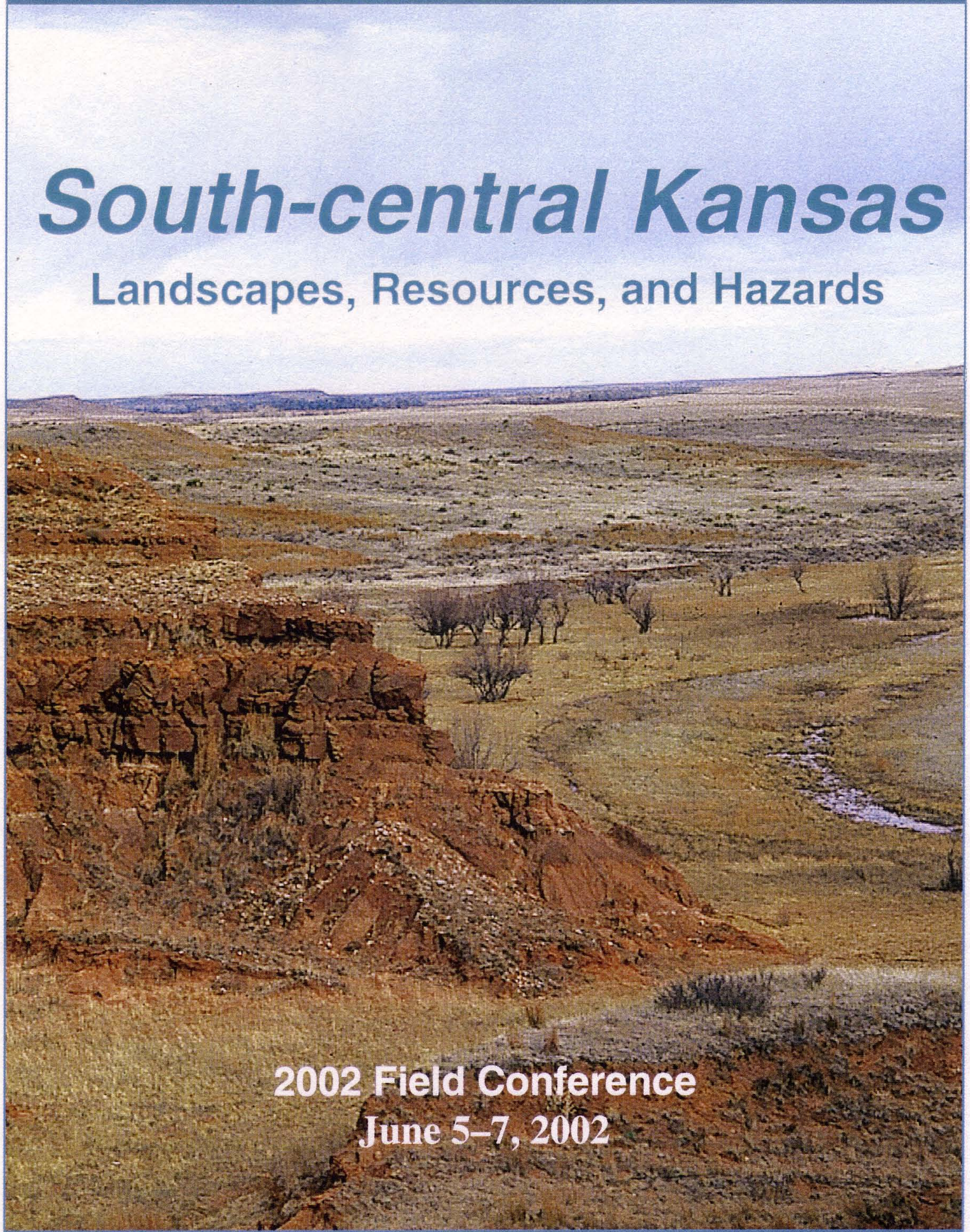
Kansas Field Conference

South-central Kansas

Landscapes, Resources, and Hazards



2002 Field Conference

June 5–7, 2002

Sponsored by
Kansas Geological Survey, Kansas Department of Wildlife and Parks,
Kansas Department of Health and Environment, and the City of Hutchinson, KS

KANSAS FIELD CONFERENCE

FIELD GUIDE

2002 FIELD CONFERENCE

South-central Kansas

Landscapes, Resources, and Hazards

June 5-7, 2002

Edited by

Robert S. Sawin
Liz Brosius
Rex C. Buchanan

This project is operated by the Kansas Geological Survey and funded, in part, by the Kansas Department of Wildlife and Parks, the Kansas Department of Health and Environment, and the City of Hutchinson, Kansas.

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REPORT 2002-22

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Acknowledgments

Many Survey staff members helped with the preparation of the 2002 Field Conference. In particular, we want to acknowledge geologist Jim McCauley, who provides commentary on the bus and helped with route and site selections, and graphic artist Jennifer Sims for the preparation of the brochure, the Field Guide cover, and many of the figures.

Kansas Field Conference

South-central Kansas

Landscapes, Resources, and Hazards

2002 FIELD CONFERENCE

June 5-7, 2002

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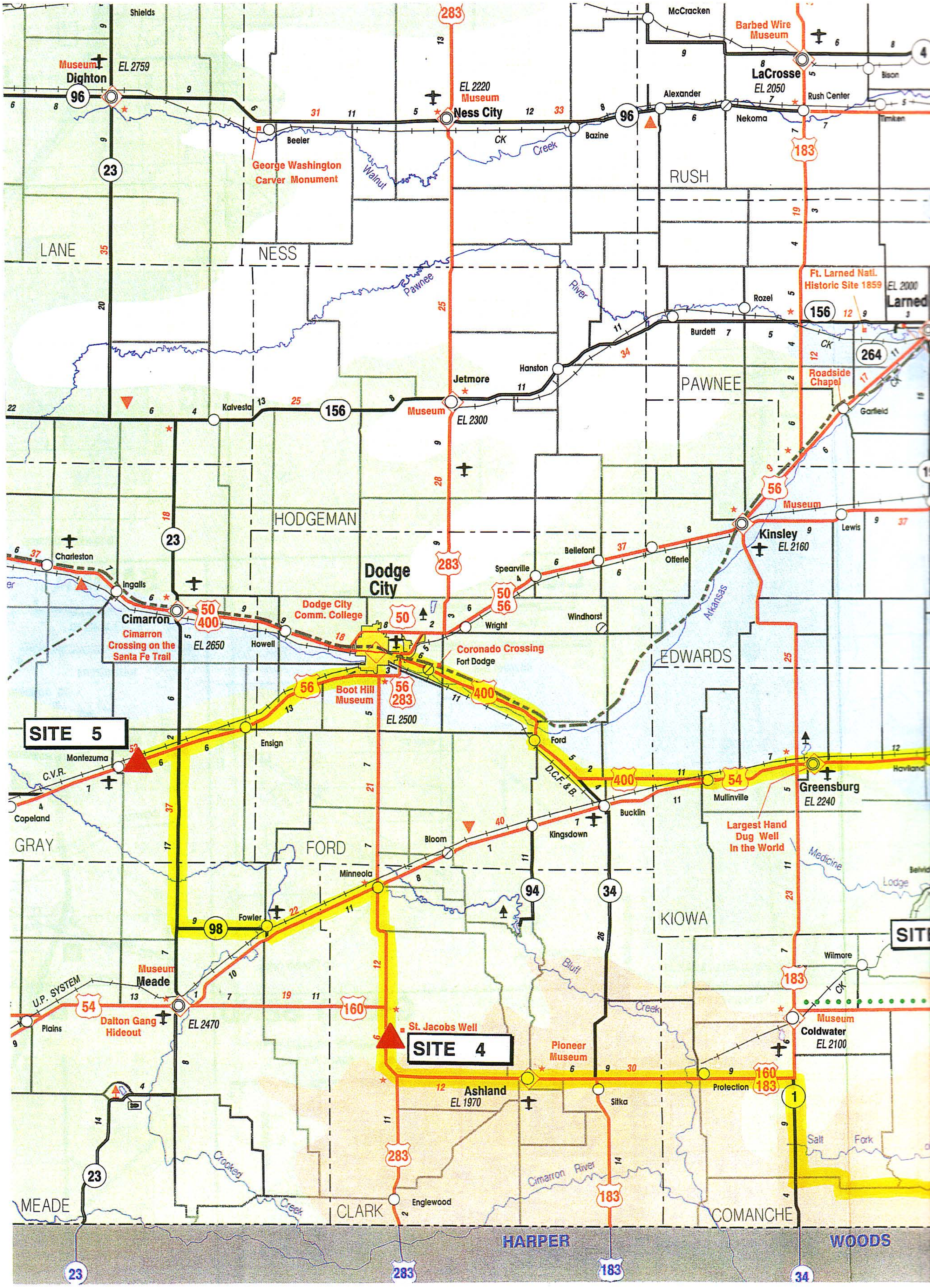

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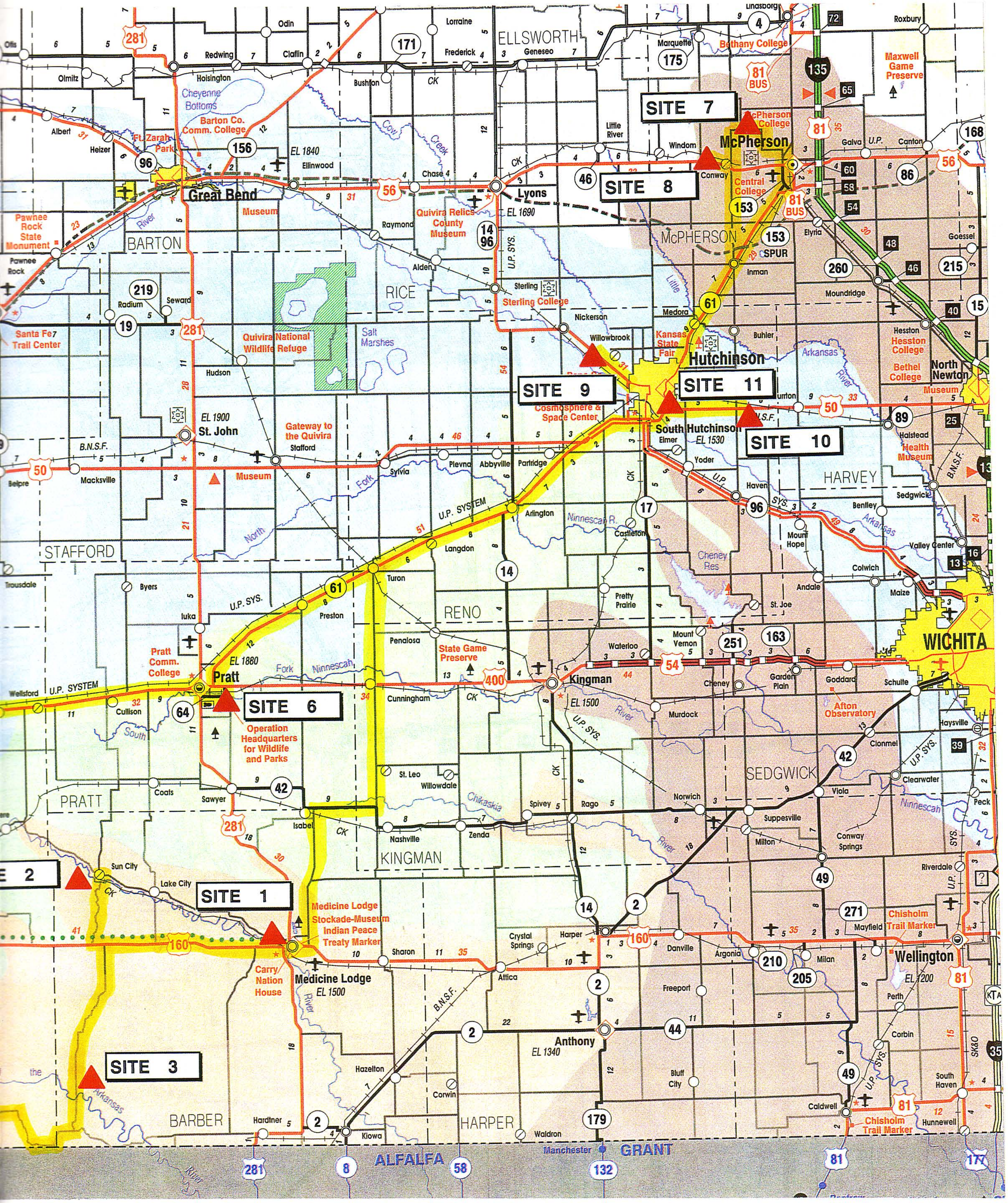
CLARK
COMANCHE
HARPER
WOODS


SITE 1
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ELLSWORTH
BARTON
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SEDGWICK
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WICHITA
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Anthony
Wellington
St. John
North Newton
Ft. Zarah Park
Barton Co. Comm. College
Cheyenne Bottoms
Pawnee Rock State Monument
Santa Fe Trail Center
Quivira National Wildlife Refuge
Salt Marshes
Gateway to the Quivira
Quivira Relics County Museum
Sterling College
Bethany College
McPherson College
Central College
Maxwell Game Preserve
Kansas State Fair
Cosmosphere & Space Center
Hesston College
Bethel College
Halstead Health Museum
Pratt Comm. College
Operation Headquarters for Wildlife and Parks
State Game Preserve
Afton Observatory
Medicine Lodge Stockade-Museum Indian Peace Treaty Marker
Carry Nation House
Chisholm Trail Marker
Cheney Res
Museum
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EL 1500
EL 1340
EL 1200

South-central Kansas

Landscapes, Resources, and Hazards

2002 FIELD CONFERENCE

June 5–7, 2002

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BIOGRAPHICAL INFORMATION

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Current Responsibilities
Secretary of Agriculture
Experience
Appointed Secretary in August 1999; 3 years as Legislative Liaison for agriculture, environment, natural resource, and water issues; Vice-President for Government Affairs, Kansas Grain & Feed Association and the Kansas Fertilizer & Chemical Asssociation; Director of Environmental & Labor Affairs, American Feed Industry Association; research analyst at U.S. Chamber of Commerce, natural resource policy section.
Education
University of Michigan – BGS, 1985
Georgetown University – MPP, 1992

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Current Responsibilities
Municipal infrastructure maintenance and construction (includes streets, parks, airport, solid waste, wastewater, flood control, engineering, fleet management).
Experience
Kansas Department of Transportation, Highway Design.
Education
Kansas State University – BSCE, 1967

Mike Cochran
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Chief, Geology Section
Affiliation
Kansas Department of Health and Environment, Bureau of Water
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Curtis Bldg., 4th Floor
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Current Responsibilities
Responsible for administration and management of the underground injection control, storage of hydrocarbons in salt caverns, and water-well programs.
Experience
Environmental geologist for KDHE since 1977, including being District Geologist in Chanute, 1978–1982.
Education
University of Kansas – BS, 1976

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Kansas House of Representatives
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Current Responsibilities
Utilities, Agriculture, Transportation, and New Economy Committees.
Experience
Retired Paraprofessional, Fredonia Elementary School (USD 484).
Education
Fredonia High School – 1951

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Current Responsibilities
Ranking Democrat on Environment Committee.
Experience
Kansas Rural Center; Kansas Organic Producers; farmer; housing.
Education
Kansas State University – BS, 1968

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Current Responsibilities
Staff for Legislative Committees: House and Senate Agriculture Committees, House Environment Committee, Senate Natural Resources, and Joint Committee on Administrative Rules and Regulations
Experience
Legislative Research, 24 years.
Education
Kansas State University – BS, 1975
Kansas State University – MS, 1979

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Current Responsibilities
Attorney; State Representative, Member of e-Government, Ethics & Elections, and Agriculture and Natural Resources Budget Committees.
Experience
Attorney.
Education
University of Kansas – BS, 1973
Washburn University – JD, 1976

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Current Responsibilities
State Representative
Education
Labette Community College – AA, 1971
Pittsburg State University

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Current Responsibilities
Secretary, Department of Wildlife and Parks.
Experience
Governor of Kansas, 1987–1991
Education
Atwood High School – 1962
Kansas State University – BA, 1967
Fort Hays State University – MA, 1974

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Current Responsibilities
Special Assistant to the Secretary.
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State Representative, 27 years; General Counsel, KCC, 2 years; Executive Director, KCC, 2 years.
Education
Augustana College – BA, 1967
University of Kansas – 1967–1968
Washburn Law School – JD, 1973

Carl Holmes
Title
Representative, 125th District

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Current Responsibilities
Chairman, Utilities and Fiscal Oversight Committees; Member, Agriculture and Natural Resources Budget Committee, and Rules & Regulations Committees; Farm/Ranch owner and manager.
Experience
Chairman, House Energy & Natural Resources Committee; President, Kansas League of Municipalities.
Education
Colorado State University – BS, 1962

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Address and Telephone
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Current Responsibilities
Member, House Agriculture and Environment Committees.
Experience
Currently serving 4th term in Kansas House of Representatives, 50th District.
Education
Washburn University – BA, 1986

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Affiliation
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Current Responsibilities
Chair, House Agriculture Committee; Owner, Johnson Ranch.
Experience
Instructor, Fort Hays State University, 1961–1969; 23 years, Kansas Army National Guard (Retired Lt. Colonel); 40 years, Johnson Ranch.
Education
Fort Hays State University – BS, 1958
Fort Hays State University – MS, 1968

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Current Responsibilities
Ranking Member, Utilities, General Government, Higher Education, and New Economy Committees.
Experience
Kansas Legislature, 6 years; Administrative Assistant to Kathleen Sebelius, 4 years.
Education
Bowling Green State University – 2 years

Wayne Lebsack
Title
President / Trustee
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Lebsack Oil Production Inc. / The Nature Conservancy
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Current Responsibilities
Trustee, The Nature Conservancy; Direct and manage oil and gas exploration and development.
Experience
Oil and gas exploration; Ground-water exploration and pollution research.
Education
Colorado School of Mines – Geol. Eng., 1949
Colorado School of Mines – Geol. Eng., 1951
Colorado School of Mines – 2 years grad. studies

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Current Responsibilities
Plan, market, develop, implement, and evaluate policies/programs for current and future water needs.

Experience
Senior Government Affairs Liaison, Gov. Graves; Administrative Assistant to Majority Leader, KS Senate, Lt. Gov. Frahm; Legislative Liaison and Agricultural Advisor, Gov. Hayden; Administrative Assistant to Majority Leader, KS House; Farmer and Stockman.

Education
Baker University – BA, 1969
University of Kansas – Graduate School

Janis Lee

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Senator, 36th District

Affiliation
Kansas Senate

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Current Responsibilities
State Senator; Ranking Minority Member, Natural Resources and Assessment & Taxation Committees.

Experience
Involved in family ranching and farming operation; USD #238 Board of Education.

Education
Kansas State University – BS, 1970

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Representative, 86th District

Affiliation
Kansas House of Representatives

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Current Responsibilities
State Representative; Classroom teacher in Wichita, KS.

Education
Bethel College – BS, 1971
Northern Arizona University – M.A. Ed., 1981

Brad Loveless

Title
Senior Manager, Biology & Conservation

Affiliation
Westar Energy

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Current Responsibilities
Manager, Biology and Conservation Programs for Westar Energy; Chair, Green Team; KACEE President; Chair of Topeka Chapter DU.

Experience
1985–1997, Manager, Environmental Management at Wolf Creek Generating Station; Green Team Steering Committee since 1991.

Education
Ohio State University – BS, 1981
University of Kansas – MS, 1985

Laura McClure

Title
Representative, 119th District

Affiliation
Kansas House of Representatives

Address and Telephone
202 South 4th
Osborne, KS 67473
785/346-2715

Current Responsibilities
Member, Environment and Utilities Committees.

Experience
School Bus Driver; Bookkeeper; Managed low-income and senior housing; Owner/operator flower and antiques shop; Grassroots Lobbyist.

Education
Mankato High School – 1968

Karl Mueldener

Title
Director, Bureau of Water

Affiliation
Kansas Department of Health and Environment

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1000 SW Jackson, Suite 420
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Current Responsibilities
Manage KDHE's Bureau of Water, water quality standards, loan program, permitting of wastewater and water supplies, nonpoint source, wells, and LPG storage.

Experience

Worked with water and waste issues at KDHE, 1975 to present.

Education

Kansas State University – BS, 1973
Kansas State University – MS, 1974

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Title

City Manager

Affiliation

City of Hutchinson

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Current Responsibilities

City Manager.

Experience

Municipal Government, 32 years.

Education

Wichita State University – BA, 1971
Wichita State University – MUA, 1976

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Geologist

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Pickrell Drilling Co.

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Current Responsibilities

Exploration Geologist; Member GSAC (Kansas Geological Survey Advisory Council).

Experience

1972–1974, Hydrocarbon Survey, Illinois and Iowa; 1974–1976, TEXACO, Illinois Basin; 1976–1979, TEXACO, Wichita, KS; 1979–present, Pickrell Drilling Co.

Education

Wichita State University – BA, 1971
Wichita State University – MS, 1977

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Assistant Secretary for Operations

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Current Responsibilities

Supervise Law Enforcement, Parks, Fish and Wildlife, Information and Education, and Environmental Services; support Department Secretary.

Education

Fort Hays State University – BS, 1969

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Executive Director

Affiliation

State Conservation Commission

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Current Responsibilities

Agency Head

Experience

Field Coordinator, Assistant Director, Executive Director, SCC, 1985–present; involved in Brown Co. family farm until 1990.

Education

Highland Community College – AA, 1983
Missouri Western State College – BS, 1985
University of Kansas – MPA, 1993

John Strickler

Title

Chair, Board of Trustees / Chair, Fund Development

Affiliation

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Current Responsibilities

Chair, Board of Trustees, The Nature Conservancy; Chair, Fund Development, KACEE.

Experience

Former Executive Director, KACEE; Special Assistant for Environment and Natural Resources to Governor Mike Hayden, 2 years; Acting Secretary, Kansas Department of Wildlife and Parks, 1987 and 1995; Kansas State and Extension Forestry, KSU, 33 years; U.S. Forest Service, 4 years.

Education
University of Missouri – BS, 1957
Kansas State University – MS, 1968

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Current Responsibilities
Legislative staff; drafting legislation; and legal advisor.
Experience
Revisor of Statutes Office, 28 years.
Education
University of Kansas – BA, 1971
University of Kansas – JD, 1974

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Chair
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Biology Department, Pittsburg State University
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Current Responsibilities
Professor and Chair, Biology Department, PSU; Chair, Neosho Basin Advisory Committee; Chair, Statewide Council of Basin Chairs.
Experience
Assistant Professor, PSU; Assistant Professor, Ohio State University, 5 years; Officer, U.S. Navy, 1968–1971.
Education
Kansas State College of Pittsburg – BA, 1966
Kansas State College of Pittsburg – MS, 1968
University of Kansas – PhD, 1976

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Experience
Teacher for 33 years.
Education
Missouri Western College – AAS, 1967
Kansas State University – BS, 1969
Emporia State University – MS, 1986

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Represent Congressman Moran in constituent-related services, including agriculture, economic development, grant assistance, FEMA, etc.
Experience
Assistant coordinator for residence life/academic services at K-State; legislative assistant for Kansas House Majority Leader Kent Glasscock.
Education
Kansas State University – BA, 1995
Kansas State University – MS, 1997

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Director of administration and geologic research.
Experience
Kansas Geological Survey, 3 years; Director and State Geologist, Utah Geological Survey, 10 years; Western Earth Science Technologies, Inc., 6 years; University of Utah Research Institute, 3 years; SOHIO, 3 years.
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University of Massachusetts – PhD, 1986

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Supervise publication and public outreach activities, media relations, and non-technical communications.
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Kansas Geological Survey, 24 years; University-Industry Research, University of Wisconsin, 3 years; Salina Journal, 4 years.
Education
Kansas Wesleyan University – BA, 1975
University of Wisconsin-Madison – MA, 1978
University of Wisconsin-Madison – MS, 1982

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Current Responsibilities
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Education
University of Kansas – BA, 1980
University of Kansas – MA, 1985

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Current Responsibilities
Geologic mapping, remote sensing, and public inquiries.
Experience
Kansas Geological Survey, 26 years; KU Remote Sensing Laboratory, 6 years.
Education
University of Kansas – BS, 1970
University of Kansas – MS, 1973
University of Kansas – PhD, 1977

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Current Responsibilities
Geology Extension, Kansas Field Conference, geologic mapping.
Experience
Kansas Geological Survey, 10 years; Petroleum Geology, 15 years; Engineering Geology, 6 years.
Education
Kansas State University – BS, 1972
Kansas State University – MS, 1977

Kansas Field Conference

South-central Kansas

Landscapes, Resources, and Hazards

2002 FIELD CONFERENCE

June 5–7, 2002

Welcome to the 2002 Field Conference, co-sponsored by the Kansas Geological Survey, the Kansas Department of Health and Environment, the Kansas Department of Wildlife and Parks, and the city of Hutchinson. Previous field conferences have focused on specific natural-resource issues, such as water or energy, or specific regions. This year the Field Conference moves to south-central Kansas.

This year's Field Conference starts in Hutchinson, loops southwest through Barber and Clark counties, and heads as far west as Gray County, before returning to central Kansas. In the process, we will travel through four of the state's physiographic regions: the Arkansas River Lowlands, the McPherson/Wellington Lowlands, the Red Hills, and the High Plains. Both the Arkansas River Lowlands and the McPherson/Wellington Lowlands are relatively flat, low-lying areas composed of sands, silts, and gravels that were deposited largely by streams during the recent geologic past. The Red Hills is a strikingly different physiographic region, an area of gypsum-capped buttes and mesas, characterized by red and orange rock outcrops deposited during the Permian Period, about 275 million years ago. The High Plains physiographic region covers much of the western third of the state, and is largely the result of sands, silts, and gravels that eroded off the face of the Rocky Mountains and were carried by streams out onto the plains of western Kansas.

A Preview

South-central Kansas faces a variety of natural-resource issues, many of them based on geology. We'll spend much of the first day in the Red Hills. Because of the rugged topography, much of this area remains in native grass and has land-use issues that differ from those in the rest of the state. Many of the rocks that crop out in the Red Hills are evaporites—rocks deposited by the evaporation of water—in this case, a shallow sea that covered this area during the Permian Period. One of those evaporites, gypsum, is mined in a quarry near Sun City and turned into wallboard at a factory near Medicine Lodge. We will see how native mid-grass prairie can be used to support bison at Ted Turner's Z-Bar Ranch in southwestern Barber County and at The Nature Conservancy/Kansas Department of Wildlife and Parks' Big Basin Prairie Preserve in Clark County (participants from the 1998 Field Conference may remember visiting here). Finally, we'll head onto the High Plains to visit the newly established wind farm near Montezuma to see how a utility company is taking advantage of one of Kansas's most plentiful natural resources, the wind.

On the second day, we'll stop in Pratt to visit the headquarters of the Kansas Department of Wildlife and Parks, the state agency responsible for overseeing the state's parks and regulating issues related to fish and wildlife (and one of this year's co-sponsors). From there we will drive northeast to tour one of Wildlife and Parks' newest facilities, the McPherson Valley Wetlands, where the Department works—along with The Nature Conservancy, Ducks Unlimited, and other partners—to re-create a wetlands environment.

At that point the Field Conference will shift gears and examine a geologic/natural-resource issue: underground storage of hydrocarbons. We will visit a facility at Conway, west of McPherson, where natural gas liquids are stored in specially created caverns in thick layers of salt. We will proceed to Hutchinson to see sites associated with natural-gas explosions that occurred in January 2001. The source of that natural gas is hypothesized to be a facility near the town of Yaggy, northwest of Hutchinson, where natural gas was stored in salt caverns. The Kansas Department of Health and Environment (KDHE) is responsible for regulating storage of hydrocarbons in salt caverns; Hutchinson city officials were obviously deeply involved, and continue to be involved, with the response to the gas crisis. Thus, both KDHE and the city of Hutchinson are co-sponsors of this year's trip.

On the final day, we will continue to examine salt-related issues. We will visit locations east of Hutchinson where ground water dissolves away salt in the subsurface, leading to subsidence of the ground's surface. We will conclude with a visit to an underground salt mine. Because salt dissolves easily in water, salt doesn't crop out at the surface. This will be an opportunity for participants to see the salt beds beneath central Kansas, to learn about current uses of salt (and the storage space created by salt mining), and to discuss the Kansas Underground Salt Museum, scheduled to open in 2004.

About the Kansas Field Conference

The 2002 Field Conference is the eighth in the Survey's annual field conferences. The purpose of the Field Conference is to provide first-hand, on-site experience on natural-resource issues to the state's decision makers. Local and regional experts in resources will describe each site and the resource issues related to it. In addition, this comprehensive Field Guide provides background on the sites and the issues, serving as a handy reference long after the Field Conference is over.

When possible, participants will interact with county, state, and regional officials, environmental groups, and citizens' organizations. This will provide participants with new and broader perspectives useful in formulating policies. During the Field Conference, participants are expected to be just that—participants. You are encouraged to make contributions to the discussions, ask questions, and otherwise participate in deliberations. **The bus microphone is open to everyone, and everyone is encouraged to contribute.**

In the course of this Field Conference, we do not seek to resolve policy or regulatory conflicts. Instead, we are trying to provide opportunities to acquaint participants with resource problems and issues. We want to go beyond merely identifying issues; we want to bring together experts who examine the unique technical, geographical, geological, environmental, social, and economic realities of the region. 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.

The Kansas Field Conference is an outreach program of the Kansas Geological Survey, administered through its Geology Extension program. The mission of the Field Conference is to provide educational opportunities to individuals who make and influence policy about natural resources and related social, economic, and environmental issues in Kansas. The Survey'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 Kansas Geological Survey to the people of the state.

The Kansas Field Conference was begun in 1995 with the support of Survey director and state geologist Lee Gerhard. 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 Kansas Geological Survey appreciates the support of Dr. Erling Brostuen, director of the Field Institute, in helping develop the Kansas project.

In 2001, the Kansas Geological Survey's Field Conference was recognized by the National Institute of Standards and Technology as among 50 Best Practices for Communication of Science and Technology to the Public. In 1998, the Field Conference received the Public Outreach Award from the Division of Environmental Geosciences of the American Association of Petroleum Geologists. Survey staff members appreciate the willingness of participants to attend the Field Conference and to share their insights for its improvement. Your input has helped make the Field Conference a model to be adopted by other state geological surveys.

Kansas Geological Survey

Since 1889, the Kansas Geological Survey has studied and reported on the state's geologic resources and hazards. Today the Survey's 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 Survey's work coincides with the state's most pressing natural-resource issues.

By statutory charge, the Survey's 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 about 75 full-time staff members and about 65 students and grant-funded staff. It is administratively divided into research and research-support sections. Survey programs can be divided by subject into water, energy, geology, and information dissemination.

Water.—Water issues directly affect the life of every Kansan. Water supplies are crucial for domestic and municipal use, and in much of the state's economic activity. Western Kansas agriculture and industry rely heavily on ground water; in eastern Kansas, growing populations and industry use surface water. The Survey's water research and service includes an annual water-level measurement program (in cooperation with the Kansas Department of Agriculture) and studies of mineral intrusion in the Big Bend and Equus Beds areas, water quality in the Arkansas River, the movement of contaminants into the Ogallala aquifer, the interaction between streams and aquifers, and a variety of other topics. The Survey recently completed a detailed analysis of the High Plains aquifer, which resulted in the publication of *An Atlas of the Kansas High Plains Aquifer*.

Energy.—Kansas produces more than $2 billion worth of oil and natural gas each year. Because much of the state has long been explored for oil and gas, maintaining that production takes research and information. The Survey studies the state's coal resources and one newly developed source of energy, coalbed methane. The Survey does research on the state's petroleum reservoirs, new methods of providing information (such as a digital petroleum atlas), and new methods of producing oil (such as the use of carbon dioxide flooding, a technique that was discussed during the 2001 Field Conference). The Survey is undertaking a multi-year study of the resources of the Hugoton Natural Gas Area and issues related to carbon sequestration. The Survey also 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.

Geology.—Much of the Survey'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 Survey 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; applies statistical analyses to geologic problems and issues; and studies specific resources, such as road and highway materials. The Survey reports on non-fuel minerals (such as salt, gypsum, aggregates, etc.) and is charged with studying geologic hazards, such as subsidence, earthquakes, and landslides.

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

Kansas Geological Survey Staff participating in the 2002 Field Conference:

- M. Lee Allison, Director and State Geologist
- Rex C. Buchanan, Associate Director, Public Outreach
- James R. McCauley, Assistant Scientist, Geologic Investigations Section
- Elizabeth A. Brosius, Research Assistant, Geology Extension/Editing
- Robert S. Sawin, Research Associate, Geology Extension

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Kansas Department of Health and Environment

The Kansas Department of Health and Environment (KDHE) is composed of four divisions: a Center for Health and Environmental Statistics, a Division of Environment, a Division of Health, and a Division of Health and Environmental Laboratories. Of most interest during this Field Conference will be the work of the Division of Environment. Its mission is the protection of the public health and environment. The Division conducts regulatory programs involving public water supplies, industrial discharges, wastewater treatment systems, solid waste landfills, hazardous waste, air emissions, radioactive materials, asbestos removal, refined petroleum storage tanks, and other sources that affect the environment. In addition, the Division administers other programs to remediate contamination, lessen nonpoint pollution, and evaluate environmental conditions across the state.

The Division of Environment works with operators to achieve compliance with state and federal environmental statutes and regulations. The regulatory programs rely upon compliance inspections and monitoring. The Division also conducts financial or technical assistance programs such as the Wastewater Revolving Loan Fund and the Pollution Prevention Program to assist the regulated community. Operators often correct compliance problems quickly and effectively; however, in some instances the Division issues administrative orders and fines. The agency's appeals section handles administrative appeals. Some cases are eventually resolved in state or federal district court.

The Division works to reduce pollution by increasing access to the Division's programs, strengthening the district offices, and providing information to the regulated community and the public at large. Notable examples are the annual state pollution-prevention conference, responses to requests for information related to property transfers, and increased training for members of the regulated community.

The Division of Environment is organized into a Bureau of Air and Radiation, Bureau of Environmental Field Services, Bureau of Environmental Remediation, Bureau of Waste Management, and Bureau of Water. The Bureau of Water has programs in livestock waste management, nonpoint source pollution, public water supply unified watershed assessment, and underground injection control.

Responsibility for regulation of storage of hydrocarbons in salt caverns resides in the underground injection control (UIC) program. The purpose of the UIC program is to prevent contamination of fresh and usable ground-water supplies by injection activities. The UIC program categorizes injection wells into hydrocarbon storage wells and five other classes of wells. These are Class I Wells, those used to inject hazardous wastes or dispose of industrial and municipal fluids; Class II Wells, those used to inject fluids associated with the production of oil and natural gas or fluids/compounds used for hydrocarbon recovery; Class III Wells, those that inject fluids for the extraction of minerals; Class IV Wells, which dispose of hazardous or radioactive wastes into or above a fresh or usable water bearing zone (these wells are prohibited); and Class V Wells, those not included in other classes. Typically Class V injection wells are shallow wells used to place a variety of fluids below the land surface.

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Clyde Graeber, Secretary
Kansas Department of Health and Environment

Ronald Hammerschmidt, Ph.D.
Division of Environment

Kansas Department of Wildlife and Parks

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

The Department'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 Department 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. The Department operates from offices in Pratt, Topeka, five regional offices, and a number of state park and wildlife area offices.

As a cabinet-level agency, the Department of Wildlife and Parks is administered by a Secretary of Wildlife and Parks and is advised by a seven-member Wildlife and Parks Commission. All positions are appointed by the Governor with the Commissioners serving staggered four-year terms. Serving as a regulatory body for the Department, the Commission is a non-partisan board, made up of no more than four members of any one political party, advising the Secretary on planning and policy issues regarding administration of the Department. Regulations approved by the Commission are adopted and administrated by the Secretary.

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City of Hutchinson

A city of approximately 40,000, Hutchinson is located just north of the Arkansas River and near the confluence of the Arkansas and Cow Creek (a separate municipality with a population of about 2,500, South Hutchinson, lies south of the Arkansas River). Hutchinson was founded in 1871 and named after C.C. Hutchinson, an Indian agent and railroad agent. Hutchinson is the seat of Reno County (named after Civil War General Jesse Lee Reno), and the county courthouse is a six-story stone building completed in 1931 just to the west of downtown.

Rock salt was first mined in Hutchinson in 1888, using solution mining (a mining method that pumps water down wells to dissolve the salt) when two wells and a salt factory were put into operation. Underground mining began at Hutchinson in 1923 when the Carey Salt Mine was officially dedicated. Salt is so strongly identified with Hutchinson that it is sometimes referred to as the "Salt City," and the mascot of Hutchinson High School is the Salt Hawk.

In addition to salt mining, Hutchinson is well-known as a regional shipping point for grain (the grain elevators on the city's east side are among the largest in the state), as the home of the Kansas State Industrial Reformatory, the Kansas Cosmosphere and Space Center (on the campus of Hutchinson Community College), the annual Kansas State Fair, and the Fox Theatre (which was recently restored to its 1930's Art Deco style). In 2002, the city will host the U.S. Women's Open (July 1–7 at the Prairie Dunes Country Club) and the annual convention of the Family Motor Coach Association.

The city of Hutchinson is governed by an elected city council. The current mayor is Mark J. Smith. The mission of Hutchinson city employees is to make the city "a quality place to live, work and play by pursuing excellence in serving and protecting the community."

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Joe Palacioz
City Manager

Dennis Clennan
Director of Public Works and Engineering

SCHEDULE & ITINERARY

Wednesday June 5, 2002

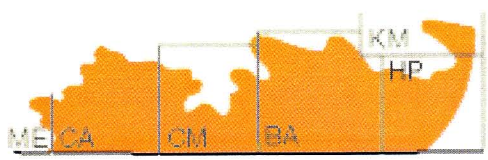
7:00 am	Breakfast at Holiday Inn Express, Hutchinson
7:20 am	Conference Overview *Lee Allison*, Director, Kansas Geological Survey
8:00 am	**Bus Leaves Microtel Inn & Suites for Site 1**
9:30 am	**SITE 1**—Medicine Lodge Wallboard Plant *Greg Whelan*, National Gypsum Company
10:15 am	Bus to Site 2
10:45 am	**SITE 2**—Sun City Gypsum Mine *Greg Whelan* and *Mark Long*, National Gypsum Company
11:30 am	Lunch at Buster's, Sun City
12:30 pm	Bus to Site 3
1:00 pm	**SITE 3**—Ted Turner's Z Bar Ranch *Keith* and *Eve Yearout*, Z Bar LLC
2:00 pm	Bus to Site 4
3:30 pm	**SITE 4**—Big Basin Prairie Preserve *Keith Sexson*, Kansas Dept. of Wildlife and Parks
3:45 pm	Bus to Site 5
4:30 pm	**SITE 5**—Gray County Wind Farm FPL Energy
5:30 pm	Bus to Dodge City
6:00 pm	Arrive Best Western Silver Spur Lodge, Dodge City
6:45 pm	Bus to Dinner
7:00 pm	Refreshments and Dinner at the Cowtown Steakhouse

Red Hills

The rugged topography of the Red Hills doesn't fit the stereotypical portrait of the Kansas landscape. Located in southern Kansas, mostly in Clark, Comanche, and Barber counties, the Red Hills are part of the Permian deposits that geologists call red beds. They get their color from iron oxide (rust), which turns bright red when exposed to oxygen.

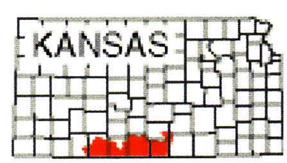
During the latter part of the Permian Period, about 260 million years ago, several thousand feet of brick-red shales, siltstones, and sandstones—along with interbedded layers of gypsum and dolomite—were deposited in Kansas. These Permian deposits have been exposed by erosion along the southern border of the state, forming a series of relatively flat-topped red hills, capped by light-colored gypsum or dolomite.

The Red Hills were known as the Medicine Hills to the plains Indians, who called the major stream that flows from them the Medicine River. They believed that spirits in the hills and streams helped to cure their illnesses and hastened the healing of wounds. In fact, the Indians were on the right track: the waters of the springs and streams contain calcium and magnesium sulfates and other natural salts dissolved from the abundant gypsum and dolomite deposits in the region. Many of these chemical compounds have therapeutic and healing effects. For example, before antibiotics were discovered, a solution of magnesium sulfate, better known as Epsom Salts, was used to draw infection from wounds and to promote healing.



Sinkholes are common features of the Red Hills region. These sinkholes were probably formed by the dissolution of salt and gypsum beds several hundred feet below the surface. The land above then collasped into the empty space, leaving a dip or sinkhole at the surface. Big Basin and Little Basin are two well-known sinkholes in western Clark County.

Gypsum, which comes in three forms, is common in the Red Hills. Selenite, one form of gypsum, consists of flat, diamond-shaped crystals, which can be found throughout the Red Hills. Another variety of gypsum is called satin spar. It is white or pink, fibrous, and has a silky luster. It is found as thin layers in beds of rock gypsum and in certain shales. The third variety, called massive or rock gypsum, is common in the Red Hills. Rock gypsum is coarsely to finely granular, white to gray, and contains varying amounts of impurities. A good outcrop of rock gypsum, part of the Blaine Formation, can be seen near milepost 213 on U.S. Highway 160, about 10 miles west of Medicine Lodge. The Blaine Formation, which includes layers of gypsum, dolomite, and red shale, is the source of the massive gypsum that is mined near Sun City in northwestern Barber County. The Gyp Hills near Medicine Lodge take their name from the gypsum in the Blaine Formation.



The Red Hills are home to numerous caves that have formed in the gypsum. In Barber County alone, there are 117 such caves. These caves are among the youngest in the state, and because they are formed in soft gypsum, they will be among the first to crumble and wash away. Closely associated with the caves are features called natural bridges. In the Red Hills, natural bridges form when a cave collapses but a section of the cave roof remains standing. South of Sun City are the remains of a natural bridge that collapsed in 1964. Before its collapse, the bridge was 35 feet wide and 55 feet long and stood 12 feet above the stream that cut through it.

The gypsum in the Red Hills (and throughout the state) was deposited during the Permian, when an arm of the inland sea was cut off from the main body of the ocean. That sea evaporated, leaving behind thick layers of sodium chloride (salt) and calcium sulfate (gypsum and anhydrite). These deposits are called evaporites, because they formed from the evaporation of water.

Source

Kansas Geological Survey, 1999, Red Hills (GeoKansas—The Place to Learn About Kansas Geology): http://www.kgs.ku.edu/Extension/redhills/redhills.html (May 13, 2002).

National Gypsum Company Gypsum Mine and Plant

Prominent beds of gypsum occur extensively in Barber and Comanche counties. Gypsum is the most common sulfate mineral—hydrous calcium sulfate ($CaSO_4 \bullet 2H_2O$)—and is widely distributed in sedimentary rocks throughout the world. It frequently occurs with limestones and shales and is often found underneath beds of rock salt (gypsum is the first mineral to crystallize when saltwater evaporates). Gypsum has been mined for many years near Sun City and is processed at the plant in Medicine Lodge. Gypsum is also produced from an underground mine near Blue Rapids in Marshall County.

In south-central Kansas, thick layers of gypsum occur in the Blaine Formation, deposited during the Permian Period, 275 million years ago (fig. 3-1). At the Sun City mine, and elsewhere, the layers are up to 30 feet thick. Dissolution by surface waters has reduced the thickness of the layers in many places.

Often associated with gypsum are layers or lenses of anhydrite. Anhydrite is chemically similar (calcium sulfate, $CaSO_4$) to gypsum, but lacks water, and is harder (if anhydrite absorbs moisture, it changes to gypsum, and increases in volume). Anhydrite is a waste product at the mine.

Gypsum production began in Barber County in the late 1880's when two brothers from England, Thomas and William Best, began manufacturing Keene's cement (a high grade of plaster) in Medicine Lodge. They had read about Kansas gypsum in Harper's Magazine (June, 1888 issue). Gypsum was first obtained from quarries 9 miles southwest of Medicine Lodge and hauled by horse or mule teams and wagons to the plant in Medicine Lodge. In 1920, the quarrying operations were moved two miles southwest of Sun City and gypsum was hauled by rail, a distance of about 25 miles (gypsum is now hauled to the plant by

Fig. 3-1. Gypsum outcrop in Barber County (the remains of the natural bridge mentioned on p. 3-2).

Fig. 3-2. The National Gypsum Company plant at Medicine Lodge, Kansas.

truck). The underground mine opened in the early 1930's. In 1938, the Best Brothers' Keene's Cement Company was sold to the National Gypsum Company.

The major use of gypsum in the United States is in the manufacture of wallboard. Other uses include plaster, additive to concrete to regulate the setting rate, soil conditioner, filler in prescription medication, and the basis for some toothpastes.

Sun City Mine and Quarry

The National Gypsum Company operates the mine and quarry near Sun City. Gypsum is mined from open-pit quarries and an underground mine. The underground mine has a horizontal entrance, and mining is done by the room-and-pillar method. Pillars are 20 feet across and the distance between pillars is 40 feet. Gypsum from the quarries contains impurities of red shale and clay; it is used for manufacturing wallboard. Because gypsum from the underground mine lacks these impurities, it is used in the manufacture of gypsum plasters (white is a desirable attribute in finish coat plasters).

Medicine Lodge Plant

National Gypsum Company's Medicine Lodge Plant manufactures gypsum plaster products and gypsum wallboard (fig. 3-2). Wallboard manufacturing was added to the plant in 1951. Presently, approximately 1.5 million square feet of wallboard and 200 tons of plaster products are produced daily. The Medicine Lodge plant currently has 130 employees, including 15 working at the Sun City mine.

Gypsum from the mine is trucked to the plant where it is crushed, dried in a rotating kiln, and then ground in a roller-type crushing mill (called a Raymond mill) into a fine powder called land plaster. The land plaster is then calcined (heated to remove three-quarters of the chemically bound water). The result is stucco (commonly known as plaster of Paris), a very dry powder that, when mixed with water, quickly rehydrates and "sets up," or hardens. Gypsum is the only natural substance that can be restored to its original rock-like state by the addition of water alone. Stucco is distributed to various storage bins or silos, based on whether it is to be used for making plaster or wallboard.

To manufacture wallboard, stucco is mixed with water to form a slurry. Several additives are induced into the slurry: starch to help with bonding, foam to help control weight, and accelerators to hasten hardening. The slurry is then sandwiched between two sheets of heavy paper. The bottom paper (face paper) is folded to form a box before passing under the mixer where the slurry is emitted onto the paper. Farther down the line, a second sheet of paper (back paper) covers the filled box. As the stucco sets, the gypsum crystallizes into long needles that grow into the paper and produce strength in the core of the wallboard. The board hardens as it travels approximately 585 feet (in about 4 minutes) down to the end of the forming line, where it is cut, and then sent into a kiln and dried for about 45 minutes.

Gypsum wallboard is an excellent building material because of its fire-retardant properties. The water that is part of gypsum's chemical composition is released as steam when it is exposed to heat or flame, thus retarding heat transfer.

Synthetic Gypsum

Many new wallboard plants are using flue gas desulfurization (FGD) gypsum, which is a waste by-product of coal-fired electrical generation plants. Synthetic gypsum is produced when lime (calcium carbonate, $CaCO_3$) is mixed with sulfur dioxide (SO_2) in the stacks of the power plant. In the past, FGD gypsum was disposed of in landfills. Using FGD gypsum to manufacture wallboard is cost effective and environmentally friendly. Disadvantages of FGD gypsum are the presence of impurities (fly ash), and smaller crystal growth, which reduces the strength of the product.

Sources

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Kulstad, R. O., Fairchild, P., and McGregor, D., 1956, Gypsum in Kansas: Kansas Geological Survey, Bulletin 113, 110 p.

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Resource Contact

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Ted Turner's Z Bar Ranch

In 1999, Ted Turner, billionaire media entrepreneur and rancher, purchased the Z Bar Ranch in southwest Barber County, near Aetna, Kansas, about 30 miles southwest of Medicine Lodge. At the time, the Z Bar was the largest contiguous ranch in Kansas. Since then, Turner has purchased additional land in the area and now controls approximately 43,500 acres. About 1,700 acres is just across the border in Woods County, Oklahoma, and 80 acres lies in Comanche County (fig. 3-3). The ranches were purchased by Z Bar, LLC, a corporation established by Turner, and are collectively known as the Z Bar Ranch.

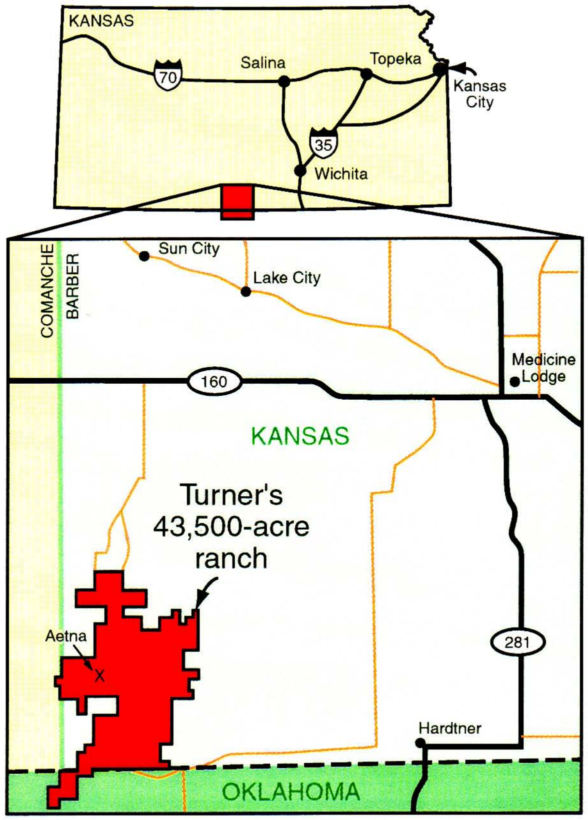

Fig. 3-3. Location of Turner's ranch in Kansas and northern Oklahoma.

The ranch is managed by Keith Yearout, with the help of his wife Eve. The Yearouts, who now reside on the ranch, previously raised bison and farmed in South Haven, Kansas. In 2000, Keith was president of the Kansas Buffalo Association, and Eve was regional director of the National Bison Association.

Since 1987, Turner has established 14 ranches, totaling about 1.75 million acres, in Kansas, Nebraska, Montana, New Mexico, and South Dakota, making him the largest private landowner in the United States. Considered the nation's largest bison rancher, Turner grazes roughly 30,000 animals, which equals nearly 10 percent of the U.S. herd. The Kansas ranch will accommodate about 2,000 bison.

Since the late 1800's, when they numbered no more than 1,500 individuals, bison have rebounded to approximately 350,000 animals located on private and public lands. Bison meat has become increasingly popular with health-conscious Americans. According to the U.S. Department of Agriculture, bison meat has fewer fat grams, calories, and cholesterol than beef, pork, or chicken.

Bison eat a wider range of plants than cattle, and will roam the entire pasture while eating. The pasture's carrying capacity is about the same for cattle and bison. In the winter, they move snow with their heads to expose the underlying vegetation, allowing them to be self-sufficient and survive extreme winter conditions. Bison can jump fences as high as six-and-a-half feet; however, unless they want out because they're hungry, thirsty, or mistreated, they can easily be maintained in their home pasture with a five-wire barbed-wire fence with an electric fence inside. Bulls weigh up to 2,000 pounds; cows weigh about 1,100 pounds. Cows live about 20 to 25 years and can calve yearly once they are three years old. Bison can run at speeds up to 30 miles per hour.

The Kansas Department of Wildlife and Parks maintains herds for public viewing at Big Basin

Prairie Preserve west of Ashland, Finney Game Refuge near Garden City, Maxwell Wildlife Refuge north of Canton, and the Mined Land Wildlife Area north of Pittsburg.

Sources

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Resource Contact

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Fig. 3-4. Bison at the Maxwell Wildlife Refuge, northeast of McPherson, Kansas.

Big Basin Prairie Preserve

The Big Basin Prairie Preserve is 1,818 acres of native short-grass to midgrass prairie in an area of steep-sided sinkholes that is managed by the Kansas Department of Wildlife and Parks. This area is in the Red Hills physiographic region of Kansas, located in Clark County about 14 miles west of Ashland on U.S. Highways 160 and 283 (fig. 3-5). The landscape can generally be described as rolling hills with level uplands and small canyons. The preserve also includes an intermittent stream, Keiger Creek, which flows through the northeast corner of the preserve, and two undrained basins that make the preserve topographically and geologically unique.

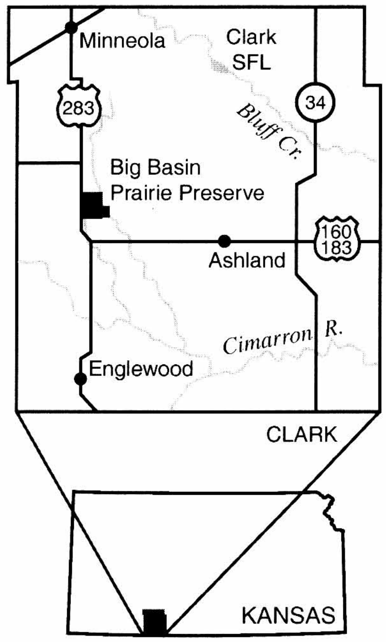

Fig. 3-5. Location of the Big Basin Prairie Preserve.

The Nature Conservancy acquired Big Basin Prairie Preserve in 1972 and sold it to the Kansas Department of Wildlife and Parks in 1974 with the stipulation that it be managed as a nature preserve. In December of 1978, the preserve was designated as a National Natural Landmark and was added to the National Registry of Natural Landmarks.

Historically, St. Jacob's Well and Big Basin were used as landmarks and watering sites on trail drives that were bringing cattle from Texas. A Living Water Monument commemorates the area's importance to early settlers.

Rocks at the surface are Permian, Cretaceous, and Tertiary in age. Permian rocks contain gypsum layers in the subsurface. Big Basin, Little Basin, and St. Jacob's Well were formed in the recent geological past by a process known as solution-subsidence. This process occurs when surface water gains access and dissolves underground deposits of salt, gypsum, or limestone. The overlaying layers of rock and minerals subside to fill the volume vacated by the water soluble deposits. Small depressions forming within Little Basin are evidence that the process of solution-subsidence is still occurring. A small sinkhole dropped about 200 yards east of St. Jacob's well in 1944.

Big Basin is a large circular depression that is one mile in diameter and about 100 feet deep. Scattered across the floor of Big Basin are small ephemeral ponds that catch and temporarily hold water that falls into the basin. U.S. Highway 283 bisects Big Basin, with approximately two-thirds of the basin lying east of the road and within the confines of the preserve. The remaining western third of the basin is privately owned.

Little Basin is about 280 yards in diameter and 35 feet from rim to floor. Within Little Basin is a small permanent pond (sinkhole) known as St. Jacob's Well (fig. 3-6). St. Jacob's Well is a pool of water about 84 feet in diameter that has never been known to go dry. The well has been the subject of many local legends, most associated with the idea that the well was bottomless or connected to an underground stream that was capable of washing away anything that fell in the well. The well was also reportedly inhabited by blind fish. Research has shown the well to be roughly funnel shaped and 58 feet deep. No evidence of an underground stream or blind fish has been found.

The primary objective in managing the preserve is to maintain the site in its natural state and thus preserve a unique ecological and geological area. Grazing is a natural and healthy activity in the prairie ecosystem, and herds of bison are maintained at the preserve to continue this natural process. The preserve is also utilized as an education center, providing opportunities for conservation education and research. The hope is that those visiting the preserve will develop a greater appreciation of the natural resources of Kansas and more concern for the conservation of all natural resources.

Vehicles are restricted to the improved trails. Maintenance of these trails is minimal so visitors should drive slowly and with caution. Foot traffic on the remainder of the area is allowed and encouraged. However, persons on foot should stay clear of the bison area. No hunting is allowed in the area.

Sources

Big Basin Prairie Preserve, Kansas Dept. of Wildlife and Parks, brochure.

Resource Contacts

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Fig. 3-6. St. Jacob's Well in the floor of Little Basin.

High Plains

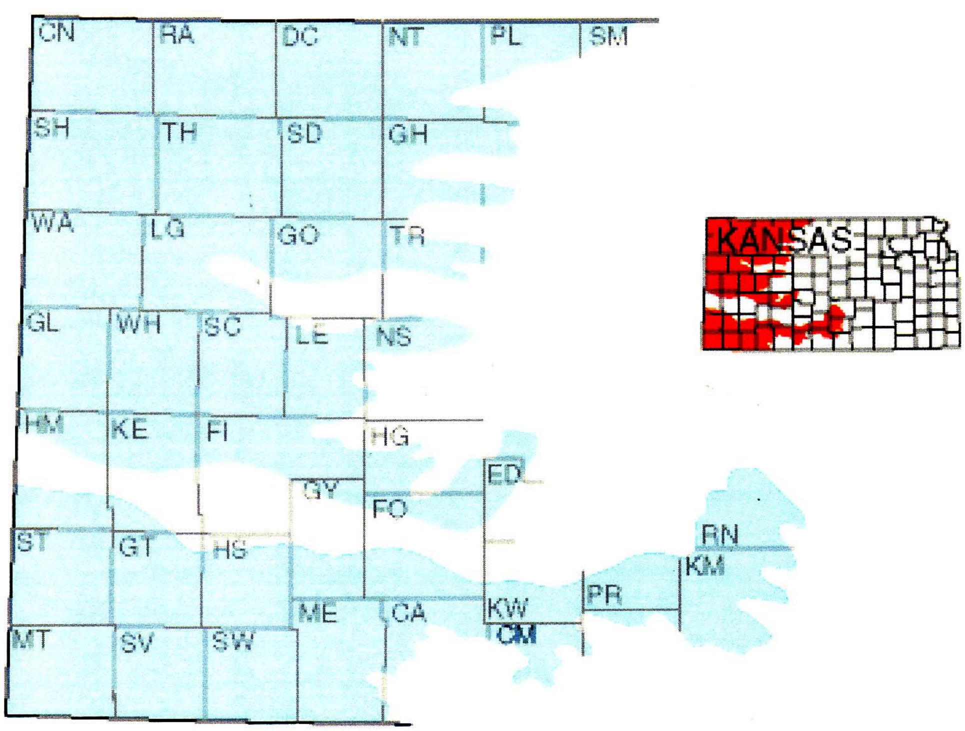
The High Plains region in Kansas encompasses most of the western one-third of the state. In this area of vast flatlands and gently rolling hills, topographic relief is largely restricted to streams and river valleys, such as the Arikaree Breaks in Cheyenne County or along the Cimarron River in Seward County.

The High Plains developed on sediments that originated in the Rocky Mountains to the west. The Rocky Mountains were formed by deformations of the earth's crust at intervals during the last part of the Cretaceous Period and the Tertiary Period. By late Tertiary time, just a few million years ago, the Rockies were being eroded by wind and water. Streams flowing eastward out of the Rocky Mountains were full of sand, gravel, silt, and other rock debris. Over millions of years, this mass of eroded material filled the stream valleys and eventually covered the hills, creating a huge, gently sloping flood plain. The remnants of that region (which extends far beyond the Kansas border) is the region we call the High Plains.

The unconsolidated deposits (sands, gravels, clays, and other materials) that eroded off the face of the Rockies lie below the surface in the High Plains and make up the Ogallala Formation. Some of the deposits in the Ogallala Formation were cemented together to form porous sandstones, known as mortarbeds. Most of the Ogallala is underground, but it crops out in many places, such as at Scott County State Lake. The Ogallala is one of the chief sources of ground water in western Kansas.

The High Plains get less precipitation than other parts of the state, averaging between 15 and 25 inches a year. The combination of low precipitation, windiness, and abundant sunshine makes for a dry, or semiarid, climate in much of the High Plains. Short, drought-tolerant grasses cover the uncultivated areas, trees are scarce, and desert-type plants, such as cactus and yucca, are common.

Loess covers much of the uplands in northern and western Kansas, concealing many of the rocks near the surface. Loess is a finely ground silt that is deposited by the wind. In the High Plains of Kansas, loess was deposited by the wind during the Ice Ages of the past million years. This finely ground silt was formed as glaciers advanced over the continent, pulverizing rocks and sediments in



their path. When the glaciers melted, this silt was deposited on the flood plains by streams coming from the melting ice sheet. Geologists think that temperature differences between the snow-covered regions to the north and the bare ground to the south may have created large differences in atmospheric pressure, which produced strong winds capable of moving large amounts of silt a considerable distance.

More then 90 percent of the soil in Thomas, Sherman, Cheyenne, Greeley, Wichita, Scott, Hamilton, and Lane counties has developed in loess deposits. In some places the loess has been eroded away by streams. The resulting draws and canyons have extremely steep sides. Loess can maintain a nearly vertical face without slumping or caving in. Along the Arikaree River in Cheyenne County, canyons carved into thick loess deposits form a rugged landscape called the Arikaree Breaks.

Sources

Kansas Geological Survey, 1999, High Plains (GeoKansas—The Place to Learn About Kansas Geology): http://www.kgs.ku.edu/Extension/highplains/highplains.html (May 13, 2002).

Gray County Wind Farm

Three miles east of Montezuma, Kansas, 170 wind turbines generate electricity at the Gray County Wind Farm. The wind farm, the state's largest, was built by FPL (Florida Power and Light) Energy, the nation's largest producer of electricity from wind energy. Construction began in May 2001 and was completed, ahead of schedule, in November 2001.

The Gray County Wind Farm is the first commercial wind farm in Kansas. The 170 wind generators are distributed over nearly 12,000 acres of farmland, north and south of U.S. Highway 56 (fig. 3-7). The area covered by all the turbines together, however, is only about 6 acres, with another 40 acres being used by service roads. Landowners can continue to farm the rest of the land and will receive about $2,000 a year for each turbine on their land for the next 20 years.

Gray County was an ideal location for the wind farm because, in addition to having lots of wind (winds average 20 miles per hour) it already had a substation and transmission lines capable of handling the additional energy load. At full capacity, the wind farm generates 107-megawatts, enough to power 33,000 households. The energy is purchased by Aquila, Inc. (formerly UtiliCorp United) and sold to customers in Kansas and Missouri.

Each wind generator consists of a 212-foot-high tower with three 77-foot blades on top. The hollow fiberglass propeller blades attach to a cast-iron hub and spin in a 154-foot-diameter circle. At full operating speed, the blade tips slice through the air at 155 miles per hour. A computer keeps the blades facing the wind. The wind generators begin to produce power at 9 mph and reach their maximum output at 33 mph. At 56 mph, the generators automatically turn the blades sideways to the wind (the blades quit spinning so they aren't damaged). The towers are designed to withstand gales up to 134 mph.

Once the winds reach 9 mph, the movement of the blades drives a shaft, which operates a generator through a gearbox and converts the mechanical energy to electricity. The electrical current travels inside the tower to underground distribution lines.

According to FPL Energy, this renewable energy source generates electricity at a cost of 4 to

Fig. 3-7. Wind turbines at the Gray County Wind Farm, near Montezuma.

6 cents per kilowatt-hour, compared to about 3.5 cents from a non-renewable source such as natural gas. Of course, the environmental costs in terms of air and water pollution are not included in that 3.5-cent price tag.

Kansas ranks third in the nation for wind energy potential—107 trillion kilowatts. Only Texas and North Dakota have higher wind power potential. FPL Energy is interested in building wind farms at other Kansas sites. In Kiowa County, Clipper Wind, LLC, an Iowa-based company, has proposed building a 67-tower wind farm.

Sources

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Johnson, Wes, 2001, "Windfall for Montezuma": The Hutchinson News, August 5, 2001.

Wetzel, Kyle K., 2002, "Kansas needs bolder approach to wind energy": Kansas City Star, February 9, 2002.

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SCHEDULE & ITINERARY

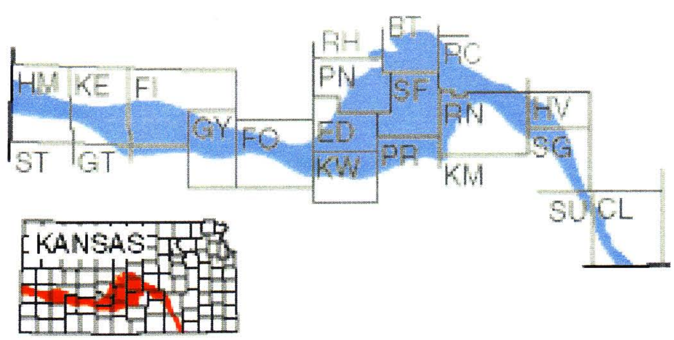
Thursday June 6, 2002

7:00 am	Breakfast at Best Western Silver Spur Lodge, Dodge City
7:45 am	**Bus Leaves Best Western for Site 6**
9:15 am	**SITE 6**—Kansas Dept. of Wildlife and Parks Operations Office, Pratt *Mike Hayden* and *Keith Sexson*, Kansas Dept. of Wildlife and Parks
10:15 am	Bus to Site 7
11:50 am	**SITE 7**—McPherson Valley Wetlands *Todd Pesch*, Kansas Dept. of Wildlife and Parks *Wayne Lebsack*, The Nature Conservancy
12:30 pm	Bus to Lunch and Site 8
12:40 pm	**SITE 8**—Conway NGL Underground Storage Facilities *Austin McClain* and *Carl Johnson*, Williams Energy Services
3:00 pm	Bus to Site 9
3:30 pm	**SITE 9**—Hutchinson Natural Gas Crisis *Joe Palacioz* and *Dennis Clennan*, City of Hutchinson *Karl Mueldener* and *Mike Cochran*, Kansas Dept. of Health and Environment *Lee Allison,* Kansas Geological Survey
4:45 pm	Bus to Rice Park
5:00 pm	Rice Park—Continue Gas Crisis/Water Quality Issues Discussion
5:30 pm	Refreshments and Dinner (Anchor Inn) at the Park
8:00 pm	Bus to Microtel Inn & Suites, Hutchinson

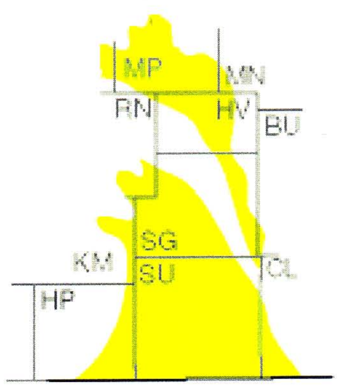
Arkansas River Lowlands and Wellington-McPherson Lowlands

The Arkansas River Lowlands and the Wellington-McPherson Lowlands, though separated into different physiographic regions, are geologically similar. Both regions are relatively flat alluvial plains, made up of sand, silt, and gravel that was dumped by streams and rivers.

The Arkansas River Lowlands is made up of rocks deposited by the Arkansas River during the last 10 million years as the river flowed through Kansas from its source high in the Rocky Mountains. In the Rockies, the Arkansas is supplied with runoff, snow melt, and rock debris that weathers from the mountains, but as it moves out onto the High Plains, it receives little in the way of additional water. In fact, it loses water to its sandy riverbed. As its flow decreases, the river's ability to carry sediments also diminishes and it begins to dump its sediment load. It changes from a degrading stream (one that cuts downward in its channel) to an aggrading stream (one that builds up the riverbed).



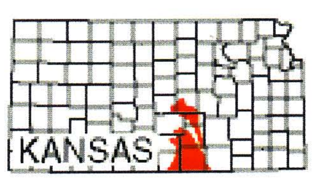
The Wellington-McPherson Lowlands of south-central Kansas is also developed on alluvial deposits. This sand, silt, and gravel was eroded from slightly older rocks in the High Plains to the north, then carried by streams flowing south into the Arkansas River during the Pleistocene Epoch, between one and two million years ago.



The Wellington-McPherson Lowlands sits on top of one of the largest salt deposits in the world. Known as the Hutchinson salt bed, this deposit underlies much of central Kansas and is as much as 400 feet thick in places. Another important underground feature of the Wellington-McPherson Lowlands is the Equus Beds aquifer. The Equus Beds is made up of thick (more than 250 feet) deposits of silt, sand, and gravel; in many places, these deposits are saturated with water. This aquifer is an important source of water for Wichita, McPherson, Newton, and other communities in this region. These Pliocene and Pleistocene deposits were named for fossils of Ice Age horses that were found among the unconsolidated deposits (*equus* is the Latin word for horse).

Sand dunes, formed by wind and water, occur in many places in both regions. Most of these dunes are covered with grass and other vegetation, which keeps the sand from shifting. Such sand dunes are considered inactive—that is, they are no longer moving in response to wind and water.

In the Arkansas River Lowlands, sand dunes are common south of the river in Hamilton, Kearny, Finney, Gray, Ford, Kiowa, Edwards, Pratt, Pawnee, Stafford, Barton, Rice, and Reno counties. North of the river, however, only a few isolated areas of sand hills occur. This leads geologists to speculate that the prevailing winds were from the north during the time of deposition, which was during the Ice Age, about a million years ago. At that time, a huge ice sheet to the



north may have created wind patterns that were the opposite of today's patterns, which are generally characterized by winds from the south. Sand along the Arkansas River is regularly dredged from the floodplain. The production of sand (and gravel) is an important industry in the state, and sand pits are common along the entire length of the river. Kansas sand is composed mostly of quartz and also contains igneous and metamorphic minerals formed outside the state and transported here by running water.

In Kansas, salt is found in thick beds in Permian rocks deep underground, the largest of which is the Hutchinson salt bed, which underlies approximately 37,000 square miles in central Kansas. This salt was deposited by the evaporation of a shallow arm of the Permian sea, which was cut off from the open ocean. When that shallow arm evaporated, it left behind thick layers of gray shale, salt, and gypsum. These deposits were subsequently buried by younger sediments and remained hidden for millions of years until salt was accidentally discovered near Hutchinson in 1887 by drillers looking for oil and gas.

Salt was also discovered in Wellington in 1887. However, because this Sumner County town is near the eastern edge of the Hutchinson salt bed, the salt was only about 50 feet thick and the salt mine that opened there soon failed. Today salt mines operate in Rice, Reno, and Ellsworth counties.

Source

Kansas Geological Survey, 1999, Arkansas River and Wellington-McPherson Lowlands (GeoKansas—The Place to Learn About Kansas Geology): http://www.kgs.ku.edu/Extension/lowlands/lowlands.html (May 13, 2002).

Kansas Department of Wildlife and Parks, Pratt Operations Offices

The Kansas Department of Wildlife and Parks (KDWP) facility at Pratt includes the Operations Headquarters, the Pratt Fish Hatchery, and the Education Center and Aquarium. The KDWP employs 394 full-time staff.

The Pratt Operations Office is headquarters for the following divisions and sections: Law Enforcement, Fish and Wildlife, Parks, Environmental Services, Information and Education, Administration, and Engineering. The office of the Assistant Secretary for Operations is also located here. The office of the Secretary and Assistant Secretary for Administration—along with legal, planning, and budget staff—are located in Topeka.

The Pratt Fish Hatchery has a long history at this location. On March 13, 1903, the Kansas Legislature approved the establishment of a state fish hatchery "at some place that is well adapted to the propagation of fish." A few months later, Pratt County donated 12 acres of land 2 miles east and 1 mile south of Pratt. Three additional acres were donated in 1905, at which time the legislature appropriated $8,400, which was used for the construction of the hatchery building. During 1912 and 1913, the hatchery expanded to almost its present configuration with the construction of a new headquarters office (now home to the Education Center and Aquarium), numerous operational buildings, and the addition of 83 fish production ponds to the seven ponds already built. At that time, the Pratt Fish Hatchery was the largest in the nation.

Today the hatchery grounds consist of 87 culture ponds and two concrete raceways. The primary water supply for the hatchery is a shallow, 5-acre reservoir on the Ninnescah River at the east edge of Pratt's Lemon Park. This is supplemented by water from two wells. Together, they provide 3,000 gallons of water per minute, which flows continuously through the hatchery and back into the Ninnescah, giving the facility high-quality water.

Fig. 4-1. Channel catfish fingerling.

Fish species raised at the Pratt Hatchery include walleye, wiper (white bass–striped bass hybrid), sauger, saugeye (walleye–sauger hybrid), large-mouth bass, channel catfish (fig. 4-1), and bluegill. Broodfish and forage fish are maintained in the ponds.

The Education Center and Aquarium contains a number of displays on Kansas wildlife. Some of the displays feature living reptiles common to Kansas (non-poisonous snakes). Others highlight wildlife such as raptors, shorebirds, waterfowl, and insects. The state's major grassland areas—tallgrass, shortgrass, and mixed—are the subject of one display, while another features wetland environments. Twelve 400- to 600-gallon aquariums display fish species that are either native to Kansas or have been successfully introduced into Kansas waters. The education center also includes a variety of free resources for teachers and students, including a reference center that loans (free of charge) educational resources from fishing poles to books, CD's, and videos.

The Pratt Backwaters Area consists of acreage along the Ninnescah River north of the Operations Office that the KDWP owns and manages for public fishing and wildlife viewing along the river. Mowed access trails are maintained east of the office for public access.

The facility grounds are landscaped with backyard wildlife in mind. Bird feeders are maintained during the winter months, and shrub and tree plantings enhance wildlife use of the area, including deer and turkey that frequent the Ninnescah river drainage. Canada Geese use the nesting structures provided in ponds near the office. Fishing clinics and hunter-education classes are sponsored by Department employees at the facility.

Sources

Kansas Department of Wildlife and Parks, 1999, Kansas Wildlife and Parks Education Center and Aquarium (brochure).

Kansas Department of Wildlife and Parks, no date, Kansas Wildlife and Parks—Serving People, Managing Wild Resources (brochure).

Kansas Department of Wildlife and Parks, no date, Pratt Fish Hatchery (brochure).

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McPherson Valley Wetlands

Before glaciation during the Pleistocene Epoch (Ice Age) caused some Kansas streams to change course, the ancestral Smoky Hill River turned near present-day Lindsborg and traveled south to the Arkansas River near Wichita. The valley created by this ancient river is 4 to 5 miles wide and contains up to 150 feet of silt, sand, and gravel. Contained within this ancient river valley is an extensive complex of wetlands in McPherson, Reno, Harvey, and Sedgwick counties. This valley also generally coincides with the dissolution front of the Hutchinson Salt Member of the Wellington Formation (see Salt-related Subsidence, p. 5-2). Sinkholes related to the dissolution front may have created some of the depressions that later became wetlands.

Before this area was drained for agricultural purposes in the early 1900's, over 30,000 acres of wetlands existed in four counties. The largest single marsh was Big Basin, which was more than 2,000 acres. Other marshes ranged in size from 10 to 500 acres. Lake Inman, the largest natural lake in Kansas at more than 100 acres, is part of this complex, and is probably a natural sinkhole.

The Kansas Department of Wildlife and Parks, The Nature Conservancy Kansas Chapter, and Ducks Unlimited have joined forces to restore portions of the McPherson Valley Wetlands.

The McPherson Valley Wetlands are less renowned than the internationally prominent Cheyenne Bottoms or Quivira National Wildlife Refuge, but they represent a critical wetland resource that, more than a century ago, rivaled Cheyenne Bottoms and the Quivira salt marshes in hosting migratory waterfowl and other wetland wildlife. In the late 1800's and early 1900's, the valley's wetlands were an important feature during the early Anglo-American settlement of the area. Local residents relied on the wetlands to feed their families, but market hunting industries also developed around the wetlands. Many citizens from the area derived a portion of their income by guiding hunters from as far away as Kansas City, Chicago, and St. Louis, who would travel by train for a day to hunt waterfowl on the wetlands.

In 1911, to make the area easier to farm, a successful effort was initiated to drain the wetlands. At the time, little was known about the benefits of natural wetlands. Eventually, most of the original wetlands were lost to farming.

Restoration of the McPherson Valley Wetlands started in 1989 when the Kansas Department of Wildlife and Parks purchased 160 acres 2 miles west of McPherson. Today, more than 3,000 acres have been brought under coordinated ownership and management by the partners. Restoration efforts are presently concentrated in three areas: Big Basin (not to be confused with Big Basin in Clark County) and Kubin marshes, located about 2 miles west of McPherson; Chain of Lakes, about 3 miles southwest of McPherson; and Little Sinkhole Marshes, just 1 mile southeast of Inman (fig. 4-2).

The partnership formed by Kansas Department of Wildlife and Parks, The Nature Conservancy Kansas Chapter, and Ducks Unlimited is committed to restoring this ecologically important resource. The Kansas Department of Wildlife and Parks, the official state wildlife resource agency, owns and manages the wetlands and has an on-site manager with experience in managing wetlands. The Kansas Department of Wildlife and Parks has provided a majority of the funding for this project. Ducks Unlimited, Inc., a private non-profit natural resource group, has provided significant funding, stewardship, and other support. The Nature Conservancy provides funding, helps locate additional funding sources, and assists with land acquisition. All wetland partners are dedicated to a three-part effort that involves acquisition, restoration, and management.

The McPherson Valley Wetlands, in conjunction with the Cheyenne Bottoms and Quivira National Wildlife Refuge marsh complexes,

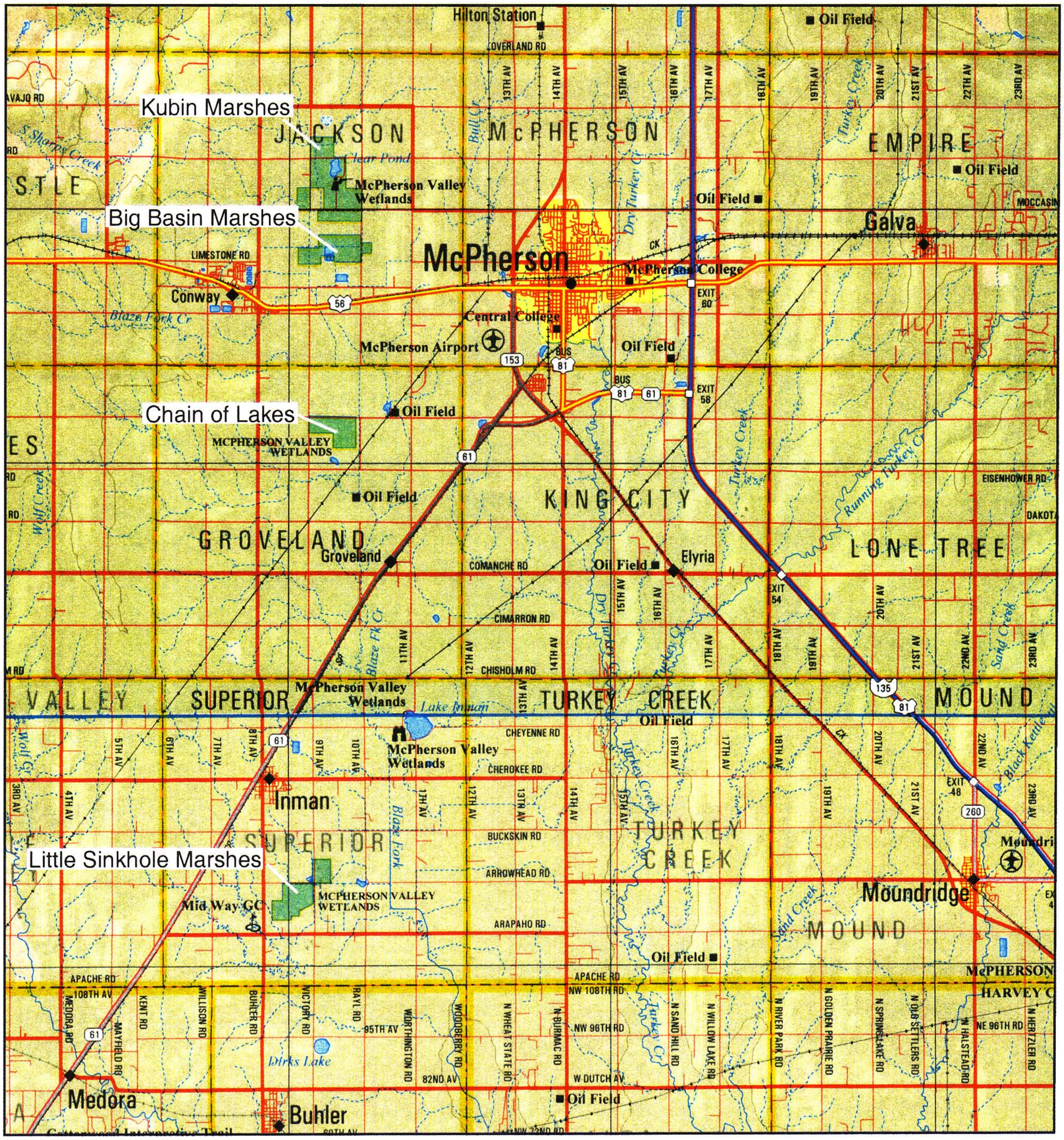

Fig. 4-2. McPherson Valley Wetlands.

provide wintering and migrational habitat for waterfowl and shorebirds. In the fall of 1995, whooping cranes, an endangered species that was once common here, were observed using McPherson Valley Wetlands—an occurrence documented for the first time in nearly 100 years.

Sources

Frye, J. C., and Leonard, A. B., 1952, Pleistocene Geology of Kansas: Kansas Geological Survey, Bulletin 99, 230 p.

Kansas Department of Wildlife and Parks, McPherson Valley Wetlands (pamphlet).
The Nature Conservancy, Kansas Chapter, 2000, McPherson Valley Wetlands Benefits From Partnership: Plains Keeper, Fall/Winter, 12 p.

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Conway Natural Gas Liquids Underground Storage Facility

One of the state's largest natural gas liquids (NGL) storage areas is located in western McPherson County, near the small town of Conway. The five Conway underground NGL storage facilities are located along the major pipeline corridor that connects the oil- and gas-producing fields in the southwestern United States with the energy markets in the upper Midwest and Gulf Coast regions (fig. 4-3).

These pipeline facilities use caverns created in the Hutchinson Salt Member of the Wellington Formation to store hydrocarbons. The Hutchinson salt is thick and fairly predictable from place to place, which makes it useful for hydrocarbon storage. At the Williams Conway facility, caverns have been created by dissolving large voids into the salt. Propane, butane, and other NGLs can then be introduced into, and removed from, these caverns relatively quickly. Williams owns and operates three of the five underground NGL storage facilities in the Conway area: Conway Underground East, Conway West, and Mitchell. Mitchell is located approximately 14 miles to the west, in Rice County, Kansas.

Natural Gas Liquids

Natural gas wells produce (1) methane, commonly referred to as natural gas or dry gas, and (2) natural gas liquids (or NGL's), which consist of varying mixtures of propane, butane, ethane, and traces of other hydrocarbons. NGL's produced at wellheads and gas-processing facilities are gathered through pipelines (as a liquid called raw feed) and then delivered for processing at fractionators (described below). In the past,

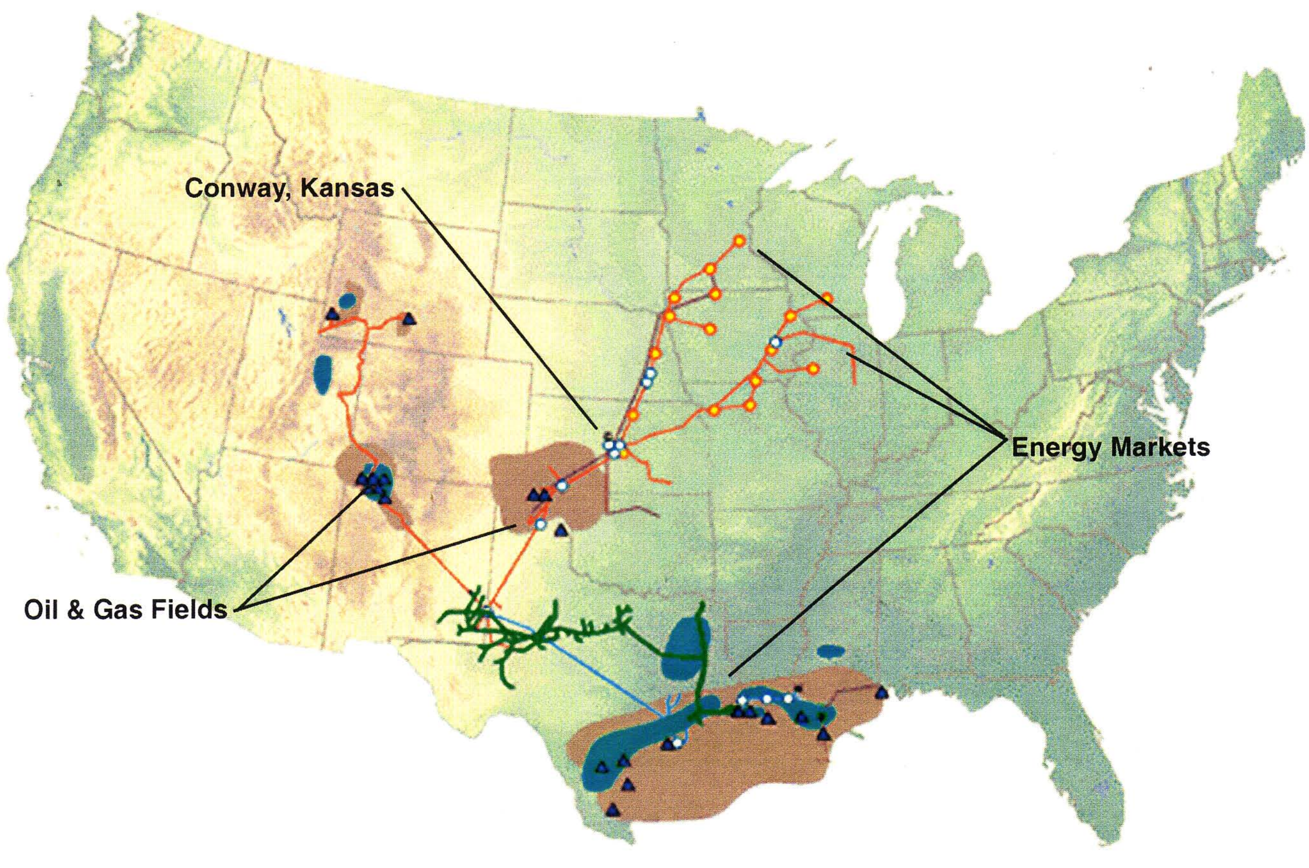

Fig. 4-3. Williams NGL system map.

raw feed was a waste material generated during oil and gas gathering and processing. Now raw feed is fractionated (or broken into its components) and sold for use in commercial energy and petrochemical industries. The Conway fractionator is designed to process 107,000 barrels (a barrel is equivalent to 42 U.S. gallons) of raw feed per day. The raw feed commonly contains low quantities of methane when it reaches the Conway fractionator; these small volumes are either used as fuel for the fractionator or blended in trace quantities with the liquids produced. Williams does not store natural gas at any of the three Conway storage facilities.

Conway Fractionator

The fractionator here at Conway is designed to process the liquid by-products generated during oil and gas production. The fractionator breaks by-products into different components, or fractions (thus the name fractionator). The Conway fractionator generates products such as propane and butane (called fractionates). The fractionates and other liquid hydrocarbon mixtures, referred to collectively as natural gas liquids (NGLs), are temporarily stored in underground caverns for subsequent use, or for delivery to the energy marketplace through interstate pipelines, railcars, and tanker trucks. The Conway fractionator is owned cooperative by Williams Midstream Natural Gas Liquids, Inc. (50%), Phillips Petroleum Co. (40%), and Texaco Producing, Inc. (10%).

At some point along the pipeline (between the producing fields and the consumer and industrial users), the raw feed must be fractionated. Every year, more than 30 million barrels of raw feed NGL is transported to Conway, fractionated, temporarily stored in the salt caverns, and subsequently transported to the marketplace. Another 70 million barrels of processed NGL's, such as propane and butane, are also transported through pipelines to Conway where they are stored pending peak seasonal demand. Because large volumes of NGL's can be stored in caverns at Conway, meeting seasonal demands for NGL energy products is not limited directly by the production rates of fractionators and production fields.

NGL's storage in Salt Caverns

NGL's can be stored on the surface in large steel spherical tanks or underground in solution-mined storage caverns in salt formations, such as the bedded salt that underlies most of central Kansas. The large spherical tanks that are used to store NGL are expensive, add cost to the consumer products, and use considerable land area. The underground storage caverns are more economical than surface storage.

Figure 4-4 illustrates an NGL storage cavern in bedded salt similar to the salt formations in Kansas. The storage cavern is created by first drilling down to the salt formation. The drill hole is sealed off from the overlying units by cementing a steel casing pipe in place. Freshwater is then injected through the pipe into the salt formation,

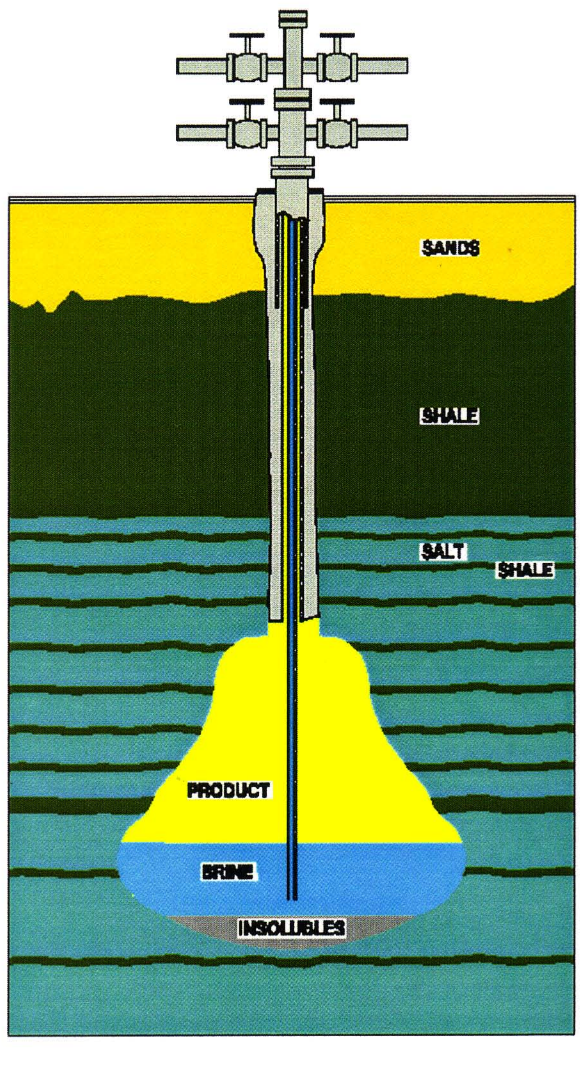

Fig. 4-4. NGL storage cavern in a bedded salt formation.

allowing it to dissolve some salt. Dissolution of the salt creates a nearly saturated brine solution that is roughly analogous to melting a hole in an ice cube with hot water. This brine solution completely fills the cavern.

To facilitate hydrocarbon storage in the newly solution-mined cavern, a steel pipe is hung from the wellhead inside the cemented steel casing. This central pipe is called the brine injection string or tubing. Because NGL's are lighter than saturated saltwater brine, they essentially float on the brine, and the movement of the NGL's out of the storage cavern is controlled by the injection of brine. Conversely, when NGL's are pumped into the cavern, brine is displaced out of the cavern and piped to lined surface storage ponds. In order to remove a barrel of NGL product from a storage cavern, a barrel of brine must be pumped in to the cavern to displace it.

How NGL Cavern Storage Differs from Natural Gas Cavern Storage

Although natural gas is not stored at Conway, natural gas can be stored in solution-mined caverns to buffer production from seasonal demand (fig. 4-5). In Kansas, natural gas storage caverns differ from liquid storage caverns in five significant ways:

1. NGL storage caverns have a history of nearly 50 years of use; natural gas storage caverns have been in use in Kansas for less than eight years. Many of the salt caverns at Conway were originally constructed in the 1950's.

2. All NGL caverns were originally designed and constructed as NGL caverns, and have never been re-entered after being plugged and abandoned.

3. Solution-mined salt caverns currently being used in Kansas to store natural gas were originally designed for NGL storage.

4. Movement of NGL products in and out of caverns is facilitated by pumping brine solution into the well to displace the hydrocarbons; natural gas is compressed and stored at pressures high enough to induce the product to flow out through pipes on demand.

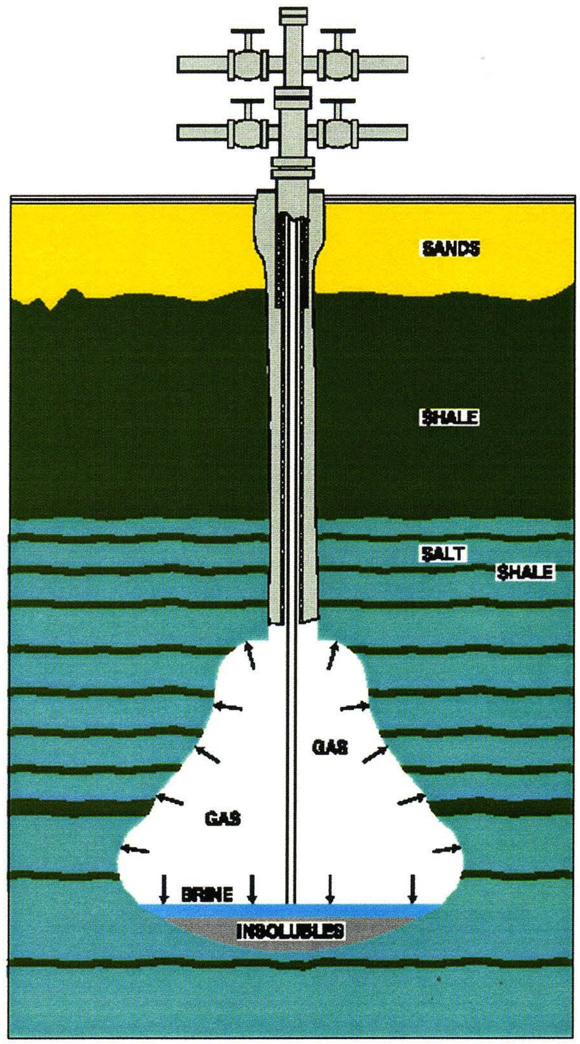

Fig. 4-5. A natural gas storage cavern in a bedded salt formation.

5. Virtually the entire volume of product in a NGL cavern can be displaced by pumping in an equivalent volume of brine; natural gas caverns must be operated above a minimum pressure to provide a base gas volume that supports the weight of the overlying rocks. The base gas volume cannot be recovered under normal conditions.

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Hutchinson Natural Gas Crisis

On the morning of January 17, 2001, an explosion occurred in downtown Hutchinson, destroying two buildings, and starting a fire that burned for hours. Later, geysers of natural gas and water spewed as high as 30 feet into the air on the east side of town. On the morning of January 18, an explosion in a trailer home on the city's east edge eventually resulted in two deaths and the evacuation of much of the east side of Hutchinson.

Today, the working hypothesis is that natural gas escaped from a storage area about 9 miles northwest of Hutchinson, moved along the contact of the Wellington Formation and the overlying Ninnescah Shale, then came to the surface through abandoned wells that had been used for the solution of salt (fig. 4-6). The natural gas had been stored in a facility near the small town of Yaggy, in salt caverns that had been dissolved into the salt for the storage of propane in the 1980's. The storage area was closed for a time in the late 1980's, then re-opened for the storage of natural gas. In the Hutchinson incident, gas probably escaped through a hole that was identified at about 600 feet below the ground in the pipe in one of the salt caverns. Kansas Gas Service, the local utility, estimates that approximately 143 million cubic feet of natural gas escaped from the facility.

In response to the natural gas loss, Kansas Gas Service drilled a series of wells that were designed to locate and vent the natural gas at the surface. Initially, many of those wells were located in areas, such as parking lots and parks, where Kansas Gas Service could gain quick access. Some of those wells located gas, but many did not (including some in locations that seemed likely to produce gas).

In an attempt to help guide the placement of those wells, the Kansas Geological Survey collected seismic data on a north-south line along Wilson Road, west of Hutchinson, between Yaggy and the city. Seismic reflection is a technique commonly used in the oil industry. Energy is put into the ground—in this case from vibrations from the pad of a specially equipped truck called a Vibroseis. That energy travels underground, reflects off of subsurface rock formations, then returns to the surface where it is recorded by microphone-like

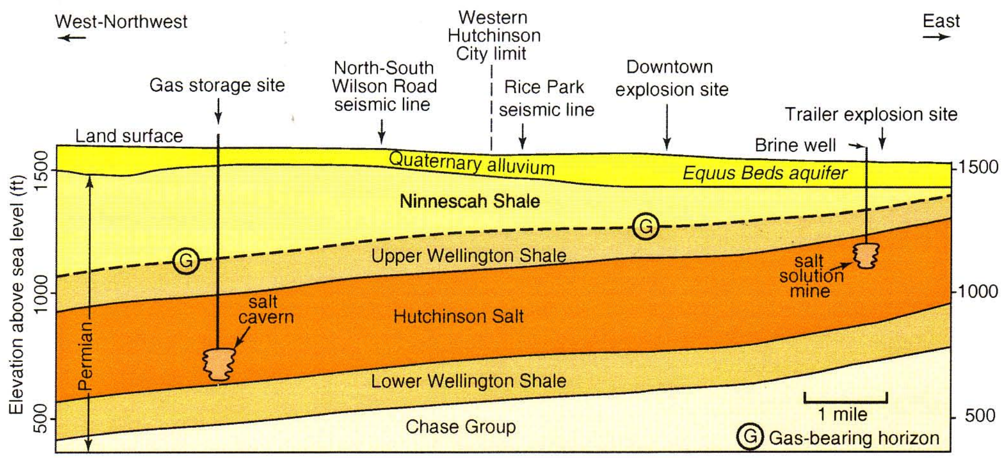

Fig. 4-6. Cross section of Reno County geology, showing the hypothetical movement of gas from a salt cavern to eastern Hutchinson.

devices called geophones. Because different rock formations reflect the vibrations in different ways, the results can be used to create an image of the subsurface, without the necessity of drilling. The Kansas Geological Survey's seismic crew specializes in shallow seismic reflection (at depths of less than 1,000 feet). Because most of the gas was being found at depths of less than 500 feet, the Survey's seismic capabilities were a good match for the problem. Based on that seismic data, two drilling locations were identified along Wilson Road, both of which eventually produced gas that was vented.

In addition to providing seismic expertise, the Survey worked with the city, the Kansas Department of Health and Environment (which regulates hydrocarbon storage in salt caverns), and Kansas Gas Service to study subsurface geology in the area, provide information, and search for other abandoned wells. Because of the long history of salt production in the area, as many as 150 wells may have been drilled into the salt and then abandoned and forgotten. The long-forgotten well that allowed gas to move to the surface for the initial explosion downtown originally provided saltwater for a hotel spa.

Today, most of the wells that were drilled for the venting of natural gas remain open. Only a few produce any natural gas, and those in extremely small amounts. In an attempt to study the amount and location of the gas remaining beneath the city, the Survey has analyzed the results of pressure tests, in which vent wells are closed for specified periods of time (some as long as 400 hours) to allow pressure to build up.

Today, most of the natural gas has been removed from the storage caverns at Yaggy (a small amount remains to provide what is called cushion gas, to support the cavern roofs so that they do not collapse). KDHE is currently revising the rules and regulations for these storage areas. According to Kansas Gas Service, a decision about re-opening the facility will depend on those rules and regulations and the ability to operate the facility safely.

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City of Hutchinson

February 2000

City Seeks to Improve Water Quality

Groundwater, which serves as the source of drinking water for the City of Hutchinson and the surounding area, has been impacted by various contaminants primarily derived from past industrial practices. The City of Hutchinson, Kansas is seeking federal assistance to construct a membrane water treatment plant which will help address complex regional groundwater issues. These groundwater issues have the potential to threaten future drinking water supplies and surface water quality in the Hutchinson area. This fact sheet provides an overview of the groundwater and surface water issues facing the City of Hutchinson and Reno County and the City's plans to address the problems.

Background

The City of Hutchinson is the county seat of Reno County and is located in the south-central portion of the State of Kansas, approximately 45 miles northwest of Wichita. The City is a community of approximately 40,000 persons occupying an area of roughly 21 square miles. The City was incorporated in 1872. The City's water supply is derived exclusively from shallow groundwater within the alluvial sands which underlie the area.

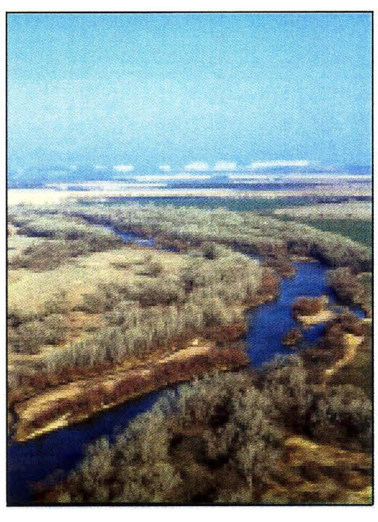
City's Water Supply

The current water supply is derived from an underground source of water called the Equus Beds Groundwater Aquifer. Seven of the City's sixteen active wells are located within the City, while nine wells are located in the agricultural areas west and northwest of the City.

Hutchinson has a total of 20 municipal wells, but four have been shut down due to groundwater contamination. The groundwater in the non-impacted wells is of high quality, and a water treatment plant has not been needed. The groundwater is disinfected with chlorine at the well head and is pumped into the water mains that distribute the water. The City has an average daily demand (1998) of approximately 6.5 million gallons per day (MGD), and a maximum daily demand of 14.9 MGD. The average annual water use (1998) is approximately 2.4 billion gallons. The permitted annual water appropriation is 3.8 billion gallons.

Groundwater Impacts: Chlorinated Solvents

Groundwater has been significantly impacted by chlorinated solvent contamination. Sources for the chlorinated solvent contamination include dry cleaners, grain elevators, manufacturing facilities, a truck maintenance facility, and a landfill. Plumes from these sources are represented by the blue [trichloroethene (TCE)], orange [perchloroethene (PCE)], green [carbon tetrachloride (CT)], and yellow [vinyl chloride (VC)] colors on the map shown on the following page. Roughly 3.5 square miles of groundwater, respresenting a volume of approximately 9 billion gallons, have been impacted by chlorinated solvents.



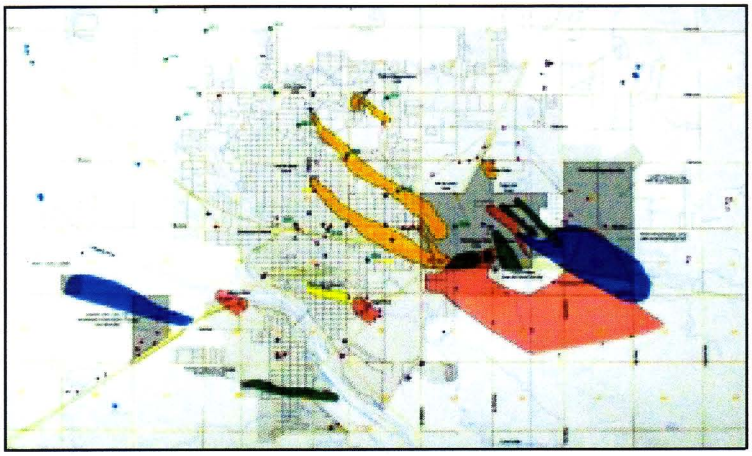
Arkansas River with City of Hutchinson and grain elevators to the Northwest.

Groundwater Impacts: Chlorides

The sandy Equus Beds aquifer is immediately underlain by geologic formations consisting of shale and salt beds. Salt mining in the area began in 1887 and continues to this day. Chloride is a component of the salt that is mined in the area. As a result, extensive chloride impacts, appearing to be derived from both natural and industrial sources, have been discovered in the groundwater in the area. Plumes representing significant chloride concentrations (exceeding 1000 milligrams per liter) are shown in red on the groundwater map provided on the next page. The known extent of the chloride impact on groundwater is at least 2.5 square miles which represents a volume of approximately 6 billion gallons. Surface water in the area, primarily the Arkansas River, has also been impacted by chlorides derived from natural sources as well as from industrial activities. The natural source of chloride in the Arkansas River occurs as the river and its tributaries flow through the salt-laden formations located upstream of the City of Hutchinson.

Groundwater Remediation

Facilities responsible for the chlorinated solvent contamination are under consent orders and/or agreements with the Kansas Department of Health and Environment to remediate the sources of contamination. Several facilities are still being evaluated to identify the most effective and appropriate remediation technology.



Known contaminant sites in Hutchinson and S. Hutchinson, Kansas September 15, 1999
Source: Kansas Department of Health and Environment, Burns & McDonnell. Colors: Orange = PCE; Blue = TCE; Green = CT; Yellow = VC; Red = chloride.

Typically, remediation of groundwater contaminated by chlorinated solvents consists of extracting the groundwater, stripping the contaminants from the water by forced air, and then discharging the treated groundwater to the nearest body of surface water.

Problem

Chloride contamination in Hutchinson will prevent traditional cost-effective remediation techniques from working properly. Current groundwater extraction rates total approximately 2.3 MGD. Future groundwater extraction rates for the purposes of preventing the migration of groundwater contaminated by chlorinated solvents may be as great as 5 MGD. The chloride concentrations in the treated extracted groundwater are too high to meet surface water discharge requirements. Other technologies which can prevent the migration of groundwater contaminated by chlorinated solvents are much more expensive to install and/or operate; are generally less effective; and will not address the chloride contamination.

Potential Solution

The City of Hutchinson is looking for federal assistance to build a membrane treatment plant which can remove the chloride contamination from the extracted groundwater which has been treated for the chlorinated solvent contaminants. Once the chloride concentration has been reduced or removed from the extracted groundwater, the high quality water can be:

- Used to allow the City to conserve groundwater resources through 100 percent utilization of pumped groundwater.
- Offered to attract new businesses to the area that have high water quality needs.

Benefits

The construction of a membrane treatment plant to remove chloride from extracted groundwater already treated for chlorinated solvent contamination will provide the following benefits:

- Allow the City to reduce the stress on the Equus Beds Aquifer (the City's water supply) by reducing groundwater demands.
- By blending in the treated groundwater from the treatment plant, the City can improve the quality of drinking water supplies to its populace.
- Allow the City to encourage economic growth by attracting industries which require high quality water (e.g. pharmaceutical or computer component manufacturers).
- Improve surface water quality through the discharge of treated wastewater which will have lower chloride concentrations.
- Reduce the mass of chloride in the groundwater and eventually improve the surface water quality in the area (a significant portion of groundwater in the area ultimately discharges to the Arkansas River).

IMC Salt Company and Hutchinson grain elevators

- Help the City and businesses economically prevent the migration of contaminated groundwater into rural agricultural areas.

Funding Request

The City will be seeking federal funding in the coming fiscal years to assist in the construction of a membrane water treatment plant. The City will fund a $45,000 feasibility study to determine whether the chloride levels are economically treatable.

Potential Sponsors, Regional Partners, and Supporters

- City of Hutchinson
- Kansas Department of Health and Environment
- Textron Inc.
- Garvey Elevators
- Farmland Industries
- Cargill, Inc.
- IMC Salt Company (International Mining Corporation)
- Reno County
- Kroger Foods
- Dillon Companies
- Groendyke Transport Inc.
- Bunge Elevator
- EPA Region VII
- Sierra Club
- Equus Beds Groundwater Management District #2
- Lowen Corporation
- REAP - Regional Area Economic Partnership

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City of Hutchinson, P.O. Box 1567, Hutchinson, Kansas 67504

Hutchinson Proposes Reverse Osmosis as Solution for Unique Water Quality Problems

The City of Hutchinson, Kansas encompasses a 22-square-mile area of Reno County, approximately 45 miles northwest of Wichita. Groundwater is the exclusive source for the municipal drinking water supply for the 41,000 residents.

Contaminated Groundwater

The City seeks to remediate contaminated groundwater contained to a limited area within the southeast portion of the community and convert this water to potable use. Industrial operations have impacted the groundwater at that location with volatile organic compounds (VOCs) and chloride contamination.

A significant volume of this water has been affected by man-made and natural pollutants. If it is restored to viable standards, it could provide additional drinking water resources to meet future demands.

Projected Water Demands

		Average Daily Flow (MGD)	Peak Daily Flow (MGD)
Existing	(2000)	7.2	16.8
Projected	(2010)	8.1	19.1
Projected	(2030)	10.0	23.4

Air Stripping

A number of municipal, state and federal entities have studied Hutchinson's groundwater problems in recent years. Three groundwater extraction wells and two air stripping units were installed in the mid-1990s to remediate and contain the spread of the VOC-contaminated groundwater plumes on the southeast side of the City.

However, air stripping is ineffective at purging the high chloride levels remaining in the water. Therefore, it remains unsuitable for drinking water and is discharged into the tributary system of the Arkansas River. This practice wastes a potential resource and could cause chloride impacts downstream.

Reverse Osmosis Treatment Process

The RO process is the most appropriate treatment to restore that portion of Hutchinson's groundwater contaminated with chloride to a useful resource.

The RO process has been used for more than 20 years at desalination plants in the Middle East and along coastal areas throughout the world. Most recently, RO has gained favor for remediating contaminated groundwater in inland areas and for recycling treated wastewater.

The process yields the highest level of liquid filtration in the water treatment industry by removing contaminants at the molecular level.

The process pumps water at sufficient pressure to reverse natural osmotic flow through a multi-layer membrane with pore sizes of just 5 to 10 Angstroms. The membrane allows the water to pass but captures dissolved organics and inorganics.

Reverse Osmosis for Hutchinson

The City seeks to construct a 6.0 MGD reverse osmosis (RO) membrane filtration plant to remediate chloride contamination and further enhance the quality and quantity of the municipal supply.

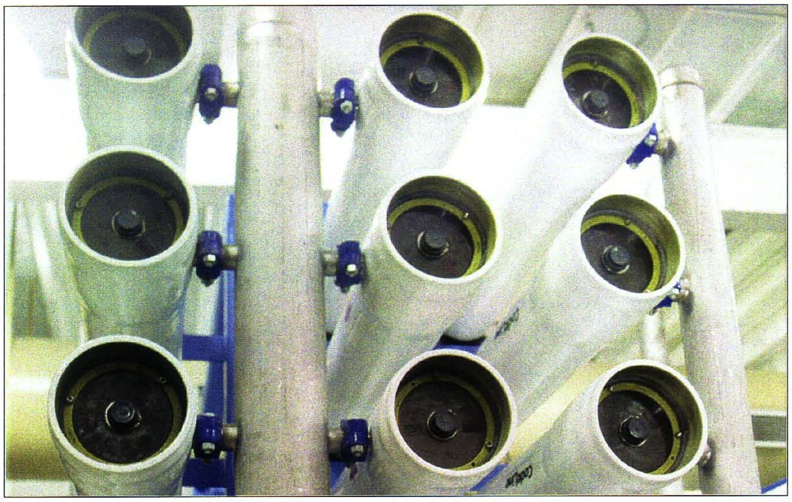
The additional water would meet a portion of the Average and Maximum Daily Demand anticipated for Year 2030. Federal funds are sought to partially underwrite the $40 million project.

The RO Blend

The higher quality RO-filtered water would be blended with the City's well water prior to entering the distribution mains.

The advanced RO treatment would resolve supply, quality, environmental and conservation issues for the City. Diluting Hutchinson's primary water source with the RO water would:

- elevate the overall quality of the water,
- enhance water supply,
- lessen potential chloride contamination of the Arkansas River, and
- gain the low-ion, high-quality water useful in recruiting industries.



RO treatment will produce water with a chloride level below the 250 ppm standard accepted for drinking water and reduce Total Hardness to a targeted 150 ppm for Year 2030 consumption.

The proposed plant would remove 98 percent of the chloride concentrations and provide VOC free water with the contamination removed and concentrated. The waste stream concentrate would be disposed via deep well injection.

The process will be designed to produce 6.0 MGD of permeate (treated water) meeting the targeted goal of 150 ppm of Total Hardness set for the 10.0 MGD Average Daily Demand in 2030.

Benefits of the Reverse Osmosis Plan

The plan would meet the water quality and demand goals for 2030 and support the ongoing remediation of contaminated groundwater by converting it to beneficial use.

In addition, at least one abandoned well could be restored to use. The recommended alternative would also impose the least capital cost and impact on the present distribution system.

The approach would also reduce stress on the Equus Beds Aquifer. The Division of Water Resources (DWR) controls those water rights within the Kansas Department of Agriculture.

Financing

The potential costs of a treatment system capable of treating both VOC and chloride contamination is cost prohibitive for the City of Hutchinson without some outside financial help.

The State of Kansas has several funds used to assist communities with funding via low cost loans, for example the State Revolving Loan Fund for water and wastewater systems. However, significant amounts of the contaminated groundwater are outside the city limits and several of the potentially responsible parties (PRP's) are also outside the city limits.

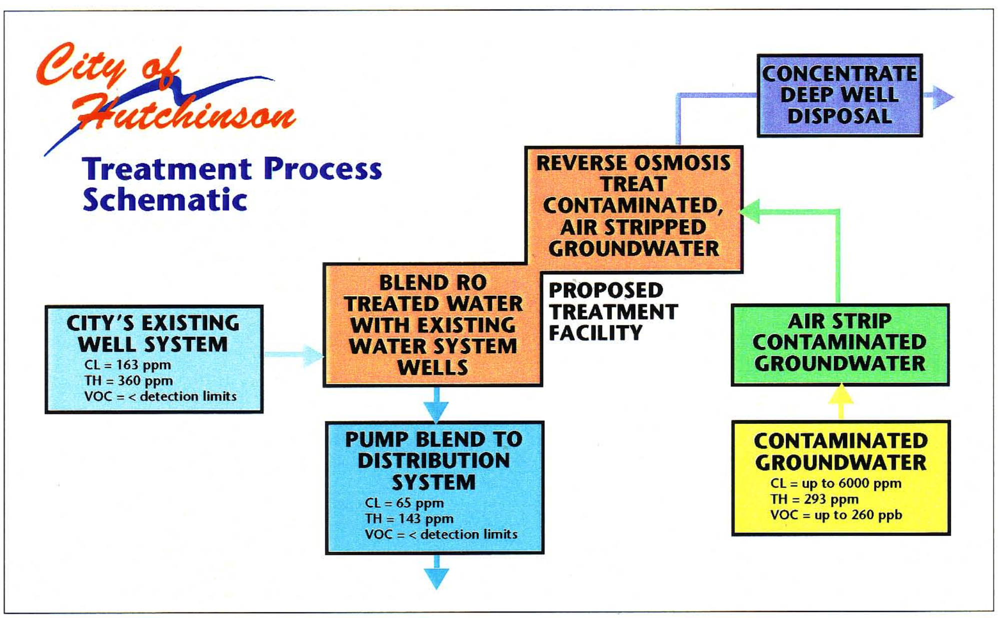
A Tax Increment financing District was created in the past to start generating funds to be an integral part of the solution. The City is currently investigating the creation of a Wholesale Water Supply District as an alternative means to help finance the undertaking and may result in a means to help in the solution.

However, the construction of the project is still almost impossible *(see the following cost estimates)* without some outside assistance and this help is currently being sought.

Cost Estimate

Cost estimates include groundwater remediation facility, RO water treatment facility and associated infrastructure.

Capital Costs $36,425,000
O & M Costs $2,220,000



SCHEDULE & ITINERARYSCHEDULE & ITINERARY

Friday June 7, 2002

7:00 am	Breakfast at Holiday Inn Express, Hutchinson
8:15 am	**Bus Leaves Microtel Inn & Suites for Site 10**
8:30 am	**SITE 10**—Salt-related Subsidence *Jim McCauley*, Kansas Geological Survey
9:00 am	Bus to Site 11
9:15 am	**SITE 11**—Kansas Underground Salt Museum *Jay Smith,* Reno County Museum
12:00 pm	Bus to Motel
12:15 pm	**Arrive Microtel Inn & Suites, Hutchinson**

Salt-related Subsidence

Salt dissolution, either natural or human-induced, is responsible for surface subsidence areas (sinkholes) in Kansas. The eastern edge of the Hutchinson Salt Member is actively being eroded, or dissolved, by contact with ground water (fig. 5-1). This area, where the salt is closest to the surface, is known as the dissolution front. Because salt is so easily dissolved in water, surface outcrops are not present in Kansas. As the salt is dissolved away, the overlying rocks and sediment settle into the void that was once occupied by the salt (fig. 5-2). Dissolution of the salt (which thickens and dips to the west) over the last several million years has caused the salt front to migrate westerly, leaving behind a broad north-south-trending depression that extends from Saline County to Sumner County. Contained within this low-lying area are numerous sinkholes and undrained depressions at the surface, and distorted bedrock and lost circulation zones (voids encountered during well drilling that drain drilling fluids from the hole) in the subsurface. This westerly migration of the salt front continues today at a rate of about 2 miles every million years, causing new sinkholes to form.

Historically, the Smoky Hill River followed this low-lying area created by the dissolution of the salt, from near Lindsborg to the Arkansas River near present-day Wichita. Then, during the Pleistocene (Ice Ages), the Kansas River system eroded to the south and captured the flow from the Smoky Hill.

Natural sinkholes, such as Lake Inman and Big Basin in McPherson County, are common in the dissolution front along the eastern edge of the Hutchinson Salt Member. Human-induced subsidence areas are rare, but when they occur, they are usually attributed to salt mining or oil and gas operations. Sinkholes that suddenly collapse are called catastrophic sinkholes. Sinkholes that have formed gradually are visible along Interstate 70 at milepost 179, west of Russell in Russell County. This subsidence is probably related to an abandoned oil well. In Reno County, gradual subsidence is occurring at the intersection of U.S. Highway 50 and Victory Road, about 6 miles east of Hutchinson, and at the Punkin Center sinkhole, 2 miles south and one-quarter mile west of the

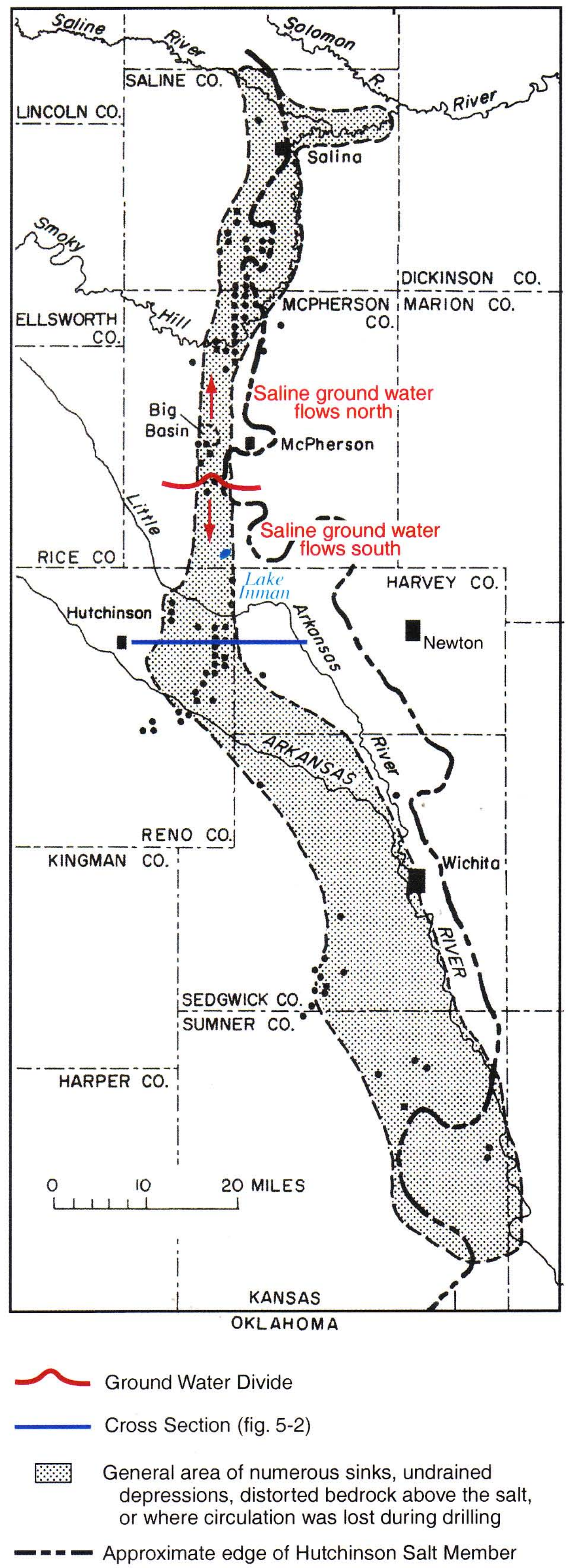


Fig. 5-1. Map showing eastern edge of the Hutchinson Salt Member (modified from Gogel, 1981).

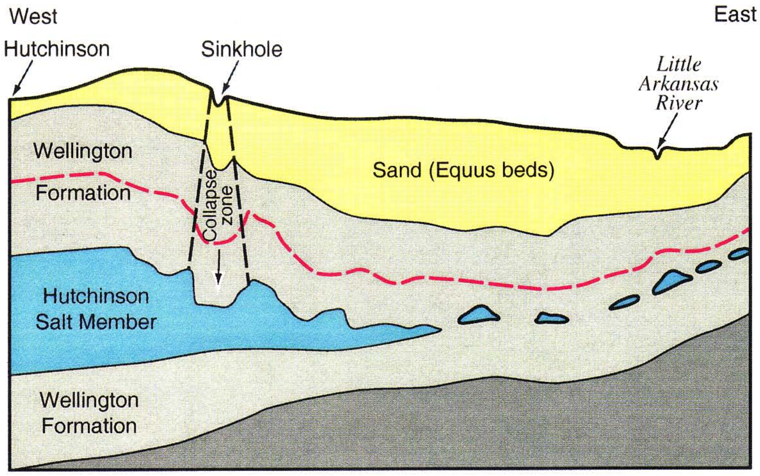


Fig. 5-2. Generalized cross section from Hutchinson to the Little Arkansas River west of Newton (in Harvey County) showing the dissolution front and related subsidence features. Red line represents deformation of beds within the shale.

U.S. Highway 50 sinkhole. Both sinkholes are probably the result of natural processes along the dissolution front.

U.S. Highway 50 Sinkhole

Monitoring of the sinkhole at the intersection of U.S. Highway 50 and Victory Road in Reno County began in 1998 after the highway sank about a foot. Since then, the highway has subsided at a rate of about 10 inches per year, or about 3.5 feet in 4 years. The symmetrical, bowl-shaped sinkhole is about 300 feet in diameter and centered about 100 feet northwest of the intersection. Water stands here most of the year.

High-resolution seismic reflection, a technique widely employed in the petroleum industry, was used to map the upper 1,000 feet of the subsurface around and below the sinkhole. Seismic reflection can provide images of the underground rocks without disturbing the ground. The technique uses a vibration, either from an explosion or a truck equipped with a special vibrating pad, that is put into the earth's surface. The vibrations move underground, bounce off the different rock layers, and travel back to the surface where they are recorded by microphone-like devices called geophones. The results, processed by computers, are images of the underground rock layers.

The seismic reflection data show voids in the 135-feet-thick Hutchinson Salt Member. The top of the salt is about 400 feet below the earth's surface. The rock layers above the salt have collapsed into these voids, forming a chimney-like feature that narrows upward from the top of the salt to surface.

The U.S. Highway 50 sinkhole is probably a reactivation of an ancient sinkhole (paleosinkhole) that formed over a million years ago. This paleosinkhole is about 1,000 feet wide and filled with sediment. Renewed salt dissolution—either from natural or human-induced sources—has probably reactivated this sinkhole, but this seismic technique cannot identify the fluid source or its pathway. However, the positions of the modern sinkhole and the paleosinkhole relative to surrounding oil and gas wells suggest the new sinkhole is probably a result of natural processes.

Surface subsidence will probably continue at a gradual rate along the northern and eastern edges of the new sinkhole at a rate of about 1 foot per year for years to come. Until the highway started to sink sometime before 1998, this paleosinkhole had been inactive for over 500,000 years. This localized, rapid (3.5 feet in 4 years) subsidence suggests that other small sinkholes could form over the next several years above the larger paleosinkhole.

Punkin Center Sinkhole

Gradual subsidence at the Punkin Center sinkhole has resulted in damage to the county road, abandonment of at least one oil well, and ponding of surface waters. Because the sinkhole is within the Burrton oil field, surface subsidence has historically been attributed to human-induced causes. Seismic reflection has been used to image the subsurface rock layers to interpret the cause of the subsidence.

The Punkin Center sinkhole covers an area of about 12 acres. Most of the sinkhole is on the north side of the county road (Stroud Road). Since the county road was built, it has sunk about 10 feet. Seismic profiles at the Punkin Center sink show that the rock units above the Hutchinson Salt Member have been deformed by dissolution of the salt and collapse of the overlying rocks. Seismic data indicates only about 130 feet of salt is present in this area (experts think the salt was originally about 275 feet thick here), and near the centers of the sinkholes, it is almost completely gone. Away from the sinkholes, the salt thickness increases abruptly.

The seismic reflection data show that dissolution of the salt in this area began millions of year ago and continues today. Sediments that are several million years old have filled paleosinkholes—evidence that subsidence started long before petroleum exploration drilling began in the late 1800's.

Although the possibility of a catastrophic subsidence event cannot be ruled out, there is no evidence that such an event is likely to occur, and future subsidence will be gradual and probably take hundreds of years to stabilize.

Saltwater Contamination

Salt has created several environmental issues in the state. Particularly along the dissolution front in central Kansas, dissolved salt sometimes winds up in rivers, streams, marshes, and lakes. For example, salt in the bedrock beneath Saline and McPherson counties has been dissolved away and the brine has moved north and east into the aquifer adjacent to the Smoky Hill River (see fig. 5-1). That has increased salinity levels in the Smoky Hill. In Reno and Rice counties, saltwater produced during the early days of salt-solution mining has led to localized problems of increased salinity levels in the Arkansas River. Salinity levels in other streams and marshes in Kansas are sometimes elevated, but that salinity is the result of natural saline contamination from salty aquifers and not from the Hutchinson Salt Member.

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Kansas Underground Salt Museum

Hutchinson will be the only city in the nation with a museum 650 feet below the ground when the Kansas Underground Salt Museum opens in September of 2004. The museum will explore the story of salt in a subterranean environment and will offer exhibits on the history of salt mining, how salt is mined and produced, the use of salt, the geology of salt, and the use of the salt mine for secure storage of documents and original television and big screen film. A special exhibits gallery will accommodate temporary exhibits. The museum will also be equipped with classrooms and a conference center.

The Kansas Underground Salt Museum will encompass more than 100,000 square feet of space below ground. A 12,000-square-foot Visitor's Center, located above ground, will provide orientation and training for the subterranean experience (fig. 5-3). Guides will be on hand to assist guests through the facility. Because Hutchinson has been the home of the salt industry for more than 110 years, individuals formerly employed in the business will serve as volunteers and docents to help provide high-quality educational experiences. Many miners and salt-plant workers have already participated in a videotaped oral history program. Their stories will be used in the underground exhibits to put a human face on the story of salt.

In 1998, the Reno County Museum set into motion the idea of creating a major attraction about the salt industry. With the advice of community and industry leaders, museum staff made an intense study of the feasibility of creating an underground museum. Museum representatives worked with officials from Underground Vaults & Storage (UVS) and the Hutchinson Salt Company. UVS, which is also located in the salt mine, is a secure warehousing facility for business records and classic Hollywood films (the mine is climatically ideal for long-term storage of film and other documents). The Hutchinson Salt Company owns the mine and leases space to UVS. UVS, in turn, subleases space to the Museum. The Hutchinson Salt Company is donating the land on which the above-ground Visitor's Center will stand. UVS and the museum are sharing the expense of digging a new mineshaft and installing the elevator, as well as building the above-ground

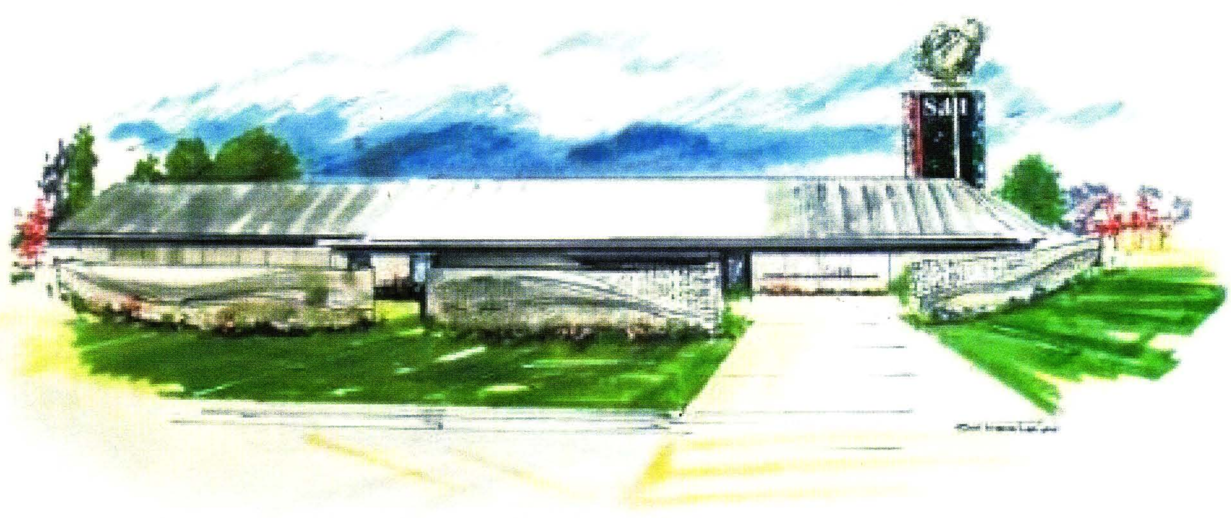

Fig. 5-3. Conceptual drawing of the Visitor's Center at the Kansas Underground Salt Museum.

facility and parking lot. UVS and the museum will share the use of the new mineshaft after it is constructed. The group created a cooperative plan for an integrated, environmentally sensitive system of fences and walls to prevent museum visitors from entering the UVS storage facility or any area where mining is being conducted.

The projected cost of the Kansas Underground Salt Museum is $7.8 million. This money will be used to finance a new mineshaft and passenger elevator, the above-ground Visitor's Center, exhibits, administrative offices and equipment, a capital-improvement fund, and a 300-car parking lot. The museum will be a self-supporting institution through admission fees, gift shop revenues, grants, memberships, meeting room space rental, and admission fees generated from special touring exhibitions. Admission fees are projected to range from $5 to $12 per person. The museum has a contract with ESA Design Concepts, of Abilene, Kansas, to design the underground museum and above-ground orientation center. The salt museum will create about 50 jobs and have a $7 to 12 million impact on the economy.

Source

Reno County Museum, Kansas Underground Salt Museum—The Case for Support (internal document).

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Kansas Geological Survey
Public Information Circular 21
May 2002

The Hutchinson Salt Member covers about 37,000 square miles in the subsurface of central and south-central Kansas

Salt in Kansas

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Introduction

Salt is an abundant and valuable natural resource in Kansas. In addition to salt's well-known uses (such as table salt or road de-icing material), large caverns dissolved out of salt beds also are used to store natural gas, natural gas liquids (such as propane and butane), and other petroleum products.

Halite (fig. 1) is the mineral name for salt. The chemical composition of halite is NaCl, or sodium chloride, which is the same as common table salt. Salt is a general term for naturally occurring sodium chloride. Rock salt is the term used for natural salt deposits composed of halite and other impurities, mainly thin beds of shale.

In Kansas, salt is mined from the Hutchinson Salt Member of the Wellington Formation (fig. 2), deposited during the Permian Period, about 275 million years ago. The Hutchinson Salt Member covers about 37,000 square miles in the subsurface of central and south-central Kansas (fig. 3), reaching a maximum thickness of more than 500 feet under Clark, Comanche, and Barber counties. About 80 percent of the rock in the Hutchinson Salt Member is salt (much of the rest is shale)—more salt and fewer impurities than most salt beds.

Thick salt layers also occur in western and southwestern Kansas in the Ninnescah Shale, Blaine Formation, and the Flower-pot Shale. These salt beds, which have never been mined, are much deeper below the surface than the eastern edge of the Hutchinson Salt Member, where mining occurs.

This circular provides a brief history of salt production in Kansas, explains the geology of the salt deposits, describes how salt is mined, and discusses environmental issues associated with salt deposits and salt mining in Kansas.

History

Before Kansas was settled by Europeans, salt marshes and salt springs were used by wildlife, Native Americans, and early travelers. Wild animals of the plains—especially bison, deer, antelope, and elk—obtained salt from places known as licks. Salt licks, or salt flats, are areas where saline ground water reaches the surface and then evaporates during dry times, leaving salt on top of the ground. Native Americans, explorers and hunters, and early ranchers obtained salt by evaporating water col-


Photo: John Charlton

Figure 1—*The mineral halite.*

It takes about 80 feet of sea water to produce a foot of salt, so it must have taken thousands of years to accumulate the thick salt deposits of central Kansas

lected from salt springs. Early hunters visited the salt marshes to jerk buffalo meat. They would either evaporate brine or dip the meat in pools of strong brine and then dry it in the sunshine or by a fire.

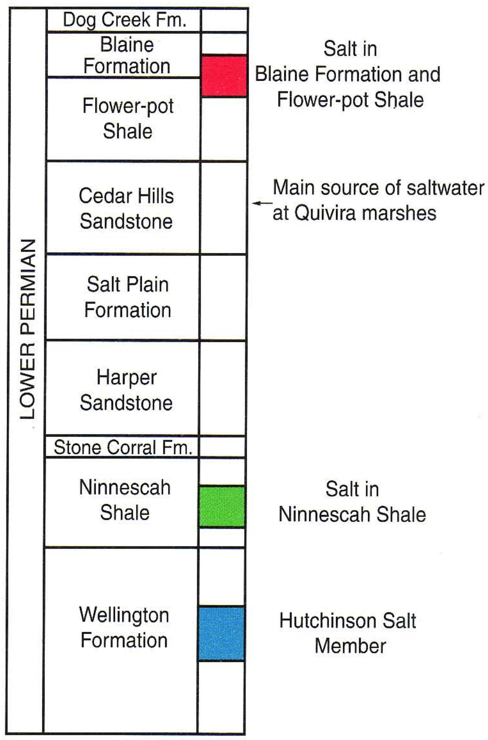

Figure 2—*Sequence of rocks associated with salt deposits in Kansas.*

Salt was commercially manufactured in Kansas as early as 1863 at the Osawatomie Salt Works in Miami County in eastern Kansas. Brine, produced from five wells that tapped a saline aquifer, was evaporated in 17 kettles (each holding 30 gallons) set in a single furnace; the salt sold locally for $1.40 per bushel (a bushel of salt weighs 56 pounds). About the same time, salt was produced in Republic County at the Tuthill marsh by scraping the salt scale from the marsh, dissolving it in water, and then siphoning off the clear brine. The brine was then evaporated to recover the salt. Salt was sold in nearby Seapo, and hauled to Manhattan, where it sold for as much as ten cents per pound. Other early salt plants were established at Solomon in Dickinson County in 1867.

Rock salt was discovered in central Kansas in 1887 by speculation companies organized to drill for coal, gas, oil, or any valuable minerals they might encounter. Although the main objectives were not found in commercial quantities, drillers repeatedly encountered beds of salt several hundred feet thick occurring at shallow depths (500 to 1,000 feet). Rock salt was first mined in Hutchinson in 1888, using solution mining (a mining method that pumps water down wells to dissolve the salt), when two wells and a salt factory were put into operation. By 1891, underground mines (using a mining method similar to underground coal mining) produced salt at Lyons, Kingman, and Kanopolis. Underground mining began at Hutchinson in 1923 when the Carey Salt Mine was officially dedicated.

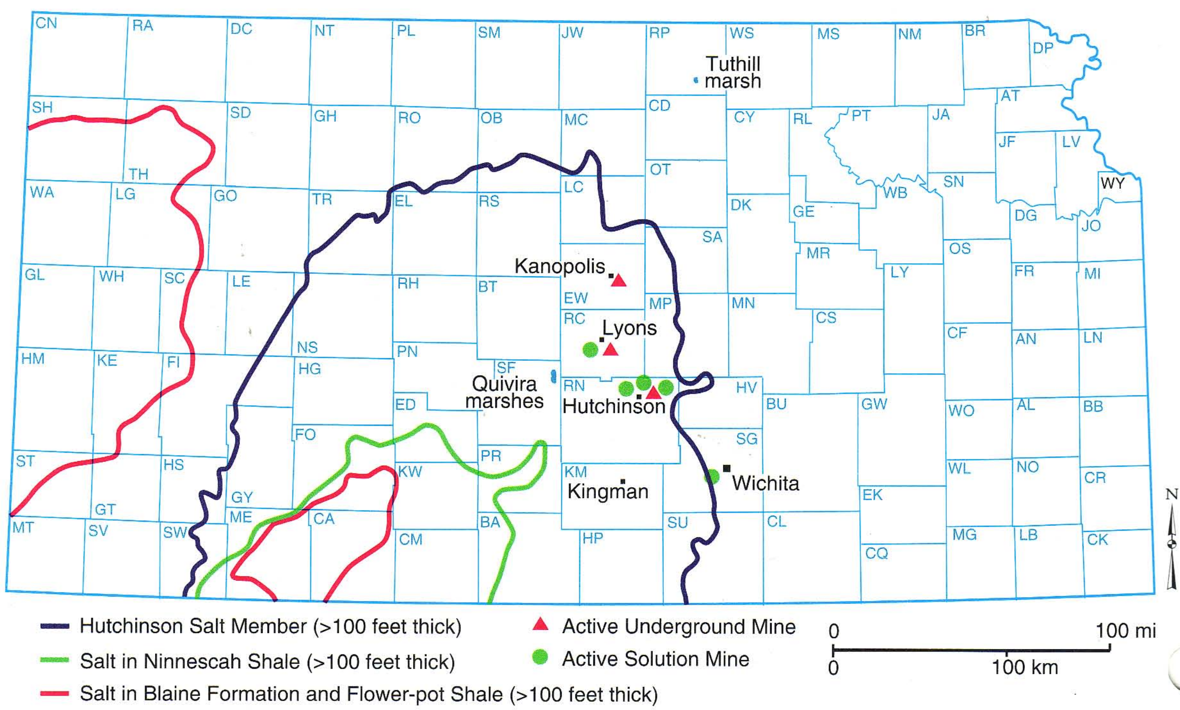

Figure 3—*Approximate limits of major salt deposits in Kansas (modified from Bayne, 1972) and location of active salt mining.*

Geology

Salt is called an evaporite mineral because it is formed by the evaporation of water. Gypsum and anhydrite are also evaporites. Sea water contains salt in solution. When sea water evaporates, salt is deposited on the ocean floor. During most of the Permian Period, shallow seas covered what is now Kansas. Sea level fluctuated—sometimes the land was exposed and a terrestrial environment existed; at other times, mudstones (shale) and limestones were deposited in a normal marine setting.

When the Hutchinson Salt Member formed, however, the climate was hot and dry, and the sea was restricted to central Kansas—probably an isolated arm of the main ocean to the south, or cut off entirely, like the Great Salt Lake in Utah today. The rate of evaporation exceeded the inflow of water, and as evaporation continued and the salt content of the water increased, thick layers of salt built up on the sea bottom. It takes about 80 feet of sea water to produce a foot of salt, so it must have taken thousands of years to accumulate the thick salt deposits of central Kansas. Over time, the salt layer was covered by younger rocks.

The eastern edge of the Hutchinson Salt Member is actively being eroded, or dissolved, by contact with ground water (fig. 4). This area, where the salt is closest to the surface, is known as the dissolution front. Because salt is so easily dissolved in water, outcrops at the surface are not present in Kansas.

Salt also has other unusual characteristics. It is plastic—that is, it will flow and move very slowly, over long periods of time, when it is under pressure, as it is underground. This plasticity allows salt to slowly heal or cover up small fractures or openings in the salt beds.

Salt Production

Salt is mined in Kansas using two methods: underground mining and solution mining. Underground mines in Kansas (fig. 5) range in depth from 600 to 1,000 feet. They use the room-and-pillar method of mining, which begins with a shaft sunk through the overlying rock to the salt deposit. The salt is removed in a checkerboard pattern, in which large square caverns alternate with square pillars of salt that serve as support for the rock above. Approximately 75 percent of the salt is mined, while 25 percent is left for pillars. Blasting breaks the salt into manageable pieces, which are conveyed to crushers and removed to the surface through the shaft with large buckets. Because of the impurities (mostly shale and anhydrite), rock salt is used mostly as road salt for melting ice. Active underground salt mines are found in Lyons, Kanopolis, and Hutchinson.

Early mining of the deep salt beds in central Kansas was done by solution mining, and this process continues today. Solution mining uses water to dissolve the salt. Freshwater forced down a cased well dissolves the salt and produces an artificial brine, which is then pumped to the surface and evaporated to recover the salt. As long as freshwater is added and saturated brine removed, the cavern continues to enlarge. The shape of the cavern is controlled by directing the water. A sonar tool is used to measure the shape and size of the cavern.

Evaporation plants produce a variety of salts for which purity is essential, such as table salt, food processing salt, salt for animal feeds, and water softening salt. Brine is evaporated in a series of large vessels called vacuum pans. The result is a high-purity product consisting of over 99.8% sodium chloride.

In 2000, Kansas ranked fifth in the U.S. in salt production, producing 2,944,000 tons valued at $111 million. Roughly 13 trillion tons of salt reserves, about 1,100 cubic miles, underlie Kansas. This is enough to form a salt cube more than 10 miles long on each edge.

Underground space created by salt mining is also valuable. In the Hutchinson mine, space is leased for high-security record storage. The constant temperature and humidity make an ideal environment to archive fragile items such as classic movies, paintings, furs, and collections. In the 1960's, the Atomic Energy Commission studied a salt mine in Lyons for the potential storage of high-level radioactive waste, an idea that was eventually abandoned. Today, an underground mine in Hutchinson is being developed into a salt museum.

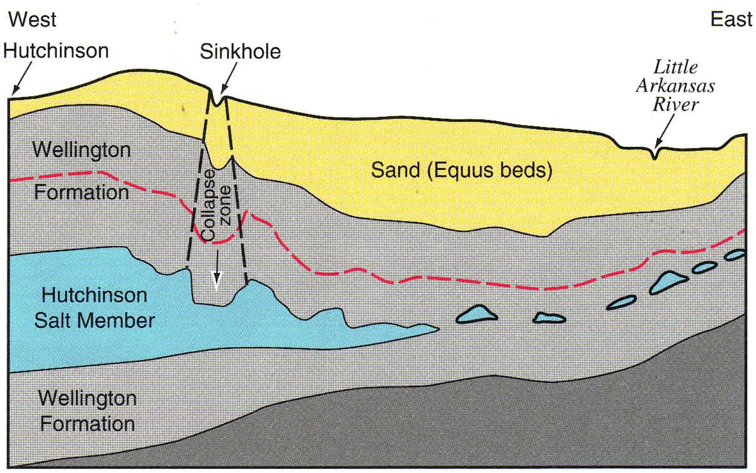

Figure 4—*Generalized cross section from Hutchinson to the Little Arkansas River west of Newton (in Harvey County) showing dissolution of the Hutchinson Salt Member and related subsidence features. Red line represents deformation of beds within the shale.*

Underground Storage

Caverns in the salt beds of Kansas are also used for storing natural gas, natural gas liquids, and other hydrocarbons. Some caverns that are now used for hydrocarbon storage were originally created during salt mining; others were created by solution specifically for the storage of hydrocarbons. Salt caverns are used for storage because salt is highly impermeable, and salt beds in Kansas are thick and fairly predictable. In addition, large quantities of gas can be introduced into, and taken out of, salt caverns relatively quickly. Energy companies use salt caverns to store natural gas during times of low demand, then quickly move it out of caverns in the winter, during times of peak demand. Natural gas is also stored in depleted oil and natural gas fields in Kansas and other parts of the country, but moving gas into and out of these depleted fields takes much longer. A typical storage cavern in Kansas salt holds about 100,000 barrels, or 4.2 million gallons, of hydrocarbons, usually under pressure.

Because Kansas is in the central part of the U.S. and relatively close to major natural gas fields, a number of pipelines run through the state. These pipelines take advantage of hydrocarbon storage facilities in the salt in central Kansas. Hydrocarbons are stored in salt caverns in at least five other states in the U.S., but Kansas has more storage caverns in salt than any other state. Storage facilities were originally developed in Kansas in the early 1950's. Today hydrocarbons are stored at sites in Rice, Reno, McPherson, and Ellsworth counties. In January 2001, a rupture in a pipe in a natural-gas storage facility in Reno County was hypothesized to be the source of gas that led to a series of explosions and geysers in the city of Hutchinson. Gas may have moved from the facility, under the city, then to the surface through long-forgotten salt-solution wells. The Kansas Geological Survey worked with the city, the local utility, and the Kansas Department of Health and Environment to try to understand the movement of the gas and to locate abandoned solution wells.

Kansas has more storage caverns in salt than any other state

Other Salt-related Issues

In addition to being a resource, salt has created several environmental problems in the state. Particularly along the dissolution front in central Kansas, dissolved salt sometimes winds up in rivers, streams, marshes, and lakes. For example, salt in the bedrock beneath Saline and McPherson counties has been naturally dissolved and the brine has moved north and east into the aquifer adjacent to the Smoky Hill River, thus increasing salinity levels in the Smoky Hill. In Reno and Rice counties, saltwater produced during the early days of salt-solution mining has led to localized problems of increased salinity in the ground water. Salinity levels in other streams and marshes in Kansas are sometimes elevated, but that salinity is the result of natural saline contamination from salty aquifers and not from the salt mining near Hutchinson (see Why are the Quivira Marshes Salty?). Saltwater from dissolution of the Hutchinson Salt Member also discharges to overlying alluvial aquifers and into streams and the Arkansas River to the south in Sumner County.

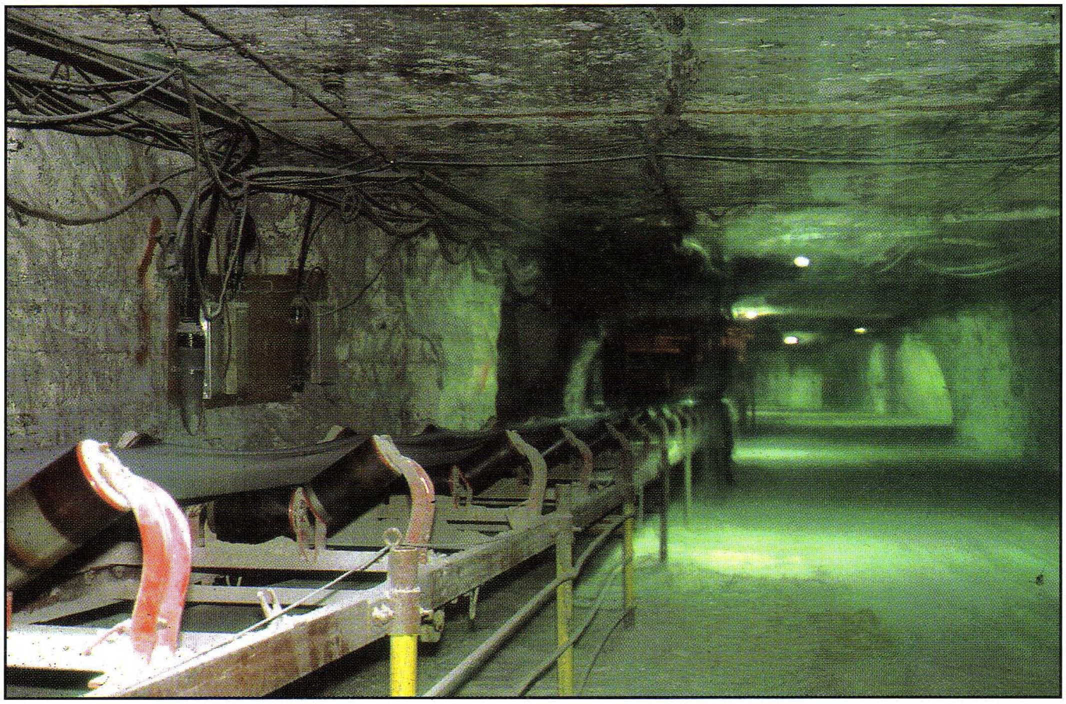

Photo: Rex C. Buchanan

Figure 5—*Underground salt mine at Hutchinson. Salt is mined in a room-and-pillar fashion, and moved along a conveyor belt and eventually to the surface.*

Salt dissolution, either natural or human-induced, is also responsible for surface subsidence areas (sinkholes) in Kansas (fig. 6). Salt layers in the subsurface are dissolved by water, creating underground void spaces. When the ceiling above those voids can no longer support the weight above, the rock layers collapse, causing subsidence at the surface. Natural sinkholes, such as Lake Inman in McPherson County, are common on the dissolution front along the eastern edge of the Hutchinson Salt Member. Human-induced subsidence areas are rare, but when they occur, they are usually attributed to salt mining or oil and gas operations. Sinkholes that suddenly collapse are called catastrophic sinkholes. Sinkholes that have formed gradually are visible along Interstate 70 at milepost 179, west of Russell in Russell County. This subsidence is probably related to an abandoned oil well. In Reno County, gradual subsidence is occurring at the intersection of U.S. Highway 50 and Victory Road, about 6 miles east of Hutchinson; it is probably the result of natural subsidence along the dissolution front.


Photo: John Charlton

Figure 6—*Aerial photo of sinkhole in Ellsworth County.*

The mission of the Kansas Geological Survey, operated by the University of Kansas in connection with its research and service program, is to conduct geological studies and research and to collect, correlate, preserve, and disseminate information leading to a better understanding of the geology of Kansas, with special emphasis on natural resources of economic value, water quality and quantity, and geologic hazards.

The Geology Extension program furthers the mission of the KGS by developing materials, projects, and services that communicate information about the geology of Kansas, the state's earth resources, and the products of the Kansas Geological Survey to the people of the state.

Public Information Circular 21
May 2002

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Printed on recycled paper with soy ink by The University of Kansas Printing Services

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Why are the Quivira Marshes Salty?

Salty surface waters and salt flats at Big and Little Salt marshes at Quivira National Wildlife Refuge in Stafford County are caused by natural saltwater in the underlying bedrock. The Quivira marshes and the surrounding area are a common discharge center (an area where ground water moves upwards toward the surface), where freshwater and saltwater aquifers converge. The surface is capped by a veneer of wind-blown dune sand.

Water is a universal solvent, dissolving and chemically reacting with the rock formations it encounters. The longer water remains in the aquifer and the greater the distance it travels, the more mineralized it becomes (if soluble minerals, such as halite, are present). Salinity at Quivira is not related to the Hutchinson Salt Member (which underlies this area); instead, salinity here is related to the Cedar Hills Sandstone, and sandstone layers in the Salt Plain Formation (see fig. 2), which lie above the Hutchinson salt. These rocks contain salt minerals—halite (or common table salt) and anhydrite (a mineral similar to gypsum). The Cedar Hills Sandstone aquifer is recharged in southwest Kansas. Regional ground-water flow carries this water, which becomes increasingly saline, in an easterly direction until it discharges near the surface into the overlying freshwater aquifer west of the Quivira marshes. A north-south-trending ridge of Permian bedrock below the marshes restricts the easterly movement of ground water toward the Arkansas River and forces saltwater to discharge into the low-lying streams and marshes.

Salt concentrations are further increased at the surface by evaporation. The average salinity of Little Salt Marsh is approximately 2,500 parts per million (ppm) chloride, whereas that of Big Salt Marsh ranges from 5,000 to 10,000 ppm (sea water averages 19,000 ppm chloride, and drinking water about 250 ppm).

The Quivira marshes are characterized by poor drainage, springs and seeps with high salt concentrations, and salt-tolerant vegetation. Evaporation of shallow lakes concentrates salts on the bare ground, creating the white salt flats characteristic of the salt marsh.

Photo: Robert Sawin

Salt flats at Big Salt Marsh, Quivira National Wildlife Refuge.