Approved: 2-27-98
Date

MINUTES OF THE HOUSE COMMITTEE ON ENVIRONMENT.

The meeting was called to order by Vice-Chairperson Joann Freeborn at 3:30 p.m. on February 2, 1998 in Room 526-S of the Capitol.

All members were present except: Rep. Steve Lloyd - excused

Committee staff present: Raney Gilliland, Legislative Research Department
Hank Avila, Legislative Research Department
Mary Torrence, Revisor of Statutes
Mary Ann Graham, Committee Secretary

Conferees appearing before the committee: Walt Aucott, KS District Chief, US Geological Survey, Water Resources Division, 4821 Quail Crest Place, Lawrence, KS 66049

Nathan Myers, Ground Water Specialist, US Geological Survey, Water Resources Division, 4821 Quail Crest Place, Lawrence, KS 66049

Others attending: See attached list

Chairperson Joann Freeborn called the meeting to order at 3:30 p.m. She announced that Raney Gilliland, Legislative Research Department, has researched some answers to questions that were asked by committee members at the committee meeting on January 26, 1998. Those documents were distributed to committee members. (See attachment 1) She reviewed the weeks agenda, a reminder of room change for Tuesday, February 3, to 313-S, **HCR 5030** will be worked and a presentation by Chester Bourff, Illinois Department of Agriculture. On Wednesday, February 4, **HB 2419** will be worked and a hearing on **HB 2732**. Dr. James Zahn, Iowa State University, will be coming on February 9. She then opened the floor for bill requests.

Rep. Dan Johnson requested a bill to change the distribution of non-resident deer permits. Motion seconded by Rep. Dennis McKinney. Motion carried.

Rep. Douglas Johnston requested a bill for a three year moratorium on Confined Animal Feeding Operations permits for over 500 animal units. Motion seconded by Rep. Laura McClure. Motion carried.

Rep. Douglas Johnston requested a bill for a limit KDHE can require for permits under 500 animal units to $25; change 500 units to 999 to $50; 1000 to 4999, $200; 5000 to 9999, $400; over 10,000, $800. Motion seconded by Rep. Marti Crow. Motion carried.

Rep. Laura McClure requested a bill to set up corridors in Kansas rivers for dredging and canoeing. Motion seconded by Rep. Douglas Johnston. Motion carried.

Rep. Vaughn Flora requested a bill for anyone disabled, regardless of age, to obtain free fishing licenses. Motion seconded by Rep. Richard Alldritt. Motion carried.

Rep. Joann Freeborn requested a bill for placing a fee on transportation of high level radio-active waste, $1000 per truck load and $2000 per rail car load. Motion seconded by Rep. Marti Crow. Motion carried.

The Chairperson opened public hearing on **HCR 5030**.

HCR 5030: **A concurrent resolution requiring the Attorney General to bring suit against the State of Nebraska to enforce the provisions of the Republican River Compact.**

No one came forward to testify. The hearing on **HCR 5030** was closed.

Chairperson Freeborn welcomed Walt Aucott, KS District Chief, Department of the Interior, US Geological Survey, to the committee.

Rep. Laura McClure commented that she had seen a visual demonstration, in Lawrence by the US Geological Survey, showing the connection between the river, ground water, and surface water. She also welcomed Mr. Aucott and Mr. Myers to the committee.

Mr. Aucott gave the committee background information on the US Geological Survey, they provide citizens of the United States with impartial information they need to effectively utilize their natural resources and to protect the health, safety and well being of the people. He had graphs and briefed the committee on the effects of the Three Mile Creek Stream Stage on Ground Water Flow, Fort Riley, Ks. Mr Aucott introduced Nathan Myers, ground water specialist, US Geological Survey. Mr. Myers had a model showing pumping wells, a river and an unlined lagoon. He inserted different color dyes into each and demonstrated the flow and interconnection between them. Although this was a small model the concept would be the same in real world situations if no clay liners were used. Questions by the committee followed. Mr. Aucott and Mr. Myers presented several documents of information. (See attachment 2)

The Chairperson thanked the guests for their presentation.

The meeting adjourned at 4:10 p.m.

The next meeting is scheduled for February 3, 1998.

HOUSE ENVIRONMENT COMMITTEE COMMITTEE
GUEST LIST

DATE: 2-2-98

NAME	REPRESENTING
R. E. Pelton	KRWAD #1
E.R. "Woody" Moses	KAPA
Mary Jane Stattelman	KDA
Earl D. Lewis	KDA
Amy Huffenberger	KDA
Marios Sophocleous	KGS
Nathan Myers	USGS
WALT AUCOTT	USGS
LarrieAnn Brown	KS Govt Consult
Charles Benjamin	KNRC/KS Sierra Club
Tom Perkins	
Erik Sartorius	Pete McGill + Assoc.
Mike Beam	Ks LVSTK ASSN.

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February 2, 1998

To: House Environment Committee

From: Raney Gilliland, Principal Analyst

Re: Requests for Information from Members of the House Environment Committee at the Meeting on January 26,1998

1. Information concerning certain lagoons with permits which dispose of the liquid waste strictly through evaporation. Attached is information regarding permits issued by Kansas Department of Health and Environment (KDHE) which are totally evaporative.

2. Information regarding the Respiratory Impact Study cited by Mr. Volland. A copy of the report is attached.

3. Information regarding the suggested changes by Spectrum Technologists (Mr. Craig Volland) to the draft regulations of the KDHE. Mr. Volland indicates that his testimony contained the comments which he had regarding the draft regulations of KDHE with respect to confined feeding operations. A copy of his testimony is attached.

4. Permit requirements for the spreading of animal waste. Agency officials indicate that there are no specific requirements to have any sort of permit in order to spread effluent. Current guidelines make some suggestions for the disposal of effluent. The draft guidelines would require that there be a waste utilization plan (these guidelines would be adopted by reference in the draft regulations).

5. Monitoring well requirements in any current guidelines for animal waste lagoons. Agency officials indicate that under current agency regulations or guidelines regarding livestock permits, there are no monitoring requirements or authorities. The draft regulations would be specific that the agency could require the installation of monitoring wells. (See the draft regulation 28-18-12.) Also, agency personnel indicate that in the other regulations with respect to water pollution that permittees may be required to install monitoring equipment or methods and that this requirement could be extended to permittees with confined animal feeding facilities. (See the attached permanent regulation K.A.R. 28-16-63.)

6. Monitoring or testing of any lagoons which have been closed and are no longer in use. There are no current requirements for the monitoring or testing of any lagoons which have been closed. The agency draft regulations contain a specific regulation on closure. However, nothing in the regulation specifically requires the continual monitoring of the closed facility.

7. Test results from Bac-Terra from Iowa State when those results become available. This information is not available.

RG/MKL

#22844.01(2/2/98{12:16PM})

House Environment
2-2-98
Attachment 1

Evaporative System for Feedlot Runoff Containment/Disposal

The system must meet the following requirements:

1. Have adequate total storage volume to contain twice the design storm runoff plus the normal annual runoff (or wastewater loading whichever approp.) from the controlled drainage area.

2. Have evaporative surface area adequate to evaporate the design storm quantity plus normal annual runoff (or wastewater loading) within one year, assuming no seepage.

3. Be sealed to achieve a seepage rate no greater than 1/8 inch per day.

Approximate Design Equations

$$V_{req} = A_c\,(2\,S + R)$$

Where:

V_{req} = required storage volume
A_c = controlled drainage area
S = design storm amount (inches)
R = normal annual runoff (inches)

$$A_{req} = A_c\,\frac{(R + S)}{E_n}$$

$$A_{req}/A_c = \frac{(R + S)}{E_n}$$

Where:

A_{req} = required pond surface area at half-full volume
E_n = net annual evaporation = annual precipitation - annual evaporation

$$V_{req} \approx A_{req} \bullet D \approx A_c\,(2\,S + R)$$

$$D \approx E_n \bullet \frac{(R + 2\,S)}{(R + S)}$$

D = usable depth

For a wastewater lagoon (rather than runoff pond), the normal annual wastewater loading replaces the normal annual runoff in the computations.

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$$D \approx E_n \cdot \frac{(R + 2\,S)}{(R + S)}$$

D = usable depth

For a wastewater lagoon (rather than runoff pond), the normal annual wastewater loading replaces the normal annual runoff in the computations.

DATA GROUP: DISPLAY REC NO: ____ Q-QUIT: __

DATA GROUPS

1 - PERMITTED FEEDLOTS   3 - PLAN/COMPLIANCE

2 - PUBLIC NOTICE/BILLING

REC. NO.	PERMIT NUMBER	FEEDLOT NAME	CN. TY.	DATE EXPIRE	TYPE	EVAPORATIVE Design (Y/N) or Both
001	A-CIST-S002	SEABOARD (#8) (WALKER)	ST	20010506	S	Y
002	N-CISW-6977	SEABOARD (AMIGO SITE)	SW		S	Unpermitted New Syst.
003	A-CIMT-S005	SEABOARD (FARM #9)	MT	20021130	S	Y.
004	A-CIST-H002	SEABOARD - FARM (#10)	ST	20000627	H	N
005	N-CISW-6972	SEABOARD FARMS	SW		H	Unpermitted New Syst.
006	A-CISV-S001	SEABOARD FARMS (#114)	SV	20001008	S	N
007	A-CIMT-S002	SEABOARD FARMS (#2)	MT	20000627	S	Y
008	A-CISV-H003	SEABOARD FARMS (#221, 223, 225)	SV	20010906	H	Y
009	A-CIMT-H001	SEABOARD FARMS (#3, 4, 5, 6, 7)	MT	20000511	H	N
010	A-CIMT-H004	SEABOARD FARMS (FARMS 227 & 228)	MT	20001203	H	N
011	A-CISV-H006	SEABOARD FARMS (HOLCOMB NO.-258)	SV	20010616	H	B.
012	A-CIMT-S004	SEABOARD FARMS (106)	MT	20010128	S	N
013	A-CISV-H001	SEABOARD FARMS (12,13,14,15,16)	SV	20010125	H	N +

A = agriculture
N = new
CI = River basin
ST = Cty.
S = state <1000 animal units
H = federal >1000 animal units
B = Both

DATA GROUP: DISPLAY REC NO: ____ Q-QUIT: __

D A T A   G R O U P S

1 - PERMITTED FEEDLOTS

2 - PUBLIC NOTICE/BILLING

3 - PLAN/COMPLIANCE

REC. NO.	PERMIT NUMBER	FEEDLOT NAME	CN. TY.	DATE EXPIRE	TYPE	EVAPORATIVE Design (Y/N) or Both
014	N-CISV-5399	SEABOARD FARMS (258)	SV		5	Unpermitted Site
015	A-CIST-H001	SEABOARD FARMS - FARM #1 & 200	ST	20000302	H	N
016	N-CISV-5546	SEABOARD FARMS - HOFFMAN	SV		H	Unpermitted Site
017	N-CISV-5547	SEABOARD FARMS - KRAMER	SV		5	"
018	A-CISV-H004	SEABOARD FARMS - SPIKES	SV		H	Not issued
019	A-CIMT-H003	SEABOARD FARMS #202/203/205/207	MT	20001106	H	N
020	A-CIMT-H005	SEABOARD FARMS INC-CALVIN & IVAN	MT	20020604	H	N
021	A-CIMT-S003	SEABOARD FARMS 101,102,103, 104	MT	20010128	S	N
022	A-CIGT-S004	SEABOARD FARMS 109-112, 115	GT	20000621	S	N
023	A-CIMT-T001	SEABOARD FARMS, FARM 0	MT	20010527	T	N Truck Wash facility
024	N-CISW-6973	SEABOARD FARMS, INC.	SW		H	Unpermitted Site
025	N-CIMT-7011	SEABOARD FARMS, INC.	MT		H	"
026	N-CISW-6955	SEABOARD FARMS, INC.	SW		H	" +

DATA GROUP: DISPLAY REC NO: ____ Q-QUIT: __

D A T A G R O U P S

1 - PERMITTED FEEDLOTS

2 - PUBLIC NOTICE/BILLING

3 - PLAN/COMPLIANCE

REC. NO.	PERMIT NUMBER	FEEDLOT NAME	CN. TY.	DATE EXPIRE	TYPE	Evaporative Design (Y/N)
027	A-CIST-S001	SEABOARD FARMS, INC. (#108)	ST	20001008	S	N
028	A-CIGT-S005	SEABOARD FARMS, INC. (#113)	GT	20001008	S	N
029	A-CIST-H003	SEABOARD FARMS, INC. (#238)	ST	20030104	H	N
030	A-CIST-H004	SEABOARD FARMS, INC. (#239)	ST	20030104	H	N
031	A-CISV-H005	SEABOARD FARMS, INC. (259)	SV	20010616	H	Y
032	A-SOSD-B005	SEALOCK DAIRY	SD	20000116	B	
033	A-SOSD-B004	SEALOCK FARM	SD	20020121	B	
034	A-ARSG-C002	SEDGWICK COUNTY FEEDYARDS	SG	19850210	C	
035	A-UASC-BA10	SEE CATTLE CO	SC		B	
036	A-UASC-S006	SEE'S PORK SHOP	SC	19900207	S	
037	N-WACL-6276	SEELIGER FARMS, INC.	CL		B	
038	A-UAPN-B005	SEIBERT, GARY	PN		B	
039	A-ARSG-M022	SEIDL DAIRY	SG	20001027	M	+

A Control Study of the Physical and Mental Health of Residents Living Near a Large-scale Swine Operation

K. Thu, K. Donham, R. Ziegenhorn, S. Reynolds, P. S. Thorne, P. Subramanian, P. Whitten, J. Stookesberry

Abstract

This article presents the results of a study assessing the physical and mental health of residents living in the vicinity of a large-scale swine confinement operation. Physical and mental health data were collected via personal interviews from a sample (n = 18) of all neighbors living within a two-mile radius of a 4,000-sow swine production facility. Results were compared to similar data collected from a random sample of demographically comparable rural residents (n = 18) living near minimal livestock production. Results indicate that neighbors of the large-scale swine operation reported experiencing significantly higher rates of four clusters of symptoms known to represent toxic or inflammatory effects on the respiratory tract. These clusters of symptoms have been well-documented among swine confinement workers. There was no evidence to suggest that neighbors of the large-scale swine operation suffered higher rates of psychological health problems manifested as anxiety or depression. A larger population-based study is needed to test the hypothesis that neighbors of large-scale swine operations experience elevated rates of physical health symptoms comparable to interior confinement workers.

Keywords. Large-scale swine operation, Environment, Neighbor health.

The movement from pasture-based or partially enclosed to totally enclosed swine production first occurred in the United States in the early 1970s. This transformation was patterned in part after changes in the poultry industry in the 1960s (Donham et al., 1977). The last decade has witnessed a dramatic proliferation of large-scale swine confinement operations throughout the United States. Large-scale facilities often have over a thousand sows with multi-acre manure lagoons located at a single site. While there is no single quantitative definition of "large-scale" swine production, it can be characterized by several features: (1) separation of ownership, management, and labor; (2) nonlocal capital; (3) owners, management, and labor do not all live on, or in many cases, in the vicinity of the operation; (4) a nonfamily corporate or company organizational structure; and (5) family labor plays a limited role if any in the operation.

This work was supported in part by a grant from the Center for Health Effects of Environmental Contamination, The University of Iowa, Iowa City, Iowa.

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The proliferation of large-scale swine production facilities has resulted in considerable concern among neighboring farmers and other rural residents over their environmental, social, economic, and health consequences (DeLind, 1995; Thu, 1995/96; Thu and Durrenberger, 1994). Among these concerns are the potential health and quality of life consequences for neighbors exposed to gases, dusts, and odors emanating from such facilities.

Beginning in the mid 1970s and continuing to the present, research has been devoted to understanding human exposures and health consequences of working in swine confinement environments (Donham, 1990; Donham et al., 1977; Kiekhaefer et al., 1995; Thorne et al., 1992). The results indicate swine confinement workers experience a number of health problems. A notable problem area is the range of respiratory conditions resulting from exposure to gases and dusts while working inside these facilities (Donham, 1993). However, very little research has been conducted on exposures to external emissions.

Research on exterior conditions has primarily targeted the reduction and elimination of odor emissions from swine operations. This research has concentrated on identifying compounds producing odors (Merkel et al., 1969; O'Neill and Phillips, 1992; Ritter, 1989), mechanisms for measuring odor (Hobbs, 1995; Longhurst, 1995; Mannebeck, 1995; Sweeten, 1988), and the development of control technologies (Fullhage, 1995; Voermans, 1995; Yokoyama, 1995). In addition, considerable research has been devoted to the uptake of ammonia from animal manure and the environmental consequences of its redeposition as rain in Europe (ApSimon and Kruse-Plass, 1991; Legg, 1990). However, little work has been devoted to understanding odor-related complaints and health problems among residents living near large livestock operations.

Emerging research (Schiffman, 1995; Schiffman et al., 1995) has investigated relationships between the psychological health of neighbors and swine-generated odors. This research indicates deleterious psychological health effects such as mood disorders result from a combination of physical agents and physiological responses to swine odor. It also suggests changing social conditions in rural neighborhoods may be a factor affecting responses. Other research (Thu and Durrenberger, 1994) supports Schiffman's suggestion that rural social issues play a role.

This study addresses a gap in research through a control approach to assessing interrelated issues of health, quality of life, and mental health of residents living in the vicinity of a large-scale swine confinement facility. The primary purpose of the study was to test a methodology for assessing neighbor health and quality of life issues, provide preliminary data to identify salient neighbor health and life quality problems, and generate hypotheses for further research.

Methodology

This study is based on a comparative control methodology. Data on physical health status, mental health, and quality of life were collected via personal interviews of neighbors of a large-scale swine production facility and from a random sample of rural residents who do not live near any livestock. Results from the two groups were compared to identify salient differences.

Survey Instrument

A questionnaire was developed to elicit data via personal interviews on physical health status, mental health, quality of life, and standard sociodemographics. An

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initial section was designed to collect basic background information, including demographics, employment, residential history, and previous occupational exposures. The second section elicited symptoms indicative of health status. Health status questions were drawn from earlier health assessment studies of swine confinement workers (Donham, 1990). They consisted of an initial set of open-ended questions concerning health problems, frequency ratings of 18 symptoms, and a series of health history and current health status questions.

To assess psychological health, mental health questions were developed in consultation with Professor Susan Schiffman, a medical psychologist at Duke University. In her research (Schiffman et al., 1995), Schiffman collected data on mood states between swine operation neighbors and controls utilizing a standardized mood profile scale (McNair and Lorr, 1992). To complement her findings, we included psychological scales to collect data on depression (Zung, 1965) and anxiety (state-trait anxiety inventory from Steer et al., 1993).

A third section included open-ended questions to solicit qualitative information on neighborhood social issues. For the case sample, questions were designed to elicit information on issues such as how well and how long neighbors knew the owners and operators of the swine facility and the nature of their relationship. Both case and control participants responded to a question on the characteristics of a "good neighbor".

Sample Selection and Procedures

A large-scale swine confinement operation was selected as the study site based on its scale and because we knew certain neighbors had expressed environmental and health concerns. The selected swine operation is one of the largest in Iowa, with approximately 4,000 sows in a farrowing operation consisting of six confinement units, an office building, and a two-stage outdoor waste lagoon about five acres in size. The entire operation is situated on an estimated 35 acres of land.

The 27 neighbors living within two miles were identified from plat maps as potential participants. Each household was sent a letter of introduction, a project summary, an invitation to participate, and a stamped return postcard. Of the 27 households contacted, 18 returned the postcard indicating an interest in participating (67% participation rate). Follow-up phone calls were made to each of the 18 interested households to schedule personal health assessment interviews. Of the 18 interested households, 10 households met the selection criterion of living closer to the large-scale swine operation than other livestock operations. Nine of these with 19 participants completed all aspects of the study. Multiple dwellers within a single household were interviewed independently from each other.

A control sample of rural residents not living near any livestock operation was selected. County level data from the 1992 Agricultural Census were used to locate areas of minimal livestock production. A county different from the case sample site was selected and all rural zip code areas within the county were checked to identify areas with the lowest population of livestock. All rural residents (n = 188) within the selected zip code area who owned a telephone were selected from a telephone data base. Letters of introduction were sent to all residents, including a project summary, an invitation to participate, and a stamped return postcard. Included in the letter was an additional screening caveat that prospective participants must not live within a mile of any type of livestock operation greater than 50 head.

Of the 188 letters sent, 14 were returned undeliverable by the Post Office, 24 postcards were returned declining participation, and 11 postcards were returned indicating they met the selection criteria and were interested in participating. All interested participants were contacted by phone to schedule interviews in their

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Table 1. Demographic comparison of case and control samples

	Gender		Marital Status		Age	Education		Occupation	
	Men	Women	Marr.	Single	Mean	H.S.	> H.S.	Farmer	Nonfarmer
Case sample	10	8	14	4	47	10	8	9	9
Control sample	11	7	14	4	47	9	9	8	10

homes at their convenience. We requested that as many members of the household as possible participate. A total of 21 interviews were conducted in 11 households. However, data from two households in which three interviews were conducted had to be eliminated because of a failure to meet our selection criteria. Consequently, the control sample consisted of 18 personal interviews across nine rural households. Neither the control or case sample participants were provided financial or other incentives to participate.

The principle author and a co-author were the primary interviewers. Both are trained in qualitative and quantitative data collection methods utilizing ethnographic and personal interview techniques from social anthropology and the social sciences (Weller and Romney, 1988). The interviewers have 12 years combined experience in data collection specific to agriculture.

All data from the interviews were coded and entered into a Paradox database. Quantitative analyses were performed using a SAS statistical package*. Qualitative data were analyzed based on a combination of results from the quantitative analysis and interviewer notes on the questionnaires.

Results

As evidenced in table 1, there was little difference in gender, marital status, age, or educational level between the two samples. In addition, all respondents were white and there was a comparable proportion of farmers and nonfarmers in our sample populations. It is unlikely that the findings are biased by demographic differences between the sample and control populations.

Physical Health Symptoms

Results of the frequency of physical symptoms are presented in figure 1. The study population reported higher frequencies of 14 out of the 18 symptoms than the control population. There was no connection between the frequency of reported physical symptoms and distance from the swine facility. Results indicate a pattern of four interconnected clusters of symptoms that include respiratory problems, nausea and weakness, headaches and plugged ears, and irritation of eyes, nose, and throat. This constellation of symptoms matched those reported by participants in response to an open-ended question posed earlier in the interview. Skin rash, muscle aches, and fever were reported more frequently among the control group, while hearing problems were reported at an identical frequency by both groups.

Table 2 presents the results of analyses assessing the significance in differences between the reported symptoms from neighbors of the swine facility and the control population. The constellation of 14 symptoms reported more frequently by the study group showed composite mean frequency scores of 21 for the study population and 15 for the control. The first line of table 2 labeled "All Symptoms" presents the

* SAS Institute Inc., Release 6.03., 1988. Cary. N.C.

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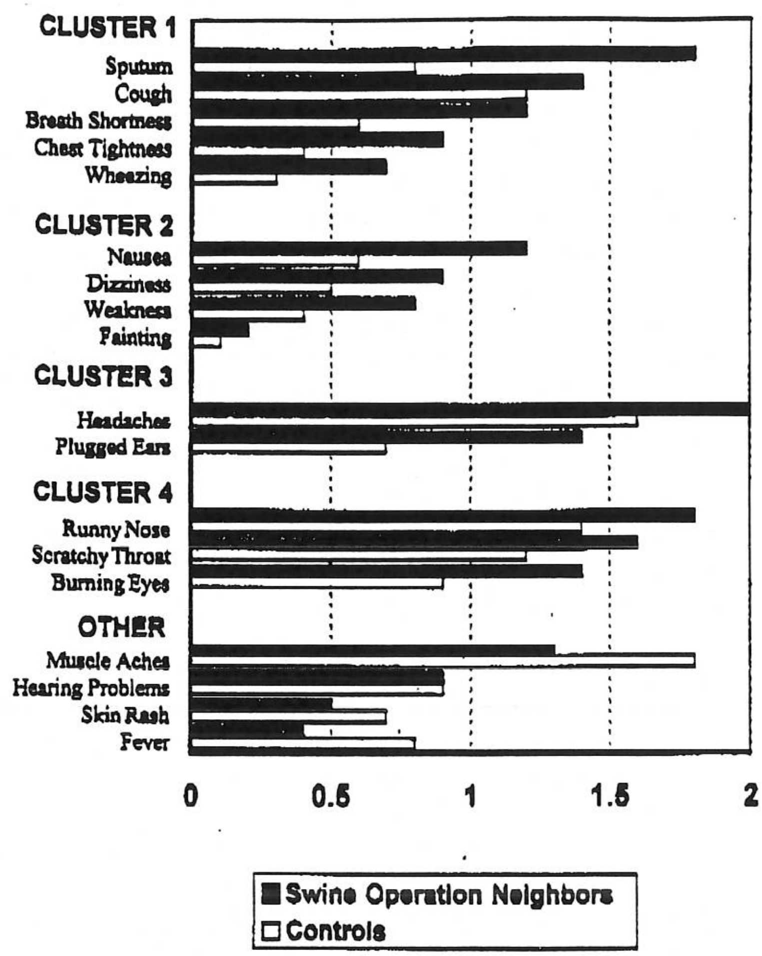

Figure 1–Frequency of physical symptoms experienced by rural resident (comparison of mean scores, 0 = Never, 4 = Very Often).

results of a Wilcoxon Test (Chi Sq = 2.3; P = 0.13) indicating this difference warrants attention but is not conclusive.

More significant is the trend among clusters of symptoms. Within the range of symptoms reported more frequently by the study sample, four clusters of related symptoms deserve particular attention. These clusters of symptoms have been recognized previously in swine facility workers (Donham, 1995). They represent toxic or inflammatory effects on different segments of the respiratory tract.

The first cluster is a combination of five symptoms indicative of inflammation of the bronchi and bronchioles, or chronic bronchitis and hyperreactive airways: sputum, cough, breath shortness, wheezing, and chest tightness. A variety of standardized survey instruments include this cluster of symptoms: the American Thoracic Society,

Table 2. Physical symptom clusters: A comparison of swine facility neighbors and rural controls

Physical Symptom Cluster	T Value	Significance Level
All symptoms combined	2.30	0.13
Cluster 1: Respiratory symptoms	2.12	0.02
Cluster 2: Nausea, weakness, dizziness and fainting	1.83	0.04
Cluster 3: Headaches and plugged ears	1.67	0.06
Cluster 4: Burning eyes, runny nose and throat	1.18	0.12

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the British Medical Research Council, and the Agricultural Dust Exposure Assessment. A one-tailed t-test was conducted to determine whether the study population reported experiencing this combination of symptoms more frequently than the control sample. As presented in Cluster 1 of table 2, results indicate that residents living in the vicinity of the large-scale operation do report experiencing significantly higher rates of symptoms associated with chronic bronchitis and hyperreactive airways (T = 2.12; P = 0.02; 26.7 degrees of freedom). This type of bronchitis is almost invariably associated with environmental exposures, e.g., air pollution, chronic agricultural dust exposure, and long-term cigarette smoking.

A second cluster of related symptoms was examined that included: nausea, weakness, dizziness, and fainting. Previous research among swine workers reveal this group of symptoms is fairly common (Donham, 1993). A one-tailed t-test was again conducted to determine whether the study population reported experiencing this combination of symptoms more frequently than the control sample. As presented in Cluster 2 of table 2, results indicate that residents living in the vicinity of the large-scale operation do report experiencing significantly higher rates of nausea, weakness, dizziness, and fainting (T = 1.83; P = 0.04; 24.5 degrees of freedom). Research among swine confinement workers suggests that long-term exposure to less than acutely toxic levels of endotoxin and hydrogen sulfide merit investigation in conjunction with these symptoms (Auger et al., 1994).

A third combination of symptoms, headaches and plugged ears, is another frequently observed among swine confinement workers. Once again, a one-tailed t-test was conducted to determine whether the study population reported experiencing this combination of symptoms more frequently than the control sample. As presented in Cluster 3 of table 2, results indicate that residents living in the vicinity of the large-scale swine operation report experiencing higher rates of headaches and plugged ears, though the difference is marginally less significant than the first two clusters (T = 1.67; P = 0.06; 24.5 degrees of freedom). The physiological explanation for these symptoms among swine confinement workers is that they are often associated with chronic sinusitis. Symptoms of chronic sinusitis are seen in nearly a quarter of active swine producers (Donham, 1993).

A final cluster of symptoms was examined that included: burning eyes, runny nose, and scratchy throat. The one-tailed t-test was replicated to compare the study and control sample. As presented in Cluster 4 of table 2, results indicate that the higher rates of these reported symptoms among neighboring residents of the large-scale operation warrant notice but the difference is less clear (T = 1.18; P = 0.12; 33 degrees of freedom). Among interior swine confinement workers, these symptoms are associated with a condition called mucous membrane irritation. Irritant gases and particulates inside swine confinement buildings are thought to affect the mucous membranes of the eyes and upper airways, resulting in the symptoms reported.

Differences in reported physical health symptoms between the study and control population are present. More notable than individual symptoms or clusters of symptoms, is the overall trend of interrelated symptom clusters reported more frequently among neighbors of the swine facility than the control sample. The constellation of symptoms reported in excess by neighbors is consistent with, but less severe and frequent, compared to symptoms of workers in swine confinement facilities. A companion article to this article reveals that ammonia, dust, and endotoxin are present in the air downwind from large swine facilities. However, these levels are much lower than those previously associated with any known illness (Reynolds et al., in press). This raises the question as to whether low levels may be associated with reported symptoms.

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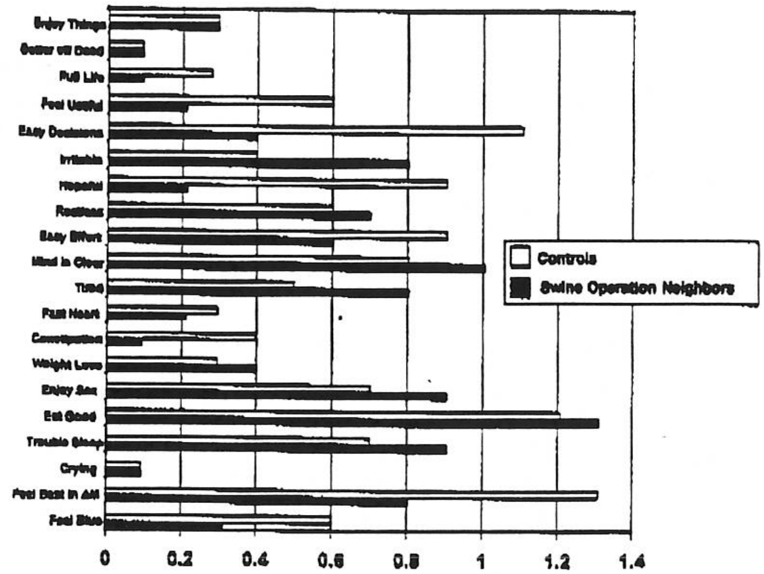

Figure 2–Frequency of depression symptoms experienced by rural residents.

Psychological Symptoms

Research in North Carolina (Schiffman et al., 1995) reported that persons living near large-scale swine operations exhibited significantly higher rates of mood disorders than did matched control participants as measured by a Profile of Mood States (POMS) scale. Neighbors living near large swine facilities experienced higher rates of tension, anger, fatigue, and confusion. Schiffman discusses how molecules responsible for odors can potentially result in physical responses linked to mood alterations. She also suggests that odor may play a role in suppressing immune system responses via physical connections between the olfactory and immune systems. The psychological scales we used measured depression and anxiety as a comparative supplement to Schiffman's research.

The depression scale is based on the work of Zung (1964) and is derived from established research utilizing factor analyses to derive the most common set of underlying characteristics that predict depression in a clinical setting. Participants in our pilot study were administered 20 questions from the Self-Rating Depression Scale (SDS) derived from this clinical work. The comparative results of mean scores of individual items are presented in figure 2.

Little difference in depressive symptoms exists between the study and control populations. Following Zung's (1964) methodology, a depression index was created by totaling the raw scores of participants and dividing them by the total possible score†. The composite mean depression index for case study participants totaled 0.37 compared with 0.40 for the controls and were not significantly different (Chi Sq = 0.35; P = 0.55). These scores compare with a mean depression index of 0.74 in Zung's clinically admitted population of depressed patients. Zung's control, or "normal" population, scored 0.33. Thus our study population is well within the range of Zung's control population, exhibiting very little depressive symptomology.

† Comparison of Mean Scores. 0 = Never or little, 3 = Most of the time. A value of one was added to each response value listed in table 2, i.e., 0 = 1, 1 = 2, 2 = 3, and 3 = 4, in order to make the index results comparable to other research.

1-13

An anxiety scale was administered based on the Beck Anxiety Inventory (BAI) developed by Beck and Steer (Steer et al., 1993). The scale is derived from analyses of in-patients exhibiting a set of symptoms distinct from other mental disorders in a clinical setting. Participants in our pilot study were administered 21 questions from the BAI derived from this clinical work. The comparative results of mean scores of individual items are presented in figure 3.

Little difference in anxiety symptoms exists between the study and control populations. Following the methodology of Steer et al. (1993), an anxiety index was created for each case by totaling the raw scores of participants and dividing it by the total possible score. The composite mean anxiety indexes for case study and control participants were virtually identical: 0.11. These scores compare with a mean anxiety score of 0.29 in Steer and coworkers' population of 250 clinically admitted patients categorized as "moderately anxious". Our study population does not appear to be suffering from anxiety related psychological symptoms. Moreover, no significant differences were found in anxiety between the study participants and the control population.

Conclusion

Evidence indicates that neighbors of the large-scale swine operation in our study reported experiencing increased rates of a number of interrelated symptoms, including headaches, respiratory problems, eye irritation, nausea, weakness, and chest tightness. The pattern of differential symptomology rates between the study and control samples suggest further study is warranted. There is little evidence to suggest that neighbors of the large-scale swine operation suffer higher rates of anxiety or depression.

Further study is needed to test the hypothesis that neighbors of large-scale swine operations experience higher rates of physical symptoms comparable to the types of symptoms experienced by interior confinement workers. A larger population-based study is needed that includes neighbors of a cross-section of various sizes and types of swine and other livestock operations. Such a study should continue to use personal interviews as the basis of health assessments. A central issue in these investigations is

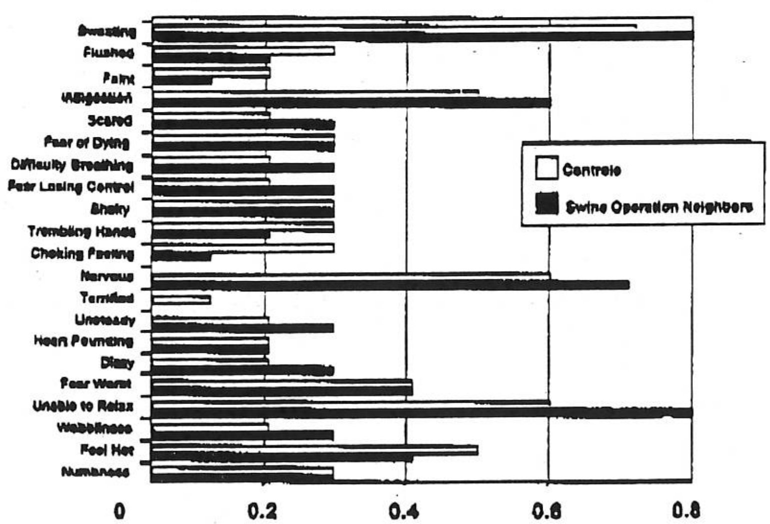

Figure 3–Frequency of anxiety symptoms experienced by rural residents.

1-14

the reliability and quality of data. Personal interviews by trained and experienced interviewers in the homes of rural residents provide a comfortable setting for participants to discuss issues in a forthright and open manner. A report based on a 1985 National Science Foundation conference on data collection points to natural settings as providing the best opportunity for collecting reliable interview data (Bernard et al., 1986). Validity of data collection is related to a host of factors, including the extent of open exchange between interviewers and persons being interviewed.

Neighbors did not appear to be concocting evidence of health or psychological problems based on any personal or political agenda. Evidence for the credibility of physical symptom reports comes from the psychological profile data. If participants wanted to concoct evidence it would have been easy for them to report high rates of depression and/or anxiety. Such reporting did not occur. Physical assessments of neighbors would provide clarification of these issues.

Permeating all the responses, regardless of whether respondents had specific health problems, was the underlying view that the owner was creating social and class divisions in the neighborhood and community. Most believed that the construction and presence of the facility violated core rural values of being a good "neighbor". For virtually all respondents, rural "neighborliness" embodies central cultural principles of egalitarian relationships, reciprocal exchange such as helping or sharing in times of need, mutual respect, and being kept informed. The facility's construction and continuing presence was viewed as eroding these cornerstones of agrarian life. Often discussed outside the strictures of the questionnaire, participants voiced concern about such issues as labor turn-over, social chasms emerging between neighbors and between children of neighbors, the influence of the facility's owner on local political and economic decision-making boards, and the ability of residents to have control over their land, homes, families, and quality of life. Clearly the issues confronting rural residents in this study reflect an intertwining of personal, environmental, economic, and social health. Further study should seek to clarify and broaden our understanding of these interrelated issues.

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Appendix — Questionnaire

Date: ______________________________

Interviewer: ______________________________

I. Background

Computer Code

1. Name ______________________________ ID # ____________
2. Address ______________________________

____

____

3. Phone # ______________________________
4. County ______________________________ ____________
5. Race ______________________________ ____________
6. Age ______________________________ ____________
7. Gender ______________________________ ____________
8. Marital status ______________________________ ____________

   How long? ______________________________ ____________

9. Occupation ______________________________ ____________
10. If farming, what kind? ______________________________
11. Off-farm employment? (what and how many hours per week?)

    ____

12. Highest level of education ____________
13. Annual household income (on- and off-farm income) ____________
14. What proportion of your annual household income comes from farming (%)? ____________
15. What proportion of your annual household income comes from hog production (%)? ____________
16. How many people live at your residence? ____________
17. How long have you lived at this residence? ____________

1-17

18. Do any exposures or conditions specific to your neighborhood bother you, or give you health problems?

____

____

____

____

II. Symptoms

19. Please check the frequency with which you experience the following symptoms:

	1 Never	2 Rarely	3 Occasionally	4 Often	5 Very Often
Headache	n	n	n	n	n
Plugged, popping ears	n	n	n	n	n
Hearing problems	n	n	n	n	n
Burning or watering eyes	n	n	n	n	n
Runny nose	n	n	n	n	n
Scratchy throat	n	n	n	n	n
Sputum or phlegm	n	n	n	n	n
Cough	n	n	n	n	n
Fever	n	n	n	n	n
Nausea or vomiting	n	n	n	n	n
Weakness	n	n	n	n	n
Dizziness	n	n	n	n	n
Fainting or blackout	n	n	n	n	n
Shortness of breath	n	n	n	n	n
Wheezing	n	n	n	n	n
Muscle aches and pains	n	n	n	n	n
Skin rash or hives	n	n	n	n	n
Tightness in chest	n	n	n	n	n
*____________________	n	n	n	n	n
*____________________	n	n	n	n	n

1-18

* ________________	n	n	n	n	n

* Fill in other symptoms bothering you that are not listed.

20. Please check the following items in terms of the frequency with which they currently apply to you.

	1 Never or a Little of the Time	2 Some of the Time	3 Good Part of the Time	4 Most of the Time
I feel down-hearted and blue	n	n	n	n
Morning is when I feel the best	n	n	n	n
I have crying spells or feel like it	n	n	n	n
I have trouble sleeping at night	n	n	n	n
I eat as much as I used to	n	n	n	n
I still enjoy sex	n	n	n	n
I notice that I am losing weight	n	n	n	n
I have trouble with constipation	n	n	n	n
My heart beats faster than usual	n	n	n	n
I get tired for no reason	n	n	n	n
My mind if as clear as it used to be	n	n	n	n
I find it easy to do the things I used to	n	n	n	n
I am restless and can't keep still	n	n	n	n
I feel hopeful about the future	n	n	n	n
I am more irritable than usual	n	n	n	n
I find it easy to make decisions	n	n	n	n
I feel that I am useful and needed	n	n	n	n
My life is pretty full	n	n	n	n
I feel that others would be better off if I were dead	n	n	n	n
I still enjoy the things I used to do	n	n	n	n

21. Please check the following items in terms of the frequency with which they currently apply to you.

	0 Not at All	1 Sometimes	2 Frequently	3 Almost Constantly
Numbness	n	n	n	n
Feeling hot	n	n	n	n
Wobbliness	n	n	n	n
Unable to relax	n	n	n	n
Fear of the worst	n	n	n	n
Dizzy	n	n	n	n
Heart pounding	n	n	n	n
Unsteady	n	n	n	n
Terrified	n	n	n	n
Nervous	n	n	n	n
Feelings of choking	n	n	n	n
Hands trembling	n	n	n	n
Shaky	n	n	n	n
Fear of losing control	n	n	n	n
Difficulty breathing	n	n	n	n
Fear of dying	n	n	n	n
Scared	n	n	n	n
Indigestion	n	n	n	n
Faint	n	n	n	n
Face flushed	n	n	n	n
Sweating	n	n	n	n

1-20

SPECTRUM *Technologists*

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KDHE's New Animal Waste Regulations Won't Solve the Hog Problem

Odor. Aside from enforcing existing, inadequate setbacks, the new regulations explicitly avoid addressing odor reduction through facility design. The hog controversy cannot be resolved without addressing this problem in a meaningful way, including emissions from barns, lagoons, waste application and sludge piles. KDHE feels they don't have authority to regulate odor unless a health impact has been demonstrated. Recent research does demonstrate such an impact near hog farms. See attachments.

Lagoon Construction. KDHE continues to allow self certification and keeps the weak, 0.25 inch/day seepage standard. The new design standards allow operators to dig lagoons and count the top one foot of remaining soil as an "in situ" liner. No compaction standard is specified, and no post construction permeability test is required. This technique is allowed in soils that contain substantial sand and gravel. Due to difficulty in achieving adequate compaction, this cannot be considered a true liner. The scientific literature does not verify that "biosealing" consistently prevents contamination of groundwater. Two examples of contamination from swine lagoons are attached. Also, analysis of strata down to the water table is not required.

Waste Application. KDHE says they will now require waste nutrient analysis and surface soil testing. Unfortunately operators won't have to provide soil tests before construction to confirm that all the waste can be absorbed. The attached swine wastewater analysis from Servitech Laboratories in Dodge City note that the liquid is "poor quality irrigation water." KDHE gives waste disposal priority over waste utilization by allowing operators to apply nitrogen at 120% of crop needs and phosphate at 200%.

Groundwater Monitoring. KDHE says they "may" require monitoring of groundwater near animal waste lagoons and application areas. "May" should be changed to "shall." The unwillingness of KDHE to require monitoring in the past is why we have so little data on the performance of waste control systems in Kansas. KDHE has required monitoring near slaughterhouse waste treatment systems, and that's how we discovered that clay lined lagoons were leaking and contaminating groundwater.

Double Standard. New slaughterhouse lagoons must have dual, plastic liners with leak detection while animal waste lagoons must have only a compacted soil liner. See attached KDHE Policy Directive. We can find no scientific justification for this double standard. KDHE has also started to require monitoring of slaughterhouse wastewater irrigation. The same should be done for large animal waste operations.

Setbacks. Waste application areas are not considered part of the facility for the purpose of determining separation distances. Yet they may be an important source of odor. Also Animal feeding facilities can be placed, and waste applied, as close as 100 feet from a drinking water well. If contamination reaches the Ogalalla aquifer, water users under these circumstances need wait only three to six months for the stuff to reach them. Ominously, the KDHE extends this distance to 200 feet when the operator uses the previously described "in-situ" liner technique for his lagoon. This is not just a problem of nitrates. See enclosed example of a cattle feedlot lagoon causing excessive chloride contamination.

Facility Closure. The new rules do not ensure that taxpayers will avoid picking up the tab for the clean up of abandoned facilities. The rules merely say that a "plan" must be submitted when the time comes. At no time are operators required to post a bond or financial guarantee.

Question 1: Have the Department of Health and Environment's Actions to Permit, Monitor, and Regulate Confined Livestock Feeding Operations Been Sufficient To Protect Kansas Water from Pollution?

The Department's design standards are less stringent than comparison states in two key areas. *Kansas' "seepage" standard specifies that the liquid from the bottom of a lagoon can't seep into the ground by more than 1/4 inch per day. Six of the eight other states allow a seepage rate of less than that—generally 1/16 inch to 1/56 inch per day. Also, Kansas requires 100 feet between a waste-control facility and a well, while most other states have a variable standard based on the quality of the well's construction.* .... page 10

We found some significant problems with the Department's animal waste regulatory program. *Although our reviews, testwork, and interviews showed the Department had adopted many good permitting, monitoring, and enforcement procedures in regulating animal wastes, they also showed the program had serious problems that weaken its effectiveness in protecting the State's water sources from pollution.* .... page 12

In 93% of the 41 cases we reviewed, the Department didn't follow its procedures or requirements for regulating animal waste-control facilities. *The Department often allowed facilities to operate even though their permits had expired—often years before—or hadn't met all the requirements for obtaining a permit. For example, some facilities had never submitted required seepage tests to ensure lagoons wouldn't leak excessively. Other facilities didn't meet design standards or special permit conditions. In one case, a facility has operated for nine years after test results showed a waste lagoon could seep at more than 20 times the allowed standard if it hadn't sealed effectively. The Department has no way to identify facilities that may pose a significant water pollution potential and need to be regulated. In addition, in trying to address a large backlog of renewal permits, the Department is shortcutting some potentially important steps.* .... page 14

We also found the Department hadn't performed the required one-, two-, or three-year inspections for nearly half the facilities in our sample; one facility hadn't been inspected since 1973, and two others hadn't been inspected since the mid-to-late 1980s. The Department also inappropriately handled complaints more than 40% of the time. When inspections or complaint investigations uncovered violations of regulations,

KDHE'S RESPONSE TO POST AUDIT REPORT ON ODOR + DUST from CAFOs

Comments Regarding Pages 29 - 32

In regard to the performance audit's assessment of KDHE's authority to regulate dust and odors, the Department agrees, in general, that its statutory authority to regulate sources of air pollution in Kansas is broad. The need for broad authority in this area results from the complexity of the federal air quality program and the authorities required to assure that Kansas maintains a federally-approved state air program. There are, however, several important statutory qualifications to these authorities that have relevance to the development of dust and odor programs that were not specifically discussed in the audit report.

The first involves the authority of the Department to require the abatement of nuisances under the provisions of K.S.A. 65-159. This statute does not apply generally to nuisances, but requires that the Department demonstrate such nuisances to be "injurious to the health (emphasis added) of the inhabitants. . . ." While odors may be more or less offensive to individuals, injury to health from odors is difficult if not impossible to demonstrate. Fugitive dust may be detrimental to health of some particularly sensitive or predisposed persons, but again it is extremely difficult to support a nuisance action on this basis. Where such action is supportable and necessary, the Department will not hesitate to use the authority. However, its application is much more limited and restricted than the report language implies.

Secondly, the provisions of the Kansas Air Quality Act (K.S.A. 65-3001, et seq.) were enacted primarily for the purpose of assuring compliance with the federal Clean Air Act in Kansas. The federal air program requirements applicable to the states do not require the development of nuisance dust and odor programs. While such state-specific air programs are not prohibited under the Kansas Air Quality Act, the Department has, traditionally, been held to a high standard through the administrative regulation process for justifying the need to expand the Kansas air program requirements into areas that extend beyond the federal program. The Kansas Air Quality Act also contains provisions that "encourage local units of government to handle air pollution problems within their respective jurisdictions" where many nuisance dust and odor problems can be most effectively resolved. In its initial enactment of the Kansas Air Quality Control Act in 1967, the Legislature included a "Declaration of policy and purpose" that remained a part of the Act until 1993. We understand its deletion then resulted from a general intent to eliminate policy and purpose statements from statutes. The Declaration may still be a reliable indicator of legislative intent. Except for protection of human health and safety, the policy adopted seems to mitigate against an expansive application of the statute and calls for a balancing of potentially competing interests and a balancing of state versus local authority and responsibility. Finally, K.S.A. 47-1505 provides that feedlots operated in accordance with the standards and regulations of the livestock commissioner are deemed to present prima facie evidence that a nuisance does not exist.

The statutory and legal issues surrounding regulation of dust and odors noted here, when combined with the extreme technical difficulties discussed in the report, render such control and regulation essentially impossible except where there is a clear, demonstrable threat to human health of inhabitants. These are the reasons why neither Kansas nor any of the other states surveyed regulate odors or dust in the CAFO programs. We concur with the conclusion that further study regarding dust and odors is necessary. That study and the development of useful technology and standards may make regulation feasible in the future. We do not agree that the statutory authority, except for situations threatening to human health, is available as described in the report and future legislation may be required after feasibility questions are answered.

From the NC Hog Roundtable- A coalition of 40 grassroots organizations and environmental groups concerned with the impact of NC's Hog Industry on the health of the people and the environment. Information was gathered for the Hog Roundtable by Melva Okun with the UNC-CH School of Public Health. 9/97

Health Information Related to Residents Who Live Near Hog Intensive Livestock Operations

Few studies have been conducted to study the potential impacts for near-by residents of hog intensive livestock operations. Most studies have focused on workers who are employed in the hog growing houses or at the slaughter houses. Studies show that nearby residents to hog intensive livestock operations experience similar, however less severe, health effects to workers employed in the hog growing houses.

Summary Health Information

1. Mental Health

Schiffman, Susan S., Sattely, Elizabeth A., Suggs, Mark S., and Graham, Brevick G. (1995). The effect of environmental odors emanating from commercial swine operations on the mood of nearby residents. Brain Research Bulletin, Vol. 37, No. 4, pp. 369-375. Dr. Schiffman's research showed a significant difference in mood states between people who live near intensive swine operations who experienced the odors and similar people who live outside of the odor area. Effects included increased rates for depression, tension, anger, lack of vigor, fatigue, and confusion. Males studied showed higher rates of anger and females were found to be more depressed.

2. Respiratory Impact 319-335-4224

Thu, K., Donham, K., Ziegenhorn, R., Reynolds, S., Thorne, P.S., Subramanian, P., Whitten, p., & Stookesberry, J. (1997). A control study of the physical and mental health of residents living near a large-scale operation. Journal of Agricultural Safety and Health, 3(1), 13-26.

Residents living within a two-mile radius of a 4000 swine production facility were compared to similar rural residents but those that didn't live near the facility. Results indicate that the neighbors of the large-scale operation reported significantly higher rates of four types of respiratory tract problems, which represent toxic or inflammatory effects. The symptoms have been well documented among swine confinement workers. The study found increased rates for headaches, respiratory problems, eye irritation, nausea, weakness, and chest tightness. Subjects did not show increased mental health problems, however, they were not selected by those who were downwind of the hog operations and so were not effected by noxious odors. Respondents did indicate the view that large scale operations are creating social and class divisions in the neighborhood and community. Most believed that the construction and presence of the facility violated core rural values of being a good 'neighbor' and that the facility was viewed as eroding the cornerstones of agrarian life. The issues confronting rural residents in this study reflect an intertwining of personal, environmental, economic, and social health.

AMMONIA

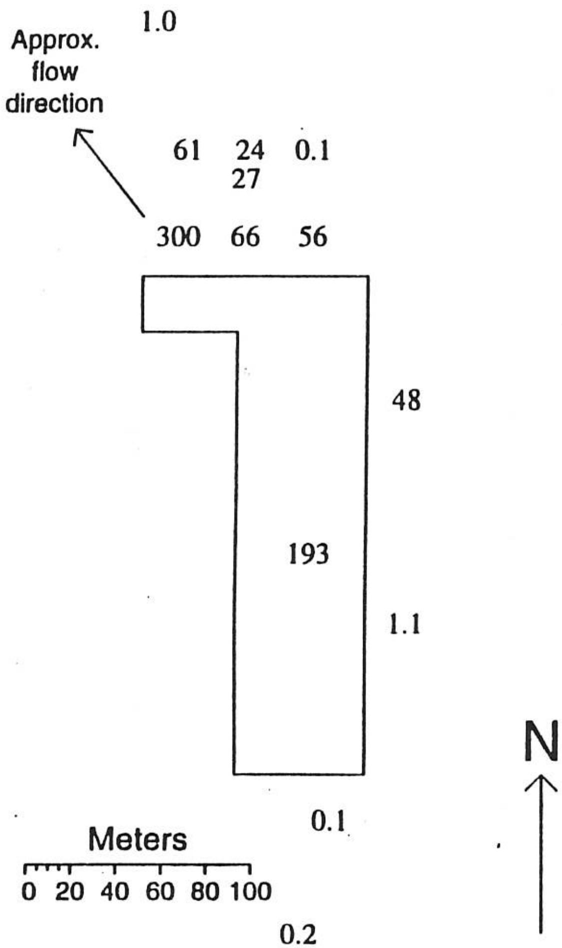


Figure 5–Ammonia-N concentrations (mg/L) in the lagoon and selected monitoring wells at Site P5, sampled 2 November 1993.

CHLORINES

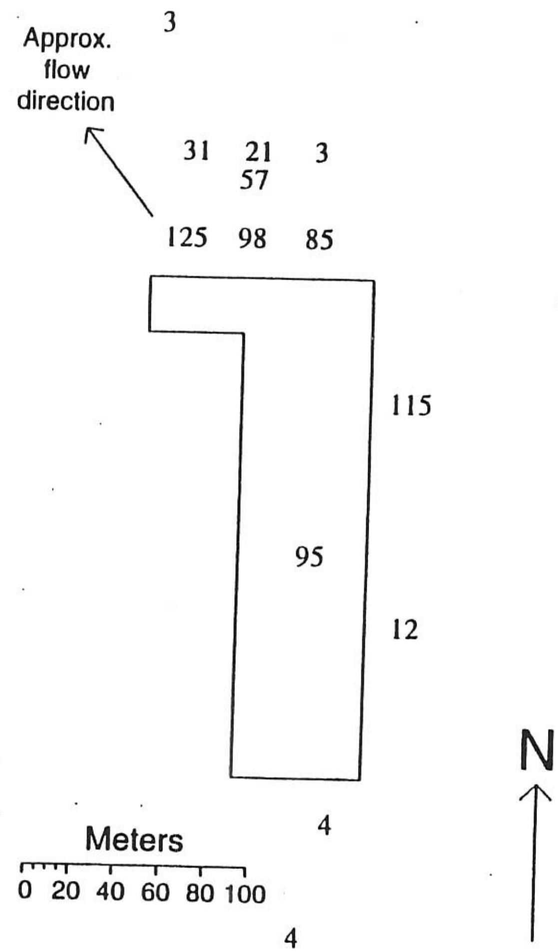


Figure 6–Chloride concentrations (mg/L) in the lagoon and selected monitoring wells at Site P5, sampled 2 November 1993.

NITRATE-

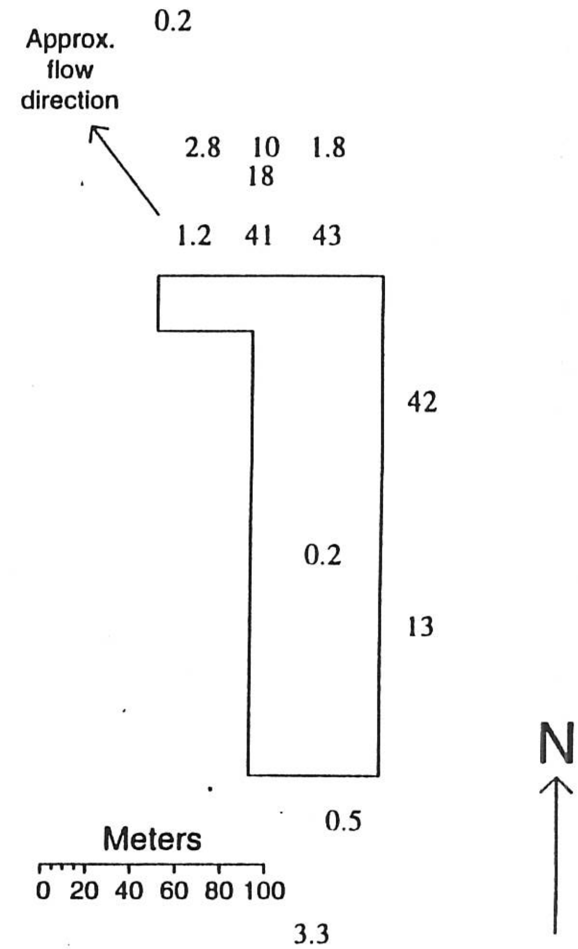


Figure 7–Nitrate-N concentrations (mg/L) in the lagoon and selected monitoring wells at Site P5, sampled 2 November 1993.

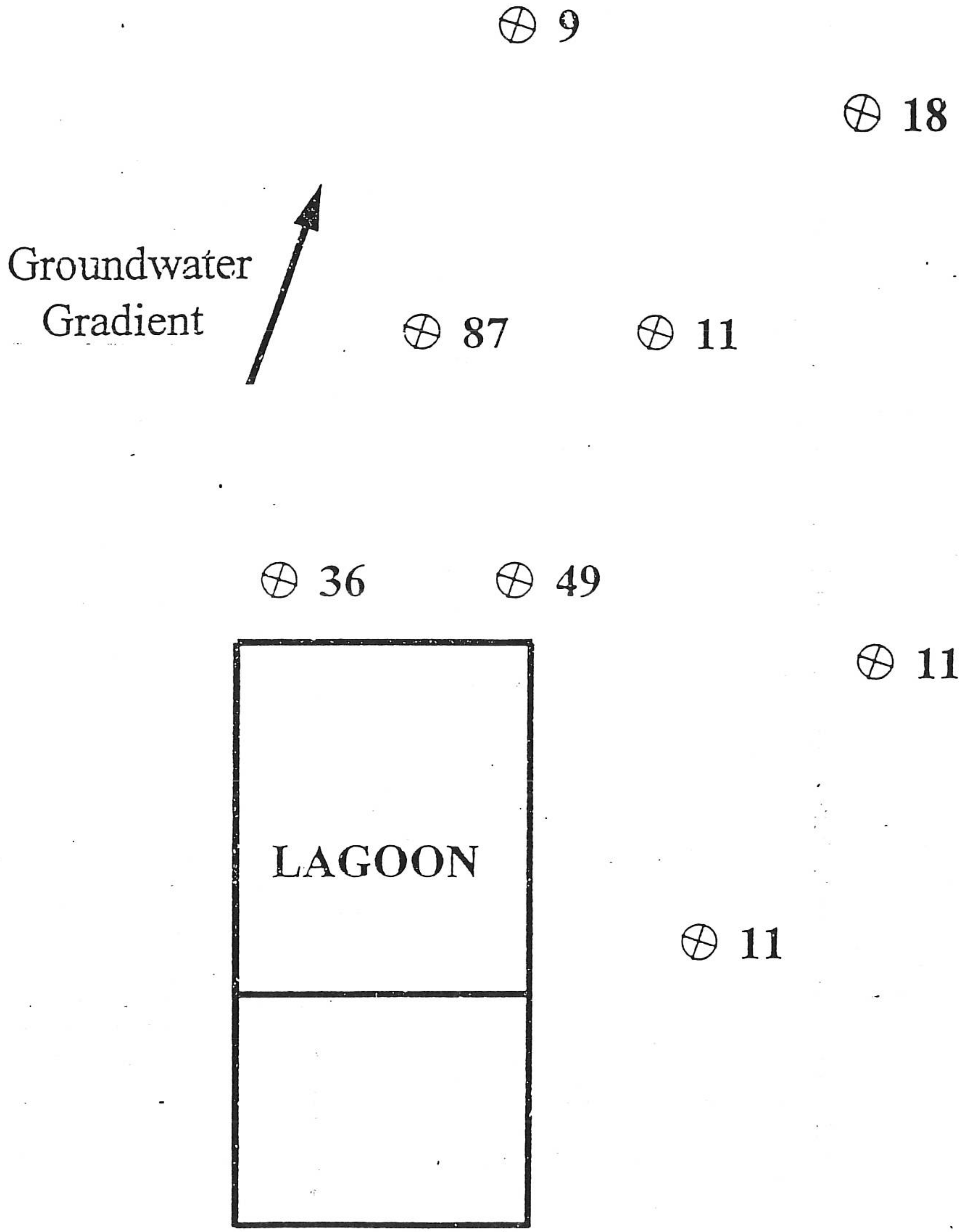
Example of Lagoon Seepage

North Carolina Site. Age 4 years. Unlined (compacted with construction equipment)

SOURCE: P.W. Westerman, R.L. Huffman, J.S. Feng
"Swine-Lagoon Seepage in Sandy Soils

NITRATE

EXAMPLE OF LAGOON SEEPAGE
LINED LAGOON



SITE #15: NO_3^- CONC (ppm) - July 14/95

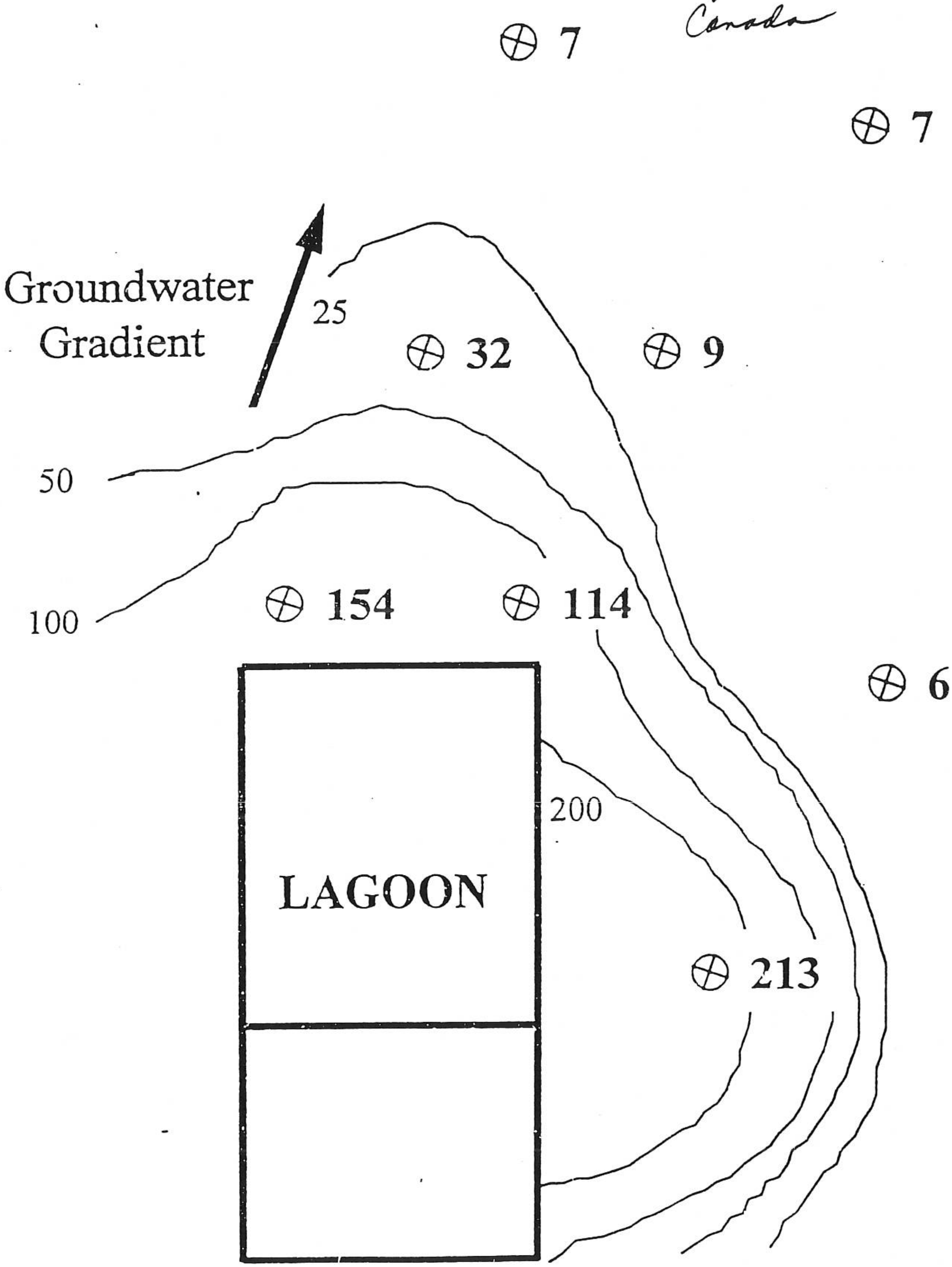
Constructed in predominantly silty till (SC to CL): Lined with 20 inches of compacted soil; 200 sow farrow to finish, Lagoon Age = 5yr. Health std = 45 ppm (as N:10)

Source: "Performance of Saskatchewan Soils for Construction of Earthen Hog Manure Lagoons" Univ. of Saskatchewan, UMA Engrg LTD.

CHLORIDE

EXAMPLE OF LAGOON SEEPAGE
LINED LAGOON

5 yr old
Canada



SITE #15: Cl⁻ CONC (ppm) - Aug 21/95

Source: See Site #15 Nitrates

Servi-Tech Laboratories

servi tech

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WATER ANALYSIS REPORT

ent To: 15647 7625	CQ HATLEY, MARK 212 NE 19TH GUYMON, OK 73942	Lab No.: Invoice No.: Date Received: Date Reported:	2507 D17766 06/25/94 06/29/94

59-5/ 43

esults For: HITCH FARMS
nalysis Description: WASTEWATER IRRIGATION SUITABILITY
ample Identification: N. LAGOON SOURCE: PIG LAGOON

SAMPLED: 06/24

ANALYSIS	UNIT	CONC.	lbs/A-Ft	meq/l
Nitrogen: Total	mg/l TKN	522.2	1,410.0	33.00
Ammonia	mg/l NH3-N	474.5	1,281.3	20.01
Nitrate	mg/l NO3-N	<0.1	<0.3	
Phosphorus: Phosphorus	mg/l P	47.00	125.9	
as P2O5 (Calc.)	mg/l P2O5	107.5	290.3	
Chloride	mg/l Cl	129	348.3	3.63
Carbonate	mg/l CO3	<1	<2.7	<0.03
Bicarbonate	mg/l HCO3	2,684.	7,246.8	44.00
Calcium	mg/l Ca	131	353.7	6.55
Magnesium	mg/l Mg	78	210.6	6.30
Sodium	mg/l Na	94	253.8	4.09
Potassium	mg/l K	294	793.8	7.54
as K2O (Calc.)	mg/l K2O	352.8	952.0	
Sulfur	mg/l S	6.0		
Boron	mg/l B	0.770	2.1	
Total Dis. Solids (Calc.)	mg/l	3,264		
Hardness (Calc.)	mg/l CaCO3	648.5		
Hardness (Calc.)	grains/gal CaCO3	37.9		
Alkalinity (Calc.)	mg/l CaCO3	2,200.9		
Electrical Conductivity	mmho/cm EC	5.10		
Sodium Adsorption Ratio (SAR)		1.6		
Adj. Sodium Adsorption Ratio (SARa)		4.8		
Sodium, % Of Cations		7.0		
Water pH		7.50		
Water pHc		6.34		

POOR QUALITY IRRIGATION WATER.

ERMEABILITY HAZARD: MEDIUM. Use with caution on fine or medium textured oils. Routine applications of gypsum and moderate leaching may be needed o maintain soil permeability. Annually monitor soil and water for changes in sodium content.

SALINITY HAZARD: VERY HIGH. May affect growth of salt tolerant crops (e.g. barley, cotton, sugarbeets). heavy leaching will be necessary to ... Annually monitor soil and water for soluble

State of Kansas

Mike Hayden, Governor

Department of Health and Environment

Division of Environment

Stanley C. Grant, Ph.D., Secretary

Forbes Field, Bldg. 740, Topeka, KS 66620-0002

(913) 296-1535
FAX (913) 296-6247

Policy Memorandum #90-2
September 1990

FROM: Karl W. Mueldener, P.E.
Director, Bureau of Water

SUBJECT: INDUSTRIAL WASTEWATER POND LINER POLICY

PURPOSE:

This document states the Bureau of Water (Bureau) policy for requirements relating to industrial wastewater ponds. This policy is intended to protect the water and soil resources from a significant risk of contamination posed by earthen lagoons utilized for the containment/treatment of industrial wastewater and to provide minimum standards for the design and construction of new industrial wastewater ponds and the retrofitting of existing earthen lagoons.

BACKGROUND:

The Bureau of Water administers the Kansas Water Pollution Control Permit program established by K.S.A. 65-164 and 65-165. Wastewater ponds which discharge to surface waters or total retention through the use of evaporation, irrigation or recycle are addressed by this program. The Department has responsibilities under K.S.A. 65-171d to prevent subsurface water pollution and soil pollution. An increased emphasis, at both the state and federal level, has been placed on addressing source control as a mechanism for preventing or minimizing groundwater contamination. Since groundwater contamination from earthen ponds has been documented, the Bureau concludes construction of new industrial wastewater ponds without impermeable liner/leak detection systems represent an unnecessary risk of polluting groundwater and soils.

POLICY:

Any new or modified wastewater ponds designed and constructed for the containment or treatment of industrial wastewater, for other than non-contact cooling water or conventional domestic-type wastewater shall meet the following requirements:

1. The pond shall have a primary and secondary liner with an intermediate leak detection system.

2. The primary liner shall be at least 30 mil in thickness.

3. The secondary liner shall also be at least 30 mil in thickness, or, depending on the situation, other alternatives may be approved on a case by case basis.

4. Compaction of the pond embankments and upper 12 inches of the interior bottoms below the secondary liner shall be a minimum of 95% of the maximum standard proctor density. The maximum thickness of the layers of material to be compacted shall be 6 inches. The moisture content range shall be optimum moisture to optimum moisture + 3%. The maximum size of dirt clods in the compacted soil shall be less than one inch diameter.

Groundwater Quality Near a Ford Co. Cattle Feedlot[1]
milligrams per liter-Average

Chemical	Wells #1&2 Background	Wells # 3&13 Down gradient at Lagoon	Well # 4 ------ 440 feet	Well # 11 Downgradient 1020 feet	Well #12 ------- 1890 feet
sodium	79.5	276.9	208.6	134	74
chloride	54.9	561.3	409.6	182	28.7
ammonia	0.1	27.7	7.2	0.2	0.1
nitrate-N	13.3[3]	1.7	5.6	5.0	24.8[3]

1. Source: "Impact on Groundwater from Livestock Waste Lagoons," Leon Hobson Masters Thesis, Kansas State Univ., April '91.

2. The maximum contaminant limit for chloride is 250 mg/l

3. Non detects included at .02 mg/l ammonia and .11 mg/l nitrate.

4. This analysis assumes the groundwater flow direstion is due east and parallel to the river as estimated by author. However a slight gradient to the southeast and toward the river is likely. This would mean background nitrate may not flow under lagoon and well number 12 may be impacted by another lagoon to the northwest or by inorganic fertilizers. This potential error would be less likely to affect the other monitoring wells.

being reissued. During any revocation and reissuance proceeding, the permittee shall comply with all conditions of the existing permit until a new final permit is reissued.

(4) If the director tentatively decides to terminate a permit under subsection (f) of this regulation, the director shall issue a notice of intent to terminate. A notice of intent to terminate is a type of draft permit which follows the same procedures as any draft permit prepared under K.A.R. 28-16-60.

(h) Transmission to regional administrator of permits. Upon issuance of any permit, a copy of the permit shall be forwarded to the regional administrator by the director.

(i) Reissuance of permits.

(1) At least 180 days prior to expiration of a permit, a permit holder wishing to renew the permit shall file an application, as required by the director.

(2) Permits shall not be reissued unless:

(A) The discharger is in compliance with or has substantially complied with all the terms, conditions, requirements and schedules of compliance contained in the existing permit;

(B) The discharger files an application and other necessary data as required by the director; and

(C) The discharge is consistent with applicable minimum standards of design, construction, and maintenance and water quality standards.

(3) The notice and hearing procedure for reissuance shall be the same as for the issuance of new permits. (Authorized by K.S.A. 65-171d, as amended by L. 1986, Ch. 204, Sec. 3, Sec. 6 and L. 1986, Ch. 201, Sec. 22; implementing K.S.A. 65-165, 65-166, effective, E-74-32, June 14, 1974; effective May 1, 1975, amended May 1, 1987.)

28-16-63. Monitoring. I. An appropriate monitoring program shall be included in all permits. The program may require the discharger to install, use and maintain at his expense, adequate monitoring equipment or methods (including, where appropriate, biological monitoring methods.)

II. Any discharge which 1) is not a minor discharge, 2) the regional administrator requests in writing to be monitored, or 3) contains a toxic pollutant for which an effluent standard has been established shall be monitored by the discharger for at least the following: (A) Flow (in gallons per day);

(B) Pollutants which are subject to reduction or elimination under the requirements, pollutants which would have a significant impact on the quality of the receiving waters, and pollutants specified by the regional administrator; and

(C) Each effluent flow or pollutant shall be monitored at intervals sufficiently frequent to yield data which reasonably characterize the nature of the discharge. Variable effluent flows and constituent levels shall be monitored at more frequent intervals.

III. Recording. (A) The discharger shall record the results of all monitoring and shall include for all samples: (1) The date, exact place, time of sampling, and who took the sample;

(2) The dates analyses were performed and who performed the analyses;

(3) Analytical techniques/methods used; and

(4) The results of such analyses.

(B) The discharger shall be required to retain for a minimum of three years any records of monitoring activities and results, including all original strip chart recording and calibration and maintenance records. The period of retention shall be extended during the course of any unresolved administrative enforcement action or litigation regarding the discharge of pollutants by the discharger or when ordered by the director.

IV. Reporting. (A) Monitoring results shall be reported on forms required by the director and forwarded to the director at specified time periods of not less than once per year.

(B) The director shall require the use of monitoring, recording, and reporting procedures which at a minimum are at least as stringent as any national monitoring, recording, and reporting requirements specified by the administrator in regulations issued pursuant to the act. (Authorized by K.S.A. 1974 Supp. 65-165, 65-166, 65-171d; effective, E-74-32, June 14, 1974; effective May 1, 1975.)

28-16-64. Reserved.

28-16-65. (Authorized by K.S.A. 12-3710 et seq.; effective, E-74-33, June 21, 1974; effective, E-76-20, May 1, 1975; effective May 1, 1976; revoked May 10, 1996.)

28-16-66. Reserved.

28-16-67. (Authorized by K.S.A. 12-3711; effective, E-78-4, Dec. 1, 1977; effective May 1, 1978; revoked May 10, 1996.)

1-31

of energy. USGS geologists, in cooperation with the Kansas Geological Survey, are involved in studies to provide information about the distribution of geologic resources and to identify potential consequences of land use and land management as well as providing information about geologic hazards such as earthquakes, landslides, and sinkholes. For geologic information contact:

Central Regional Geologist
Denver Federal Center, Mail Stop 911
Denver, CO 80225
(303) 236-5438
fax: (303 235–5448
http://geology.cr.usgs.gov/

or

National Earthquake Information Center
P.O. Box 25046
Denver Federal Center, Mail Stop 967
Denver, CO 80225
(303) 273-8500

Biological Information

For information on biological data, studies, and research conducted by the USGS in Kansas contact:

Regional Chief Biologist
Biological Resources Division
P.O. Box 25046, M.S. 300
Denver Federal Center
Denver, CO 80225
(303) 236-2730
fax: (303) 236–2733
http://www.nbs.gov/

Formal and Informal Reports

The formal report series of the USGS includes Professional Papers, Circulars, Bulletins, Techniques of Water-Resources Investigations, Water-Supply Papers, and Fact Sheets. The informal report series includes Data Reports, Open-File Reports, and Water-Resources Investigations Reports. Some of the reports are available from the USGS district offices in the various States; however, selection will be limited to the local area. Major libraries serve as depositories for many of these reports, but if you wish to obtain a personal copy, contact the following office for ordering information:

U.S. Geological Survey
Information Services, Box 25286
Denver, CO 80225-0286
(303) 202-4700
1-800-HELP-MAP

A bibliography of water-related reports prepared by or in cooperation with the USGS in Kansas is available on the Internet through the USGS-Kansas District home page at:

http://www-ks.cr.usgs.gov/

A limited number of paper copies of the bibliography are available from:

U.S. Geological Survey
4821 Quail Crest Place
Lawrence, KS 66049-3839
(785) 842-9909
fax: (785) 832-3500

USGS Learning Web

The Learning Web is a portion of the USGS Web dedicated to K-12 education, exploration, and life-long learning. There are four highlighted areas in The Learning Web—adventures, volcanoes, teaching, and living. "Adventures in the Learning Web" provides examples of science adventures from a list of USGS education materials. "Volcanoes in the Learning Web" explores why and where volcanoes erupt. "Teaching in the Learning Web" explores education resources that can be used in the classroom to teach earth-science concepts. "Living in the Learning Web" investigates topics about the Earth that affect people everyday and everwhere. The Learning Web may be accessed on the Internet at:

http://www.usgs.gov/education/

USGS
science for a changing world

House Environment
2-2-98
Attachment 2

Guide to obtaining information from the U.S. Geological Survey in

Kansas

1998

U.S. GEOLOGICAL SURVEY

Water Resources Division
4821 Quail Crest Place
Lawrence, Kansas 66049-3839
(785) 842-9909
fax: (785) 832-3500
Internet: http://www-ks.cr.usgs.gov/

2/98

USGS Mission

The mission of the U.S. Geological Survey (USGS) is to provide the citizens of the United States with the impartial information they need to effectively utilize their natural resources and to protect the health, safety, and well-being of the people. More information about the USGS can be obtained through the USGS home page at:

http://www.usgs.gov/

The State Representative for the USGS in Kansas is:

Walter R. Aucott, District Chief
U.S. Geological Survey
4821 Quail Crest Place
Lawrence, KS 66049-3839
(785) 842-9909
fax: (785) 832-3500
email: waucott@usgs.gov

Water-Resources Data Base

The Water Resources Division of the USGS, in cooperation with other local, State, and Federal agencies, collects a large amount of data pertaining to the water resources of Kansas each year. These data, accumulated during many years, constitute a valuable data base for developing an improved understanding of the water resources of the State. Water-resources information in the data base consists of stage, discharge, and water quality of streams; elevation and contents of lakes or reservoirs, water levels of ground-water wells, chemical quality of ground water and precipitation, and suspended-sediment data. For help in obtaining information from the USGS data base contact:

James E. Putnam
Chief, Hydrologic Data Management
U.S. Geological Survey
4821 Quail Crest Place
Lawrence, KS 66049-3839
(785) 832-3573
email:jputnam@usgs.gov

Near Real-Time Streamflow Information

Near real-time data for key USGS streamflow-gaging stations across Kansas are available on the Internet. Data in tabular and graphical format include stream stage or elevation referred to a gage datum and discharge or quantity of flow. These data may be accessed through the USGS-Kansas District home page at:

http://www-ks.cr.usgs.gov/

Maps

The USGS offers a wide variety of maps for sale. Topographic maps, image maps, thematic maps are but a few of the selections offered. USGS topographic maps for the State of Kansas may be purchased from:

Kansas Geological Survey
1930 Constant Avenue-Campus West
Lawrence, KS 66047–3726
(785) 864-3965

or

U.S. Geological Survey
Information Services, Box 25286
Denver, CO 80225
1 (800) HELP-MAP
To order by fax:(303) 202-4693

Digital Geographic Spatial Data

For many years the USGS has jointly funded and produced maps and, more recently, computerized (digital) geographic data products in cooperation with State and Federal governmental agencies in Kansas. Geographic spatial data compilation for Kansas has resulted in a myriad of geographic information system (GIS) uses for addressing various natural-resources, conservation, waste-disposal, emergency, hazard, and other environmental and societal issues. For information on the availability of digital, geographic spatial data for Kansas contact:

Kansas Geographic Information Systems
Data Access and Support Center
Kansas Geological Survey
1930 Constant Avenue-Campus West
Lawrence, KS 66047
(785) 864-3965 ext. 347
fax: (785) 864-5317
email: nelson@kgs.ukans.edu

or visit the USGS Geospatial Data home page:

http://mcmcweb.er.usgs.gov/

Earth Science Information and Sales

Earth Science Information Centers (ESICs) offer nationwide information and sales service for USGS map products and earth-science publications. These ESICs provide information about geologic, hydrologic, topographic, and land-use maps, books, and reports; aerial, satellite, and radar images and related products; earth-science and map data in digital format and related applications software; and geodetic data.

For further information contact one of the following ESICs or call 1-800-USA-MAPS:

Denver-ESIC
Box 25286, Building 810
Denver Federal Center
Denver, CO 80225
(303) 202-4200; fax: (303) 202-4188
email: infoservices@usgs.gov

Rolla-ESIC
1400 Independence Road, MS 231
Rolla, MO 65401-2602
(573) 308-3500; fax: (573) 308-3615
TDD* (573) 341-2716
email: mcmcesic@usgs.gov

Geologic Information

Kansas faces immediate and long-term problems of land use and land management, engineering construction, and future energy-resource potential. The State requires new sources of construction materials, new sources of water, and new sources

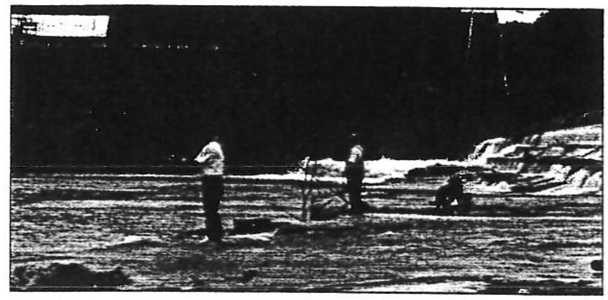
Current Kansas Stream and Lake Information Available on the Internet for Water Recreationists

USGS science for a changing world

U.S. Department of the Interior—U.S. Geological Survey

Water Data on the INTERNET

Near real-time water-level information is currently available on the INTERNET for 103 gaging stations on streams and 24 locations on lakes in Kansas. Monitoring stage and streamflow at these gaging stations, located at points along streams and lakes throughout the State, can tell boaters and other water sports enthusiasts using the river when conditions are favorable or unsafe. Instantaneous gage-height (stage) and discharge (streamflow) data are processed every 6 hours and more frequently during floods for each station.

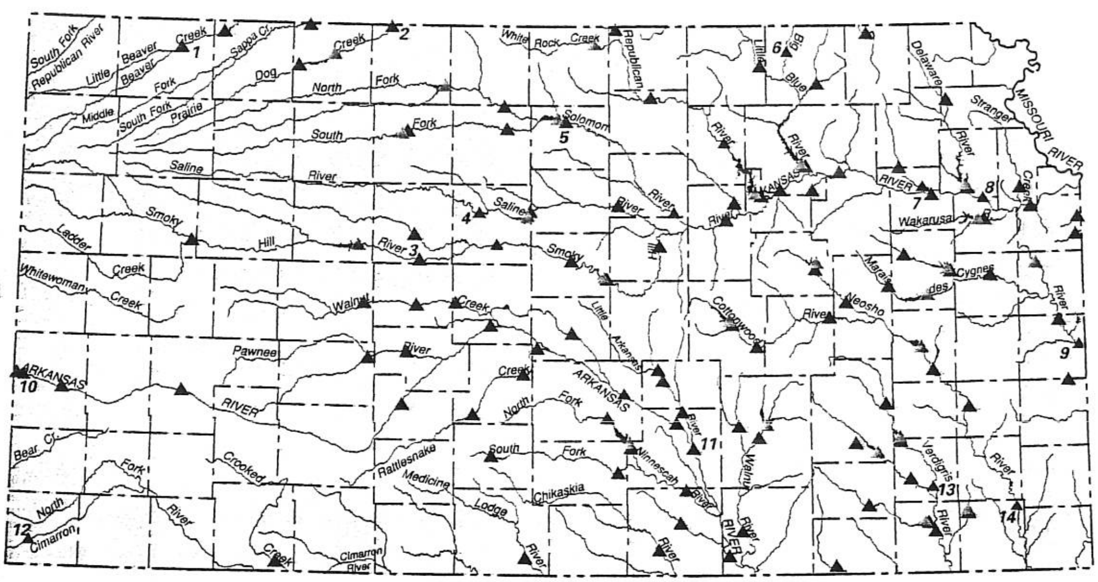


Fishing on the Kansas River below Bowersock Dam in Lawrence, Kansas.

These locations have near real-time stream and lake information available.

EXPLANATION

- 9▲ **Gaging station**—An example of real-time information for these stations is shown in table below. Number is map number used in table below
- ▲ **Gaging station**—Real-time information also available from these stations but not shown in table below
- ▲ **Lake gaging station**—Lake elevation and inflow and outflow real-time informaton available for twenty-four lakes and reservoirs operated by the USGS and the U.S. Army Corps of Engineers, Tulsa District



Example of near real-time data available on the INTERNET for selected stations in Kansas.

Map Number	Station Number	Station Name	Long-term median flow 08/19	Min Flow	Flood Stage	Most Current Water: Flow	Stage	Date	Time	Funding
1	06846000	BEAVER CREEK AT LUDELL	1.0	--	11	00	3.01	08/19	07:00	■■
2	06848500	PRAIRIE DOG CREEK NEAR WOODRUFF	1.8	--	18	20	4.15	08/19	04:00	■■
3	06862850	SMOKY HILL R BELOW SCHENCHEN	0	--	10	47	3.52	08/19	04:45	■■
4	06867000	SALINE RIVER NEAR RUSSELL	23	2	18	70	4.72	08/19	04:00	■■■
5	06875900	SOLOMON RIVER NEAR GLEN ELDER	75	--	21	50	7.91	08/19	04:30	■■
6	06882510	BIG BLUE RIVER AT MARYSVILLE	543	90	35	633	13.21	08/19	05:30	■
7	06889000	KANSAS RIVER AT TOPEKA	3280	--	26	2530	6.41	08/19	07:45	■
8	06891000	KANSAS RIVER AT LECOMPTON	3500	--	17	2700	3.19	08/19	07:00	■
9	06916600	MARIAS DES CYGNES R NR KS-MO LINE	125	--	25	910	3.17	08/19	05:30	■■■
10	07137500	ARKANSAS RIVER NEAR COOLIDGE	138	--	8	735	4.48	08/19	06:00	■■
11	07143375	ARKANSAS RIVER NEAR MAIZE	135	--	12	858	7.37	08/19	04:00	■■
12	07155590	CIMARRON RIVER NEAR ELKHART	0	--	11	82	3.28	08/19	07:15	■■
13	07166500	VERDIGRIS RIVER NEAR ALTOONA	41	--	23	128	3.05	08/19	05:15	
14	07183500	NEOSHO RIVER NEAR PARSONS	265	50	21	1720	8.96	08/19	05:00	■ ■

EXPLANATION

Source of funding by cooperative agency

- ■ Kansas Water Office (Funds from Kansas Water Plan)
- ■ U.S. Army Corps of Engineers, Kansas City District
- U.S. Army Corps of Engineers, Tulsa District
- ■ City of Wichita
- ■ Arkansas River Compact Administration
- ■ Kansas State Department of Agriculture, Division of Water Resources
- ■ City of Hays
- ■ U.S. Geological Survey

Streamflow—In cubic feet per second

Stage—Height of water surface above gage datum, a reference elevation, in feet

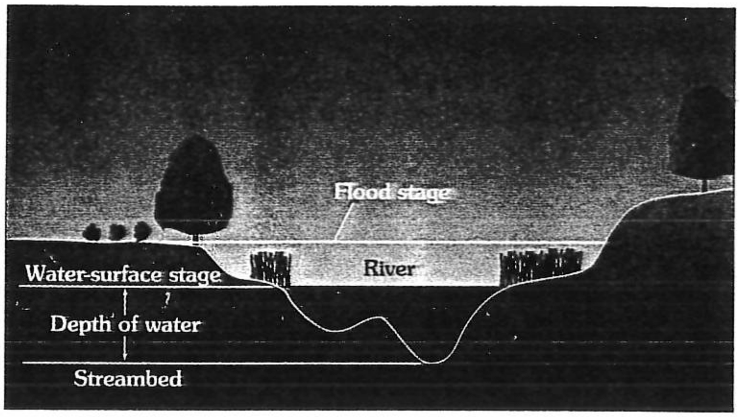
Min flow—In cubic feet per second. Minimum desirable streamflow provided by the Kansas Water Office

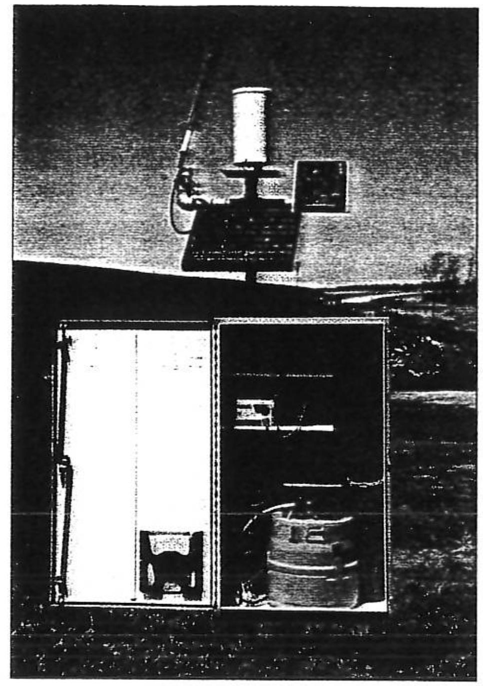
Flood stage—Level where stream begins to overflow its banks (from National Weather Service), in feet

Datum—Datum for each gaging station is shown on "complete station data" page. When datum is added to stage, the result is water surface elevation above mean sea level, in feet

Median—Middle value, half the historical streamflow values are above, half below

Instruments at the gaging station record continuous river stage. River stage is the height of the water surface above gage datum, a reference elevation. Flood stage is the level where the stream begins to overflow its banks. If the stage of the streambed is known and subtracted from the water-surface stage, then the result is the depth of water in the stream. Monitoring stage changes provides information to river users about river stage due to reservoir releases and significant rainfall.

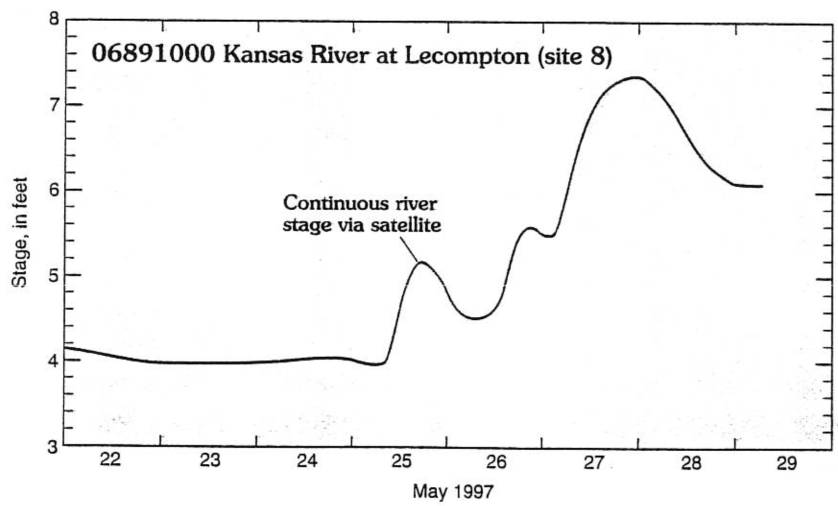




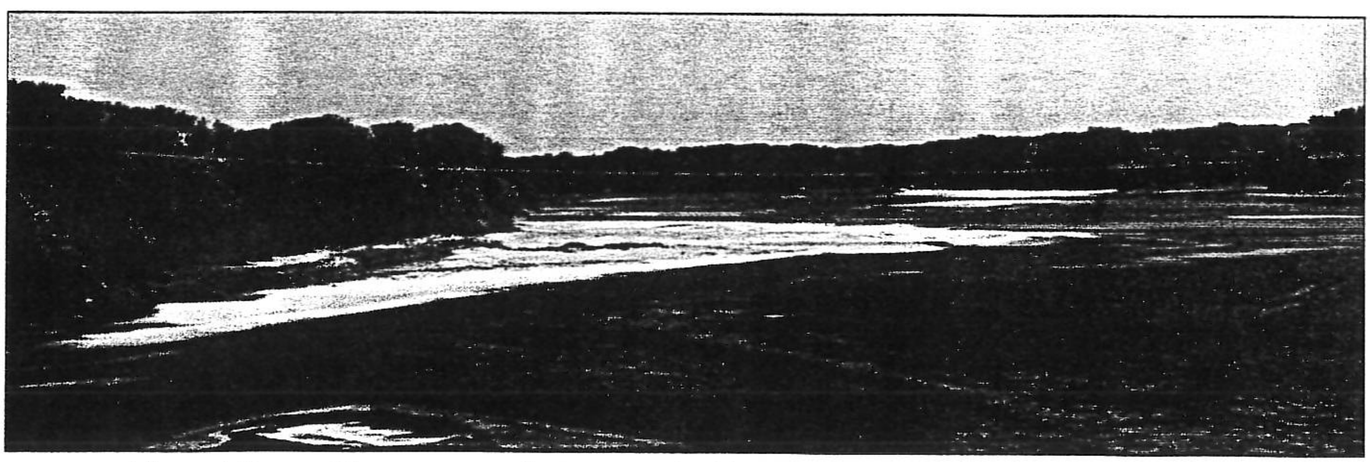
Typical USGS streamflow-gage house equipment used to transmit data from stream bank to satellite to the USGS office and onto the INTERNET.

Gage height graph

Knowledge of U.S. Geological Survey (USGS) stage-monitoring information like this stage data recorded in May 1997 for the Kansas River at Lecompton can make boating and other recreational activities on the river much safer and more enjoyable. If river stages are at or near flood conditions, the river may be unsafe. In contrast, when the river stages are indicated to be near the streambed, the stream may be too shallow or nearly dry in some places and may not be enjoyable for recreational activities.



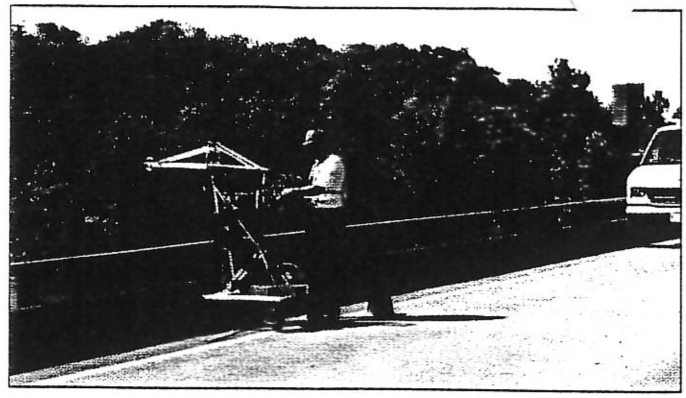
INTERNET record of stage data recorded May 1997 for Kansas River at Lecompton.



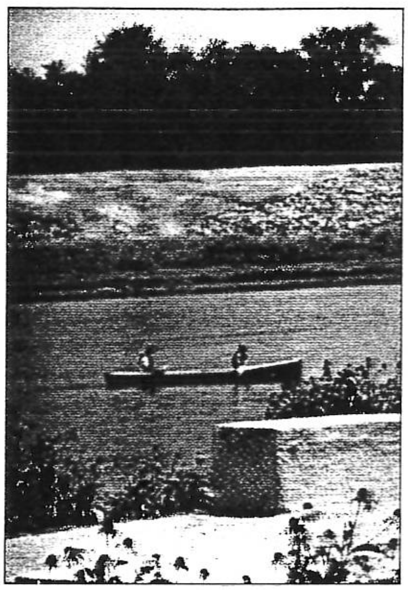
View of Kansas River near medium stage, looking upstream from the Lecompton bridge.

Streamflow measurments define gage height-discharge relation.

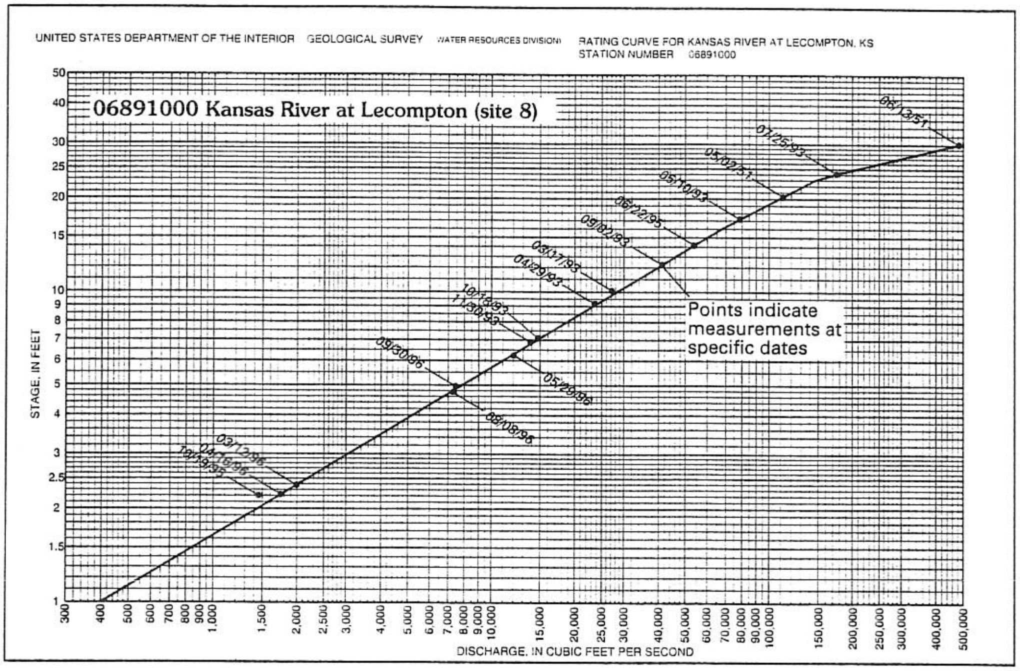
USGS technicians measure discharge or flow at all gaging stations on a routine schedule. Measurements of water depth and velocity are made at approximately 30 locations across the stream. The distance between measurement locations (width), the speed of the water (velocity), and water depth are multiplied to compute discharge (or streamflow) in cubic feet per second (ft^3/s). Many of these measurements made over the range in stage of the stream are plotted against the corresponding stages to define the stage-discharge relation that is used in conjunction with the recorded stage to determine continuous discharge throughout the year.



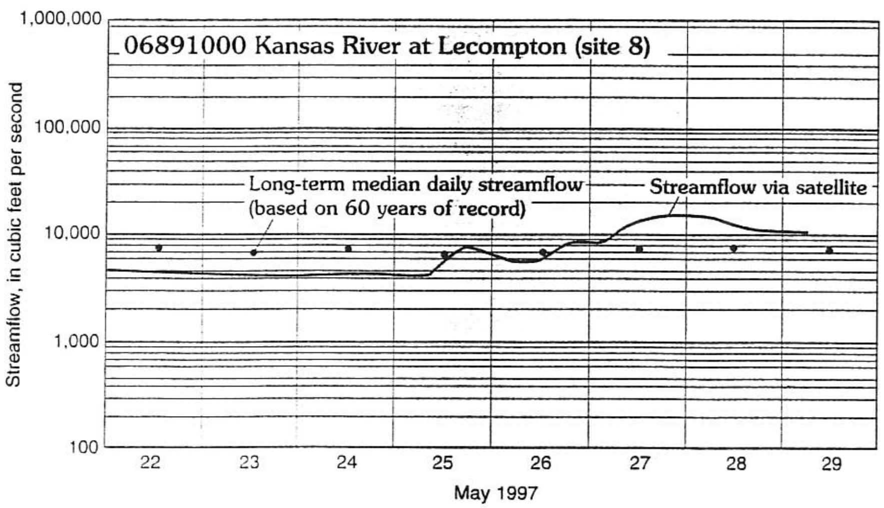
USGS technician measuring discharge on the Kansas River at Lecompton.



Canoeist enjoying the Kansas River at Burcham Park in Lawrence, Kansas.



Stage-discharge relation for Kansas River at Lecompton.



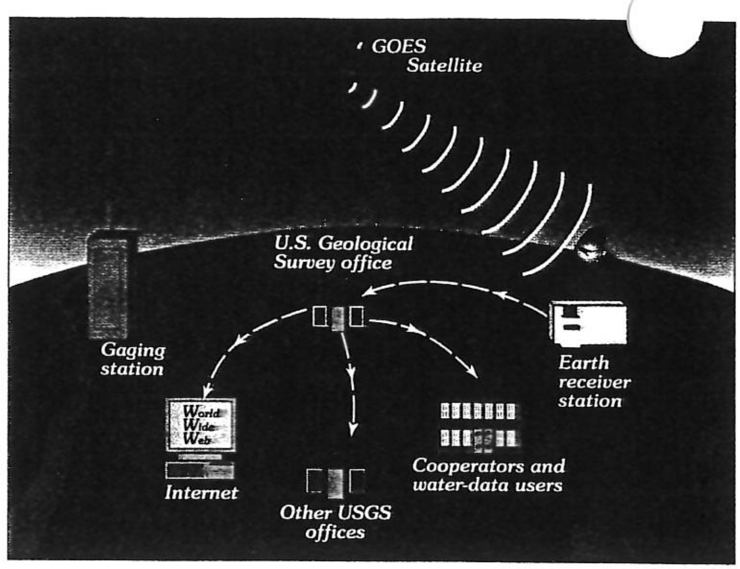
Hydrograph of flow for Kansas River at Lecompton from INTERNET.

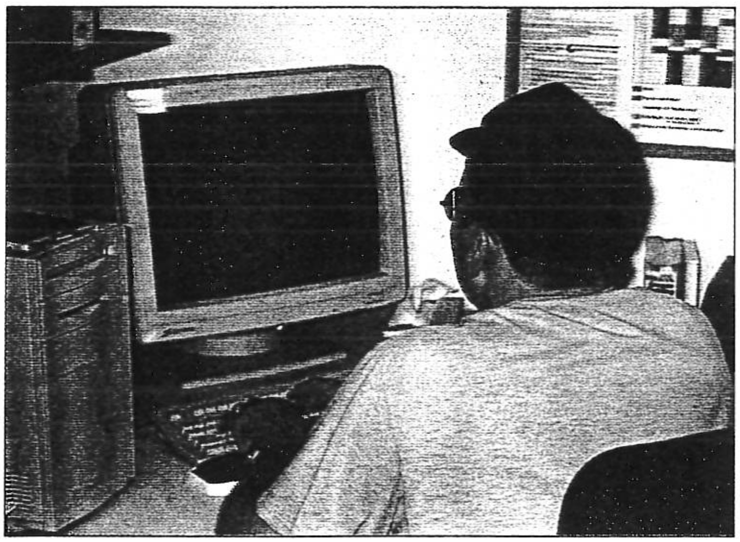
Discharge graphs

Continuous discharge information at gaging stations, like this "hydrograph" of the flow of the Kansas River at Lecompton, is useful to boaters and other recreational users. Because discharge is related to stream velocity, those experienced with the river can relate discharge information to how fast the water is moving down the stream. For example, veteran boatmen on the Kansas River have been able, through experience, to determine a relationship between the river's discharge and good or poor boating conditions.

USGS provides real-time stream and lake information

Access to USGS real-time water-level information on the INTERNET is made possible by satellite links with USGS offices. Recorded stage data are transmitted around the clock from gaging stations to one of two Geostationary Operations Environmental Satellites (GOES) that are positioned at an altitude of 22,300 miles above the equator. The satellites are operated by the National Oceanic and Atmospheric Administration (NOAA). These water-level data are relayed to ground stations and the signal is transmitted on to the USGS. The stage data are processed with the stored stage-discharge relation to compute continuous streamflow (discharge). This automated telemetry provides water-data users with provisional stage and streamflow information in a timeframe that meets recreational and water management needs.





Near real-time water-level data can be accessed easily though your internet connection.

The technology also permits the USGS field offices to monitor the operation of the hydrological stations continuously, time visits to stations to coincide with times of maximum need for data (such as during floods), and to service equipment at the stations.

Other water resources information such as publications, historical streamflow data, and research in the Kansas District USGS are available at this site.

Many organizations are linked to the USGS and use its data regularly. Streamflow data are important for reservoir operation, flood warning and forecasting, design of bridges and flood-control structures, water-supply development and management, flood-plain regulation and insurance purposes, water-rights administration, as well as recreational activities. Because of its importance, funding for gaging stations operated by the USGS in Kansas is provided by the Kansas Water Office (using State Water Plan funds), the U.S. Army Corps of Engineers, the USGS, and to a limited extent by many other State and local agencies.

—James E. Putnam

Surfin' the Net' for Kansas Stream and Lake Information

Starting address is **http://www-ks.cr.usgs.gov/**

Choose from these options on INTERNET homepage:

1. Current Streamflow Conditions--
   Then click on station name to get stage graph page. Four options are:
   a. Streamflow hydrograph (discharge Graph)
   b. Complete station data (previous years daily discharge
   c. Historical and peakflow data (annual floods for periods of record)
   d. Map of area surrounding the gaging station (can zoom in or out)
2. Current Streamflow Conditions Map--
   Then click on station location to get stage graph and get options a, b, c, and d above.
3. Lakes and Reservoirs--
   Then click on lake or reservoir name for individual lakes (format varies) or Corps of Engineers report for Missouri or Arkansas River Basin Reservoirs

The USGS is a member of the Kaw Valley Heritage Alliance and through this partnership responds to the needs of water-resource interests in the Kansas River Valley. People with recreational interests also can access this data from another Kaw Valley Alliance partner, the Kansas Canoe Association's INTERNET address (http://www.kansas.net/~tjhittle) and then link to the USGS.

For additional information contact:

U.S. Geological Survey
4821 Quail Crest Place
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(785) 842-9909
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Major Components of Flow in the Republican River During Drought Conditions from Near Hardy, Nebraska, to Concordia, Kansas

Background

Streamflow in the Republican River from the Nebraska-Kansas stateline to Milford Lake, Kansas (fig. 1), was below normal from March 1988 through June 1992 because of drought conditions in the river's drainage basin and probably because of increased ground- and surface-water usage. The Republican River is the main source of inflow to Milford Lake; water released from Milford Lake may be used for industrial, municipal, and agricultural purposes and for maintenance of instream uses. Therefore, any loss of flow in the Republican River decreases the amount of water available to replenish storage in Milford Lake for downstream uses and may, if the losses are large enough, cause flow to fall below the minimum desirable streamflow (MDS) requirement at Concordia, Kansas, set by Kansas law K.S.A. 82a–703a.

Following the droughts and floods of the 1930's, the Bureau of Reclamation (BOR) and U.S. Army Corps of Engineers began construction of a series of dams and surface-water irrigation networks intended to reduce flooding and to provide water for agriculture. The Kansas Bostwick Irrigation District (KBID) (fig. 1), which was built by BOR and began operation in the study area in 1958, receives most of its water from requested releases from Harlan County Dam in Nebraska; Harlan County Dam, which was completed in 1952, generally does not release water unless it is requested by an irrigation district or precipitation is abundant. The releases for the KBID flow down the Republican River and are diverted at Guide Rock, Nebraska, by the Superior-Courtland Diversion Dam (completed in 1952) into the Courtland Canal, which transports the water to Lovewell Reservoir in Kansas. Lovewell Reservoir, which was completed in 1957, generally does not release water unless it is requested by the KBID or precipitation is abundant. Water released from Lovewell Reservoir for use by the KBID is distributed by a network of canals that begins just upstream of the gaging station on White Rock Creek at Lovewell. The lands irrigated by the KBID in the study area are the flat to gently rolling uplands west of the Republican River that are drained by Buffalo and White Rock Creeks and part of the valley east of the river (fig. 1).

This fact sheet briefly summarizes the preliminary results of a study by the U.S. Geological Survey (USGS) to quantify those components that have the most effect on streamflow in the Republican River during drought conditions from near Hardy, Nebraska, to Concordia, Kansas. A water budget describing the hydrologic system of flow in this section of the Republican River was developed using these major components of flow. Monthly estimates of the major components of flow are compared to monthly water-budget estimates, and monthly water-budget estimates are compared to measured streamflow in the Republican River at Concordia, which is at the downstream end of the study area. A companion study of flow from Concordia to Clay Center, Kansas, is being conducted by the Kansas Geological Survey.

The drought period from March 1988 through June 1992 was chosen for study to take advantage of the hydrologic and water-use data available for this period. Monthly major-component and water-budget estimates were quantified using data available from the BOR, the KBID, the Kansas Department of Agriculture, Division of Water Resources (DWR), and the USGS. The monthly interval was chosen as a compromise among the varying intervals (daily to annual) of the available data.

This study was done in cooperation with the Kansas Water Office and supported in part by the Kansas State Water Plan Fund.

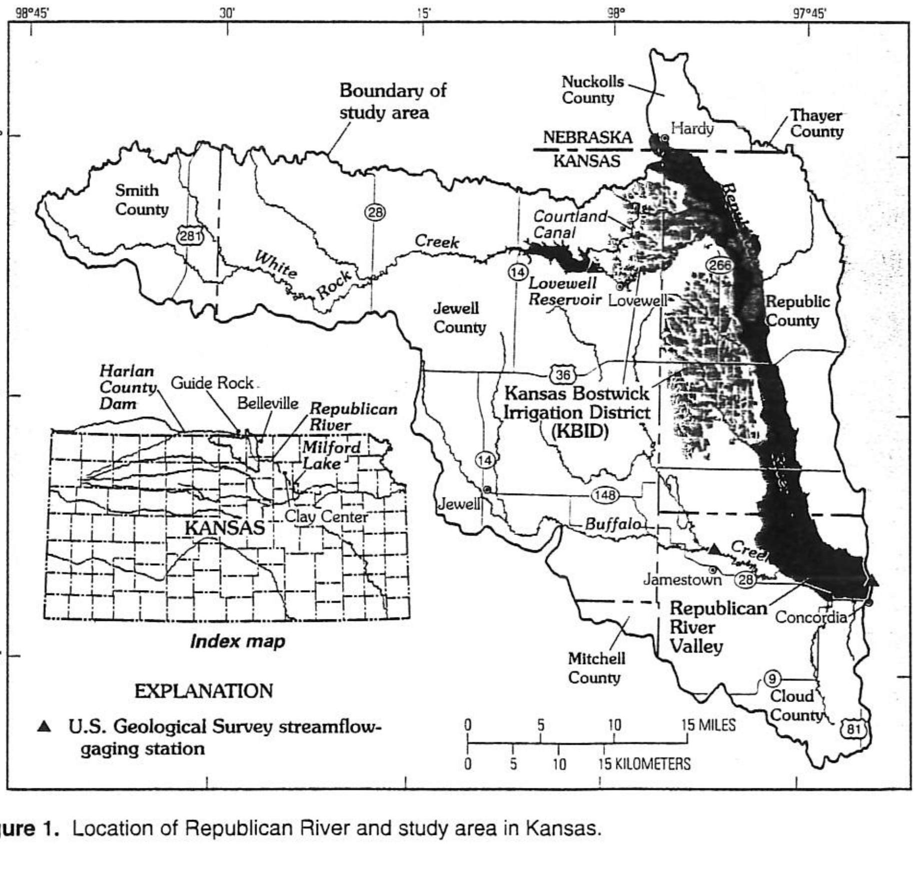


Figure 1. Location of Republican River and study area in Kansas.

Droughts

Climate is of great importance in the study area because most of the area's economy is dependent on raising crops and livestock. The climate of the study area is subhumid (Kansas Water Resources Board, 1961, p. 27), with average annual precipitation (1951–80) ranging from 25 to 29 inches per year from west to east (Hedman and Engel, 1989). Recorded annual precipitation at a long-term weather station at Belleville, Kansas, has varied from 11.79 inches in 1934 to 49.46 inches in 1993 (fig. 2). This unpredictability and lack of precipitation in some years has led to poor crop yields or crop failures in the study area.

Droughts occur when precipitation is less than average for several consecutive years (Clement, 1991, p. 288). The data in figure 2 and table 1 show the two regional droughts during 1929–41 and 1952–57 identified by Clement (1991) and the drought during 1988–92. Continuous precipitation and streamflow data before 1931 are not available for sites in or near the study area. Figure 2A and table 1 show that, although precipitation amounts at Belleville, Kansas, were similar during the three droughts, streamflow in the Republican River near Hardy, Nebraska, generally decreased after Harlan County Dam was completed in 1952.

Although precipitation was greater during the drought of 1988–92 than during the drought of 1952–57 (figs. *2B* and *2C*, table 1), streamflow was less near Hardy, Nebraska, and at Concordia, Kansas (table 1), during the 1988–92 drought. The decrease in streamflow may be due in part to diversion of water from the Republican River upstream of Hardy for use by the KBID and other irrigators. Streamflow gains between the gaging stations near Hardy, Nebraska, and at Concordia, Kansas, during the 1988–92 drought were almost double the gains during the 1952–57 drought (table 1). The larger streamflow gains during the 1988–92 drought probably were caused by canal return flows from the KBID, which did not begin full operation until 1958. At times during the 1952–57 and 1988–92 droughts, the streamflow at Concordia, Kansas, was less than the MDS. Streamflow at Concordia, Kansas, during September through November 1991 was much less than the MDS than at any time during the drought of 1952–57 (compare figs. 2B and 2C).

Components of Flow

Components that contribute or remove water from a hydrologic system can be estimated as part of a water budget, which can be used to describe the system. Components that contribute water to the hydrologic system of the study area from outside the area are the Republican River itself, the Courtland Canal, and the movement of ground water through the adjacent aquifer. Within the study area, precipitation is the main source of water to the hydrologic system. For example, precipitation may fall directly into water bodies; move by overland flow into tributaries, canals, or the Republican River; or infiltrate into the ground where it may be used by plants or continue down to the water table (fig. 3). Evaporation from water bodies and the land surface and evaporation and transpiration (evapotranspiration) by plants remove water from the hydrologic system within the study area, whereas the Republican River itself and ground-water movement through the adjacent aquifer remove

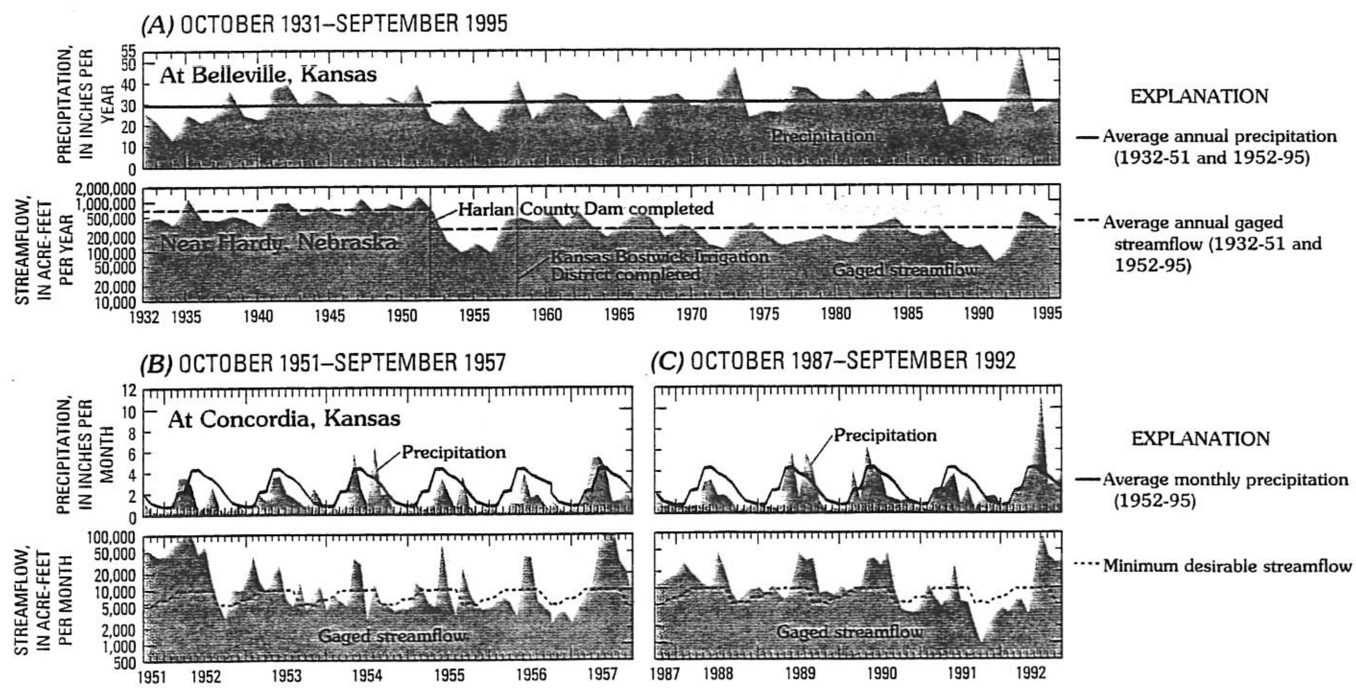


Figure 2. Precipitation and gaged streamflow in the study area: *A*, Average annual, October 1931–September 1995; *B*, Average monthly, October 1952–September 1956; *C*, Average monthly, October 1987–September 1992. (Sources: precipitation data from National Climatic Data Center, Asheville, North Carolina, 1996; streamflow data from U.S. Geological Survey, Lawrence, Kansas, 1996)

Table 1. Comparison of average annual precipitation and streamflow during three drought and three reference periods in the study area

[Precipitation is average annual precipitation in inches per year; streamflow is average annual streamflow in acre-feet per year; --, no data; purple shading indicates drought periods. Precipitation data from National Climatic Data Center, Asheville, North Carolina, 1996. Streamflow data from U.S. Geological Survey, Lawrence, Kansas, 1996]

Environmental factors and locations	Time periods					
	1932–1941	1942–1951	1952–1957	1958–1987	1988–1992	1993–1995
Precipitation						
Belleville, Kansas	24.97	32.74	23.12	31.87	24.15	36.97
Concordia, Kansas	--	--	18.89	29.42	24.25	32.76
Streamflow						
Near Hardy, Nebraska	517,784	763,296	238,863	273,253	100,662	407,018
Concordia, Kansas	--	--	285,488	450,245	184,036	790,029

water from the system to outside the study area. Water diverted within the study area by humans may be consumed and removed from the system, but some of the diverted water may be returned to the system by infiltration to the water table or through discharges into tributaries, canals, or the Republican River.

The water budget used in this study describes flow in the Republican River only and not the hydrologic system of the entire study area. Therefore, not all components that contributed water to or removed water from the study area (fig. 3) were considered part of the water budget describing the flow in the Republican River. Water that enters or leaves the Republican River in the study area through tributaries or canals, through exchange of water between the aquifer and the river by streambed seepage, or through use by humans were considered to be major components of flow to the Republican River and were used in the water budget. Other components of flow were considered minor and were not used in the water budget because they are included within the major components or are small in comparison. For example, most of the precipitation that falls within the study area becomes part of other components (for example, flow in tributaries) before it reaches the Republican River and, therefore, is accounted for in the contributions made by the major components; the remaining precipitation that falls directly on the Republican River is small and was ignored. Other minor components were evaporation from water bodies and the land surface, evapotranspiration from plants, and infiltration to the water table from all sources other than seepage across the streambed of the Republican River (fig. 3).

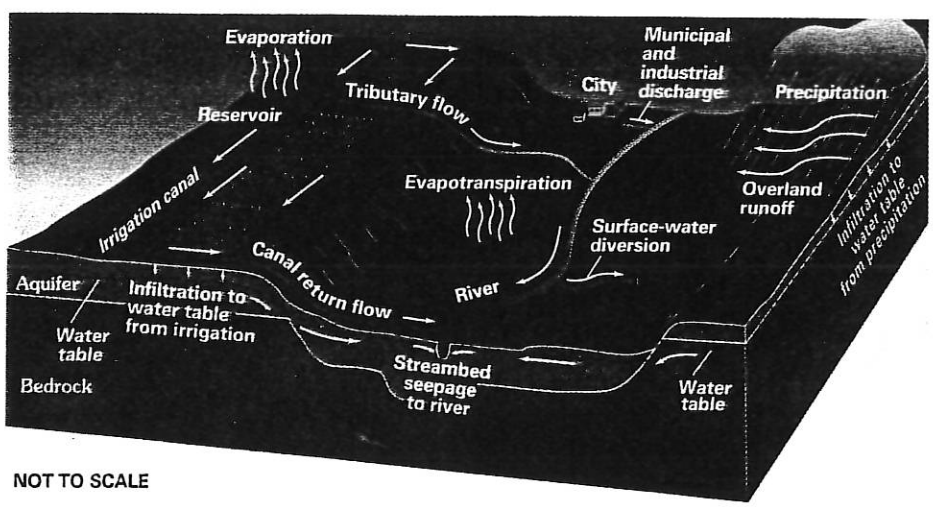
Water-Budget Estimates

Each of the components of flow used in the water budget were quantified on a monthly basis for the drought period during March 1988 through June 1992. These quantified components then were combined to make monthly estimates of flow in the Republican River at Concordia, Kansas, during this drought period. The water budget and major components of flow used to describe flow in the Republican River in the study area are ***upstream flow*** near Hardy, Nebraska, plus ***tributary flow*** (including municipal and industrial discharges), plus ***streambed seepage***, plus ***canal return flow***, minus ***surface-water diversions***.

Upstream flow data were collected and measured by the USGS at a streamflow gaging station near Hardy, Nebraska. These data provided a measurable inflow for purposes of the water budget. Because water in the Republican River takes about 1 day to travel from the gaging station near Hardy, Nebraska, to the gaging station at Concordia, Kansas, the upstream flow used was for the day previous to that measured at Concordia.

Tributary flow includes streamflow data collected and measured by the USGS at gaging stations on White Rock Creek at Lovewell, Kansas, and on Buffalo Creek near Jamestown, Kansas; estimates of ungaged flow, which were made on the basis of statistical methods; and discharge of water from municipal and industrial sources. Monthly discharge from municipal and industrial sources was estimated from annual discharge values and monthly diversion values reported by the municipality or industry to the DWR.

Streambed seepage is defined in this study as the increase or decrease of flow in the Republican River from seepage between the aquifer and the river. Streambed seepage was estimated using the com-



NOT TO SCALE

Figure 3. Components of flow in the study area.

puter program BFI4 (Wahl and Wahl, 1995) that computes daily streambed seepage from average daily streamflow. The average daily streamflow data collected and measured by the USGS at gaging stations at Concordia, Kansas, and near Hardy, Nebraska, were used as input to the program. The BFI4 program uses streamflow hydrograph-separation techniques to estimate the part of the flow in an unregulated stream that is from streambed seepage. The Republican River is regulated by Harlan County Reservoir. Under low-flow conditions, releases from Harlan County Reservoir typically are fully diverted into the Courtland Canal at Guide Rock, Nebraska. Therefore, for the purposes of this study, the Republican River can be considered to begin immediately downstream of the Guide Rock diversion (Thomas Stiles, Kansas Water Office, oral commun., 1996). Under these conditions, the Republican River in the study area may be viewed as unregulated and suitable for application of the BFI4 program. The amount of streambed seepage to and from the Republican River was estimated as the BF14 results for the gaging station near Hardy, Nebraska, subtracted from the BF14 results for the gaging station at Concordia, Kansas, after compensating for a 1-day traveltime.

Table 2. Monthly water-budget estimates of flow in the Republican River from near Hardy, Nebraska, to Concordia, Kansas, compared to measured downstream flow and minimum desirable streamflow at Concordia, Kansas, during October 1990 through May 1992

[All values are in acre-feet. Minimum desirable streamflow from Kansas law K.S.A. 82a-703a. Blue shading indicates critical irrigation period; purple shading indicates peak of drought period]

Year	Month	Upstream flow +	Tributary flow +	Streambed seepage +	Canal return flow −	Surface-water diversions =	Water-budget estimate of downstream flow	Measured downstream flow at Concordia, Kansas	Minimum desirable streamflow at Concordia, Kansas
1990	October	2,150	203	1,715	0	0	4,068	3,955	5,227
	November	2,138	286	1,197	0	0	3,621	3,495	4,760
	December	2,172	293	1,197	0	0	3,662	3,420	6,149
1991	January	3,800	549	1,573	0	0	5,923	5,260	6,149
	February	8,255	1,985	637	0	0	10,877	11,151	6,942
	March	4,274	1,665	2,265	0	0	8,204	6,538	9,223
	April	2,313	3,320	1,567	0	0	7,200	4,514	8,926
	May	5,361	6,083	1,627	0	0	13,072	6,849	9,223
	June	14,236	6,458	2,687	1,096	1,360	23,117	26,918	8,926
	July	3,320	210	2,286	2,655	3,756	4,715	5,435	9,223
	August	3,600	156	1,522	1,264	1,360	5,183	5,282	9,223
	September	920	151	26	0	0	1,097	1,864	4,760
	October	1,033	129	-199	0	0	964	895	5,227
	November	1,333	88	494	0	0	1,914	2,021	4,760
	December	1,595	134	1,169	0	0	2,897	3,013	6,149
1992	January	2,075	231	2,120	0	0	4,427	4,267	6,149
	February	1,551	185	1,923	0	0	3,659	3,550	6,942
	March	4,417	580	1,933	0	0	6,930	5,794	9,223
	April	3,739	753	2,208	0	0	6,700	5,798	8,926
	May	1,835	271	1,296	0	0	3,402	3,148	9,223
	Total	**70,117**	**23,730**	**29,243**	**5,015**	**6,476**	**121,632**	**113,167**	**145,330**
Monthly average		**3,506**	**1,186**	**1,462**	**251**	**324**	**6,082**	**5,658**	**7,266**

Canal return flow data were collected and measured by the KBID and BOR at discharge gates at the end of canals in the KBID. Canal return flow from the KBID to the Republican River generally occurs only during the months that irrigation is allowed in the district (June through September). Although irrigation does not occur in all 4 months during all years, canal return flow has occurred in July and August every year since 1958.

Surface-water diversions, the amount of surface water removed (diverted) by humans, were estimated from annual water-use data reported to DWR by the users. The only uses for which surface water was diverted in the study area were irrigation and recreation. Many of the diversions (including the large diversions to and from Lovewell Reservoir for the KBID) were upstream from the gaging stations on White Rock Creek at Lovewell or on Buffalo Creek at Jamestown; these diversions already are accounted for in the tributary or canal-return-flow components. Only diversions from tributaries and canals in the ungaged part of the study area or from the Republican River in the study area were considered to be part of this component. All water from these surface-water diversions was used for irrigation. The annual surface-water irrigation-use data for these diversions were divided into monthly data in the same ratios as the monthly irrigation data available from the KBID.

Comparison of Water-Budget Estimates

Three important periods within the March 1988 through June 1992 drought were identified. The first period was when measured streamflow at the gaging station at Concordia, Kansas (downstream flow), commonly was less than the MDS (October 1990 through May 1992). The second period was at the peak of the drought when downstream flow was extremely low (September and October 1991). The third period was the critical irrigation period (July and August 1991) when upstream and downstream flow was low and irrigation demand was high. Annual precipitation at Concordia, Kansas, was 70, 37, and 49 percent of average (1952–95), respectively, during these three periods. Table 2 shows the monthly estimates of the major components of flow and the water-budget estimates for October 1990 through May 1992 (which includes peak of the drought and critical irrigation periods). Measured downstream flow and MDS are included in table 2 for comparison purposes. Each month's water-budget estimate of downstream flow can be compared with the monthly measured downstream flow (table 2). Table 3 shows comparison of estimates of each of the major components of flow and of mea-

Table 3. Comparison of major components of flow and downstream flow to water-budget estimates of downstream flow during important periods in 1988–92 drought

[MDS, minimum desirable streamflow at Concordia, Kansas (Kansas law K.S.A. 82a–703a). Components of flow may not add up to 100 percent due to errors in estimation]

Major component	Component as a percentage of water-budget estimate of downstream flow			
	Period with downstream flow generally less than MDS (October 1990–May 1992)		Peak of drought period (September–October 1991)	Critical irrigation period (July–August 1991)
	Monthly range	Monthly average	Monthly average	Monthly average
Upstream flow	32 to 107	58	95	70
Tributary flow	3 to 46	20	14	4
Streambed seepage	-21 to 52	24	-8	38
Canal return flow	0 to 56	4	0	40
Surface-water diversions [1]	0 to 80	5	0	52
Measured downstream flow	52 to 170	93	134	108

[1]Diversions are removals of water from the system and are substracted when combining the major components of flow to make the water-budget estimates.

sured downstream flow to the water-budget estimates of downstream flow during each of the three periods identified within the March 1988 through June 1992 drought.

Upstream flow is generally the largest contributor to the water-budget estimates. Even during the period from October 1990 through May 1992 when upstream flow was only about 16 percent of average (1952–95) and downstream flow commonly was less than the MDS, upstream flow typically contributed more than one-half and averaged about 58 percent of the water-budget estimates (tables 2 and 3). During the peak of the drought (September and October 1991), upstream flow was only about 4 percent of average (September and October 1952–95), but its contribution to the water-budget estimates increased to about 95 percent. During the critical irrigation period (July and August 1991), upstream flow was about 13 percent of average (July and August 1952–95) and contributed about 70 percent of the water-budget estimates.

Tributary flow can be a major contributor to the water budget, especially when evapotranspiration is low (winter and early spring) or when precipitation is consistently about 2 or more inches per month (for example, April through June 1991). However, during October 1990 through May 1992, tributary flow commonly was less than 10 percent of the water budget but averaged about 20 percent due to large contributions in some months (tables 2 and 3). Tributary flow averaged a little less, about 14 percent of the water-budget estimates, during the peak of the drought. However, during the critical irrigation period, the contribution of tributary flow was very small, averaging only about 4 percent of the water-budget estimates. Although tributary flow can contribute substantial amounts of water to the water-budget estimates, it cannot be considered a reliable source of water during the critical irrigation months of July and August or during periods when precipitation is consistently less than about 2 inches per month.

Streambed seepage generally is positive, indicating that the Republican River is a gaining stream—that is, the ground water flows into the river from the adjacent aquifer because the water table is higher than the water level in the river (fig. 3; tables 2 and 3). A negative streambed-seepage value may indicate that this situation is reversed and that the water table in the adjacent aquifer is lower than the water level in the river causing the river to lose water to the aquifer (for example, October 1991, table 2). Streambed seepage averaged about 24 percent of the water-budget estimates during October 1990 through May 1992. However, during the peak of the drought when streamflow was very low in the Republican River, streambed seepage averaged -8 percent, indicating a loss to the adjacent aquifer. During the critical irrigation period, streambed seepage contributed about 38 percent of the water-budget estimates. Although streambed seepage can contribute substantially to the water-budget estimates during most of a drought, it cannot be considered a reliable source of water during periods of very low flow.

Canal return flow and *surface-water diversions* occur only during the irrigation season (commonly the months of June through September); therefore, they can seem to be insignificant components of the water-budget estimates if averaged over a period longer than the irrigation season. For example, canal return flow contributed about 4 percent to, and surface-water diversions removed about 5 percent from, the water-budget estimates if averaged over the period of October 1990 through May 1992; nothing was contributed to or removed from the water-budget estimates by these components during the peak of the drought (September and October 1991). However, during the critical irrigation period (July and August 1991), canal return flow contributed about 40 percent to and surface-water diversions removed about 52 percent from the water-budget estimates. The combination of these two components can be considered to show the effect of human use (irrigation) on the water-budget estimates in the ungaged part of the study area. In 10 out of the 15 months that irrigation is estimated to have occurred during the March 1988 through June 1992 drought, the combination of the canal return flow and surface-water diversions resulted in a small net contribution of about 1 percent to the water-budget estimates of downstream flow. However, during the 1991 irrigation season, the members of the KBID were restricted in their use of water, and surface-water diversions by other users were greater than in previous years. The combination of the canal return flow and surface-water diversions during July and August 1991 resulted in a net withdrawal of about 12 percent from the water-budget estimates.

Downstream flow data were collected and measured by the USGS at a streamflow-gaging station on the Republican River at Concordia, Kansas. These data provided a measurable outflow for comparison with the water-budget estimates. Downstream flow was about 16 percent of average (1952–95) during the drought period, and commonly was less than the MDS. Downstream flow decreased to about 4 percent of average (September and October 1952–95) during the peak of the drought period (table 2). Tables 2 and 3 show that although there was substantial disagreement between the water-budget estimates and downstream flow from month to month during October 1990 through May 1992, monthly water-budget estimates varied on average less than 10 percent from measured downstream flow during both the period when downstream flow commonly was less than the MDS and the critical irrigation period. However, during the peak of the drought period, measured downstream flow exceeded water-budget estimates of downstream flow by about one-third; this may be due to errors in estimating the tributary flow.

Conclusions

During the drought of March 1988 through June 1992, there were three important periods—the period when flow in the Republican River at Concordia, Kansas, commonly was less than the MDS (October 1990 through May 1992); the period at the peak of the drought when flow in the Republican River was very low (September and October 1991); and the critical irrigation period (July and August 1991).

During all three periods, the upstream flow was the most important and most reliable component of the monthly water-budget estimates. Upstream flow is considered the most important and reliable source of water to the Republican River, with its importance increasing as the drought worsens. Tributary flow was an important component of the water-budget estimates during the periods when downstream flow commonly was less than the MDS and when the drought peaked. However, it was not a significant component during the critical irrigation period and, therefore, is not considered a reliable source of water to the Republican River during drought periods. Streambed seepage was an important component of the water-budget estimates during the period when downstream flow commonly was less than the MDS and during the critical irrigation period. However, the value of this component can become negative, as it did during the peak of the drought period, resulting in removals from rather than contributions to the water-budget estimates. This indicates that streambed seepage is not always an available or reliable source of water to the Republican River because at times the river loses water to the adjacent aquifer. Canal return flow and surface-water diversions were small if averaged over the period when downstream flow was less than the MDS and were zero during the period at the peak of the drought; however, they accounted for large contributions to and removal from the water-budget estimates during the critical irrigation period. Although the combination of canal return flow and surface-water diversions commonly results in a net contribution to the water-budget estimates, when water usage by the KBID is restricted, as it was during the critical irrigation period, their combination may become negative and result in a net withdrawal. Therefore, canal return flows and surface-water diversions are each considered important components of the flow in the Republican River during irrigation seasons, but their combination may change from a net contribution to a net withdrawal of water from the river if water usage by the KBID is restricted.

Consideration of upstream flow, canal return flow, and surface-water diversions and how these components can be managed to minimize the effect of drought conditions may allow streamflow in the Republican River at Concordia, Kansas, to remain above the MDS and ensure an adequate supply of water to fulfill the needs of downstream users.

—*Cristi V. Hansen*

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