Approved: 5-1-98
Date

MINUTES OF THE SENATE COMMITTEE ON ENERGY AND NATURAL RESOURCES.

The meeting was called to order by Chairperson David Corbin at 8:30 a.m. on April 29, 1998 in Room 330-E of the Capitol.

All members were present except: Senator Schraad

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

Conferees appearing before the committee:
Jay Ham, Department of Agronomy, Kansas State University
Charles Rice, Department of Agronomy, Kansas State University
Lakshmi Reddi, Department of Civil Engineering, Kansas State University
Patrick Murphy, Department of Biological and Agricultural Engineering, Kansas State University

Others attending: See attached list

Chairperson Corbin called the meeting to order. The Kansas Center for Agricultural Resources and the Environment of K-State Research and Extension of Kansas State University presented an update and summary of the Evaluation of Lagoons for Containment of Animal Waste by Kansas State University (Attachment 1), and the slides are (Attachment 2). These minutes were prepared by Lila McClaflin, committee secretary, and they were submitted to members of the Committee for their approval.

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REPORT TO THE ENERGY AND NATURAL RESOURCES COMMITTEE, KANSAS SENATE AND ENVIRONMENT COMMITTEE, KANSAS HOUSE OF REPRESENTATIVES

29 April, 1998

Update and Summary of Evaluation of Lagoons for Containment of Animal Waste by Kansas State University

Principal Investigators

Dr. Jay Ham, Associate Professor of Agronomy Department
Dr. Pat Murphy, Professor, Department of Biological and Agricultural Engineering
Dr. Lakshmi Reddi, Associate Professor, Civil Engineering Department
Dr. Chuck Rice, Associate Professor, Agronomy Department

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KCARE

Senate Energy & Natural Res.
attachment 1
April 29, 1998
1/1

Executive Summary

Earthen storage lagoons are an integral part of the waste management and treatment system at many concentrated animal operations (CAOs) in Kansas. Lagoon waste contains significant concentrations of nitrogen, phosphorous, and other nutrients that are eventually applied to nearby farmland as liquid fertilizer. However, concerns have arisen that subsurface seepage losses from earthen lagoons could affect water quality in underlying aquifers. Therefore, research was initiated with the short-term objective of determining if lagoons built in accordance with Kansas regulations will keep seepage losses to less than 0.25 in./day, the recommended design standard. The long-term objectives of the project are to determine the relationship between seepage losses and groundwater quality. The initial research plan had four components: (1) a laboratory assessment of hydraulic conductivity (permeability) of several Kansas soils and the movement of water and animal wastes through those soils; (2) water balance studies of whole-lagoon seepage rates and waste chemistry at existing cattle feedlots and swine operations; (3) a preliminary survey of well-water quality in the vicinity of CAOs; and (4) a detailed review and summary of previous research conducted on seepage losses from earthen lagoons for animal waste. Research in these areas is ongoing and results presented here represent results to date, not final conclusions.

1. The laboratory study evaluated 22 soil samples covering a wide range of textures and physical properties. Permeability was measured using standard laboratory methods after unconsolidated soil samples were compacted at near-optimum water contents in 5-cm tall cores. The coefficient of permeability ranged from 4.95×10^{-7} to 4.8×10^{-9} cm/sec. If the soils analyzed were used to construct compacted liners 3 feet thick and subjected to a hydraulic head of 20 ft, the calculated seepage rates would lie between 0.13 to 0.0013 in./day. These data suggest that the existing standard of 0.25 in./day can be achieved with these soils provided field compaction is adequate and liner thickness is greater than 12 inches. When waste was used as the test fluid, the permeability of the soil cores tended to decrease with time but the effect was not pronounced or consistent. The waste used for the analysis was the liquid effluent, not the sludge that normally accumulates on the bottom of lagoons. Chemical and microbial analysis of leachate from the waste-permeated cores was highly variable. This will require additional study. Compaction characteristics of the samples showed that construction practices may strongly influence liner permeability.

2. Whole-lagoon seepage rates of three swine-waste lagoons and one cattle-feedlot runoff lagoon were measured using the water balance method. Seepage was calculated as the difference between evaporation and the change in water depth from data collected during periods when waste additions to the lagoons were precluded. Evaporation and depth changes were measured with automated floating lysimeters and water-level recorders developed specifically for the

experiments. The swine lagoons tested were built in the mid 1990s, ranged in size from 2 to 6 acres, and contained 16.5 to 19 ft of waste. Seepage rates from the three swine lagoons were 0.05, 0.08, and 0.02 in./day. Seepage from an older cattle-feedlot lagoon was 0.09 in./day when waste depth was 4 to 5 ft. Losses were below the recommended standard of 0.25 in./day, and evaluation of soil hydraulic properties indicated that some degree of sealing resulted from organic sludge on the bottom of the lagoons.

Analysis of waste from the field experiments showed that ammonium was the primary form of nitrogen in the effluent, averaging 684 mg/L in swine-waste lagoons and 140 mg/L in cattle-feedlot runoff lagoons. Data on waste chemistry were used in combination with measurements of whole-lagoon seepage to estimate the mass of nitrogen being lost through the soil liners.

3. Although the well-water analysis is limited and ongoing, the current sampling scheme indicates no widespread nitrate contamination of groundwater in the vicinity of CAOs. However, a more comprehensive sampling approach is needed to draw definite conclusions about spatial patterns of nitrate movement near lagoons and other sources of nitrogen.

4. A review of over 200 scientific papers shows that seepage losses from lagoons typically decrease rapidly during the first six months following the application of manure. The mat of organic sludge that accumulates on the bottom of the lagoon reduces liner permeability by the physical clogging of soil pores, with biological factors playing a minor role in the sealing process. Although measurements of whole-lagoon seepage rates are rare, available data show that seepage is typically less than 0.2 in./day in almost all cases after sufficient time for sealing has elapsed. However, there is evidence that most of the seepage is from the sides of the lagoon where the liquid surface meets the side-embankment. Lack of a sludge layer, coupled with erosion, pediogenesis, freezing-thawing, wetting-drying, and biological processes (roots, arthropods, etc.) can increase the permeability in this zone. It is likely that overall lagoon performance is the net result of extremely low permeability on the sludge-laden bottom zone coupled with an offsetting higher permeability of the side embankments. In the review of literature, measurements of water quality near waste lagoons were highly variable. However, the majority of studies in medium to finer-textured soils found no appreciable nitrogen contamination in the groundwater within about 100 ft of the lagoons. Several studies conducted outside Kansas in coarse-textured soils with high water tables, however, found appreciable contamination and seepage. Regional and statewide studies of well-water samples found that nitrate concentrations in the groundwater were negligible, regardless of proximity to CAOs, when the depth to the water table was greater than 100 to 130 feet. Analysis of lagoon waste shows that 95% of the nitrogen is in the form of ammonium, and a large fraction of the leachate is absorbed in soil directly under the lagoon. A significant and potentially hazardous quantity of this stored nitrogen could be converted to the mobile nitrate form when the lagoons are dried or

abandoned. This finding points to the importance of developing a plan to reclaim the nitrogen beneath the lagoon after a facility is emptied or closed.

In summary, results provided in this report, coupled with a review of the literature, suggest that lagoons built in accordance with Kansas guidelines should have average seepage rates less than 0.25 in./day. Very low seepage rates (<0.1 in./day) can easily be achieved using 12- to 18-inch compacted soil liners built from appropriate soils. Questions remain concerning the relationships between seepage rates and groundwater quality. However, no widespread evidence of contamination in the vicinity of livestock operations is evident at this time. Locations with coarse-textured soils, low soil cation exchange capacities, and shallow water tables may require low-permeability soil liners or synthetic liners to protect local groundwater supplies. Given the variation in geology, soils, and types of animal operations in Kansas, decisions regarding lagoon permitting, construction, and management should consider both nitrogen input loading (e.g., nitrogen concentrations in the waste, liner performance, and seepage rates) and aquifer vulnerability (e.g., depth to groundwater, underlying soil hydraulic and chemical properties). Additional research on the fate and transport of chemicals beneath lagoons, coupled with risk analyses, will be required to tailor this approach for Kansas and surrounding states.

News & Features

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From Kansas State University's Agricultural Experiment Station and Cooperative Extension Service

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Mailed: April 29, 1998

K-State Releases Its Latest Report
On Animal Waste Lagoons

MANHATTAN--Kansas State University's latest report on animal waste lagoons holds encouraging news about the environment and good news for the state's growing livestock industry.

"Our report indicates animal waste containment lagoons built in accordance with present Kansas guidelines should have average seepage rates of less than .25 inches per day," said Jay M. Ham, K-State Research and Extension environmental physicist and associate professor of agronomy. "We also determined that very low seepage rates--less than .10 inches per day--are achievable if waste lagoons are built with a 12- to 18-inch thick compacted soil liner made from readily available Kansas soils.

The report also addresses concerns that lagoon seepage may affect groundwater.

"Our analysis of well water is limited and on-going, but our sampling indicates no widespread nitrate contamination of groundwater in the vicinity of concentrated animal operations (CAOs)," Ham added. "At the same time, we need to conduct more comprehensive sampling to determine how lagoon nitrates move in the soil and if other sources of nitrogen contribute to well-water contamination.

"Our laboratory study of 22 Kansas soil samples measured the permeability of compacted soil liners. The compaction characteristics of these soils show that field construction practices will strongly influence the permeability of soil liners."

Other KSU scientists involved in the ongoing effort are Charles Rice, associate professor of agronomy; Lakshmi Reddi, associate professor of civil engineering; and J. Patrick Murphy, professor and Extension state leader in biological and agricultural engineering. Several large livestock operations also participated in the research--allowing K-State scientists to collect 'real' data at their lagoon sites.

The researchers also measured whole-lagoon seepage rates of three swine waste lagoons and one cattle feedlot runoff lagoon. They calculated seepage as the difference between evaporation and the change in water depth during periods in which no new waste was added to the lagoons. The 2 to 6-acre swine lagoons tested were built in the mid-1990s and contained 16.5 to 19 feet of waste. Seepage from these lagoons ranged from .02 inches to .08 inches per day. Seepage from the cattle feedlot runoff lagoon containing 4 to 5 feet of waste was .09 inches per day.

"These seepage losses are below the recommended standard of .25 inches per day set by the Kansas Department of Health and the Environment (KDHE)," Ham said. "We also noted that organic sludge in the bottom of lagoons forms a mat which helps partially seal lagoon liners.

"Our analysis of multiple lagoon waste samples shows that ammonium is the primary form of nitrogen present in lagoons. Ammonium concentration in swine lagoon waste samples averaged 684 parts per million (ppm) and 140 ppm in the cattle feedlot lagoon waste sample."

-more-

In their review of more than 200 scientific papers, K-State researchers also found that most lagoon seepage occurs on the sides--where the liquid's surface meets the side embankment. The extremely low permeability of the sludge-sealed bottom liner is somewhat offset by the high permeability of the lagoon's sides.

"Still, our literature review of regional and statewide well water studies revealed negligible nitrate concentrations when the depth to the water table exceeded 100 to 130 feet--regardless of proximity to CAOs," Ham said. "A large fraction of the ammonium leachate is apparently absorbed by the soil directly under lagoons. Because this stored nitrogen could be converted to readily mobile nitrates when a lagoon is dried or abandoned, it is important that CAOs have a plan to reclaim this nitrogen after the lagoon is emptied or the facility closes."

"Common sense also tells us coarse-textured, sandy, highly permeable soils may be unsuitable for lagoon construction in areas with shallow water tables, unless a low permeability liner is used. Guidelines for lagoon permits, construction and management should consider nitrogen input loading (N concentration in waste, seepage, liner performance) and aquifer vulnerability (depth to groundwater, hydraulic and chemical properties of soils under lagoons)."

Ham said lagoon guidelines tailored to Kansas soil and water conditions should be based on more research into lagoon wastes (chemical composition, soil movement) and on groundwater risk analyses.

K-State's latest report is part of an ongoing scientific study on animal waste containment lagoons, coordinated by the Kansas Center for Ag Resources and the Environment (KCARE). The research should help determine whether present Kansas lagoon guidelines are adequate and identify ways to safeguard groundwater quality.

K-State Research and Extension is a short name for the Kansas State University Agricultural Experiment Station and Cooperative Extension Service, a program designed to generate and distribute useful knowledge for the well-being of Kansans. Supported by county, state, federal and private funds, the program has county Extension offices, experimental fields, area Extension offices and regional research centers statewide. Its headquarters are on the K-State campus in Manhattan.

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Tim W. McAlavy
Communications Specialist
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Environmental Quality
A,B,E,S
Call Bill Hargrove, KCARE director at 785-532-7103.

Evaluation of Lagoons for Containment of Animal Waste

Jay Ham, Department of Agronomy

Charles Rice, Department of Agronomy

Lakshmi Reddi, Department of Civil Engineering

Patrick Murphy, Dept. Of Biological and Agricultural Engineering

Main Objectives

Short- term

√ Determine if lagoons built and managed under existing guidelines will keep seepage rates below the recommended level of 0.25"/day.

Long-term

√ Quantify relationships between Seepage rates and groundwater quality

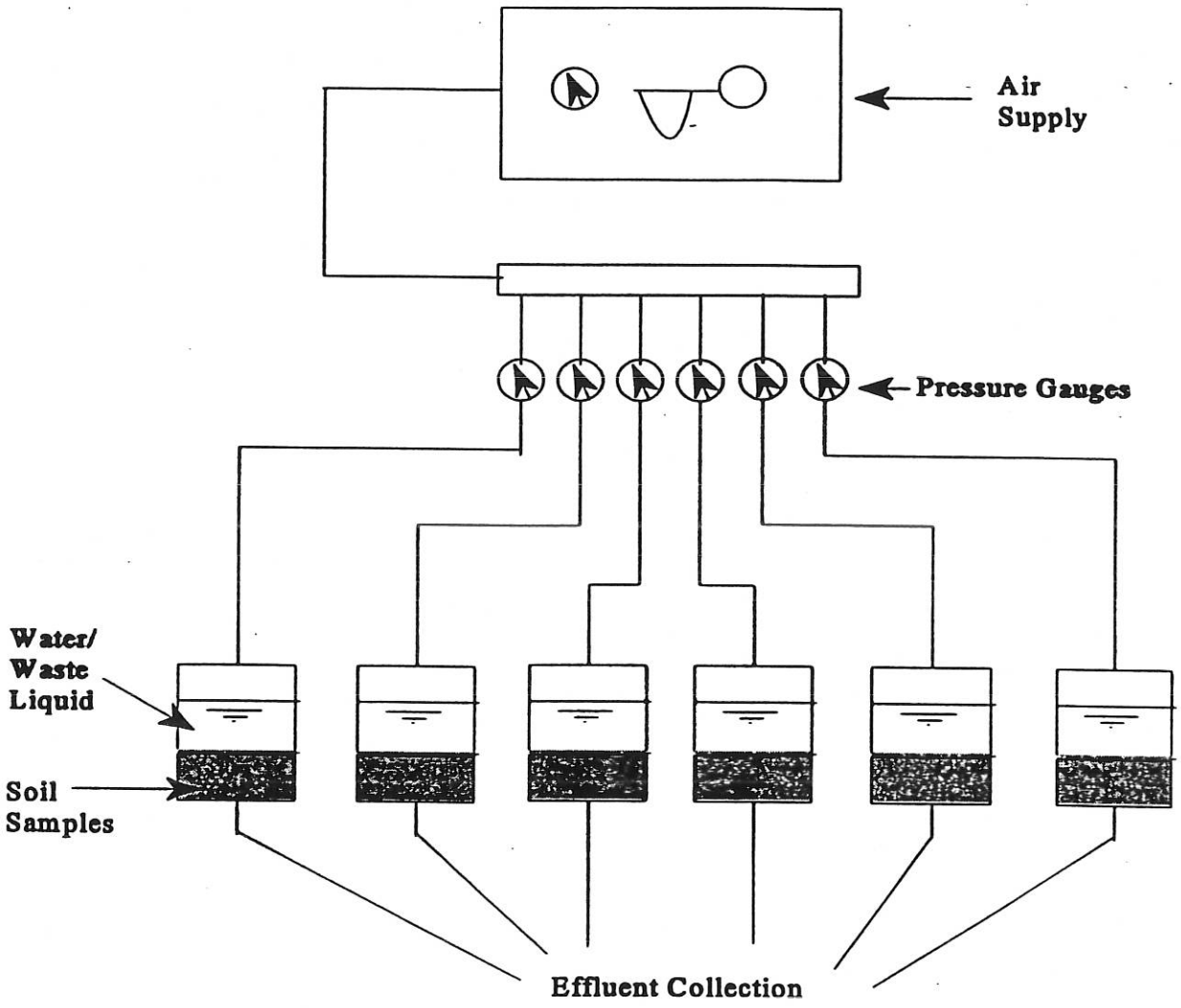
Research Thrusts and Priorities

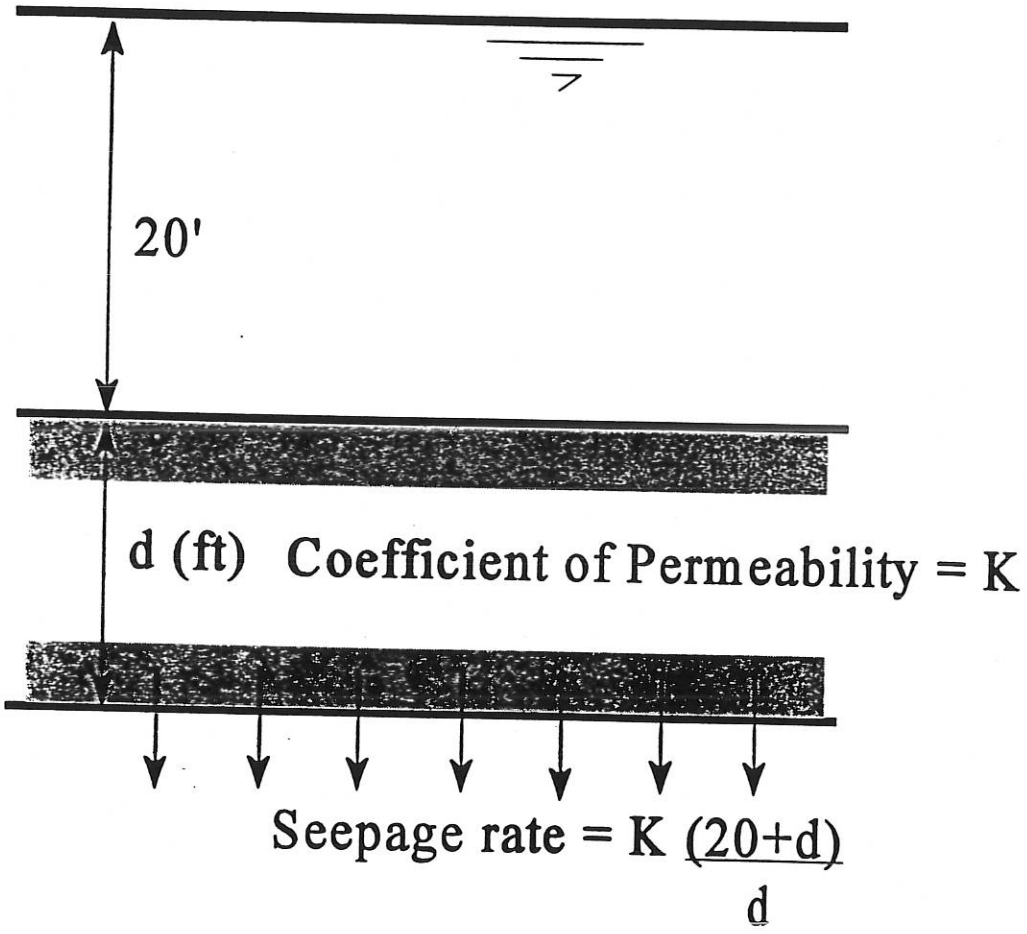
√ **Field Research**
Measurements on Existing Lagoons

√ **Laboratory Analysis**
Permeability of Kansas soils

√ **Water Survey**
Well-water Study

√ **Review of Previous Research**


Air
Supply
Pressure Gauges
Water/
Waste
Liquid
Soil
Samples
Effluent Collection

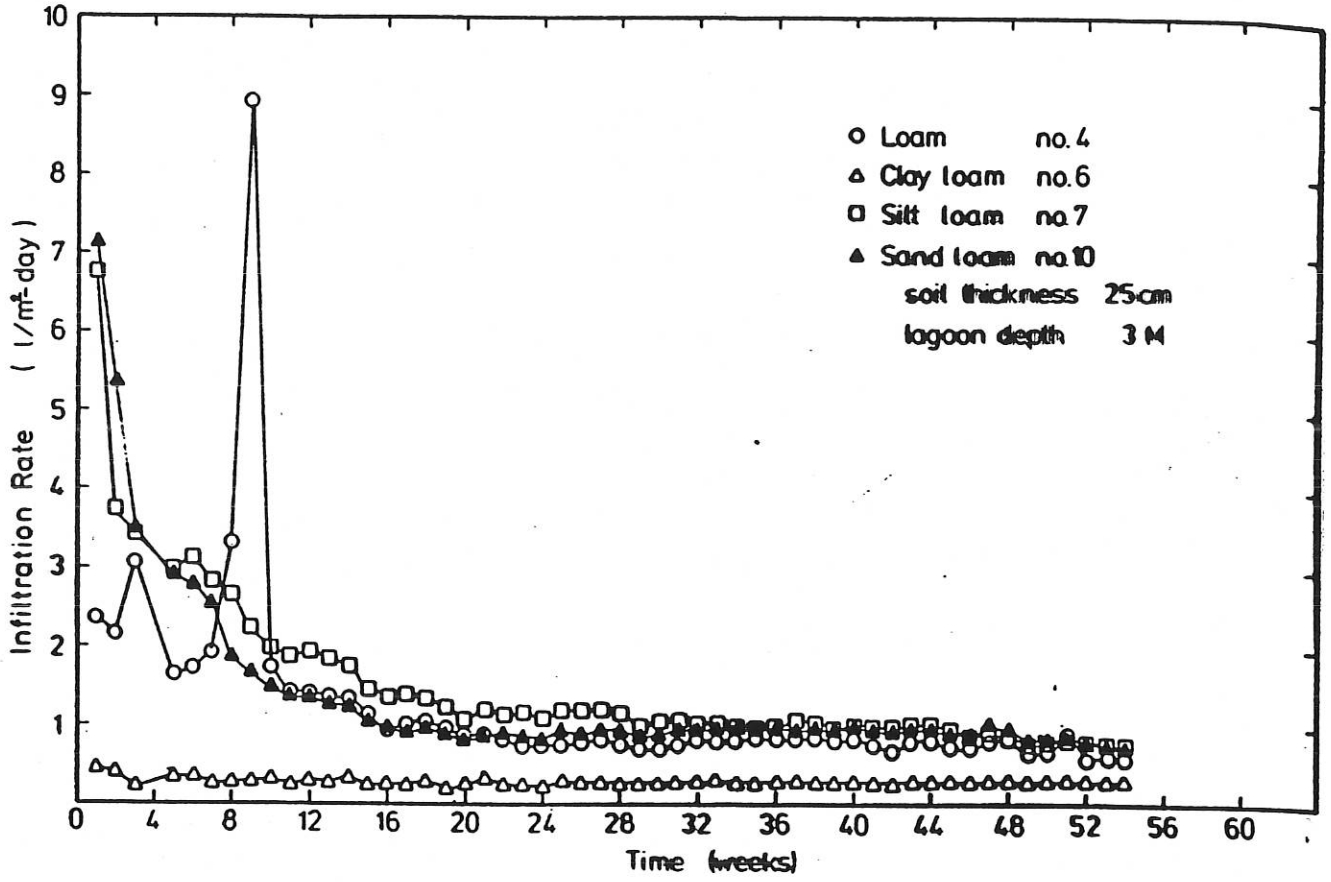

20'
d (ft) Coefficient of Permeability = K
Seepage rate = K (20+d)/d

Results From Laboratory Soil Core Experiment

Expected Seepage Rates Based On Measured Hydraulic Conductivity

12 Inch Soil Liner, 20 Feet of Waste

- **13 of 22 Samples: Seepage < 1/32 in/ day**
- **18 of 22 Samples: Seepage < 1/8" in/day**
- **20 of 22 Samples: Seepage < 1/4" in/day**


Infiltration Rate (l/m²-day)
Time (weeks)
Loam no. 4
Clay loam no. 6
Silt loam no. 7
Sand loam no. 10
soil thickness 25 cm
lagoon depth 3 M

HILLS, 1976

Figure 9–11 Waste collection from an unpaved beef feedlot

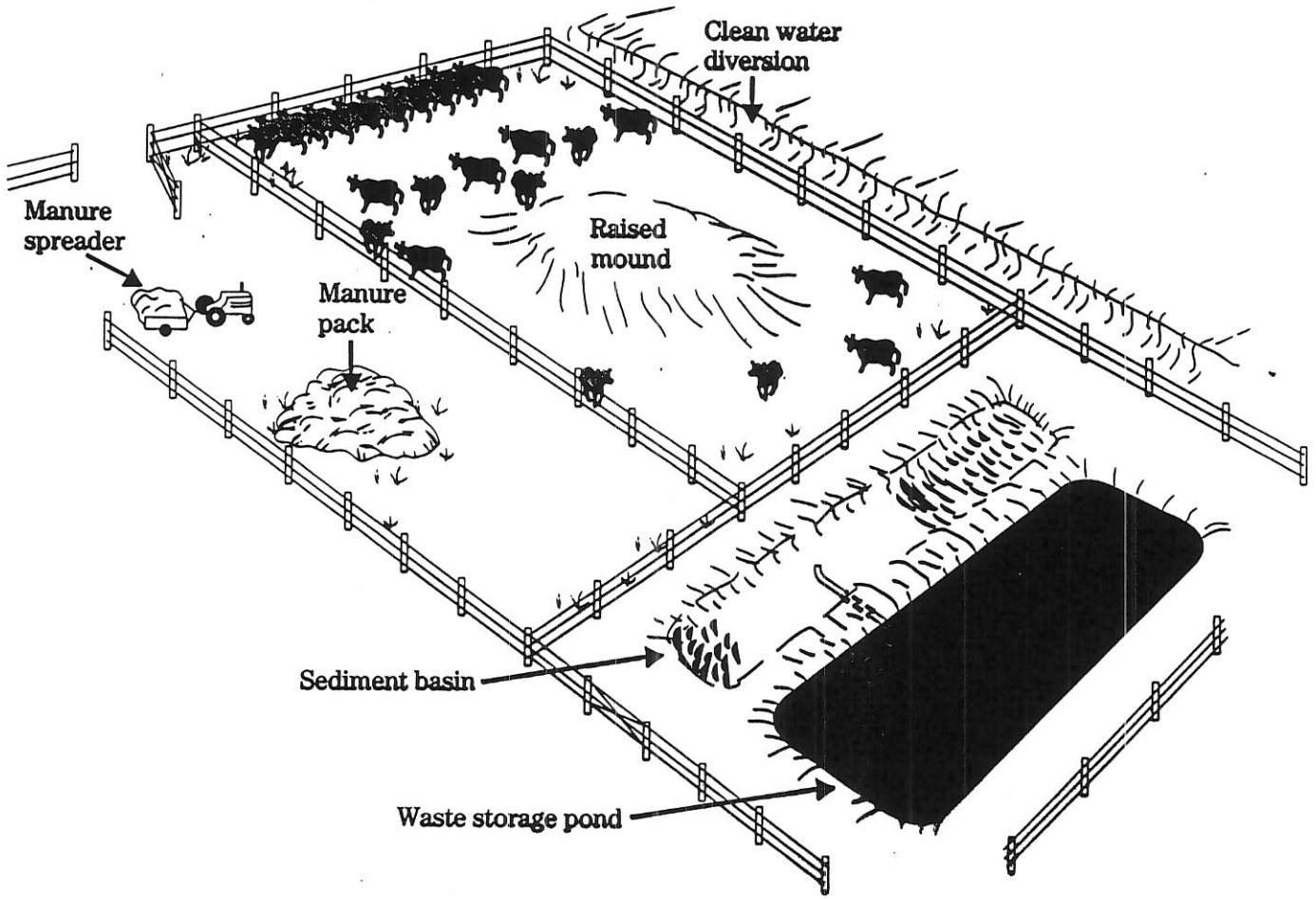


Figure 9–17 Fed hogs in confined area with concrete floor and tank storage liquid manure handling

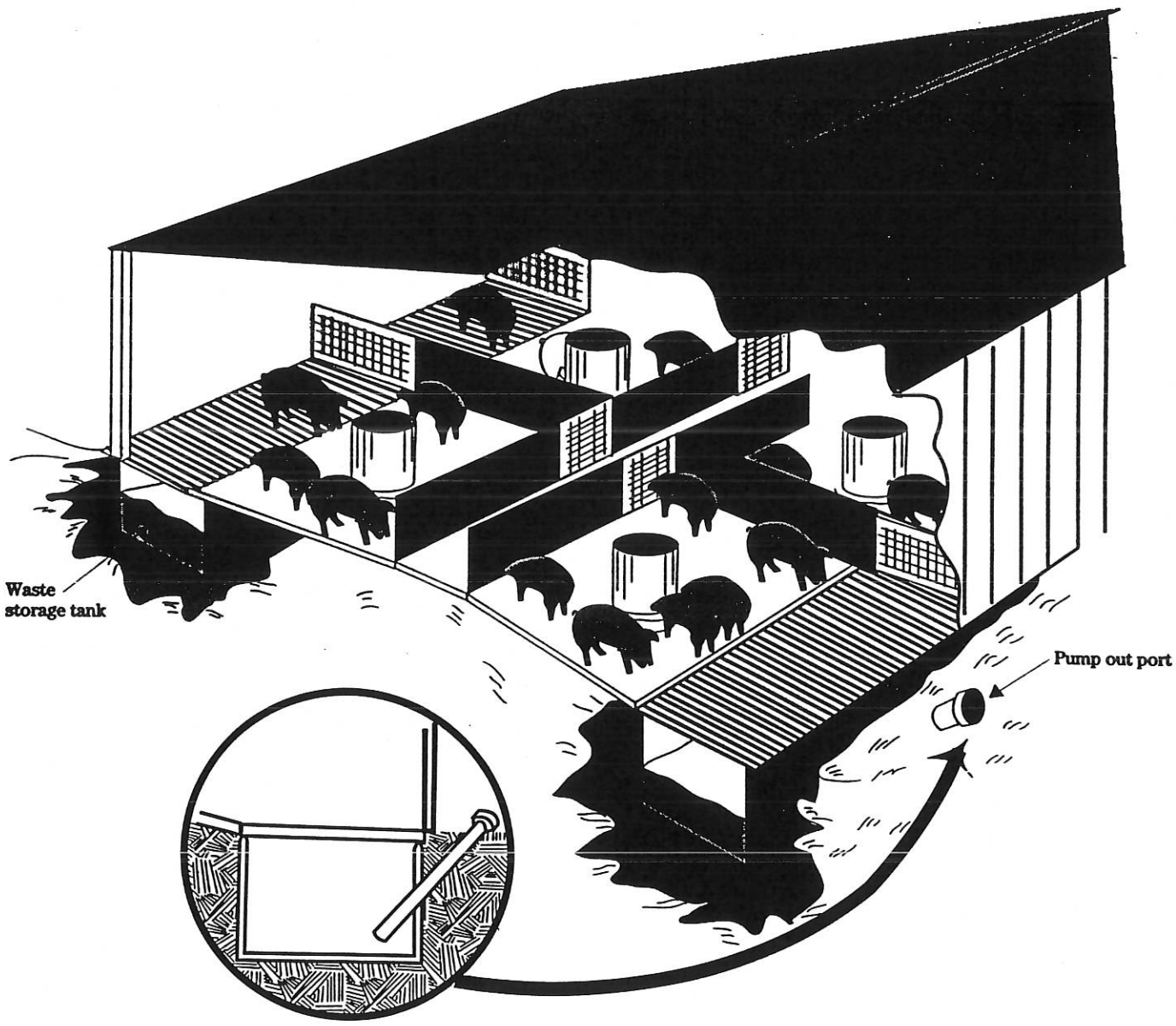
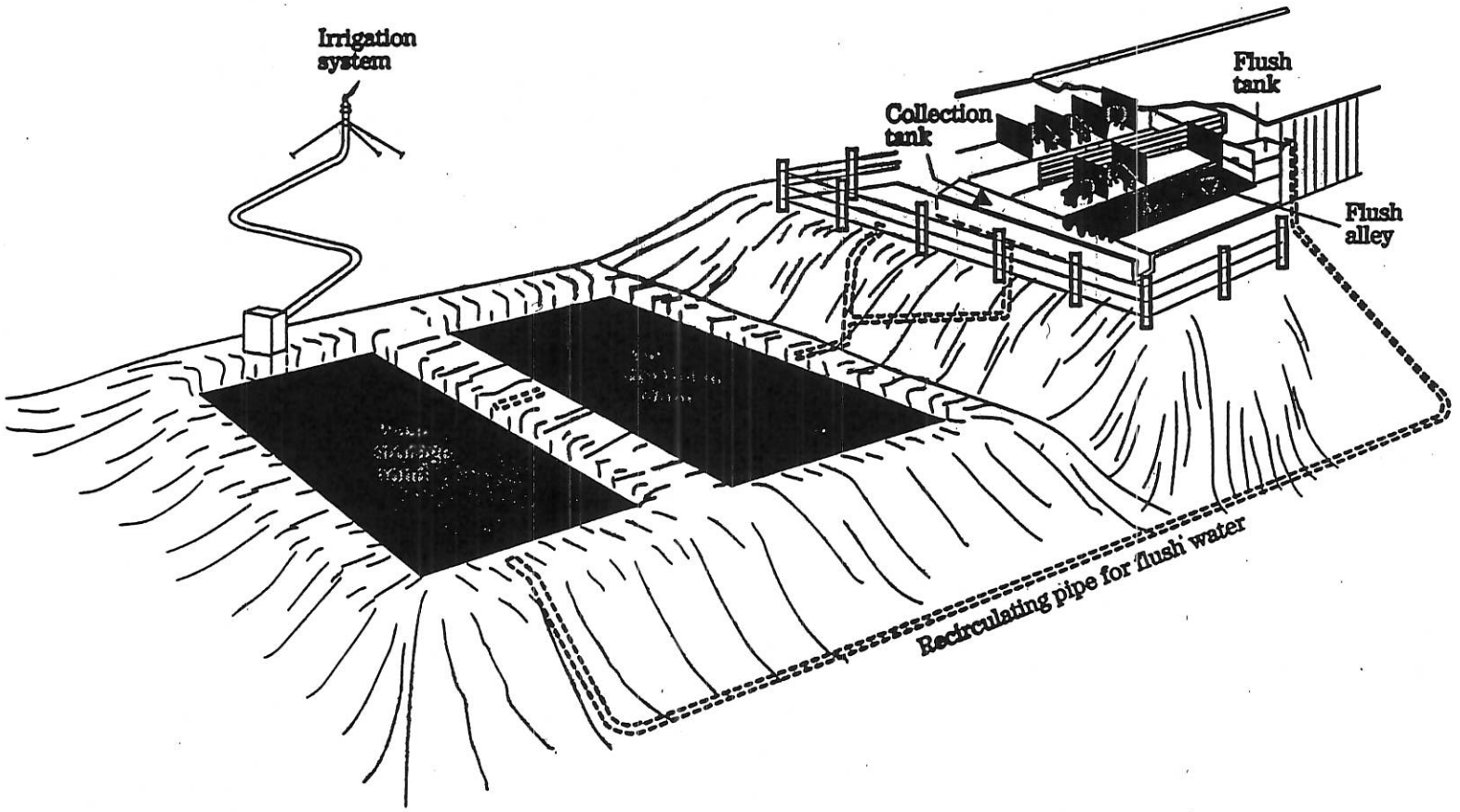


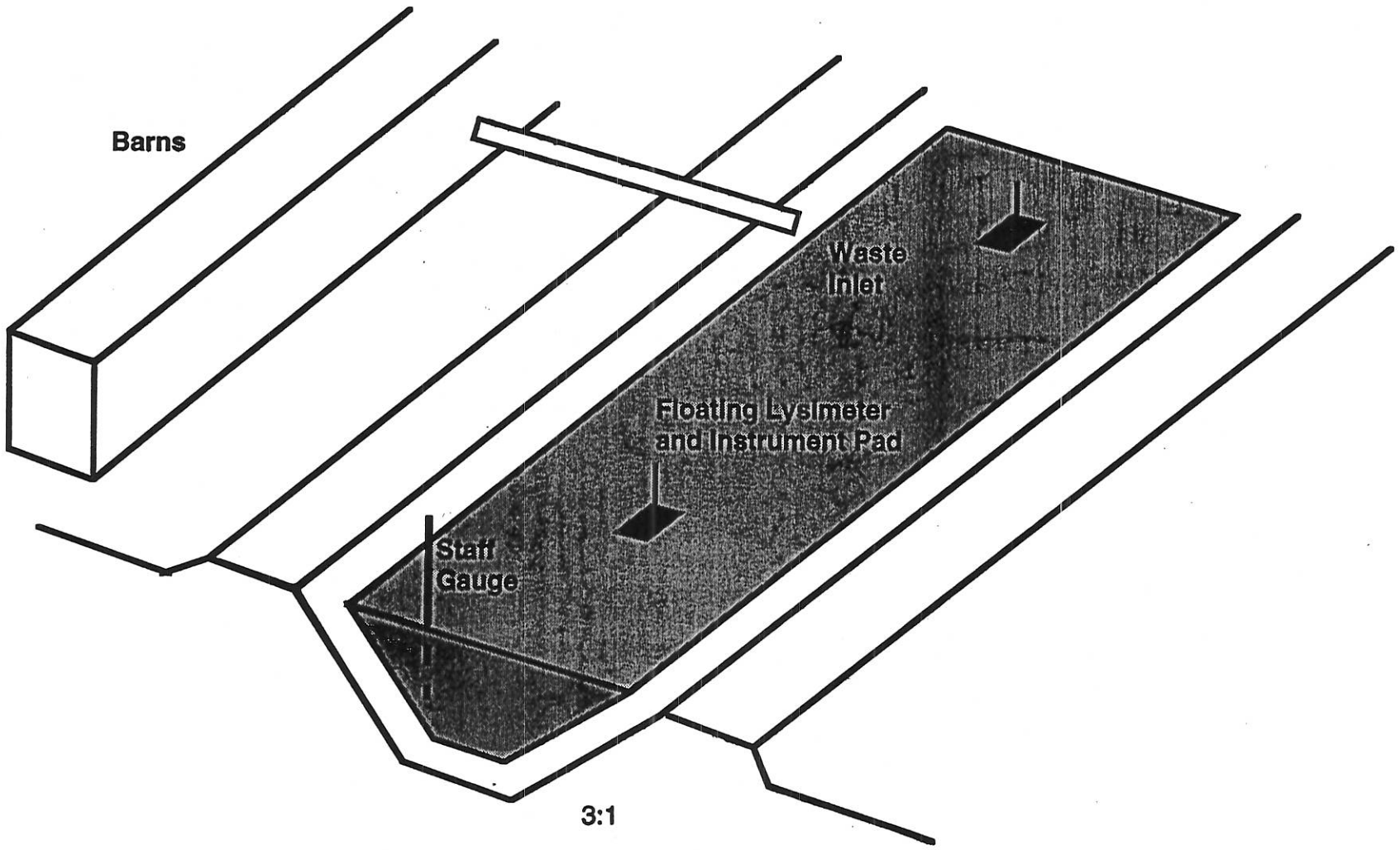
Figure 9–18 Two stage aerobic lagoon system for treatment of waste flushed from swine building



Water Budget of a Lagoon (Simple Case)

Seepage = Change in Depth - Evaporation

all expressed as a depth of water per day


Barns
Waste Inlet
Floating Lysimeter and Instrument Pad
Staff Gauge
3:1

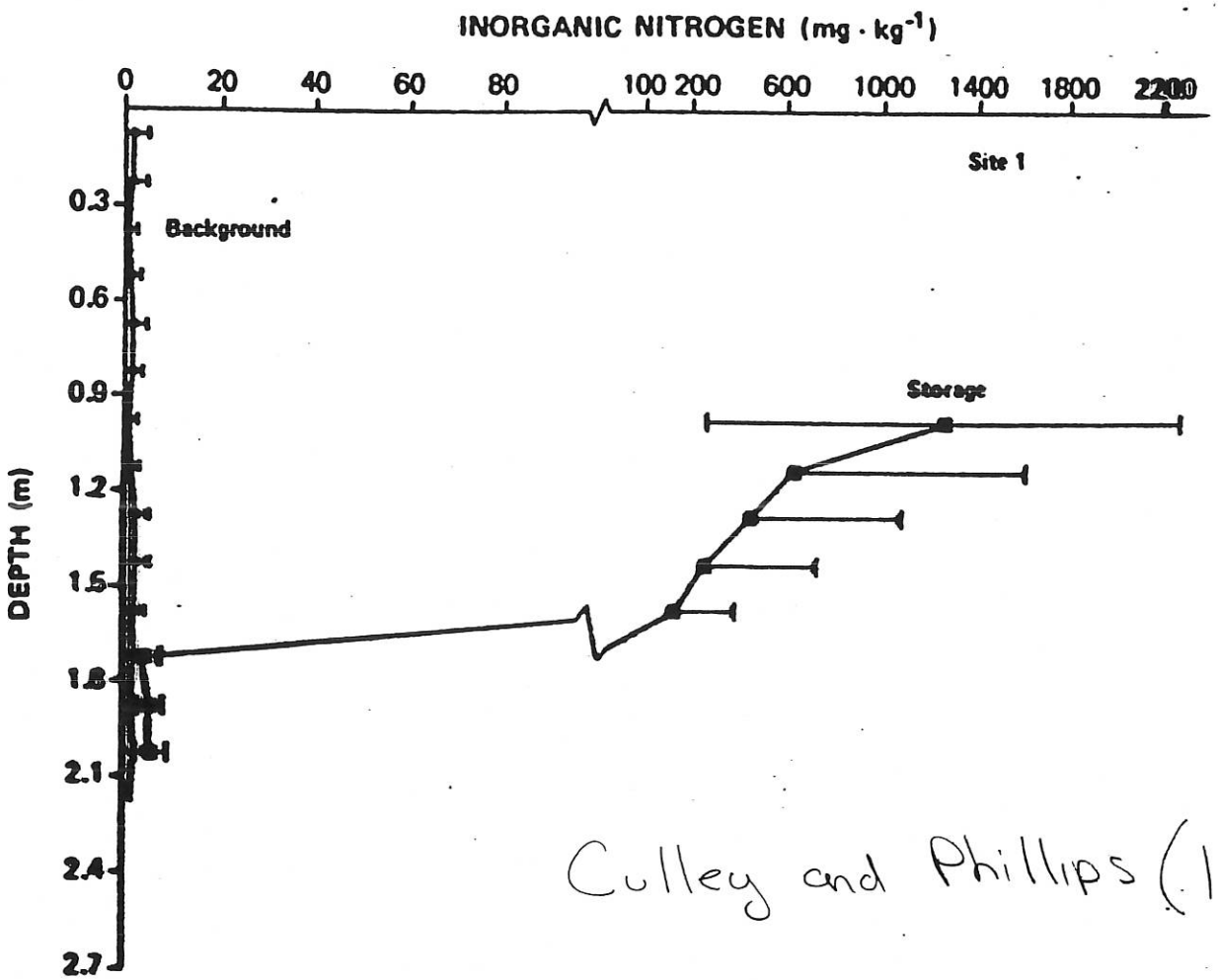
Results of Whole-Lagoon Water Balance Studies

Type of Operation	Size	Daily Seepage Rate (inches per day)
Swine (Nursery)	2 acres	0.05
Swine (Sow)	6 acres	0.08
Swine (Finish)	5 acres	0.03
Cattle	4 acres	0.09

Seepage rates were all less than 0.25 inches per day

Seepage (in/day)	Waste Type	Size	Depth	Soil Type	Reference
0.2	Dairy	1/3 acre	5 ft	sandy loam	Davis et al. (1973)
0.12	Cattle Feedlot	mini-plots	4 ft	clay loam	Robinson (1973)
0.14	Cattle Feedlot	mini-plots	8 ft	10-cm clay liner	Clark (1975)
0.09	Cattle Feedlot	4.0 acres	4 ft	clay loam	Harn and Desutter (1997)
0.05	Swine	2.2 acres	17 ft	silt loam	Harn and Desutter (1998)
0.08	Swine	5.0 acre	19 ft	silt loam	Harn and Desutter (1998)
0.02	Swine	4 acres	17 ft	silt loam	Harn and DeSutter (1998)

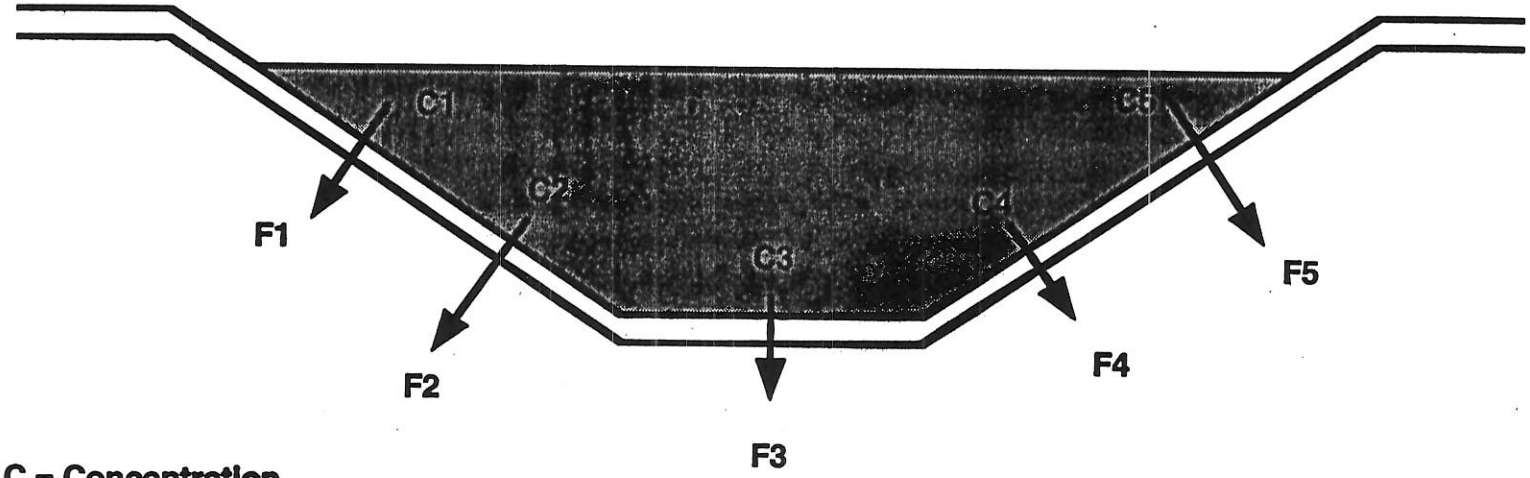
Ammonium-N (mg/L)	Waste Type	Description	Location	Reference
3,530	Swine	Cement Storage Tank	Canada	Campbell et al. (1997)
702	Swine	Breeding/Farrowing	KS	Ham and DeSutter (1998)
639	Swine	Nursery	KS	Ham and DeSutter (1998)
711	Swine	Finishing	KS	Ham and DeSutter (1998)
100-300	Swine	Finishing	NC	Westerman et al. (1995)
140	Cattle	Feedlot Runoff	KS	Ham and DeSutter (1998)
159	Cattle	Feedlot Runoff	TX	Sweeten et al. (1992)
162	Dairy	Milk Parlor and Holding Lot Runoff	TX	Sweeten et al. (1992)
130-210	Dairy	Holding Lot Runoff	TN	Sewell (1978)



Culley and Phillips (1989)

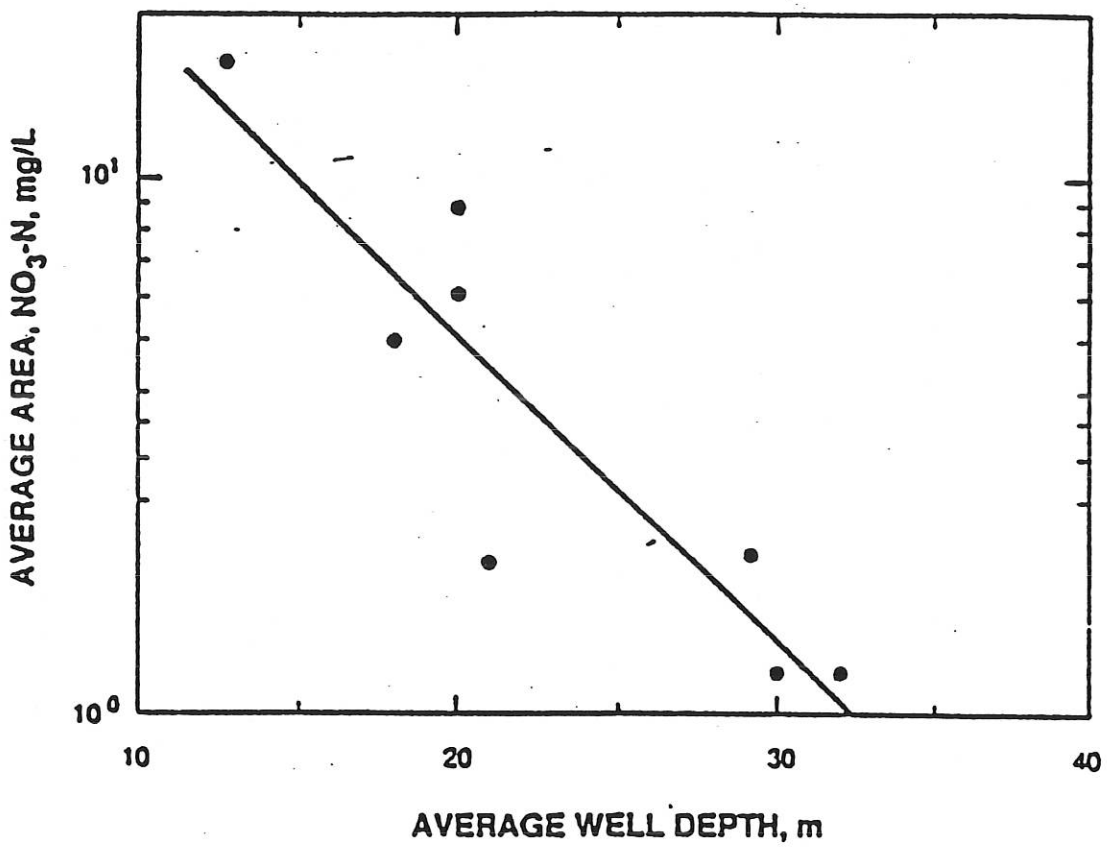
Chemical or Nutrient Flux

Boundary Conditions and Nutrient Balance



C = Concentration
F = Hydraulic Flux (seepage)

$$J = \Sigma \Sigma (F_{xy} * C_{xy})$$



Sievers and Fulhage, 1992

Conclusions

- Lagoons built in accordance with Kansas guidelines should have average seepage rates less than 0.25 in./day.

- Very low seepage rates (<0.1 in./day) can easily be achieved using 12- to 18-inch compacted soil liners built from appropriate soils.

- Questions remain concerning the relationships between seepage rates and groundwater quality.

- No widespread evidence of contamination in the vicinity of livestock operations is evident

- Decisions regarding lagoon permitting, construction, and management should consider both nitrogen input loading and aquifer vulnerability.

- Additional research on the fate and transport of chemicals beneath lagoons, coupled with risk analyses, will be required to tailor this approach for Kansas and surrounding states.