Environmental Management for the Beef Cattle Industry: State and EPA Considerations[1]

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Introduction

The major environmental issues connected with livestock and poultry feeding operations are: water quality, air quality, and sustainability of land and soil. Climate change and global warming is another emerging issue. Carbon dioxide and methane gas are given off from animal feeding operations. It's by no means a significant amount when you look at all the other sources of CO_2 and methane worldwide, but still it's a contributing factor being studied by the EPA Office of Global Warming as well as animal scientists at Texas A&M University.

Water use efficiency and availability are problems in many places -- it takes a well pumping at 70gpm continuously to supply each 10,000 head of feedlot cattle with no downtime or wastes.

Water Pollution Abatement

When it rains on an open feedlot surface, a lot of runoff occurs. About the first half-inch of moisture gets absorbed (depending on slope, amount of manure and antecedent moisture) and the rest runs off. That runoff is high in many constituents including bacterial organisms, total solids, volatile solids, nutrients, and salts. It is about 10 to 20 times as strong as raw domestic sewage for most of these constituents, so it has to be captured. Many feedlots in the High Plains have been built on playa lakes, which it appears are going to be considered waste water treatment ponds and allowed to continue. But from now on, it may be very difficult to convert existing playas for use as holding ponds because they're considered in the province of wetlands and wildlife habitat. And recent research shows more potential for ground water pollution than previously thought.

Nearly a generation ago, feedlots became regulated as point sources of water pollution. The runoff has to be captured and irrigated on land. In the major cattle feeding states, there's been tremendous progress made in controlling water pollution. In some of the minor feeding states, however, there's been less progress. You can go across the state line and see a difference, but that is all changing rapidly.

An animal feeding operation, as defined by USEPA in 1976 as a result of the Clean Water Act of 1972, is an area where animals are stabled or confined and fed or maintained for a total of 45 days per year or more in any 12-month period, and crops, vegetation, forage growth or post-harvest residues are not sustained in the area of confinement during the normal growing season. What that means is, if it's devoid of vegetation and there's animals in it, and animals are being fed for 45 days per year on more, then it is an animal feeding operation. This includes auction markets as well as feedlots. Now, over 300 head if on a stream or 1000 head if away from a stream is considered a "concentrated animal feeding operation" (or CAFO). At that point it becomes a point source subject to state and federal regulations. The absence of vegetation is a visually-determined criteria that integrates climate, soils, etc. The absence-of-vegetation criteria is important also because runoff is accelerated; due to the bare surface; there is no plant evapotranspiration or nutrient uptake; and there is no vegetative filter. The time of concentration of runoff is very short so that peak runoff rate is high and carries a lot of sediment (soil and manure particles).

I want to define the difference between a point source and a non-point source. A point source consists of a man-made conveyance structure such as a pipe or a ditch or a spillway. Items that are included in a point source are confinement building and feedlot surfaces. Maybe a veterinary clinic could be considered a point source, especially if you had enough animals in it. Slurry storage pits and stockpiles are considered to be included, plus irrigation systems, to the point of effluent release from the distribution device. But when the applied waste water enters the soil, it becomes part of the earth and is a non-point source. Animal disposal pits and dip vats are considered to be part of the point source definition. State and federal government has the right under the Federal Clean Water Act of 1972 to regulate point sources.

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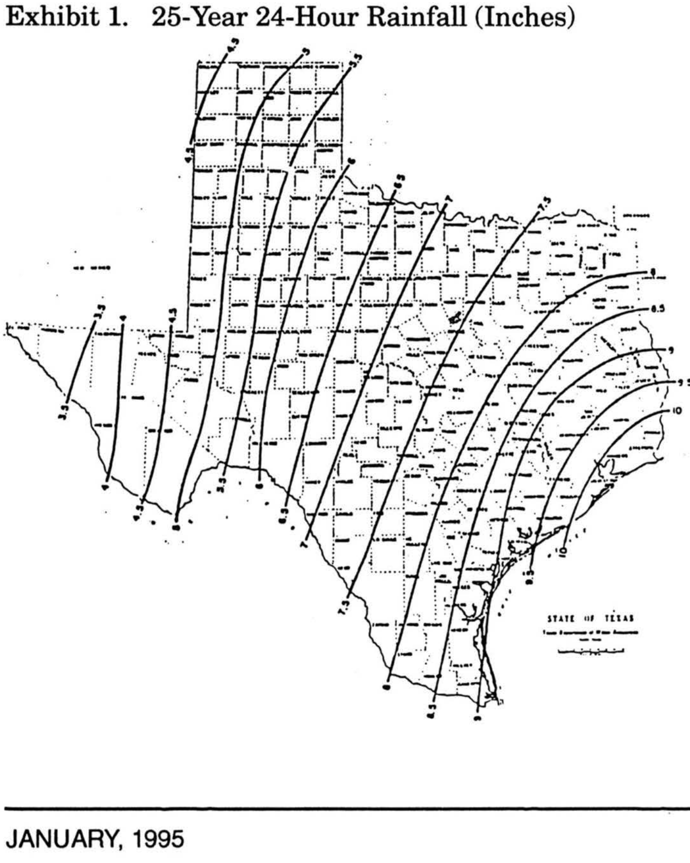
However, non-point sources are a different situation subject to a different program without specific regulations. Non-point sources consist of diffuse runoff, such as manure-treated cropland and pastures, rangeland, forests and so forth.

Texas is one of the states that has specific regulations on concentrated animal feeding operations. Our regulations say there is to be no discharge of waste or waste water from concentrated animal-feeding operations into the waters of the state, but rather that these materials should be retained, utilized or disposed of on agricultural lands. With more than 1000 beef cattle, or 250 head of lactating dairy cattle, you must have a state permit. The criteria for beef cattle feedlots is to collect the rainfall runoff and dispose of it on agricultural land according to the regulations.

Runoff Control

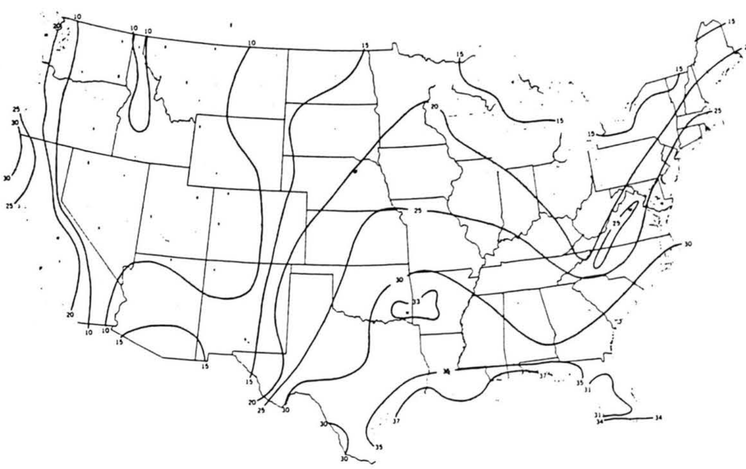
This map shows the 25-year frequency, 24-hour duration storm which varies from only about 3.5 inches in one day around El Paso all the way up to 10 inches per day down near the Golf Coast. Our cattle feeding industry is located in western third of the state. Partly it's because of these rainfall lines, i.e. you only have to design against a 5-inch one-day rainfall in Amarillo versus 7½ inches in central Texas. The Soil Conservation Service-USDA has a soil cover complex Curve No. 90 that converts rainfall to runoff. A 5-inch rainfall equates to 3.8 inch runoff and a 7.5 inch storm equates to 6.3 inches runoff. That's a lot of difference in terms of rainfall runoff volume. Also, you've got to design for sludge storage in the bottom of holding ponds.

Exhibit 1. 25-Year 24-Hour Rainfall (Inches)



Cattle feeders need to de-water the retention ponds by irrigating within about 3 weeks after rainfall if possible; but if you desire to store it longer, it is necessary to build in some additional storage. It is difficult to provide for treatment of organic solids in runoff retention ponds with open feedlots because of intermittent loading. (By contrast, for a dairy with a continual daily waste water production there is an advantage to designing for sufficient capacity to achieve some waste water treatment). Another component of the manure and waste water storage volume where applicable is overflow watering systems, which can contribute a lot of waste water.

Exhibit 2. Annual runoff from unsurfaced feedlots (CN-90) as percent of precipitation for the year.



This map shows the percentage of annual rainfall that ends up as runoff. The farther east you go, the higher the percentage. Around Amarillo approximately 15 to 20% of the annual rainfall runs off. If it rains 18 inches per year and 20% runs off, that's only 3.6 inches of runoff a year in an average year which is about equal to the 25-year 24 hour storm runoff, so once a year their ponds are going to fill up there on the average. East of there, 30% runs off, so if you get 30 inches of rain, that's 9 inches of runoff. It makes a lot of difference. That's why we want to keep any open lot feeding systems out west. A good illustration of what would be the difference between Des Moines, Iowa (7.4 inches of annual runoff) versus Greeley, Colorado 1½ inches of annual runoff).

Runoff holding ponds are supposed to provide temporary storage to allow for irrigation, and then stay empty much of the time. By contrast, you will often find runoff holding ponds with a lot of water in them, partly as a result of overflow cattle watering systems.

Feedlot Surface Management

Feedlot surface conditions are important from the standpoint of trying to prevent muddy corrals in a dry climate, and also for purposes of water and air pollution control. Beef cattle feedlots use an animal spacing (stocking density) from 100 to 400 square feet per head depending on climate and size of cattle. Typically our cattle feedlot industry on the High Plains was designed for about 150-200 square feet per head. Around Wichita, Kansas they're looking at 300 square feet per head because it receives more moisture. In Southern California they may use only 100 square feet per head.

Now, beef cattle excrete about 6 gallons of moisture per day per 1,000 pounds liveweight. At 400 square feet per head, this excretion rate amounts to an average of about 9 inches of moisture a year equivalent depth. At 200 square feet per head, that is about 18 inches of moisture a year, and 100 square feet per head, 36 inches of moisture a year.

A few years ago feedlots were operating at about 200 square feet per head in Texas, and now they're not building many more pens because of environmental regulations. Yet we have record numbers of cattle on feed. So many are really achieving about 150 square foot per head in many cases which equals about 25-30 inches per year of manure moisture in addition to rainfall of 16 to 20 inches annually. This last winter, many Texas, Oklahoma and Kansas feedlots received 50 inches or more of snowfall, which amounts to 6 to 8 inches of moisture with little runoff. That caused mud problems especially in those feedlots operating over-capacity.

On the other hand, you can give cattle 600 square feet per head and get down to were the manure moisture is insignificant, but then you've got 3 times the area to collect runnoff from and dust is more likely to become a problem.

Keep in mind moisture deficit (evaporation minus rainfall). If you draw a line from Minneapolis through the quad-cities of Iowa and down through Texarkana and Nacogdoches, Texas to Houston you're on the zero moisture deficit line -- where it rains as much as it evaporates every year. West of that line, evaporation exceeds rainfall (moisture deficit) by as much as 40 to 60 inches per year. So an additional 16 inches of moisture on a feedlot surface doesn't hurt much out here, but in central Texas or in central and eastern Kansas and Nebraska that extra 16 inches per year means the difference between mud and no mud. A wet year puts you over the line. I don't like to see open lots built east of a 30-inch moisture deficit line.

There are alternatives. Put a roof over them, or put them on concrete. There's an experiment we're doing with a utility company and the cattle feeding industry up in the Texas Panhandle. They have a problem with fly ash disposal. When they haul Wyoming coal to the High Plains only about 90 to 95% of it burns at the electric power plant. The other 5 to 10% is caught as fly ash that needs to be disposed of in an environmentally conscientious manner. They're trying everything from building highways with it to building alleys at feedlots. There are several cattle feedpens that have been surfaced with fly ash. It sets up like a low grade of concrete (e.g. grout) and I think it's going to work out well.

Managing the feedlot surface is very important from the standpoint of cattle performance and environmental protection. Manure needs to be harvested frequently. You don't want to collect all the manure. Rather you want to harvest surface manure and leave an undisturbed manure pack to provide a surface seal or "pad" for the cattle to stand on, to provide for rapid drainage from the feedlot surface, and to prevent groundwater contamination. Maintain good drainage with uniformly sloping pens; backfill and prevent wet spots; maintain the concrete aprons around feedbunks and water troughs; construct pens with 3 to 4% slope away from the feed bunk to the back of the pens; and build mounds where needed in flat pens.

I'm in favor of as much as 20 feet width of concrete apron behind the feedbunk. In a well-maintained feedlot, the cattle stand on the compacted/undisturbed manure layer above an interfacial layer of soil and manure right above the higher-density soil beneath. The interfacial layer provides an excellent seal that prevents infiltration, dentrifies nitrogen, and provides excellent drainage. A slice of a manure pack in a feedlot will show a black layer to be maintained over the clearly-distinguished subsoil. Notice there should be no ridges of manure beneath the fence line that can trap water and provide a fly-breeding source.

As a "standard of perfection" feedlot manure can be collected about once per month with a box scraper. This will improve drainage, maintain a good grade, and help as a dust control measure because there's less pulverized manure to create dust with.

The size of the manure "sponge" is reduced with frequent collection. This will maximize runoff and minimize absorption of water on a feedlot surface. This has a huge implication with respect to odor. Odor intensity is 50 times or more stronger from a wet feedlot than from a dry one according to the research in Australian feedlots.

Groundwater Pollution Control

Potential sources of groundwater contamination include: (a) the feedlot surface if improperly managed; (b) runoff retention ponds, which must be properly sealed, and (c) land disposal areas, which should not be overloaded with manure or waste water. Holding ponds must be built with proper soils engineering, testing and placement, meeting both state and U.S. EPA requirements. Most states use a soil permeability criteria of 1 x 10^{-7} cm/sec, which is only 1½ inches per year. The Texas Water Commission requires 1.0 feet of imported clay that meets the permeability criteria, and the U.S. EPA General Permit for Region 6 requires 1.5 feet, or else be able to prove that what you have is adequate to prevent groundwater contamination or a hydrologic connection to surface waters.

We've participated in studies of groundwater quality at cattle feedlots on the High Plains assisted by the High Plains Underground Water District, which covers 15 counties, and the Texas Cattle Feeders Association. The bottom line is that out of 28 wells sampled at 26 feedyards, the nitrate concentration in water from the Ogallala Aquifer averaged only 2.4 mg per liter (mg/L) with a peak value of 9.4 mg/L. That's below the 10 mg/L that the U.S. EPA has as their nitrate-nitrogen drinking water standard. So these 26 feedlots were in good shape relative to drinking water standards. Most of our feedlots have excellent groundwater quality and they want to maintain it. When choosing a feedlot site, you want to have a location with a relatively deep aquifer, a restrictive layer above the water table, and moderate-textured top soil and subsoils. The total dissolved solids of ground water should contain less than 3,000 mg/L to serve as a useful water source.

State regulations are providing separation distances between concentrated animal feeding facilities and water supply wells. A separation distance of 150 feet is the minimum state and U.S. EPA Region 6 requirement for feedlots in Texas.

Land Application of Manure and Waste Water

Land application of manure and wastewater is important from the standpoint of land and soil sustainability, considering annual nutrient balances and salt management. Keep in mind, when you have a feedlot, that another aspect of land and soil sustainability is to be able to close the feedlot down sometime in the future and restore the site to agricultural or other uses.

When you over-fertilize with manure, the nitrates and phosphorus in the soil build up which may increase potential for water quality impairments. In most instances, 10 tons per acre per year on irrigated cropland is the proper agronomic application rate that will not cause nitrate accumulation in the soil.

Every CAFO operation needs to have a nutrient management plan which takes into account the amount of nitrogen and phosphorus produced in feedlot manure and depends on crop acreage, yield and nutrient composition. State Extension Services or commercial soil and water testing labs can supply soil test recommendations based on the current soil nutrient status and crop nutrient uptake table to use as a guide for nutrient planning.

Runoff potential and leaching potential as well as nutrient balance, should be taken into account when planning and conducting land application of manure and wastewater.

We conduct occasional surveys of manure contractors to determine manure pricing structure and typical application rates. We've determined that they're applying manure at rates consistent with research results and soil testing recommendations for irrigated cropland, i.e. around 10 to 11 tons (as-received basis) per acre per year. The manure contractors deal directly with farmers to ensure that the feedlots can meet nutrient management requirements and thus keep producing more beef and more manure. It's one thing to prescribe an application rate, and it's another thing to get it right. The manure spreading operations need to be calibrated occasionally. The way to check it is to lay out square plastic sheets 4 feet-8 inches on a side. Since that will be 1/2000th of an acre, every pound of manure that lands on the sheet is one ton per acre. So if you're shooting for 10 tons per acre, you will expect 10 pounds of manure to fall on the sheet. It's also the best way to collect manure samples for analysis.

Land area needs to be sufficient to achieve nutrient balance, within a reasonable haul distance, and away from streams. How much land does it take? For a 10,000-head feedlot, where they apply an average of 10 tons per acre per year (irrigated cropland), it's going to take about 2,250 irrigated acres. For non-irrigated land, it is going to take about twice that, or 4,500 acres. If feedlots don't have enough land, they need to work with farmers to gain access to that much.

It takes a lot less land for irrigation of the open lot runoff because you can apply it at 4 to 6 inches per year. If annual average runoff yield from a feedlot is 4 inches per year, then about an acre of cropland per acre of feedlot drainage area is needed in an average year for runoff irrigation.

Feedlot runoff typically is very high in "total salinity," and from the standpoint of "soluble sodium" it's considered to be in the medium range. To manage salts and to grow sufficient crop to uptake the applied nutrients, you may need to add more irrigation water. Ideally, feedlots should have supplemental irrigation water available for dilution, additional water or leaching as needed to properly manage the nutrients and salts.

We did a study at a feedlot that put an old dryland cotton farm into wheat production with level borders and underground pipe with risers. The only source of irrigation water was the effluent in runoff holding ponds.

The collected runoff has been monitored nine times in about 5 years, and found to be high in nutrients and salts. Total nitrogen is about 300 mg/L mostly in the ammonium form, which is highly available to crops upon application. It's very high in salt, i.e. electrical conductivity (EC) has averaged 12 mmhos/cm. Sodium absorption ration (SAR) is 11.5. So this feedlot runoff is loaded with beneficial nutrients but it's high in salts, too.

Our study involved 12 plots or level wheat borders. We irrigated some at 3 different rates and left some as controls. On the control plots, which received no effluent or irrigation water, the EC after 4 years was 0.5 mmhos/cm. For those plots receiving 1 annual irrigation of 3.5 to 4 inches for 4 years, the EC went up to 3.3 mmhos/cm; at 2 irrigations a year, 3.4 mmhos/cm; and at 3 irrigations per year, 3.7 mmhos/cm. The nutrient concentration went up also. Without any irrigation water, the nitrate-nitrogen concentration was 7 ppm. It went up to 60 ppm of nitrate-N in the soil after 4 years of applying effluent at the highest rate. After deep chiseling it and ample rainfall (34 inches) the soil is now apparently stabilized at an EC of around 3 to 4 mmhos/cm so wheat will keep growing fairly normally. Our results have shown the best effluent application rate was twice annually totaling 6.88 inches a year of feedlot runoff on an average.

Odor Control

Odors are an annoyance to people that affects their well being. There are 4 quantifiable aspects to odor -- frequency, intensity (or concentration), duration and offensiveness -- that are related to climate and to management of the feedlot surface. In an open feedlot, odor intensity, duration and offensiveness are partially controllable by managing manure moisture and the inventory of manure and wastewater.

The strength or intensity of an odor can be quantified using gas chromatography (or chemical-specific tubes) or human sensory methods. The latter is more universally accepted. Humans can measure odor in terms of dilutions to threshold by different devices, or by supra-threshold referencing which entails a comparison of the undiluted odor with a reference gas such as n-butanol vapor.

With chemical-specific tubes, you simply draw an air sample through a packed bed of chemical reagent using a syringe. To measure ammonia concentration for example, you use a different tube than if you're trying to measure hydrogen sulphide or one of the amine compounds. The color change gives a direct readout accurate to within about 20%. This method is used frequently for occupational safety and health applications. There's an electronic odor meter that's being used to obtain an indirect measure of odor concentration. These sell for about $2,500 and they measure the resistance of an electric current across an airstream and a silicon chip. The more molecules of a gas that come in contact with the reactive surfaces the higher the reading.

The butanol olfactometer produces a stream of butanol at known concentrations. An odor panel of 6 to 8 people can measure the odor in a feedlot as against an equivalent concentration of n-butanol. (A typical value for feedlots would be 10 to 20 ppm).

Most of the world uses a dynamic forced-choice olfactometer. With this device, the odorous air sample is bagged in the field, then into a lab, and put through a computer-operated device that sets 5 or more dilutions with odor-free air. Panelists determine if they can or cannot sell the diluted odorous sample out of 2 or 3 samples presented simultaneously. The dilutions can range from tens of hundreds to thousands. A panel of 8 people is normally used.

According to research in Queensland, Australia, on a dry open lot surface, the odor was less than 100 odor units (or dilutions to threshold). On a wet feedlot surface, the odor concentration went up to 2,000 or 3,000 dilutions to threshold. This would indicate that the odor concentration produced from a wet feedlot surface would be 20 to 50 times greater than for a typically fairly dry feedlot surface.

The simplest way to measure odor is with a Barnaby-Cheney Scentometer, that costs about $500. For example, we used a Scentometer to measure odors around a 2,000-head feedlot that was located near a subdivision and a country club in Oklahoma. We found strong odors at the feedlot, but downwind they dropped off to near background levels. Nevertheless, the feedlot was closed down.

The point is that you can quantify odor, manage accordingly, and change the operation as necessary. Odor does dissipate rapidly with distance downwind except in atmospheric inversion situations. When you pick feedlot sites, you've got to be downwind of neighbors by a mile or more if at all possible, avoiding a valley situation that can limit dispersion.

Dust Control

Feedlot dust is also an important issue today. Cattle stir up a lot of dust in early evening in dry areas, which can create both a nuisance condition and potential for traffic accidents.

High-volume air samplers are used to measure total suspended particulate (TSP), and a PM-10 monitoring device is used to measure dust with less than 10 micron aerodynamic particle size. In California they came up 654-micrograms per cubic meter ($\mu g/m^3$) average total suspended particulates at 25 feedlots. We didn't believe that that would be a good number for Texas because they're so much dryer than we are, and through research in 1987, we came up with a mean of 412 $\mu g/m^3$ after monitoring three feedlots on 3 different occasions. The EPA primary standard for TSP is 250 $\mu g/m^3$.

The 1990 Federal Clean Air Act established that any source that may generate over 100 tons of emissions per year is a "major source." With respect to feedlots, it would take only about 2,500 head of cattle to generate 100 tons per year, if you use the U.S. EPA "standard emission factor" of 280 pounds per day per 1,000 head that EPA derived from the California data. We're developing emission rates from our own data and finding them a lot lower than this. Some states are trying to avoid having to count the feedlot surface in addition to the feedmill in calculating potential emissions. For major sources, emission fees are going to be charged at the rate of $25 per ton per year. If you use the EPA standard emission factor for feedlots, emission fees could run as high as $45,000 per year, as compared to fees of only about $500 per year now for a 35,000 head feedlot.

Feedlot dust can be partially controlled by (a) frequent manure harvesting; (b) increasing stocking density; (c) sprinkling pens and alleys; and (d) possibly by surfacing the alleys and pens with fly ash, which we're studying now.

Software for Planning Feedlot Waste Management Systems

The Texas Agricultural Extension Service has some computer worksheets available wherein you can very easily rough out the design of waste management system for feedlots, dairies or for other species. This MANURE Spreadsheet is in our Extension software catalog. It's based on the American Society of Agricultural Engineers (ASAE) standards for manure production. It has different worksheets that can help you to calculate production of manure and its constituents, waste water production, land area needed for nutrient utilization, and the size of lagoons and holding ponds. The Soil Conservation Service - USDA in Texas and many consultants are using this to plan facilities, and the Texas Water Commission and our Texas Air Control Board use it to check design plans that come in to them for permits. (These two agencies merged on September 1, 1993 into the new Texas Natural Resource Conservation Commission.)

Summary

The main livestock waste management issues are water quality management (surface and ground water); soil and land sustainability with respect to manure and effluent utilization for nutrient recycling; and air pollution control (odor and dust). Technology has been developed to satisfy these environmental concerns, and these technologies are largely compatible with improved management of cattle. Some states including Texas and USEPA Region 6, have strong regulatory programs. There's a lot happening right now in the livestock waste management area with respect to adoption of best management practices and in meeting requirements of state and federal agencies. It is time that all producers with CAFO's develop and adopt pollution prevention plans. As bovine veterinarians, you can have a lot of influence with your producers to do so.

Panel Discussion on Environmental Issues

Question: When using fly ash in cattle pens, how is crop land effected when pen waste is disposed on it?

Dr. Sweeten: We are trying to determine, through this experiment, what the effect will be. We'll be looking at the chemical quality of the manure, as well as effects of any leaching beneath the pad. There may be some trace minerals in fly ash that could leach out. We don't think it's going to be significant, but we're going to be looking at it. Another aspect has to do with reduction of any debris such as rocks or chunks that might get in it. Using a surfacing material has the opportunity to change the equipment that's used. I think feedlots in general can use lighter equipment and collect manure more frequently.

Question: Discuss the application procedures, cost, etc., for fly ash on roads and pens.

Dr. Sweeten: I don't have a good answer on cost as yet. We're looking at different thicknesses, trying 3, 4½, 6 or 8 inches. That will have something to do with cost. Secondly, can you use a pure material that's mixed with caliche, which will help reduce the cost? We're just getting started on working on fly ash. I pointed it out as an example of something that holds promise and moves in the right direction toward being able to maintain the feedlot surface and improve cattle performance, and hopefully will be of environmental benefit as well.

Question: What is the average moisture content of manure used on farm land as a fertilizer?

Dr. Sweeten: Feedlot manure as collected and hauled is about a third moisture on a wet basis. It may be as high as 60% moisture, or as low as about 20% where it gets real dusty. All the application rates that I spoke of were on a wet-basis at about that 35 to 40% moisture, rather than dry tons.

Question: Does the size of an operation, such as 250 dairy cows versus 6,000 head, effect the necessary distance from live water sources?

Dr. Sweeten: It does indirectly in terms of land area needed for construction of wastewater retention facilities, for land application or manure and wastewater, and buffer distance for odor control. It does not affect the distance from water wells, according to the new EPA Region 6 regulations for example. You can have very well constructed wells closer to corrals and land application sites, or vice versa. The essential point is, don't locate feeding facilities near streams or water wells.