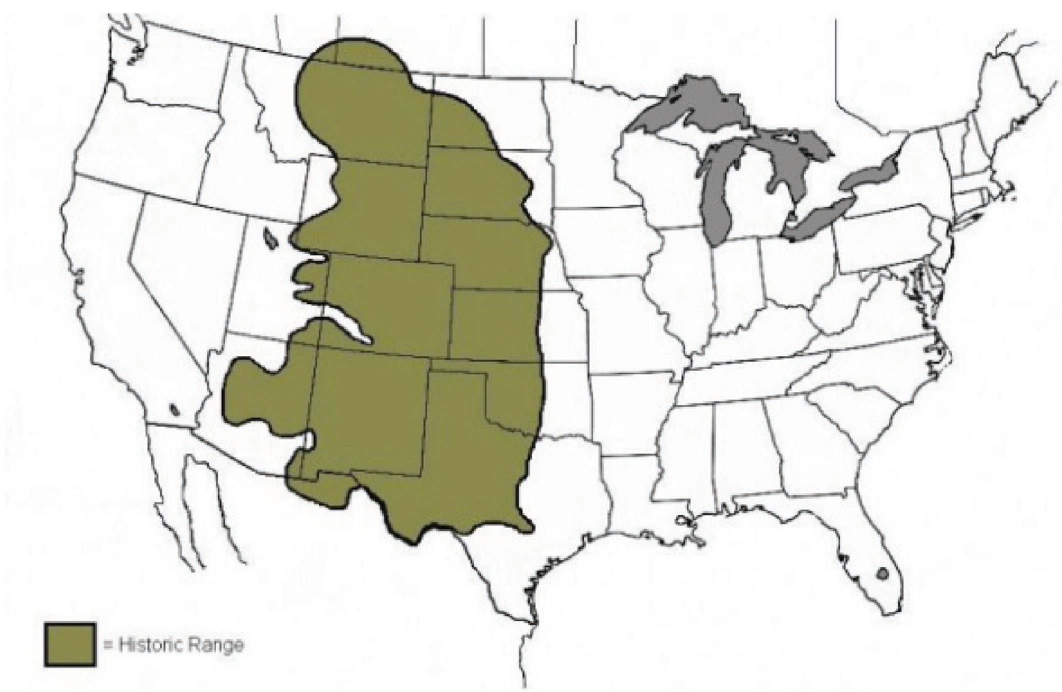

Figure 2–Historic range of the black-footed ferret.

a project is proposed that will impact the species' preferred habitat within its probable range, the project sponsor must contact the Ecological Services Section, Kansas Department of Wildlife, Parks and Tourism (KDWPT).

Because there has been no confirmed record of a live, non-reintroduced ferret in Kansas since 1957, it is unknown if any sustaining ferret populations beyond the experimental ones still exist in the state. The USFWS and KDWPT have a continuing program to investigate ferret reports. To date, no designated areas of critical ferret habitat are found in Kansas. Critical habitats include those areas documented as currently supporting self-sustaining populations of any threatened or endangered species of wildlife as well as areas determined by KDWPT to be essential for the conservation of any threatened or endangered species of wildlife. The USFWS has authority to designate areas of critical habitat for Federally listed endangered species, but has not done so for the black-footed ferret in Kansas.

In 1996 the USFWS established a Black-footed Ferret Recovery Implementation Team (BFFRIT) to help guide recovery efforts. An advisory board, BFFRIT is made up of representatives from Federal and State governments, Native American tribes, zoos, private landowners, and non-profit organizations. KDWPT and Audubon of Kansas are both members of the BFFRIT Executive Committee.

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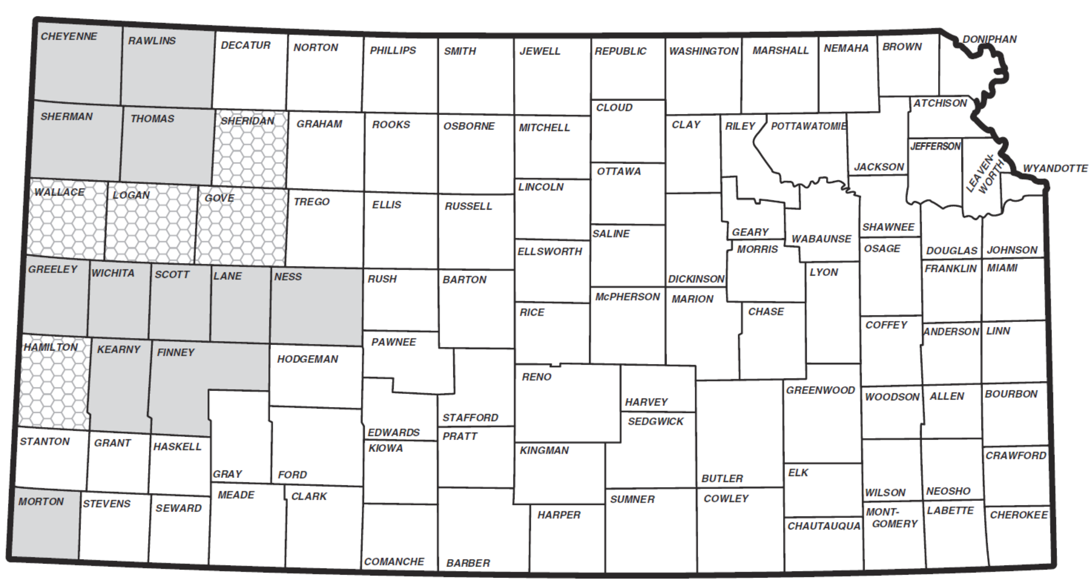

Figure 3–Known historic range (hatched pattern) and probable historic range (gray) of the black-footed ferret habitat in Kansas (KDWP, 2000)

Figure 4—Black-footed ferret being turned loose in Kansas (photo by Dan Mulhern/FWS; Mulhern, 2011).

Commercial Farming and Agricultural Economics

Ninety eight percent of farms in the United States are family operations, and even the very largest are still predominantly family run. Farm production has been shifting from small to larger operations, and the forecast for small farms shows a continued slow, long-term decline. This ongoing shift is due in large part to financial pressures and aging operators. Larger farms have a competitive advantage in most commodities because the average cost of production declines as the size of the operation grows (i.e., economy of scale). In addition, many small-commercial-farm operators are at least 65 years old and are leaving farming as they grow older. Overall, large-scale farms account for 12% of U.S. farms and 84% of production.

Farm Categories

The size and number of farms varies by measurement methodology, but the U.S. Department of Agriculture (USDA) estimates there are about 2 million farms in the United States. Gross cash farm income is one measure of farm size and includes a farm's cash from commodity sales, government payments, and other farm-related income such as fees from production contracts. Farm size based on gross cash income can be divided into four groups (fig. 1):

- Noncommercial < $10,000
- Small commercial $10,000 – $249,000
- Large farms $250,000 – $999,999
- Very large farms > $1,000,000

Farm Size and Production

Most small farms produce very little, while very large farms account for nearly half of the production (fig. 1). In 2007 noncommercial operations accounted for about half of all U.S. farms but only 1% of total production. Noncommercial operators typically have nonfarm income or are retired. Small commercial farm numbers declined from about half to a third of all farms, and their production share declined from about 40% to 20% between 1991 to 2007. Large and very large farms grossing more than $500,000 have doubled in number, but still account for only about 105,000 of the 2 million farms in the United States. The two classes of larger farms have increased production and picked up the 20% decline in small commercial farms production, with the very large farm production increasing from a fourth to nearly half of the total U.S. production.

The production shift to very large farms partly reflects technological advancements in farming. Technological factors, such as the development of larger and faster equipment, information and Global Positioning System technologies, and more routine pest control through genetically modified seeds expanded the crop acreage that producers could effectively control. Another factor is the low

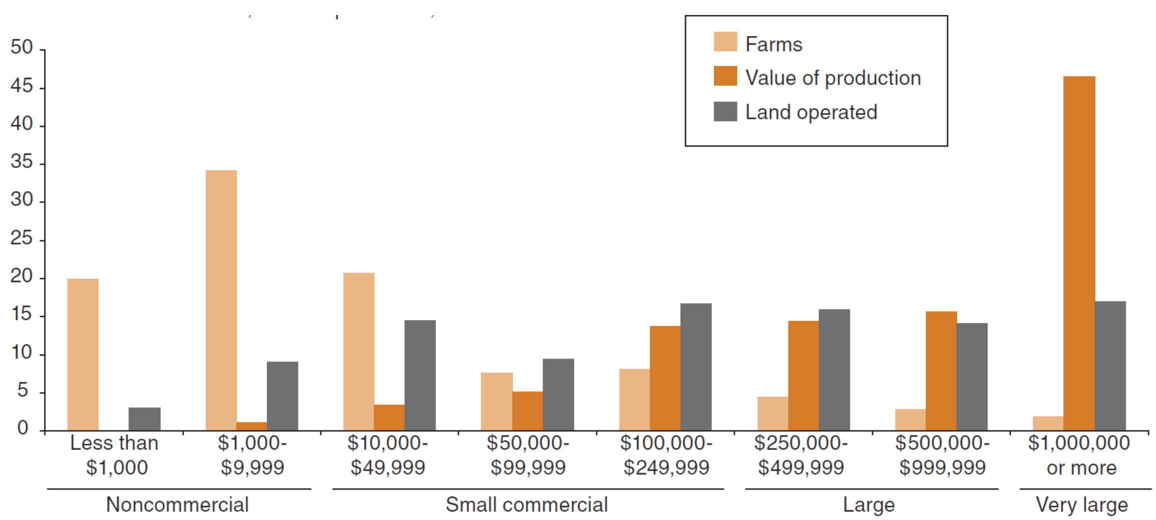

Figure 1–The 2007 distribution of total farms, gross cash farm income, and land operated in the U.S. (USDA, 2007).

profitability of small commercial farms, which contributed to their declining shares of farms and production. Nearly 60% of small commercial farms had negative operating profits in 1991 and 2007. Only 23% of very large farms and 15% of large farms had negative operating profits. This underscores the competitive advantage larger operations have due to economy of scale and greater ability to utilize new technology.

Median Income

In spite of negative operating profits, most small commercial farms do not have low household income because operators and spouses often have off-farm income sources as well as other supplemental income, such as social security, pensions, and investments. Off-farm income is critical to small commercial farms. Most small commercial farming commodities are produced on a part-time basis, reflecting the reliance on off-farm income in this farming class.

Typically, farming income is positive when gross cash farm income exceeds $50,000 (fig. 2). In general, small-commercial-farm household incomes are comparable to the U.S. average household income ($47,300 in 2007) and large-farm household incomes exceed the U.S. average self-employed income ($75,700 in 2007). Although small commercial-farm income is comparable to other U.S. households, their net worth ($750,000) is six times higher than the U.S. average ($120,000). Much of that wealth, however, is tied up in land and not in a liquid asset.

Farming Trends

Competitive forces and retirement of an older work force will likely continue to reduce the number of small commercial farms and shift production to larger farms. Nevertheless, some small commercial farms are profitable. Substantial numbers of small commercial operators can remain in business if

- their farms produce positive—or even high—operating profit margins that allow the operators to resist competitive pressures and stay in business;

- their farms have negative operating profits but positive net farm income because net farm income places no value on the operators' labor and the operators are satisfied with undervaluing their labor, or;

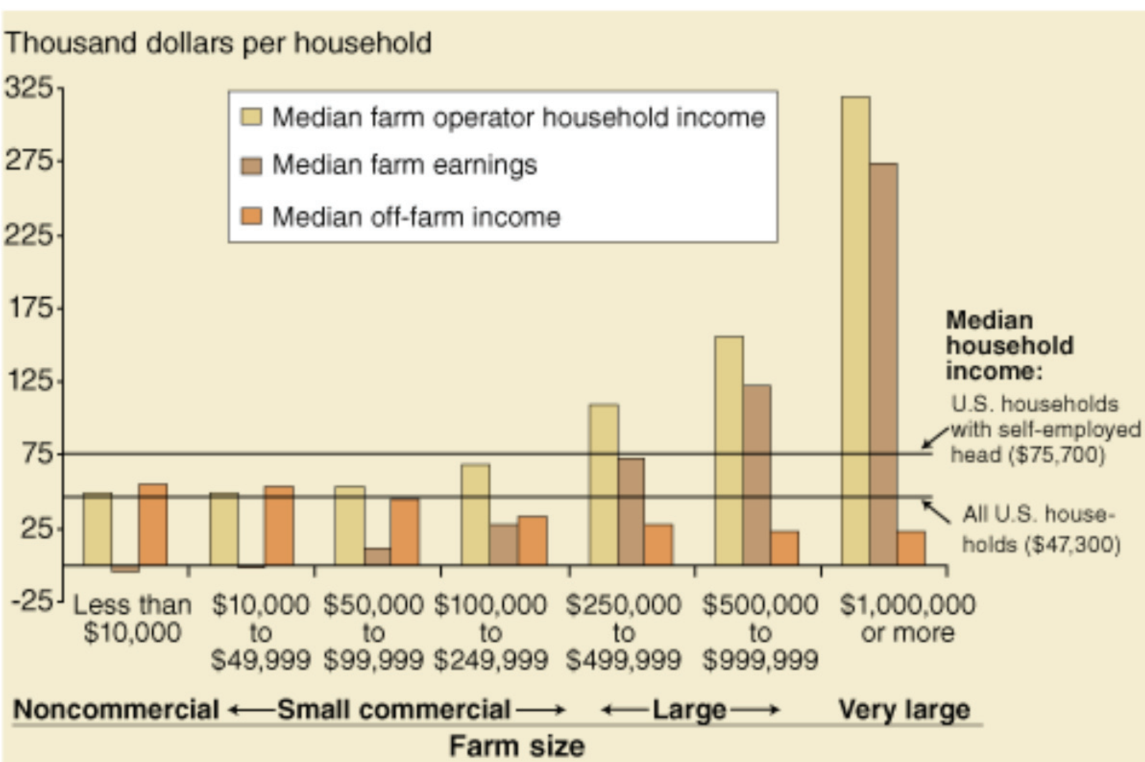

Figure 2–Farming income turns positive when gross cash farm income exceeds $50,000 (USDA, 2007; Federal Reserve Board, 2007).

• they accept losses and stay in business by relying on off-farm income to cover farm and living expenses.

Sources

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U.S. Department of Agriculture, 2007, Economic Research Service and National Agricultural Statistics Service, 2007: U.S. Department of Agriculture, Agricultural Resource Management Survey, Phase III, for farm households.

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Drought Tolerant Corn

Declining water-level trends in the High Plains aquifer can result in water-use restrictions and soaring pumping costs for irrigation (fig. 1). As a result, the agricultural industry has developed and is researching alternative ways to grow crops that better conserve the water resources in semi-arid regions of the state. Both public- and private-sector crop scientists are working on plants that can stand up to heat and are more water-efficient. In general, new crop varieties are developed by either selecting for desirable plant characteristics through hybridization by breeding or through genetic engineering. Drought-tolerant corn strains developed through hybridization have been available since the 1930s, and different genetic engineered traits were first tested on a large scale in the 1980s. The U.S. Department of Agriculture (USDA) approved the first genetically engineered strain for drought resistant traits in late 2011. While hybridization does not require regulatory approval, genetic engineering does.

Hybrid Corn Seed Development and Production

Plant breeders produce hybrid-corn seed by cross-pollinating inbred lines. Inbred lines are produced by self-pollinating plants with selected desirable characteristics. Self pollination involves pollinating silks with pollen from the plant's own tassel. Because field corn is naturally cross-pollinated (that is, silks are pollinated by pollen from other plants' tassels), special processes are used to ensure self-pollination of inbreds. Tassels are covered with a bag before silk emergence to collect pollen and the ears are covered to prevent accidental cross-pollination. Pollen collected in the tassel bag is dusted over the silk and then the tassel bag is fastened over the ear to ensure self-pollination.

Commercial hybrid production involves planting male and female inbred lines in separate rows in an isolated field where possibility of foreign pollen contamination is rare (fig.2). The female inbred is

Figure 1–Corn and other water intensive crops in semi-arid regions of Kansas are typically supplemented with high-volume center-pivot irrigation (Kansas Geological Survey).

normally mechanically detasselled before pollen is shed to ensure cross-pollination by the male inbred. Male inbred rows are destroyed following pollination to prevent seed mixture during harvest. Ears from the cross-pollinated female inbred are harvested, processed, and sold to the producer to plant as hybrid seed.

Genetically Engineered Crops

Genetic engineering techniques are designed to precisely target and alter a single plant trait. Genetic engineering is defined by the USDA as "the genetic modification of organisms by recombinant DNA techniques." Biotechnology methods include tissue cell culture, genetic engineering, and molecular mapping to modify plant traits.

Genetic engineering crops are typically classified into one of three generations:

- First generation—enhanced-input traits, such as herbicide tolerance and environmental stresses, such as drought.
- Second generation—added-value output traits, such as nutrient enhancement.
- Third generation—pharmaceutical or bio-fuel enhancement traits.

Presently, adoption of genetic engineering crops is limited to first-generation traits, which were first tested on a large scale in the 1980s. Genetic engineering food ingredients (e.g., corn meal, oils, and sugars) have been used in consumer foods in the United States for approximately the last 15 years. The USDA recently approved the unlimited sale of a biotech corn developed by Monsanto to resist drought conditions. Monsanto will not yet be broadly selling the corn but rather will be testing the crops in on-farm trials. Farm trials will occur in about 10,000 acres in dry states, such as Texas and Kansas. Second and third generation crops are still in various stages of research and development.

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Figure 2–Managed water applications are used to select drought tolerant corn strains that perform well during drought stress (Pioneer, 2012).

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Schedule and Itinerary*

Thursday, June 7, 2012

6:00 a.m.	Breakfast at the City Limits Convention Center adjacent to the Comfort Inn, Colby (starting time is informal)
8:00 a.m.	**Bus leaves Comfort Inn for Site 4**
9:00 a.m.	**SITE 4** – U.S. Interstate 70 (I–70)
	I-70 Reconstruction and Aggregate Issues *Mike King,* Secretary, KS Dept. of Transportation *Rick Kreider,* KS Dept. of Transportation
9:30 a.m.	Restroom Break – Burlington, CO
10:00 a.m.	Bus to Site 5
	Bus Session – Deep Regional Ground-Water Flow *Jim Butler,* Kansas Geological Survey
10:45 a.m.	**SITE 5** – Bonny Reservoir, CO
	Republican River Compact Accounting *Burke Griggs*, KS Dept. of Agriculture, Division of Water Resources *Aaron Thompson*, Bureau of Reclamation
11:30 a.m.	Lunch – Bonny Reservoir, CO
12:30 p.m.	Bus to Site 6
1:30 p.m.	**SITE 6–** Republican River Compliance Pipeline Overlook – Laird, CO
	Republican River Compact Augmentation *Burke Griggs*, KS Dept. of Agriculture, Division of Water Resources
2:00 p.m.	Bus to Haigler, NE
2:15 p.m.	Restroom Break – Haigler, NE

* All times shown are in Central Daylight Time.

3:00 p.m. Bus to Site 7

3:15 p.m. **SITE 7** – Geology of the Arikaree Breaks, Cheyenne County
Bob Sawin, Kansas Geological Survey

3:45 p.m. Bus to Holiday Inn Express, Goodland

Bus Session – Water Use and Trends for Fracking
Lane Letourneau, KS Dept. of Agriculture, Division of Water Resources

5:00 p.m. Arrive at Holiday Inn Express, Goodland

6:00 p.m. Bus to Supper – High Plains Museum, Goodland

7:30 p.m. Return to Holiday Inn Express, Goodland

I–70 Reconstruction Projects in Western Kansas

U.S. Interstate 70 (I–70), a major east-west corridor in Kansas, is a vital transportation and economic link for public, rural, and commercial traffic across the state. Deteriorating pavement on the highway impairs safety and hinders the smooth flow of traffic and commerce. To address these issues, the Kansas Department of Transportation (KDOT) is reconstructing portions of I–70 in western Kansas. One project (70–91 KA–0718–01) is located between the state line and the Caruso exit, while the other project (70–91 KA–0719–01) is located between the Edson exit and the Sherman–Thomas county line.

KDOT Project KA–0718–01

KA–0718–01 (fig. 1) had 8 inches of concrete placed over the top of asphalt in 1985. Unfortunately, the asphalt did not provide proper support for the concrete, most likely due to some “stripping” of an asphalt layer beneath the new concrete. Stripping is the loss of bond between an aggregate surface and the asphalt, primarily due to the effects of moisture. Aggregate selection, asphalt additives, drainage, and other factors can influence pavement distress due to stripping. For the most part, stripping begins at the bottom asphalt layer and translates upward, causing weakening and concrete pavement cracks that require repair. Highway mitigation included full-depth concrete patching in 1992, adding modified slurry in 2000, and crack sealing and another modified slurry in 2006.

KDOT Project KA–0719–01

KA–0719–01 (fig. 2) has prevalent pavement rutting, fatigue cracking, and transverse cracking. In 1993 a large maintenance project consisted of milling 4 inches of material, 4 inches of cold in-place recycling, laying 5 inches of hot-recycled asphalt, and adding a top 1.5-inch layer of surface hot-mix asphalt. An additional slurry seal was placed in 1998 to mitigate continued pavement rutting. The next action, in 2004, consisted of a 1.5-inch cold milling and laying of 4 inches of hot-mix asphalt. The most recent action was a chip seal in 2009.

Aggregate Issues

KDOT expects concrete pavements to last at least 20 years before they need any type of major maintenance action. Within Kansas, almost all of the concrete aggregate supply is quarried from limestone in the eastern part of the state and sand in the west. Since the development of the interstate highway system, significant research has been completed to understand the limitations of regional aggregate sources and the different aggregates’ potential to exacerbate road pavement damage.

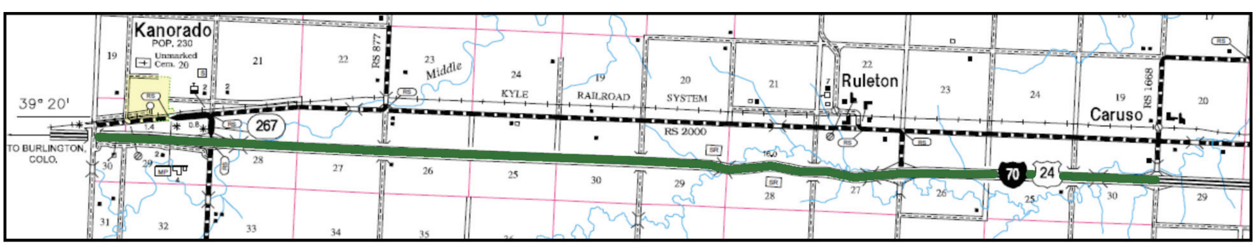

Figure 1—KDOT project KA–0718–01 between the Colorado/Kansas state line at the Caruso exit (KDOT, 2012).

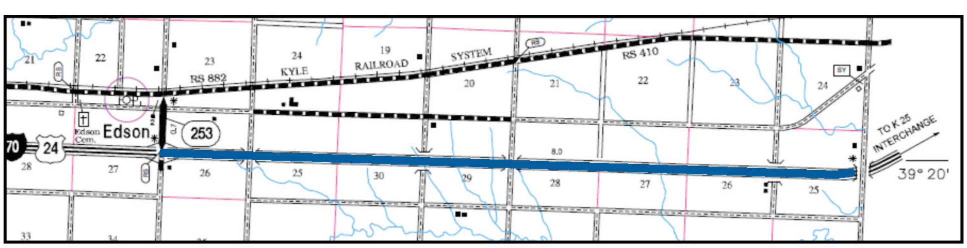

Figure 2—KDOT project alignment KA–0719–01 between the Edson exit and the Sherman/Thomas County line (KDOT, 2012).

Much of the limestone concrete aggregate within the region has a tendency to deteriorate at an unacceptable rate, which leads to a form of freeze-thaw pavement deterioration referred to as D-cracking (fig. 3). D-cracking is a series of parallel concrete cracks along slab joints and edges caused by critically saturated aggregate particles that expand and contract with freeze-thaw cycles. Deterioration of poor limestone aggregate is exacerbated by the extreme temperature variability in Kansas, which makes pavement especially susceptible to road maintenance issues associated with freeze-thaw cycles. KDOT has over 80 years of research experience attempting to identify which limestone formations will produce durable aggregate most resistant to D-cracking. That has been, and continues to be, a major KDOT concern due to continued premature failure of concrete pavements.

Figure 3—D-cracking along a transverse joint caused by failure of coarse limestone aggregate (Portland Cement Association).

Some sands tend to be susceptible to alkali-silica reactivity (ASR). ASR is the result of a reaction between the hydroxyl ions in the alkaline cement pore solution and reactive forms of silica in the aggregate (eg, chert, quartzite, opal, and strained quartz crystals). The reaction produces a gel that increases in volume by taking up water and, by doing so, exerts an expansive pressure that causes the concrete to fail (fig. 4). ASR causes characteristic ‘map cracking’ or ‘Isle of Man cracking’. Like D-cracking, ASR can dramatically reduce the time before the first major maintenance action is required on concrete pavements. Unlike with D-cracking, there are methods to help mitigate against ASR.

Figure 4—ASR cracking caused when the mineral constituents of some aggregates react with the alkali hydroxides in the concrete (Portland Cement Association).

Sources

Federal Highway Administration, 2006, Highway concrete pavement technology development and testing: Volume II—Field evaluation of strategic highway research program (SHRP) C–203 test sites (freeze-thaw sesistance): Federal Highway Administration, Publication FHWA–RD–02–083, 50 p., available online at http://www.fhwa.dot.gov/pavement/pccp/pubs/02083/02083.pdf

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Bonny Reservoir and the Republic River Compact

Like Keith Sebelius Lake (Day 1, Stop 1), Bonny Reservoir was created by the U.S. Bureau of Reclamation as a flood control and irrigation project within the Republican River basin. Bonny Dam and Reservoir impounds the South Fork of the Republican River and is included in the Armel Unit of the Missouri Basin program. Shortly after the reservoir was completed in 1951, the former Colorado Division of Game, Fish and Parks negotiated an agreement with the Bureau of Reclamation to manage fish, wildlife, and recreational assets of the reservoir and the Federal land around the lake. The Bureau of Reclamation operates the reservoir and Colorado owns the water rights.

Republican River Compact

In 1943, Colorado, Nebraska, and Kansas entered into the Republican River Compact to divide the water supply of the Republican River basin. The basin includes portions of eastern Colorado, northwest Kansas, and southwest Nebraska (fig. 1). It allocates the waters of the basin, tributary by tributary, including the North Fork of the Republican River (North Fork) and the South Fork of the Republican River (South Fork) in Colorado.

With the advent of center-pivot irrigation in the 1950s, ground-water pumping began to deplete streamflows across all three states. In the late 1970s both Colorado and Kansas essentially discontinued new ground-water irrigation development in the basin, slowing the decline. Nebraska, however, did not and fell out of compliance with the Compact. In 1998, Kansas filed suit in the Supreme Court of the United States to enforce the Compact against Nebraska.

Because of the 1998 suit, the Supreme Court held that each state is responsible for the effects of its ground-water pumping on streamflows. This enabled State cooperation that established the Final Settlement Stipulation (FSS), which specifies how ground-water pumping, and its effects on streamflow, are accounted under the Compact. State cooperation also resulted in the creation of the Republican

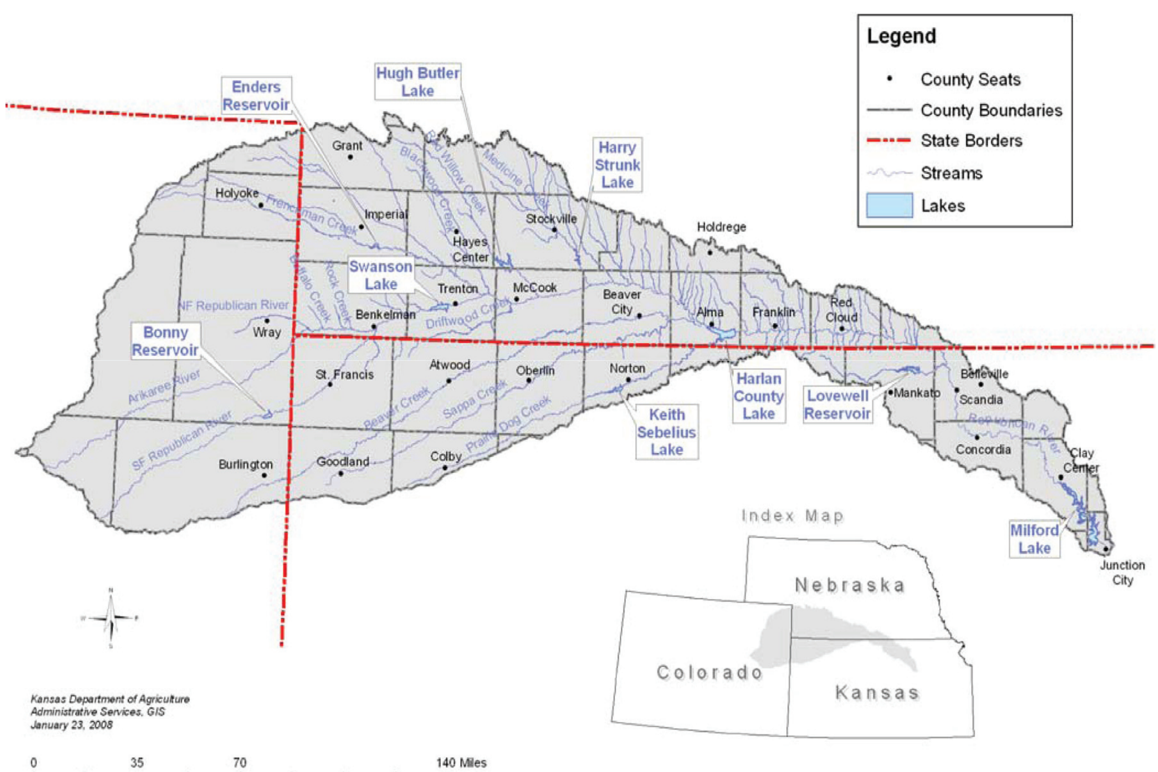

Figure 1–Republican River basin (Kansas Department of Agriculture Division of Water Resources).

River Compact Administration Groundwater Model (RRCA), which adopts the FSS accounting procedures and calculates streamflow depletion due to ground-water pumping. Together, the FSS and RRCA have specific water accounting, reporting, and computations to calculate water supply, allocations, imported water supply credit, and beneficial use. Adoption of the FSS and RRCA in 2003 finalized a settlement between the states and formally ended litigation of the 1998 suit.

Republican River Water Accounting

The accounting procedures in the FSS document address the various input and output water sources. Long-term water-level changes in the aquifer result from an imbalance between discharge and recharge to the High Plains aquifer hydrologic system. Discharge is primarily ground water withdrawn for irrigation although it also includes water pumped out for public water supply and other uses. Water also is discharged through evapotranspiration from surface-water bodies such as Bonny Reservoir and seepage to streams, springs, and other surface-water bodies where the water table intersects the land surface. Recharge comes primarily from precipitation. Other sources of recharge include seepage from streams, canals, reservoirs, and irrigation return flows. As water accounting computations show, withdrawals from irrigation wells can lower the water table below stream and river beds and dry up surface-water sources.

Republican River Compact Compliance

Colorado has overused its Compact water allocation on the South Fork and the North Fork. To comply with the compact, each state has a basic choice—reduce excessive ground-water pumping to maintain streamflows and baseflows at a sustainable level for compliance or continue pumping out ground water at unsustainable levels and make up the difference by other means.

Colorado acknowledges statewide overuse and has proposed building a Compact compliance pipeline to deliver water to the North Fork at a point close to the Colorado–Nebraska state line, east of Wray, Colorado. In addition, Colorado chose to drain Bonny Reservoir on the South Fork (fig. 1), rather

Figure 2—Bonny Reservoir, April 2011 (photo by Steve Adams, KDWPT).

than restrict the use of upstream irrigation wells. Draining the reservoir eliminated annual evaporative water loss from its water budget and, ironically, aquifer recharge that came from reservoir seepage.

As a matter of law, Colorado must comply with the Compact; but as a matter of policy, Colorado is largely free to decide how to comply. Kansas had no say in Colorado's decisions to build the Compact compliance pipeline and drain Bonny Reservoir. Colorado decided to sacrifice Bonny Reservoir, and it was drained in 2011, based on the conclusion that its recreational economy and other benefits did not justify reduced ground-water pumping in the South Fork basin. Kansas never requested, much less "demanded" that Colorado drain Bonny Reservoir and would have preferred that Colorado had reduced ground-water pumping and maintained the reservoir. Policy decisions by Colorado, however, resulted in the opposite outcome (fig. 2).

Sources

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Simonds, J., 2009, The Armel Unit—Pick–Sloan Missouri Basin Program: Bureau of Reclamation, December 2009, 22 p., available online at http://www.usbr.gov/projects//ImageServer?imgName=Doc_1262208530114.pdf

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Republican River Compact Augmentation

In 1943, Colorado, Nebraska, and Kansas entered into the Republican River Compact to divide the water supply of the Republican River basin. The basin includes portions of eastern Colorado, northwest Kansas, and southwest Nebraska (fig. 1). Colorado has overused its allocation on the Republican River, acknowledged its own statewide overuse, drained Bonny Reservoir on the South Fork, and is constructing a compact compliance pipeline to discharge water into the North Fork from an outfall structure east of Wray, Colorado, and just west of the Colorado–Nebraska state line. Water will be pumped from an Ogallala irrigation well battery located about 13 miles north of the North Fork. Diverted ground water will augment or supplement surface water flowing out of Colorado.

The Republican River Water Conservation District (RRWCD), a coalition of ground-water irrigators, opted to build the pipeline on the North Fork with the financing assistance of the State of Colorado. The RRWCD was formed in 2004 to assist Colorado with the compact compliance. In June 2009, RRWCD purchased 14,798 acre-feet of water rights—at an estimated cost of more than $40 million—to supply the pipeline. According to both Colorado and the RRWCD, the pipeline will enable irrigators in the RRWCD to maintain their ground-water pumping and comply with the Compact on the North Fork (fig. 2).

Nebraska has given its assent to the pipeline, and Colorado and Kansas are currently in negotiations over it. Colorado believes that ground water from the Ogallala portion of the High Plains aquifer can provide a reliable water supply to augment its surface-water shortfall and proceeded with pipeline construction in September 2011. The pipeline is scheduled for completion in July 2012.

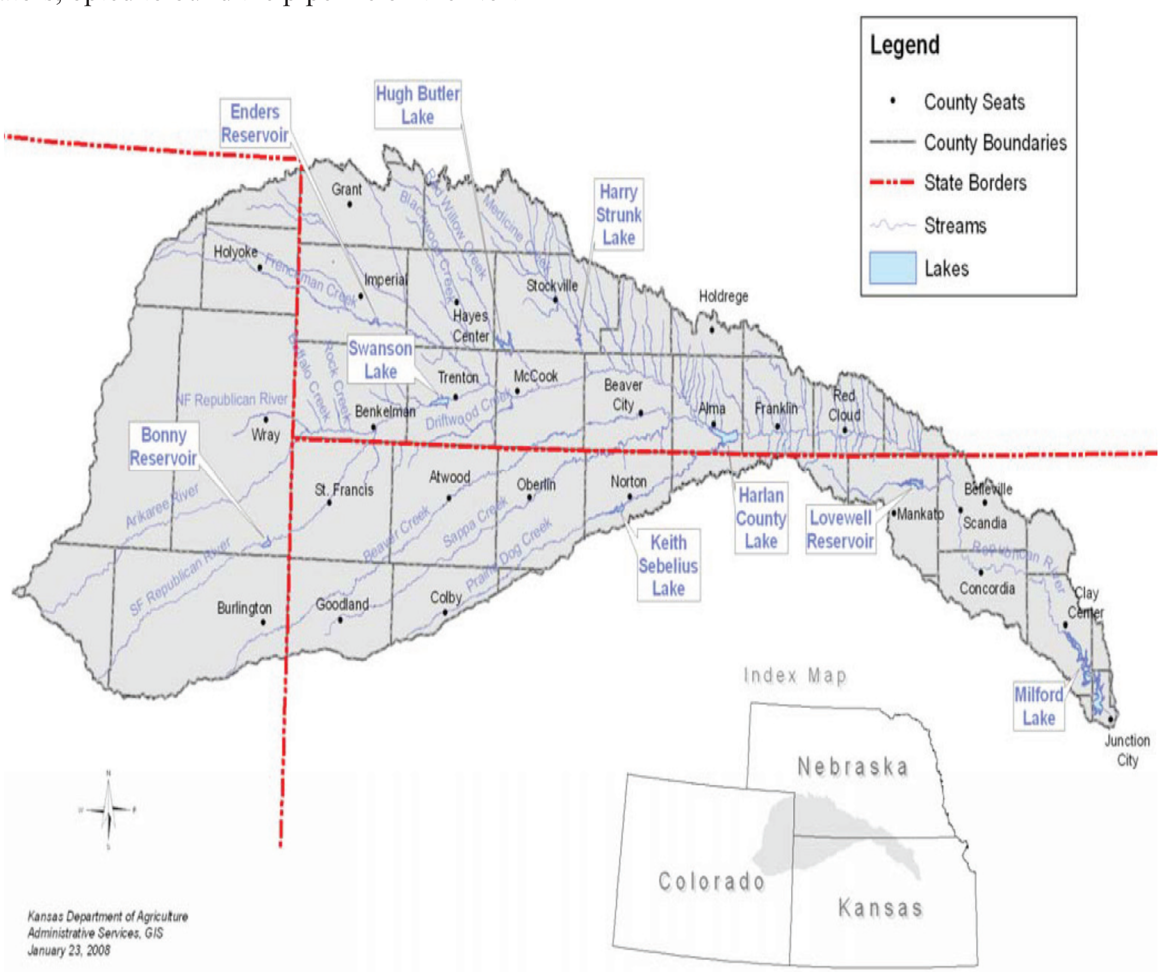

Figure 1—Republican River basin (Kansas Department of Agriculture Division of Water Resources).

While the pipeline outfall will discharge into the North Fork in Colorado and flow into Nebraska, Kansas still has a say in the matter because Colorado has two distinct tests for whether it is in compliance with the Compact: a tributary-by-tributary test and a statewide test, which evaluates Colorado's overall water use. Final acceptance of the Compact compliance pipeline is still subject to Kansas' acceptance of delivery location and accounting of augmentation credit.

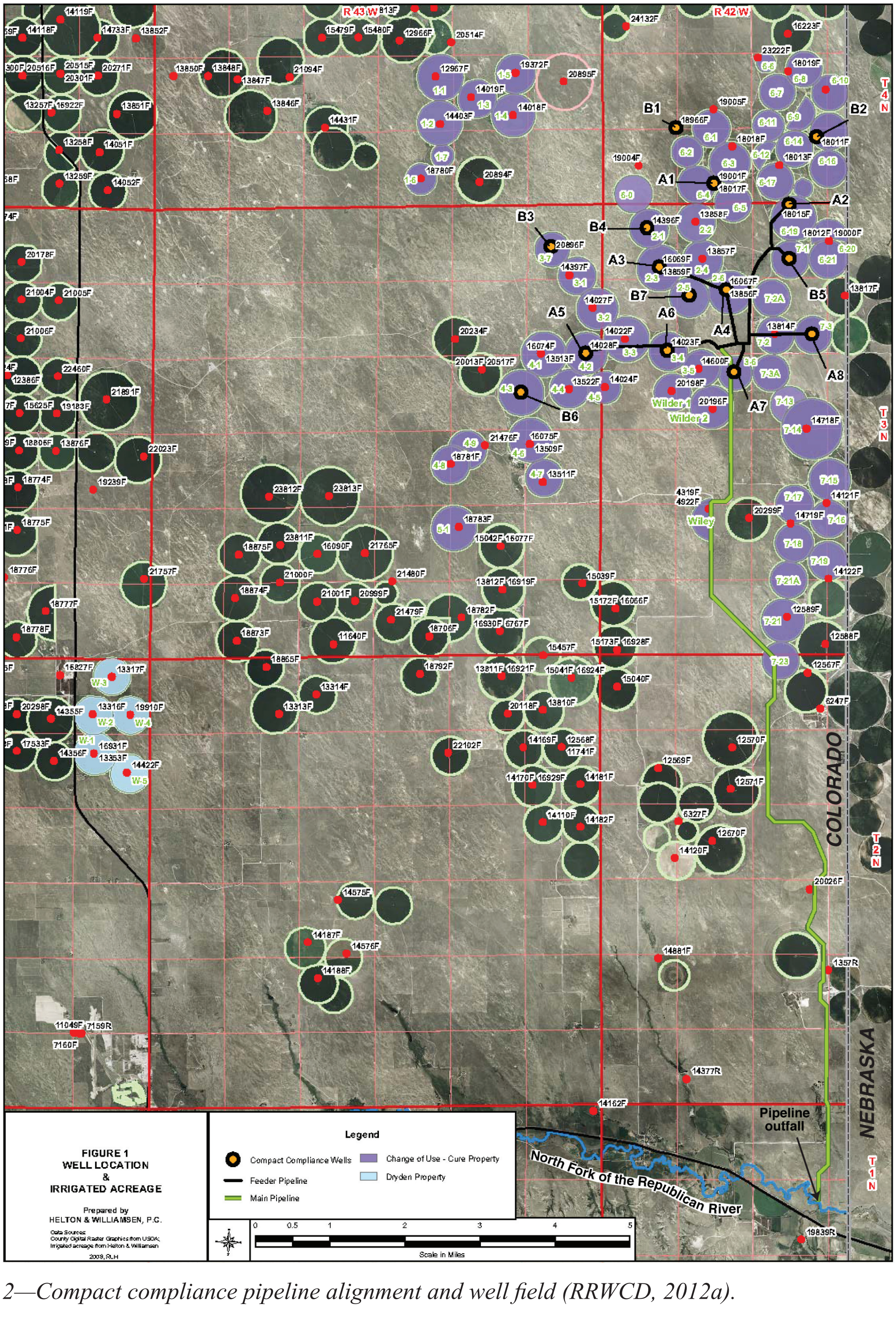

Figure 2—Compact compliance pipeline alignment and well field (RRWCD, 2012a).

Compact Compliance Pipeline

Ground water from a battery of high-capacity Ogallala irrigation wells will augment surface water in the North Fork. A 12.7-mile Compact compliance pipeline is currently being constructed to deliver this ground water to the North Fork (fig 2). The initial capacity of the pipeline will be 15,000 acre-feet per year over a nine-month delivery season. The main conveyance pipeline will be designed so that a pump could be added to increase the pipeline capacity to approximately 25,000 acre-feet/year, if needed in the future.

Preliminary design of the well field will consist of eight wells, numbered A1 through A8 on the map in fig. 2. The well-field design will also allow for an additional seven wells, numbered B1 through B7 on the map, if needed in the future. Water pumped from the individual wells will be collected in a series of 12-inch to 18-inch conveyance pipes connected to a 1-million-gallon re-regulating storage tank. The storage tank will provide reserve capacity and provide surge and negative pressure protection. Water in the storage tank will flow by gravity approximately 12.7 miles through a reducing series of 42-, 36- and 30-inch-diameter conveyance pipe to an outlet structure constructed near the North Fork (figs. 3 and 4). The pipeline will include access manholes, air release valves, and drain valves at appropriate locations along the pipeline, as determined during the final design.

Sources

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Figure 3—Installation of a 36-inch-diameter conveyance pipe (RRWCD, 2012b).

Figure 4—Construction of the Compact compliance pipeline outfall, which will discharge into the North Fork (RRWCD, 2012b).

Notice by Kansas pursuant to final settlement stipulation VII.B.6, November 1, 2010, Re Arbitrator's Final Decision of October 7, 2010, available online at http://www.ksda.gov/includes/document_center/interstate_water_issues/RRC_Docs/2010_11_1_Kansas_Response_Pipeline.pdf

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The State of Colorado and the Republican River Water Conservation District, March 2008, The Republican River compact compliance pipeline, Exhibit 1, 12 p., available online at http://republicanriver.com/Pipeline/ColoradosProposedResolution/Exhibit1/tabid/184/Default.aspx

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Arikaree Breaks

Stereotypically High Plains, the topography in much of Cheyenne County is flat to gently rolling plain. In sharp contrast, the far northwest corner of the county features one of the state's most unique and rugged landscapes (fig. 1). A strip of stream-cut canyonland just 2 to 3 miles wide—known as the Arikaree Breaks in Kansas—stretches several miles across the corner of the county (fig. 2). Beginning not far across the state line in Colorado and extending a short distance into Nebraska, the breaks were carved out by tributaries to the Arikaree and Republican rivers.

The now-intermittent tributaries run northwest to the Arikaree River or north over the state line to the Republican River, which is formed by the confluence of the Arikaree and North Fork of the Republican rivers. Farther east, similar stream-carved terrain along the Cheyenne–Rawlins county line includes the Burntwood Creek archeological area visited at Stop 8. This region is sometimes considered to be part of the Arikaree Breaks. To the south and east of the Arikaree Breaks, narrower, more subtle canyons drain to the South Fork of the Republican River (fig. 3), which diagonally dissects Cheyenne County before joining the Republican River in Nebraska.

Geology

Gullies and ravines in much of Cheyenne County cut through thick layers of loess—loosely consolidated buff-to-yellowish-tan sediment formed from windblown silt. Loess covers about 65% of the surface of Kansas although it varies in thickness throughout the state and is rarely as exposed as it is in the Arikaree Breaks, where it is up to 100 feet thick (Welch and Hale, 1987). Paradoxically, while running water easily erodes loess, angular grains in the loess create enough cohesion to keep steep or vertical faces, like those found in the Arikaree Breaks, from collapsing (fig. 4).

In some of the deeper canyons, streams have cut completely through the loess to expose the underlying Ogallala Formation and even deeper Cretaceous-age Pierre Shale. In northern Cheyenne

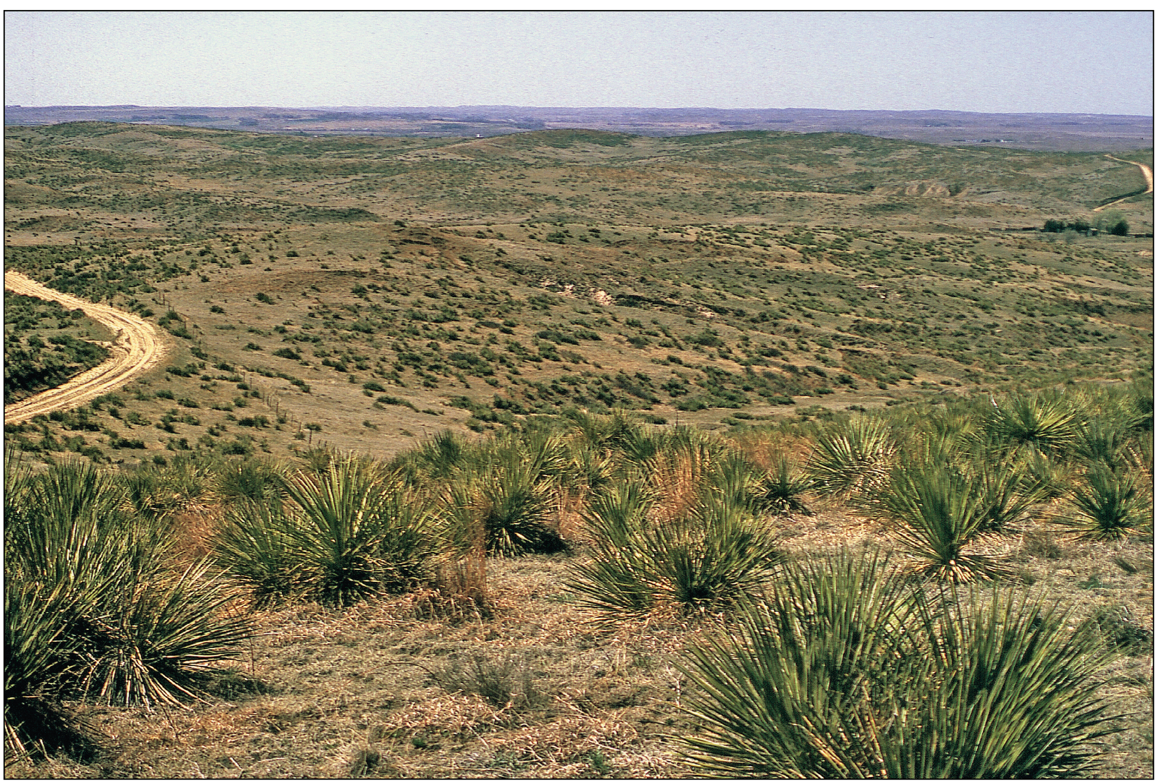

Figure 1—Northwest Cheyenne County, Kansas (Kansas Geological Survey).

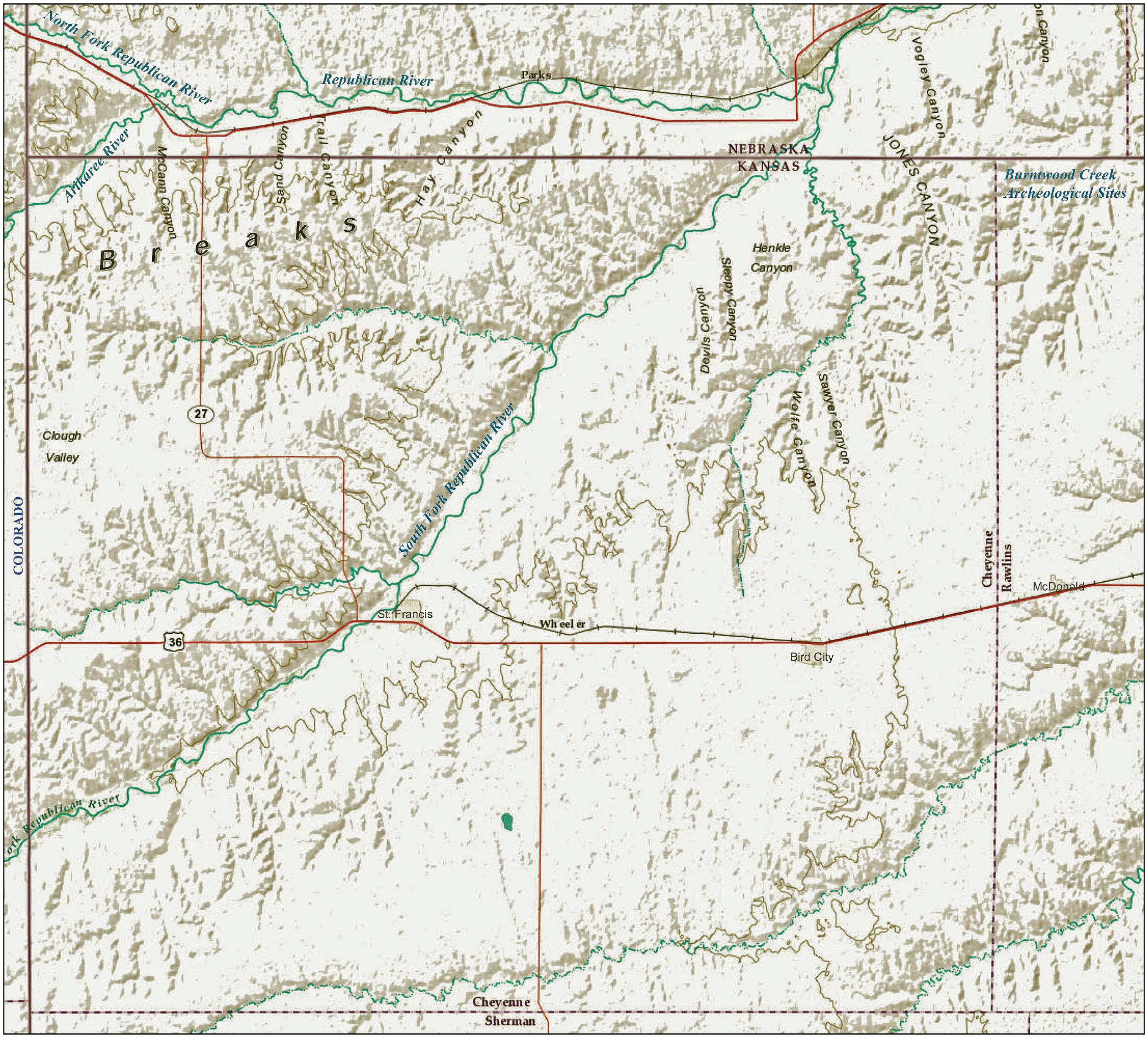

Figure 2—Map showing the Arikaree Breaks, the South Fork of the Republican River canyons in Cheyenne County, and the Burntwood Creek Archeological Sites (Stop 8) in Rawlins County (modified from U.S. Geological Survey topographic maps).

Figure 3—South Fork of the Republican River, Cheyenne County, Kansas (Kansas Geological Survey).

Figure 4—Near-vertical loess walls, Arikaree Breaks, Cheyenne County, Kansas (Kansas Geological Survey).

County, the water-bearing Ogallala is thin or even absent due to erosion, and the loess often directly contacts the Pierre Shale.

Formed from debris carried in by streams from the west as the Rocky Mountains uplifted about five million years ago (fig. 5), the permeable Ogallala provides most of the ground water for western Kansas, although not in northern Cheyenne County where the Ogallala is spotty. Ground water there is drawn mainly from younger shallow alluvium (unconsolidated sand, gravel, and silt) along the South Fork of the Republican River (South Fork) and smaller streams.

The near-impermeable Pierre Shale, formed in ancient Cretaceous seas about 66 million years ago (fig. 5), impedes the downward percolation of ground water from the Ogallala and stream-valley alluvium. Small springs in Cheyenne County are mainly located in valleys carved out by the South Fork tributaries where the water table intersects the ground surface

Era	Period	Epoch	Geologic Events
Cenozoic	Quaternary	Holocene	Deposition of Bignell Loess
			17,000 YA* (Holocene–Pleistocene transition)
		Pleistocene	Deposition of Peoria Loess
			2.59 million YA*
	Neogene**	Pleiocene	
			5.33 million YA* Deposition of Ogallala Formation
		Miocene	
			23 million YA*
	Paleogene**	Oligocene	
			33.9 million YA*
		Eocene	
			55.8 million YA*
		Paleocene	
			65.5 million YA* Deposition of Pierre Shale
←Mesozoic	←Cretaceous	Upper Cretaceous	

*Years ago
**Formerly Tertiary

Figure 5—Timetable of the Cenozoic and early Mesozoic eras (modified from Gradstein et al., 2004).

(Prescott, 1952). No springs are found in valleys formed by tributaries of the Arikaree and Republican rivers (Willey, 2009).

Loess and the Pleistocene–Holocene Transition

In western Kansas and throughout much of the central Great Plains, loess was deposited in cycles in conjunction with the last glacial age during the Pleistocene Epoch and later during the Holocene Epoch of the Quaternary Period (fig. 5). The late Pleistocene glaciers did not reach Kansas and only had an indirect affect on the loess deposits in the region. The thickest loess in northwestern Kansas—the Peoria Loess—was deposited in the late Pleistocene up until about 15,000 years ago when the transition from a relatively cool and wet climate to a more arid climate was well underway. Overlaying the Peoria, the Bignell Loess was deposited during the early Holocene as drought conditions and more extreme temperatures escalated. The source of the silt- and clay-sized particles carried in by strong winds to form these loess layers has long been debated. Theories suggest the material came from regional active sand dunes—most likely the source of the Bignell Loess (Mason et al., 2008)—or regional fluvial (water) or eolian (wind) erosion of the Ogallala Formation (Welch and Hale, 1987).

The boundary between the Peoria and Bignell is hard to distinguish except where a layer of buried soil, called the Brady soil, is present. During prolonged periods when the influx of dust was low and conditions were stable, soil would develop in the top layer of loess. (The loess itself is sediment, not soil.) As rock or sediment at or near the surface weathers—due to temperature change, precipitation, freezing and thawing, plant and animal action, etc.—soil development proceeds downward from the surface (Frye, 1952). The Brady soil formed in the Peoria Loess. Where it was not buried by the Bignell Loess, it eroded or was overprinted with modern soil development (Johnson and Willey, 2000). In Cheyenne County, Brady soil has been found in the uplands away from stream valleys but is not present in the Arikaree Breaks or South Fork canyons (Willey, 2009). Much of the fertile topsoil in Kansas today was developed from loess or alluvium.

Loess deposits provide a valuable record that helps explain climate change during the Pleistocene–Holocene transition about 12,000 to 9,000 years ago when major climatic and environmental alterations influenced such events as the accelerated extinction of plants and animals and the arrival, or proliferation, of humans, which has been recorded in the archeological record (Mason et al., 2008).

Current Conditions

Findings from studies of the Pleistocene–Holocene transition in the region can give insight into the impact of current climatic and environmental conditions. Today, the climate of Cheyenne County is characterized by large significant seasonal and daily temperature variations. Outbreaks of polar air are common in the winter, but warm summer temperatures provide a long growing season. However, because the county is east of the strong rainshadow effects of the Rocky Mountains and generally west of the flow of moisture-laden air from the Gulf of Mexico, it receives, on average, only 18 inches of rain a year. Low, sporadic rainfall and relatively high winds can lead to significant soil loss and crop damage in drier years (Hamilton and Gier, 1989). The terrain immediately around the deep ravines and gullies of the Arikaree Breaks precludes agriculture altogether, and is mostly covered with short grass prairie. Vegetation in the semi-arid region includes buffalo grass, yucca, sage, and prickly-pear cactus.

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Schedule and Itinerary*

Friday, June 8, 2012

6:00 a.m.	Breakfast at Holiday Inn Express, Goodland (starting time is informal)
8:00 a.m.	**Bus leaves Holiday Inn Express for Site 8**
	Bus Session – Kansas Forest Service 125th Anniversary *Larry Biles*, State Forester, Kansas Forest Service
9:30 a.m.	**SITE 8** – Burntwood Creek, Rawlins County
	Geoarcheology of the Burntwood Creek Rockshelter and Bison Jump *Rolfe Mandel*, Kansas Geological Survey
10:30 a.m.	Bus to McDonald
10:45 a.m.	Restroom Break, McDonald
11:15 a.m.	Bus to Site 9
12:00 p.m.	**SITE 9** – Gateway Civic Center, Oberlin
	Working Lunch – Exploration and Development of the Mississippian Lime in Kansas *Kevin R. White*, SandRidge Energy Corporation
1:30 p.m.	Bus to Sleep Inn, Norton
2:00 p.m.	End Field Conference at Sleep Inn, Norton

* All times shown are in Central Daylight Time.

Burntwood Creek Archeology Sites in Rawlins County

Bison bones at the foot of a bluff caught the attention of University of Kansas paleontologists in the early 1920s and, more recently, archeologists. Over time, the remains of dozens of bison along with two projectile points have been found in the Rawlins County bonebed. Using such techniques as radiocarbon dating[1] and analysis of stratigraphic units, archeologists determined Paleoindian hunters drove the bison over the bluff to their death about 9,000 years ago.

Altogether, five archeological sites, including the Paleoindian bison jump (fig. 1) and a nearby rockshelter (fig. 2), have been recorded within proximity of each other along Burntwood Creek (fig. 3) north of McDonald. Although the bison jump and rockshelter—the two most closely studied of the five Burntwood Creek sites—are near in distance, they have separately yielded evidence of people who lived thousands of years apart.

While Late Paleoindians made the projectile points found at the bison jump about 9000 B.P. (before present[2]; Hofman, 2010), archeological evidence just across the creek at the rockshelter, including fire pits, bison and deer bones, burned seeds, charcoal, and chipped stone, has been radiocarbon dated to several later Archaic-age human occupations—ranging from approximately 2340 B.P. to 1870 B.P. It is likely the Paleoindians would have also used the rockshelter; however, no solid archeological evidence of that has been discovered. Of the three other Burntwood Creek sites (14RW3, 14RW4, and 14RW5 in fig. 3), one is a kill or

Figure 1—Excavation at the Burntwood Creek bison jump site (14RW2; Kansas Geological Survey).

Work at the Burntwood Creek sites has been partially funded by the Odyssey Archaeological Research program endowed by retired Denver oilman Joe Cramer. The endowment, whose purpose is to fund the search for the earliest evidence of humans in the Great Plains, supports fieldwork, travel, graduate students, and laboratory analysis.

[1]Radiocarbon, or Carbon-14 (^{14}C), dating is based on the amount of ^{14}C measured in the organic material in an archeological or geological sample. When a living organism stops accumulating ^{14}C from the atmosphere upon death, the ^{14}C it has absorbed starts to decay at a fixed exponential rate. The age of the sample can be estimated based on how much ^{14}C it contains at the time the measurement is taken.

[2]B.P stands for “before present.” Because present time changes continuously, “present” was established as the year 1950 A.D., around the time radiocarbon dating was perfected. The B.P. designation is most often based on radiocarbon dating but also may be based on dates established by other means, such as determination of stratigraphic location.

Figure 2—Burntwood Creek rockshelter site (14RW418; Kansas Geological Survey).

Figure 3—Google Earth image of the Burntwood Creek locality showing the five registered archeological sites. Green dots represent the locations of permanent datums set between 2006 and 2007 (Murphy, 2008).

butcher site and the other two have been identified by scattered chipped stones but have not been excavated (Murphy and Mandel, in press).

Paleoindians and Archaic People in the Central Plains

Prior to the introduction of ceramic technology and an increasing reliance on domesticated plants, Central Plains economies of the Paleoindian and Archaic periods were based mainly on hunting and gathering. Paleoindians, the first known people in North America, were in Kansas at least 11,500 years ago and appear to have been heavily reliant on big game. Following the Paleoindian era, Archaic-age hunting and gathering cultural groups began focusing on more diverse, locally available resources (Blackmar and Hofman, 2006).

There is no distinct line between the Paleoindian era, which lasted from before 11,500 B.P. to about 8000 B.P., and the Archaic, which spanned about 8000 B.P to 2000 B.P. Several sites in Kansas have both Paleoindian and Archaic components (Blackmar and Hofman, 2006). Paleoindian and Archaic evidence is sparse, especially between the time when Paleoindians used the Burntwood Creek bison jump and the Late Archaic people occupied the Burntwood Creek rockshelter. Some researchers speculate people left the region as the environment grew hotter and drier, but others think the paucity of evidence may be more attributable to later environmental conditions that, alternatively, eroded and buried archeological evidence (Mandel, 2006a).

Geology and the Paleoenvironment at the Burntwood Creek Sites

The Burntwood Creek bison jump and rockshelter are capped with a layer of caliche, a cemented, weather-resistant layer in the Ogallala Formation, often referred to as "mortar beds." Formed mainly from sediment eroded off the eastern Rocky Mountains and carried east by water and wind, the widespread Ogallala Formation is now mainly in the subsurface. Besides sands and gravels, the Formation also consists of loess deposits, volcanic ash beds, and diatomite—a chalk-like rock formed from shells of fossilized algae (Johnson and Park, 1996). In northwestern Kansas, the Ogallala Formation is covered by later loess deposits and only exposed where the loess has eroded, such as along Burntwood Creek (Murphy and Mandel, in press).

Between 12,000 and 9,000 years ago, during a time known as the Pleistocene–Holocene transition, major environmental changes occurred in North America. The climate, which had been influenced by glacial cycles during much of the Pleistocene, became warmer and drier. That trend continued and intensified in the early Holocene when the Paleoindians were first known to be at Burntwood Creek (Mandel, 2006b). By about 11,000 B.P., horses, camels, and mammoths—more common than bison during the Pleistocene—had disappeared, and the bison population had expanded to fill the herbivore niche. Bison became smaller and more herd-oriented during the early Holocene and reached their current size by about 4000 B.P. (Blackmar and Hofman, 2006).

Geoarcheology

Geoarcheologists, who investigate and interpret sediments, soils, and landforms, are among the archeologists working at Burntwood Creek and other Paleoindian and Archaic sites across the state. The understanding of temporal and spatial patterns of buried soils and sediment provided by geoarcheological studies helps identify areas with potential cultural deposits, date artifacts and features based on their stratigraphic location, and assess prehistoric environments (Mandel, 2006b).

Geologic processes, in particular erosion and sedimentation, have had both positive and negative affects on archeological materials. Past wind and water erosion destroyed much evidence of prehistoric human activities, but recent erosion can help expose locations containing artifacts (projectile points, etc.) and features (fire pits and other evidence that can't be removed). Rapid sedimentation can preserve artifacts and features by protecting them from weathering and erosion but also often keeps them hidden. Geoarcheologists study these processes to determine their influence on the archeological record.

Burntwood Creek Bison Jump

By comparing the projectile points and other radiocarbon-dated components at the Burntwood

Creek bison jump to those found in other locations, archeologists have determined Paleoindians at the site were associated with people of the Allen complex, an archeological classification based on findings at the James Allen site in Wyoming. The Allen complex dates to about 9200–8500 B.P. (Hofman, 2010). Groups of people are considered to be in the same "complex" if they have similar traits, including projectile-point manufacturing techniques and economic activities (Blackmar and Hofman, 2006). Because most archeological evidence at Paleoindian locales is limited, stone projectile points that survive weathering often play an integral role. Such is the case at Burntwood Creek where two points from the bonebed—one complete and one partial (fig. 4)—have Allen point characteristics. The fact that one of the projectile points was made out of chert transported from no closer than north-central Texas attests to the distances Paleoindians traveled and traded.

While Allen sites and projectile points are common throughout the Plains region, known bison jumps from the Allen and other Paleoindian complexes are rare. Besides Burntwood Creek, the only site classified as a possible Paleoindian bison jump to date is in southern Texas. All other known bison jumps are Archaic in age, and other discovered Paleoindian kill sites appear to be arroyo or dune traps (Hofman, 2010). The Winger site, an Allen complex kill and butcher site in Stanton County that the Kansas Field Conference visited in 2009, is thought to be an arroyo or gully trap.

Burntwood Creek Rockshelter

Similar to caves in the way they are formed, rockshelters tend to be more wide than deep. In contrast to caves, they have a broader connection to the outside environment and are more readily illuminated by sunlight. Although rockshelters vary in size, most have projecting overhangs large enough to provide protection from the elements. The potential for finding archeological evidence in a rockshelter is good because multiple cultures are likely to have occupied it over many centuries, and artifacts and features under a roof are partially protected from the elements (Goldberg and Mandel, 2008). Mesa Verde in southwestern Colorado is an example of a large rockshelter.

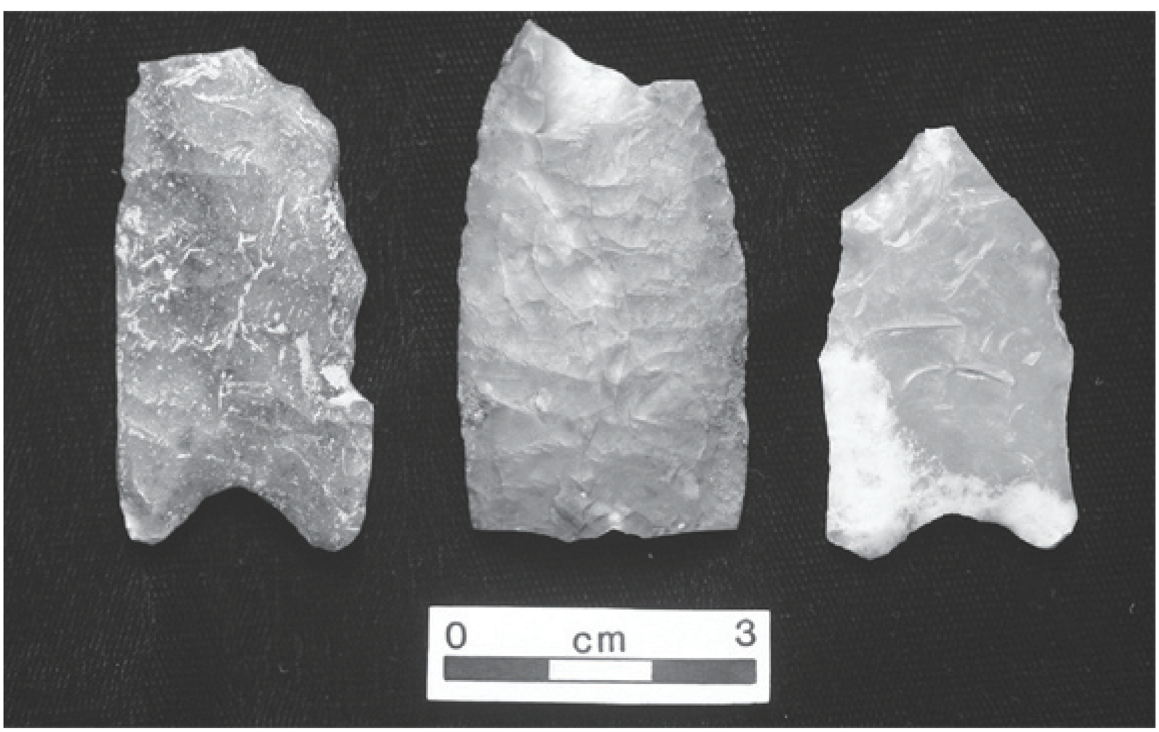

Figure 4—Burntwood Creek jump site (14RW2) projectile points. The specimen on right is from the surface near the site and the other two are from the bonebed (from Hofman, 2010).

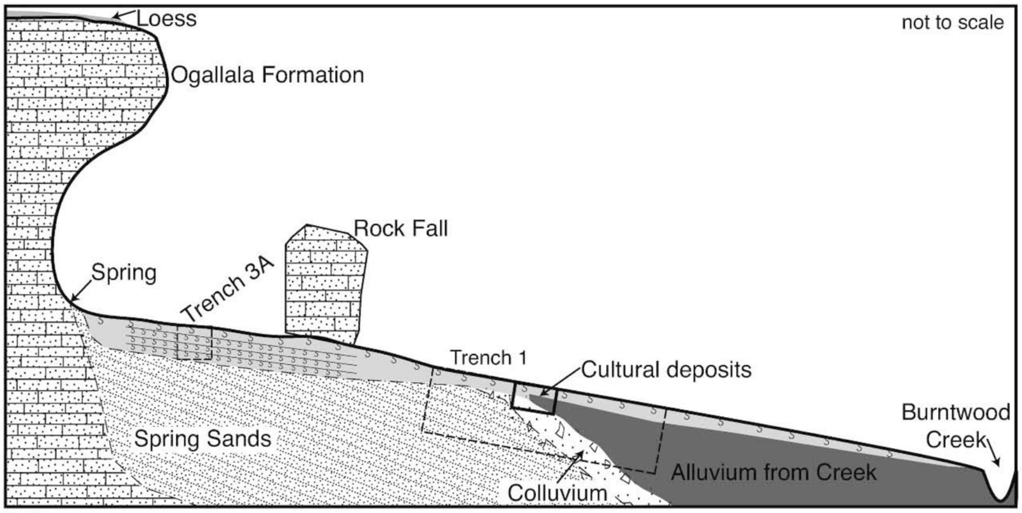

Figure 5—Illustration showing general fills and the approximate location of Trenches 1 and 3A at the Burntwood Creek rockshelter site (14RW418). The illustration is not to scale (from Murphy and Mandel, in press).

The Burntwood Creek rockshelter, one of 34 rockshelters in Kansas, is the only one in the state that has been subject to a systematic geoarcheological study. In 2007, three backhole trenches were excavated there and cultural materials were recorded and collected (Fig. 5; Murphy and Mandel, in press). While large blocks of eroded rock that periodically fell from the rockshelter overhang probably destroyed some archeological materials, it also sealed, and thus preserved, others.

Burntwood Creek and nearby springs discharged from the Ogallala Formation would have attracted people to the rockshelter, which was used for tool maintenance, food processing, and cooking. Archeological testing shows that Archaic people there sharpened tools crafted mainly out of local materials and used local hackberry trees for fuel or food. Two unlined hearth features (fire pits) have been identified, and five layers of charcoal were found about 3–4 feet below the land surface in one of the excavated trenches. Separated by thin layers of silt, the charcoal layers represent several human occupations. A right bison maxilla with a full row of teeth was found among the large quantity of burned bison and deer bone and chipped stone in the charcoal (Murphy and Mandel, in press).

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Exploration and Development of the Mississippian Oil Play

Recent drilling in the Mississippian formation, a proven oil play in Oklahoma and Kansas, has changed the way petroleum reserves are considered in Kansas. Horizontal drilling coupled with hyrdrofracturing, or "fracking," has led to speculation of a potentially years-long petroleum boom that could extend from south-central Kansas—where multiple horizontal wells are already completed or underway—into the northwest corner of the state.

Colloqually called the "Mississippi Lime" (shortened from Mississippian limestone) the Mississippian is composed of limestone as well as shale, mudstone, and other rock strata. The production zone of the Mississippian is a 100-foot thick sequence of carbonate rock, mostly limestone, about 4,500 to 7,500 feet below ground. The play has been extensively developed with vertical wells for over 50 years, and until recently, it was considered a mature field with declining reserves.

The core of the current horizontal-well play is centered around north-central Oklahoma and south-central Kansas. Some of the larger petroleum companies working in Kansas, such as SandRidge Energy Inc. and Chesapeake Energy Corporation, have actively expanded their lease holdings and are trying to establish how far the play extends into northwest Kansas. As high oil prices and new horizontal-drilling techniques have driven exploration and redevelopment in this region and other older oil fields throughout the continental United States, well-defined production zones and the ability to reach previously inaccessible oil have resulted in relatively low-risk exploration opportunities.

Paleogeography

Deposition of the Mississippian strata occurred during the Mississippian Subperiod, 359 to 318 million years ago (Ma). At the time, the southern half of Kansas was an equatorial, subtropical to tropical, shallow marine shelf or inland sea (fig. 1). Large-scale deposition of carbonate rocks occurred on the marine shelf next to the convergent plate boundary between two paleocontinents, Laurussia and Gondwana, that were well on their way towards the

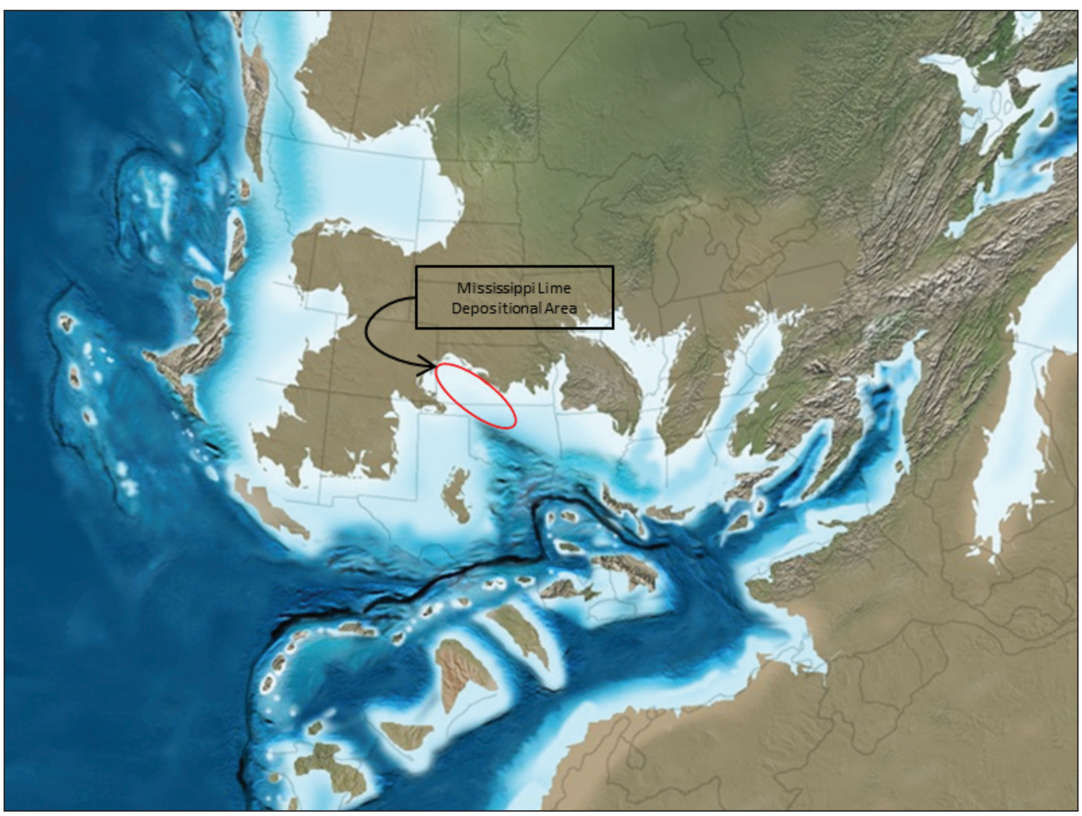

Figure 1— Mississippian Subperiod (359–318 Ma) paleogeography that led to the deposition of the Mississippian oil production zone (courtesy Ron Blakely, NAU Geology).

assembly of Pangea. The decline of CO_2, sequestered in soils and eventually captured by fossil fuels like coal, lowered the greenhouse effect, and started a series of glacial cycles that caused the sea level to rise and fall. The converging plates and regressing sea levels led to periods of regional uplift and erosion.

Geology

In the subsurface, the Mississippian is an expansive carbonate reservoir rock at relatively shallow production depths ranging from about 4,500 to 7,500 feet below ground surface. The Mississippian is somewhat different from other horizontal drill plays in the United States in that it is composed of carbonate rock rather than shale.

The reservoir lies along the regional unconformity at the boundary between the end of the Mississippian (359 –318 Ma) and the start of the Pennsylvanian (318–229 Ma) Subperiods (fig 2). The unconformity represents nondeposition resulting from uplift, alteration, and erosion of shallow marine carbonates before deposition resumed at the start of the Pennsylvanian.

The unconformity is represented by the uppermost Mississippian member, a widespread debris-flow deposit consisting of weathered chert, limestone, and dolomite called "chat." The Mississippian chat was formed through a combination of uplift, weathering, and erosion of rock. Subaerial exposure to effects of weathering dissolved the more soluble limestone, leaving behind more insoluble portions like the siliceous chert.

The Mississippian strata underlies the chat and was also exposed to uplift and subaerial weathering and carbonate dissolution. This weathered surface, somewhat analogous to the Ozark karst terrane in southern Missouri and southeast Kansas, created secondary porosity or void space in the rock that generally ranges between 10% and 20%. The voids provide reservoir storage space and the deeply weathered zone forms subtle stratigraphic traps where oil tends to accumulate. Permeability of the rock is relatively good at 1 to 2 millidarcies, which is a measure of the relative ease with which fluid will flow through a porous medium. It is influenced by interconnectedness of pores and fluid characteristics like viscosity, density, and temperature. This rock unit can be more than 100 feet thick and is the target zone for horizontal drilling (fig. 2).

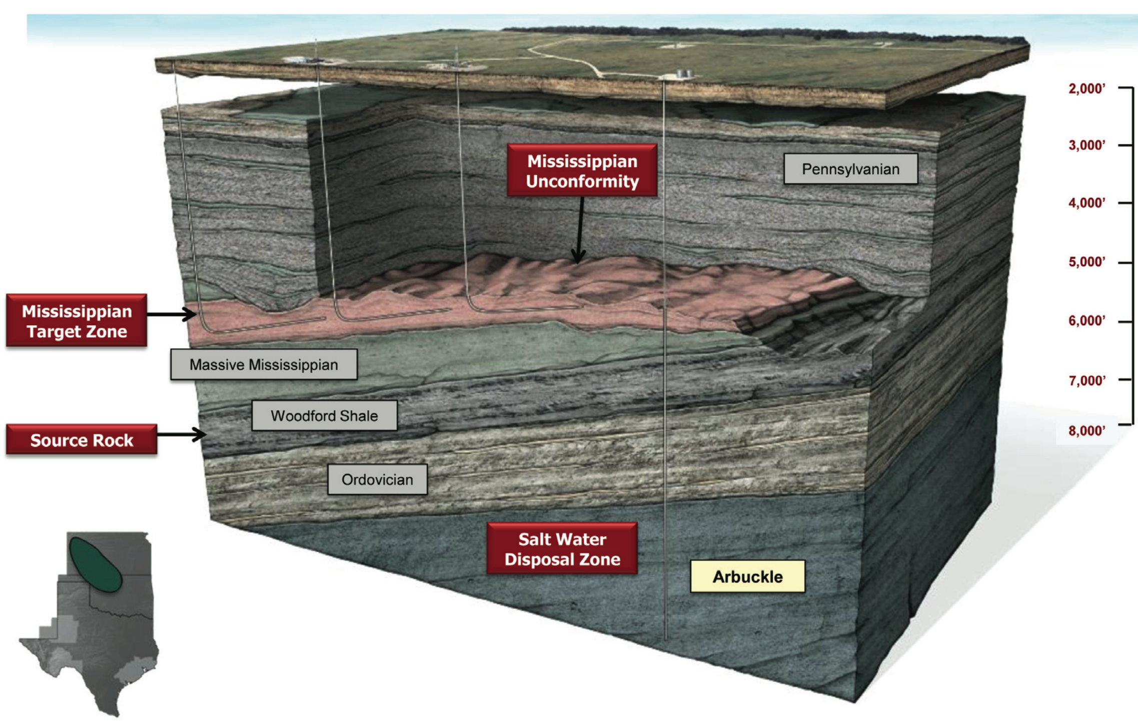

Figure 2—Midcontinent Mississippian geologic model (SandRidge Energy Inc.).

Horizontal Drilling and Exploration Economics

Horizontal drilling in old plays like the Mississippian capitalizes on extensive geologic knowledge gained from decades of drilling vertical wells. A horizontal well installation starts out vertical then turns horizontal for long distances through a known petroleum reservoir. A horizontal well with a lateral length of 2,500 to 4,000 feet reaches far more of a formation than a vertical well with a 100-foot production zone.

After installation, the horizontal section of the well is hydrofractured or "fracked" in stages to free trapped oil. Fracking breaks or cracks the rock around a wellbore by injecting fluids and sand under high pressure. Small cracks, propped open by the sand, interconnect the rock pores to increase permeability and enhance the amount of oil withdrawn by a well. Although the number and magnitude of frack jobs have increased with horizontal drilling, fracking is not new technology. The first experimental frack in the United States was conducted in 1947 in the Hugoton gas field in Grant County, Kansas. Most oil and gas wells, vertical and horizontal, are fracked as a matter of routine, the economic recovery of oil or gas typically is not feasible without it.

The application of horizontal drilling and fracking along with shallow production depth and the well-understood geology make it easier, and relatively cheap, to drill this play.

In Kansas, the cost to drill and complete a horizontal well in the Misssissippian play is approximately $3 million, roughly 10 times the cost of a vertical well. Assuming these installation costs and recent oil prices, petroleum companies require about $4,110 per day in profit for a 2-year payout. Early pilot wells completed in the core of the play have ranged from about $1,000 to $10,000 per day. As more horizontal wells are installed, the basic economic question will be how to determine if a single horizontal well is more effective than 10 vertical wells at draining an oil reservoir.

SandRidge Energy Inc. installed one of the largest producing horizontal wells to date in Harper County, Kansas. Early production from the well is about 48,000 thousand cubic feet (mcf) of natural gas and 25,500 barrels of oil per month. The well is, by far, a production outlier, but horizontal wells such as this will push speculation and more exploration to define the extent the play.

Exploration

While horizontal-well development in the Mississippian oil play is quite active, it's also in its earliest stages. Mineral-rights leasing from landowners continues ahead of drilling and lays the groundwork for future drilling locations. Petroleum companies have leased large tracts of land for future development should the extent of the play continue into northwest Kansas. SandRidge Energy Inc. and Chesapeake Energy Corporation are the industry leaders in terms of land leased, although about 30 different operators in Kansas have recently either filed a notice of intent to drill or drilled a horizontal well in the Mississippian.

A notice of intent to drill is a good indication of petroleum development in the state (rig count is another). Operators submit the notices to obtain a drilling permit from the Kansas Corporation Commission, the agency that regulates oil and gas production. The notices include drilling information and design specifications to ensure that wells are installed correctly to protect other natural resources like freshwater aquifers. In 2010, 2011, and January to February 2012, there were one, nine, and 20 intent to drill notices, respectively, for horizontal wells in the Mississippian. Most were in Comanche, Barber, and Harper counties (fig 3).

While intent to drill count is up, the pace of drilling has recently slowed as petroleum operators evaluate the effectiveness of their initial drilling programs. Still, early production results have led petroleum companies to issue optimistic and forward-looking statements to their investors. SandRidge Energy Inc. has raised approximately $2.33 billion through joint ventures and initial public offerings of stock to develop the play and has reported to its investors plans for 380 horizontal wells in 2012. In response to low natural gas prices, Chesapeake Energy Corporation has indicated plans to divert some of its assets from natural gas to oil exploration.

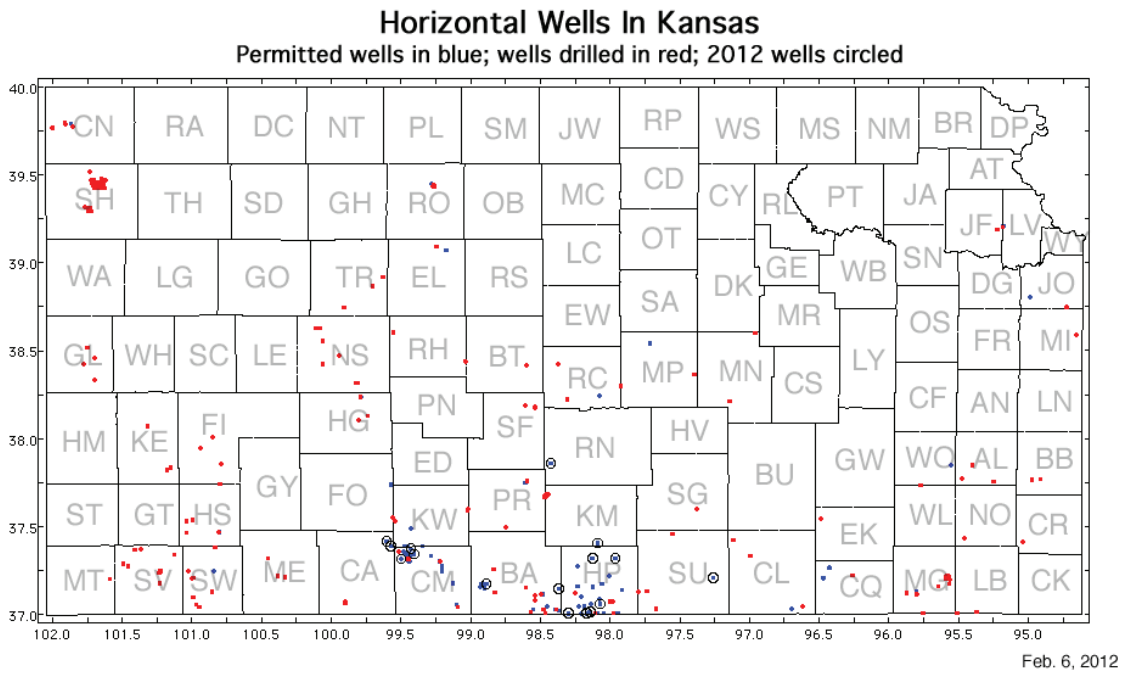

Figure 3—All permitted and completed horizontal wells in Kansas. Circled wells were permitted in 2012. Most of the intent to drill permits (blue) represent petroleum development of Mississippian strata in Comanche, Barber, and Harper counties. Tracts of leased ground (not depicted on the figure) extend into northwest Kansas (Kansas Geological Survey).

Despite the considerable optimism expressed by the petroleum industry, the ultimate extent of the play in Kansas is not known. Future expansion and development in the play will be determined by the sustained viability and performance of existing horizontal wells and the success of the drilling planned for 2012.

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