Livestock Waste Management

WHAT DO YOU DO WITH A REGULATION?

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The most obvious step in deciding what to do with a regulation is to determine what the regulation will do with you. This is important whether you are a private citizen about to be regulated or a regulator about to adopt a regulation. Take a quick look at the effect of regulations by asking a number of questions. Some are outlined in Table 1.

The first question of critical importance in water quality is what will be the result of the regulation? Is the desired result the maintenance of existing water quality? What is the existing quality? Be sure these criteria are defined and that everyone understands the definition. Much confusion arose within one committee on how to explain to cattlemen "land which was *rural* but not *agricultural* having no row crops but only sagebrush, grasses, and cows."

If the regulation is designed to increase water quality, how and up to what standard? Will this require the cessation of existing activities; are you willing as an owner to cease some of your farming or ranching? Can you fence all your cattle off from their live water source? Water freezes at 0°C (32°F) and gets rather solid at -20°F. Some shoreline acts exempt cattle wintering operations from permit systems so that cattle have access to running or live water.

Can you as a regulator show the scientific justification for the regulation? For example, if you prohibit all row cropping or timber clearcutting within a watershed to improve the sediment load level and improve water quality for a dying fishery, are you certain that forbidding those activities will give the desired result (more fish)? If the fish are also being overharvested and diseased, such methods may be inappropriate. The bottom line should be: Does the regulation produce the desired product?

Is the regulation possible, technically and administratively? If the regulation reads that one culvert shall be placed every 273 m (300 yds), there would be five within every mile; however, if the terrain is broken or if one discharges into an erosive area, perhaps the regulation should read, "Five culverts should be placed within every mile." The regulation must be adaptable to the geography, for the geography will not change to meet a regulation. Does the regulation conform to the administratively established procedures already in place? A great deal of grief has descended upon the heads of regulators because of a simple omission for a system of due process or appeal in the adoption of a regulation. When this occurs in the legislative process, constitutional questions are raised. Responsible agency people go to laudable lengths to include existing agency procedures in new regulations, saving their agencies much public relations and court time.

Does the regulation follow its legal parent? The regulation should cite the antecedent law or act *specifically*, by section. The enforcement and appeal processes should be set out and, if possible, the legislative intent or desired result should be given.

Is the regulation compatible with other laws and requirements? As a Nation of free people with a strong ethic for individual civil rights, we have assumed that laws and regulations are constitutional, contain due process procedures, and assure compensation for private property taken for public uses. With the invention of "the public trust doctrine," which purports to precede constitutional rights, these assumptions are naive if not stupid. The most controversy and litigation occurs between regulators and the regulated over this point. In addition to the loss of property, the failure to address this issue before the regulation is adopted leads to administrative nightmares.

In Washington State it is now illegal to drive a mechanical vehicle through *any* wetland. How is that compatible with good farming practices, building settling ponds or manure lagoons for 208 Best Management Practices, or with protecting your property "in a responsible and diligent manner" for FEMA or your insurer, not to mention your banker?

In addition to these conflicts, if farming is precluded, the resultant subdivision is even less desirable in trying to create a "quality environment." Also in the interest of water quality for fishable waters, Washington water rights owners can use only hand-held tools to divert water from water courses without a 45-day permit. Great Lakes States concerned with downstream desires for their water should note that this is the best downstream water steal yet devised.

The last question, where the most practical problems arise, is, what is the cost? As a regulator, perhaps you should balance the first consideration, "does the regulation produce the product," against the man-hours needed to administer and enforce the regulation. Sometimes many hours are spent in hearings, courts, and in-house meetings to regulate the easy activities while the more difficult problems are ignored. A lack of scientific research may account for some of these instances. An excellent example is demonstrated by various interest groups' perceptions of the problem or value of livestock waste. Wes Jackson, in New Roots for Agriculture, writes that,

> Livestock manure is of tremendous value in holding the soil. Its spongy nature absorbs the blows of the rain and water itself. Sixteen tons of manure on a 9 percent slope in Iowa reduced the soil loss in 1 year by over 17 tons. It is clear that organic matter is meant to be left in the field and in no way regarded as waste . . .

Many environmental groups believe that manure should never be used when it has the potential for reaching a waterway or wetland. A recent article in a major Seattle daily cites small animal keeping operations' failure to fence in animals as a major cause of shellfish pollution. So are septic tank failures. These causes of pollution, if true, lend themselves best to the nonregulatory approach of the best management practices in the development of State 208 plans under the Clean Water Act. Under this approach public acceptance is quicker and more supportive, and administrative cost is much less.

The second cost is to the landowner, the regulated. This can be a requirement for outlay of capital such as settling ponds or manure lagoons, lost production, and lost jobs in secondary industries such as food processing, machinery sales, the support of rural towns, and so on. There is some support for strict. punitive regulation because it creates bureaucratic jobs. I have never seen a job for job equality here, and it must be kept in mind that you are weighing a production activity against a consuming activity.

The last cost and the most difficult task for both regulated and regulator is to assure that the beneficiary bears the cost. This problem is thousands of years old but given new impetus because of the current feeling that the unidentified public has rights to a pure environment superior to all rights of life, liberty, and property. In the 1500's peasants in France "were forbidden to weed their fields or to mow hay at certain times of the year for fear that they would disturb nesting partridges or destroy their eggs" (Blum, 1982). In 1984 the Washington State Game Department prepared a pamphlet, The Path Between Habitat and Development, that suggests farming practices that can benefit wildlife, including the "timing of farming operations to avoid nesting, brood periods; particularly beneficial is delaying the first cutting on alfalfa for 1 to 3 weeks." Since these regulations provide cost-free benefit to the hunters, the nobility, or the affluent, and no mention is made in either case of compensation to the peasants for deferral or loss of crops, we come to the last—and growing—problem.

Is there just compensation? Is there any compensation at all? If a landowner is required to lose a right to use his property for his productive purposes and that right is given to others, how do you pay him for that loss? Of course the public trust theory claims that the public has a superior right similar to that of the French nobility, but in the United States is that either defensible, necessary, or useful in solving our environmental problems?

Perhaps we should ask one more question: is there an alternative to regulation? Certainly in the management and uses of livestock waste, a biodegradable product, we have learned a great deal through the participation of the public, the regulators, and the regulated-to-be, in the adoption of 208 nonpoint source programs (the majority of which are voluntary.)

Voluntary best management practices or cooperative ventures have many practical advantages over regulation. In seeking improved water quality, regulators can work with water and land-owners on a site-specific basis, using the geography to determine the BMP's that will most rapidly improve water quality at the least cost to the landowner and the administrative agency. Much of the technical information gathered had the chance to be tried on the ground. Some of the potential practices, such as zero runoff, have the opportunity to be abandoned before being cast in bureaucratic concrete. Thousands of farmers, ranchers, and agency persons possess a vast information and technical base we ought to put to use. We ought not to regulate our land and people as much as we should be taught by them.

Table 1.—What do you do with a regulation?

I. What is meant to be the product of the regulation?
   A. Maintain the status quo
   B. Increase water quality
   C. Control activity
   D. Eliminate current uses
II. Is the regulation administratively and technically possible?
   A. Will it fit on the ground
   B. Will it fit existing administrative procedures
III. Does the regulation follow its legal parent?
IV. Is the regulation compatible with other laws and requirements?
   A. Constitutional
   B. Other laws
   C. Management requirements
V. What will be the cost of the regulation?
   A. To administer and enforce
   B. To the land or water owner
   C. In lost production or jobs
   D. Do the beneficiaries bear the cost

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A NATIONAL PERSPECTIVE FOR LIVESTOCK WASTE MANAGEMENT

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Thirteen years have passed since enactment of P.L. 92-500, the Federal Pollution Control Act of 1972, and although the level of public awareness has increased, progress in controlling nonpoint source pollution has been slow, largely because of the wrong perceptions created by inaccurate and unreliable information.

Policy makers need credible information and data to make decisions that will evolve into workable management plans. Plans that will in turn respond to meet designed objectives—in this case, clean water.

National planning and policy directives many times fall short of their goal because of a lack of practical and applicable techniques that assure implementation responsive to local needs.

On the other hand, local decisions many times fail because of an unwillingness to address the "big picture" that interacts with the social, political, and economic interests at the national level.

Simply stated, this means best management practices should be implemented only when a state or an areawide agency has properly identified the problem, made an assessment that has examined all of the alternative practices, and has had appropriate public participation.

Identification of the problem is important. It must recognize that pollution from nonpoint sources can be attributable to a number of activities. Included among these activities are:

1. Agriculture—cropland, pastures, rangeland, woodlands, and small livestock and poultry feeding operations;
2. Silviculture—forest growing stock, logging, and forest road building;
3. Construction—urban or commercial development and highway construction;
4. Surface mining;
5. Terrestrial disposal of agricultural, industrial, commercial and municipal waste and wastewaters; and
6. Stormwater drainage from urban areas.

Erosion, runoff, and water quality effects must consider local soil, vegetation, aquatic, geology, hydrology and land use relationships.

Here is where the "big picture" group collides with the "local" group. To illustrate this point, let's use the "big picture" syndrome approach that is used in Washington when an issue of this magnitude is debated in Congress.

Proponents for controlling nonpoint source pollution create the perception that millions of acres of our cropland are being washed away annually. "Any day you can stand on the bridge overlooking the Mississippi River and watch five farms float away!" What a preposterous exaggeration of fact! And yet, this exaggeration is what stirs the emotional level of the public into "doing something" to stop this abuse of our soil and water resources.

The real mission here is to create a proper perspective to encourage practical solutions to these problems. Using this example, let us create a more realistic perception based upon reliable data (Assessing Erosion, 1984). Let's take a close look at the land erosion classes, their makeup and some practical solutions:

Nonerosive: about 37 percent (63 million ha) of U.S. cropland. Its rate of soil erosion will always be less than *4.5 metric tons* per hectare per year under any management. Operators of 53 percent of such land, some of them encouraged by Federal programs, use one or more conservation practices to control their minimal erosion problems.

Moderately erosive, but within tolerable levels: about 40 percent (69 million ha) of U.S. cropland. This land has the potential to erode above this tolerable level of *4.5 metric tons* per hectare per year, but the operators, by using crop rotations, contour plowing, minimum tillage, and terraces, keep their erosion below that level.

Moderately erosive, but above the tolerable level: about 15 percent (25.5 million ha) of U.S. cropland. With good farm management, this land could also be worked to keep its rate of erosion below the tolerable *4.5 metric tons* per hectare per year. But the type of management practiced causes topsoil to wash away, in some places exceeding *22.7 metric tons* per hectare per year. About half of the operators of such land apparently make no effort to stem their losses by applying conservation practice. This land and these owners should be targeted for Federal conservation programs.

Highly erosive: about 8 percent (13.4 ha) of U.S. cropland. It will erode by more than *4.5 metric tons* per hectare per year with any kind of cultivation. The only way to prevent erosion on this land is to put it in permanent sod or convert it to another less intensive land use. More than two-thirds of this land is planted to row crops like corn and soybeans, which cause serious erosion problems. Furthermore, operators of nearly half of this land have applied no conservation practices.

These figures hardly support the perception that five farms per day float down the Mississippi River! My point is simply this, we cannot afford the luxury of dealing with misperceptions based on the misapplications of data. Already we have made too many decisions based upon faulty information that has cost U.S. taxpayers dearly. Our current Federal deficit is part and parcel of a misapplication of taxpayers' dollars for perceived water quality goals that were never achievable.

Washington, D.C., the mecca of all policy, is a little town within a big city where a lot of little fish in a big pond struggle for clean water. The goal is to achieve fishable, swimmable waters. To achieve that goal, we must balance the social, political, and economic values innate to our society, apply the lessons of history, and make every effort to interact with the various publics whose interests vary from practical to absurd.

Let us keep in mind that the problem of water pollution is not new. Richard Graber in his publication, Agricultural Animals and the Environment, noted that "early travellers and settlers often experienced difficulty in locating a stream of potable water because of the activities of large herds of buffalo. The buffalo found the rivers and streams not only a source of drinking water but a haven from the heat and a source of mud to protect themselves from biting insects. As a consequence, the streams flowed richly with manure, urine and mud. This situation is acknowledged in the name the Pawnee Indians gave the Republican River in Nebraska. The English translation is something close to "Buffalo Manure Creek." (Graber, no date).

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ECOPSYCHORRHEA

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William Ruckelshaus is a distinguished public servant who has twice administered our top environmental agency. Upon his recent departure from public service he released a comprehensive statement on the need for risk assessment and risk management policies for the management of our environmental concerns and regulatory actions (Ruckelshaus, 1985).

Ruckelshaus outlines the sudden appearance of environmentalism on the American scene in the mid-sixties and Congress' rapid response to regulate matters after 1970. In typical legal jargon Congress wrote laws with unattainable goals, poor time schedules, conflicting directions, and absolutely no understanding of the total environment. Congress made promises that could not be kept.

Senator Daniel Moynihan (D-N.Y.) said of this, "The malaise of over promising derives almost wholly, in my experience, from the failure of executives and legislators to understand what is *risked* when promises are made . . . When things don't work out as promised it is all too easy to suspect that someone *intends* that they should not." (Emphasis added.)

Ruckelshaus feels that after 15 years environmentalism has changed, that the U.S. Environmental Protection Agency is getting on a better track—that of perceiving the big picture as President Nixon described it when he set about reorganizing the government to cope with the problems of burning rivers, raw sewage, and brown air.

The big concern now is toxic substance exposure and carcinogens that brings us into a new area of controversy, one that raises more questions than we have answers for. Edith Efron's book, The Apocalyptics, reveals a miserable track record in the handling of carcinogen research by the regulatory scientists. Efron's work has drawn high praise, making one suspect all that is said about science in government hands. One must question the motives of Rachel Carson, Barry Commoner, Ralph Nader, and others who predicted such dire happenings in this area 20 years ago, predictions that time has proven to be false.

This brings us to the topic of this paper: ecopsychorrhea. Ruckelshaus referred to the new terms coined for the American language by the environmental revolution. I crafted ecopsychorrhea. It comes from three Greek words: Eco meaning the environment; psycho referring to the mental processes; and rrhea meaning a continuing flowing through. Ecopsychorrhea infects those people who constantly talk about the environment without any basic knowledge of how it actually works on a continuing basis.

Ecopsychorrhea was epidemic in the sixties. Brown air was highly visible, raw sewage in rivers was quite obvious. Corrections were needed. How well I remember the day when Dr. Carver of the Idaho Health Department called me to his office. "Hovenden," he said, "after we get all of our cities on sewage treatment plants, your cattle feeders will be next! Got it?" I got it. No big environmental impact statement or expensive study, just get yourself in gear and get going. That one-minute conversation changed my life.

Along with the Idaho Cattle Feeders Association I was committed to finding answers. There were no answers in 1968. By 1969 we were getting calls from the League of Women Voters and American Association of University Women. They would inform me that they were "ecologists" and that a feedlot of 10,000 cattle was the equivalent of a city of 50,000 people with no sewage treatment plant. These were acute cases of Ecopsychorrhea!

In 1969 the directors of the Cattle Feeders Association agreed to participate in a feedlot study by the Federal Water Quality Administration. I helped the engineer designated for the study to devise a questionnaire that was mailed to about 120 feedlot operators. Forty-five people responded. The response was very useful as the answers came from throughout the principal cattle feeding areas of Idaho.

The resulting report that we received in July of 1970 was frightening. The recommendations would have removed all of the beef and dairy cattle from the Boise Valley and other areas with high water tables. I was launched into a career of finding answers to feedlot pollution.

The greatest set of answers came from the Second International Symposium on Livestock Wastes at Ohio State University April 19 to 22, 1971. The program was arranged by Dr. J. R. Miner of Iowa State University; local arrangements were under the direction of Dr. E. P. Taiganides of Ohio State. At this conference I made valuable contacts with those two individuals as well as Dr. Tom McCalla, distinguished microbiologist at USDA's Agricultural Research Service station at the University of Nebraska at Lincoln. All I know about manure and pollution I have learned from these men and from John Sweeten of Texas A&M.

In 1973 the EPA, through its Robert S. Kerr Laboratories in Oklahoma, approached the American National Cattlemen's Association with an offer to hold a conference between the cattle industry, a number of top EPA officials and members of the scientific community. The agenda contained the research results of the last 5 years. George Spencer of the Cattlemen's Association immediately borrowed me from the Idaho Association because our association was out in front in seeking answers and working with research personnel. No other cattle association, including the national, had an executive with the amount of experience that I possessed at that time.

Lynn Schuyler of the Kerr Laboratory at Ada, Oklahoma, and I arranged the program for this Action Conference. Rep. Morris Udall (D-AZ) accepted our invitation to be the keynote speaker. From the EPA came Michael Glenn, Acting Deputy Assistant Administrator for Water Enforcement; Albert Prinz, Director of the Permit Program; and Harold Coughlin of the Effluent Standards Division.

Speakers from the academic and research community included Dr. Paul Taiganides who spoke on the life history of a river and Dr. Dan Wells of Texas Tech who spoke on the subject of Manure, How it Works.

We presented a manual to participants and later offered it for sale to livestock associations as well as individuals around the country. The second day of the program was a discussion of the manual. The attendees were divided into three groups: Arid Areas, the Corn Belt and the Southeast.

On the policy side, we talked of the ultimate requirement of controlling the runoff from a storm of 24-hour duration and 25-year frequency. In the final wrapup, I asked the representatives from the Corn Belt and Southeast if they could live with this requirement. In these latter two areas, annual rainfall exceeds annual precipitation, giving them a much larger runoff control problem. They agreed that this was within reason. Those who created this guideline understood that there was a limit to the degree of control that could be asked of any individual operation. It is far more equitable than the "no discharge" standard adopted by some States. This means zero. We learned in other controversies that someting as small as 10 parts per trillion was more than zero.

Before all of this information was available, I wrote a pamphlet for my Idaho people. Entitled Total Retention, the piece advocated keeping all runoff out of the irrigation ditches, streams, and rivers. I soon learned that this was the wrong approach.

Others made errors too. Kansas adopted a rule for feedlots that called for cleaning all manure from the pens every 90 days. It required cleaning the manure right down to the bare ground. Later research by Dr. Tom McCalla and others proved that this was the worst thing they could do. It destroyed the seal between the earth and the organic material in the manure. This seal prevented most of the liquids from percolating into the soil underneath the feedlot.

My position as Action Conference chairman conferred upon me the responsibility of responding to the Hamilton Standard study of feedlots. The study was done for EPA in preparation for issuing feedlot guidelines in the Federal Register. The scientific community came forth in great numbers at a special meeting in Lincoln, Nebraska, to prepare comments. We were able to study one of the few available copies of the report. I wrote the ANCA's response to the proposed guideline based on our group discussions that day on the Nebraska campus.

I also represented the national association before the EPA and Congressional committees on the subject of feedlot guidelines. I drafted the responses and mailed them to the volunteers on our consulting committee. They called me with their comments before I delivered the testimony to Washington.

In early 1974 we went through the National Pollutant Discharge Elimination System program with the EPA. The Natural Resources Defense Council sued in Federal Court and obtained a judgment against EPA on the guidelines. In March 1976, EPA issued new feedlot criteria saying that "Those feedlots that only discharge in the event of a 25 year or greater storm do not need permits." I commented to Permit Program Director Albert Prinz at the time of this new release, "Sounds to me like if you now have a permit that you no longer need one!" He concurred.

Basically, a feedlot operator with the will to do so can control runoff. A good educational program is most helpful; Bill Ruckelshaus feels that this is a proper role for EPA.

As we have learned through practical experience, a great amount of the feedlot pollution only existed in people's minds. They tend to associate this fermented byproduct with a vulgar four letter word that is used in less than polite circles. It is this perception that leads to the development of ecopsychorrhea.

One of the strongest forces working for us can be peer pressure, which is 90 to 95 percent effective. Our regulations and police power are only needed for that small percentage of people who believe in doing what they like without regard for their neighbors.

I was appointed to the Idaho Advisory Committee authorized by section 208 of the 1977 Clean Water Act. I served for the full life of this committee, from 1976 until 1983. For the last 4 years, I chaired the agricultural subcommittee. When we started trying to control nonpoint source pollution, agricultural return flows were the big item in an agricultural State like Idaho. We were told to adopt best management practices. EPA's instructions called for mandatory compliance and regulations. I objected, holding that if we could show our farmers how to keep their $3,000 per acre land from being washed into the Snake River they would willingly cooperate. We held steadfast to this position and the EPA in Region X finally agreed to our program.

Most of the 208 funds allocated to Idaho were used to build demonstration projects. A project was created along the L-Q Drain just west of the city of Twin Falls. The next year the Balanced Rock Soil Conservation District took notice of this. Their photographs of the silt-laden water of nearby Deep Creek (a return flow artery in western Twin Falls County) in the spring sparked voluntary action.

By the following year this District had many management practices in place. They took colored slides of their projects and of the improvement of the water in Deep Creek. Voluntary cooperation was working.

In the spring of 1983 the EPA sent a man from Seattle to meet with our 208 Advisory Committee. He came to praise us. Idaho was far ahead of any other western State in developing its nonpoint source program. The praise was so extensive that it was almost, but not quite, frightening. Peer pressure and demonstration projects had prevailed. The people in Idaho are proud of their accomplishments. Farmers and ranchers can be true environmentalists even if they don't carry cards in the Sierra Club or similar organizations.

Our efforts did close down two poorly-run feedlots on the Payette River. These lots were built on gravel beds. No one wanted to use manure with a lot of rocks in it. Consequently, the operators simply pushed their manure into the river for easy disposal. Their actions gave the rest of the cattle feeders a bad image. They contributed to ecopsychorrhea.

We must continue to work with those great tools of humankind, education and peer pressure.

When we embarked upon a search for practical solutions to the discharge permit requirements, I realized that man had lived close to cattle for many thousands of years and that they had not hurt him. I did not panic at the thoughts being circulated by people who wanted to compare manure to human wastes. Instead, I agreed that we could abide by information developed by sound, scientific investigation. Our great soil scientists and microbiologists found the answers.

Manure is a friendly product. It arrives on the feedlot at about 85 percent moisture. It is loaded with bacteria that immediately begin degrading it, giving it a half-life of 120 days. Coliform bacteria find it hard to survive in such an environment. After all, manure is only alfalfa and grain that have been through a time proven fermentation process. When it is dry it has no odor. It can readily be washed from one's bare feet or hands.

I love it. It smells like money to me.

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CONTROLLING WATER POLLUTION FROM NONPOINT SOURCE LIVESTOCK OPERATIONS

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CONFINED CATTLE OPERATIONS

The 1972 Federal Water Pollution Control Act Amendments and the 1977 Clean Water Act created a system of Federal effluent guidelines, performance standards for new sources, and permits for point sources that include cattle feedlots with 1,000-head capacity or more. The point source water pollution control program encompasses most of the 12 million head of cattle on feed for slaughter in the Nation. Since the early 1970's, virtually all the large cattle feedlots have installed water pollution abatement systems that prevent discharge of pollutants. These feedlots now comply with the Federal and State regulations. Feedlot runoff holding ponds must be designed to collect all runoff from the 25-year frequency, 24-hour duration rainfall event or process-generated wastewater, followed by land disposal by irrigation or evaporation.

UNCONFINED CATTLE OPERATIONS

Approximately 100 million cattle are raised on 360 million ha (900 million acres), or about 40 percent of the land area in the United States, by hundreds of thousands of individual producers. The size of cow–calf herds varies with region, but averages less than 100 cows nationwide on pastures or rangeland. This unconfined cattle production accounts for half the almost 109 million metric tons (120 million dry tons) of animal manure generated each year in the United States. Cattle stocking densities on range and pasture lands vary by 1000-fold or more, from up to 10 head/ha with temporary grazing of irrigated, fertilized pastures and grainfields, to an average of only 1 head/160 ha on certain arid native rangelands (Sweeten and Reddell, 1978).

Unconfined cattle operations with these stocking densities clearly satisfy part of the definition of nonpoint sources as "diffuse or multiple outlets," but in many cases it is doubtful whether the presence of unconfined cattle on range or pasturelands can be discerned from natural or background levels of water quality parameters.

Research in recent years has determined the effects of cattle grazing operations on runoff quantity and water quality in streams. This research has determined that unconfined livestock production is an environmentally sound water quality management practice.

The most common change in stream water quality from unconfined livestock production is elevated counts of indicator bacteria and sediment concentrations (Milne, 1976; Saxton et al., 1983). Chemical pollutant concentrations are sometimes increased slightly, but they seldom exceed stream quality standards. The available data have shown that any detectable water pollution from unconfined cattle operations may not be related to cattle numbers or manure quantity involved, but rather to hydrogeological factors that contribute to rapid surface runoff or sediment movement (Dixon, 1983).

AGRICULTURAL NONPOINT SOURCES

Agricultural nonpoint sources of water pollution, under section 208 of the Federal Clean Water Act, include runoff from dryland and irrigated cropland, livestock production on range and pastureland, small-scale livestock confinement facilities, and manure disposal areas. Water pollutants from agricultural nonpoint sources may include sediment, nutrients, salts, organic matter, certain indicator bacteria, or pesticides.

Pollutants from nonpoint sources are entrained and conveyed by rainfall runoff, and may not be traceable to individual operations. In those areas where agricultural activities contribute a major share of the nonpoint source pollution load, the vastness of the land areas involved relative to other land uses, rather than acute problems, is primarily accountable.

Nonpoint source pollutants can generally be controlled by management techniques known as best management practices (BMP's) instead of wastewater treatment methods. BMP's reduce the volume and concentration of runoff from nonpoint sources. For example, BMP's for cropland include maintaining vegetative cover, conservation tillage, furrow diking, contour plowing, and terracing to conserve rainfall and reduce loss of soil, nutrients, and pesticides in runoff. These practices save the farmer or rancher both cash inputs and irreplaceable resources. Using marginal croplands for hay production or cattle grazing is also consistent with good soil and water conservation practices, and with nonpoint source pollution abatement principles.

CATTLE GRAZING OPERATIONS AS NONPOINT SOURCES

Watersheds containing cattle grazing sometimes show increased concentrations in adjacent streams of bacterial indicator organisms, primarily coliforms and streptococcus (Dixon, 1983; Milne, 1976). Reported effects, however, are erratic and detectable only for short distances downstream. Fecal deposits along drainage ways may contribute a disproportionate share of the bacteria from grazed watersheds. Often the effects of cattle are indistinguishable from the effects of wildlife within the watershed (Doran et al. 1981; Dixon, 1983).

Water quality standards for coliform indicator organisms, developed for point sources, have questionable value for assessing water quality effects of cattle grazing operations, according to U.S. EPA research on grazing watersheds (Doran et al. 1981; White et al. 1983; Saxton et al. 1983). The amount of nitrogen and phosphorus carried away each year from grazed pastureland (Tables 1 and 2) is far less than from feedlots (Loehr, 1974; Doran et al. 1983). In fact, runoff from livestock pastures often does not exceed nutrient levels in runoff from ungrazed pasturelands, forests, dryland farms, or even precipitation (Saxton et al. 1983). Nutrient losses and runoff amounts are usually greater for overgrazed pastures than for properly managed grazing systems.

Within a pasture, manure deposits may cover only 1–20 percent of the surface area depending on stocking density and duration (Sweeten and Reddell, 1978). Dung deposits are greatest on cattle bedgrounds and resting areas, which typically are on well-drained soils (Powell et al. 1983). Direct movement of dung deposits into stream channels is minimal because standing vegetation and grass litter serve as filters.

Unconfined livestock may decrease vegetative cover and increase runoff, erosion, and transport of sediment, plant nutrients, and oxygen demand. At high-impact feeding and watering sites, sediment load can be minimized by management practices that include protecting fragile stream banks, maintaining vegetative cover, low or moderate stocking levels, distributing salt and water, and providing feed, salt, or water away from streams.

BMP'S FOR SMALL CONFINEMENT CATTLE OPERATIONS

Small feedlots (below 1,000 animal units or beef cattle equivalents) are regarded as nonpoint sources of pollution in most states. The distinction between feeding operations that are point sources and those that are nonpoint sources varies among States, but it is typically based on number of head, animal spacing, proximity to streams, and likelihood of wastewater discharge.

BMP's for nonpoint source water pollution control at small feedlots include:

1. Locating the feeding facility away from a stream or drainage channel;
2. Diverting outside runoff away from the feedlot surface using diversion terraces and roof gutters;
3. Collecting solids carried off the feedlot surface by runoff water; solids should be settled out in channels, debris basins, or grass waterways where they can be removed and disposed of properly on land;
4. Installing a grass filter strip at least twice as large as the feedlot, where a small feeding site is close to a waterbody, to improve runoff quality before it enters the water;
5. Installing a runoff holding pond if the water quality risk is high and the location of a feedlot prevents the use of a vegetated filter. The collected runoff should be disposed of by irrigation onto nearby crop or pasture land; and
6. Making the best use of nutrients in the manure to improve the soil's physical properties by applying manure to cropland.

ANIMAL MANURE DISPOSAL METHODS FOR WATER POLLUTION CONTROL

A great deal of research has been conducted to help cattlemen and farmers properly use manure. The proper manure application rate is normally determined based on soil and plant requirements for nitrogen (Gilbertson, 1983). Phosphorus and salt content are sometimes limiting factors also.

Manure application rates are usually about 22 metric tons/ha/yr (10 tons/acre/yr) for irrigated corn, grain sorghum, wheat, vegetables and hay crops, and about half this amount or 12 metric tons/ha/yr (5–6 tons/acre/yr) for dryland crops. Application rates should be selected based on soil sample and manure nutrient analysis, using the advice of a professional agronomist.

Solid manure should be spread evenly with a spreader truck or tractordrawn box spreader and disked into the soil promptly to conserve nutrients. Soil injection of liquid manure will conserve nutrients and prevent runoff, odors, and flies. Site-specific factors influence the type of liquid manure application equipment that is most advantageous.

Table 1.—Annual yield and concentrations of nitrogen and phosphorus[1].

	Total nitrogen		Total phosphorus	
Source	lb/acre	PPM	lb/acre	PPM
Precipitation	5.0-8.9	1.2-1.3	0.04-0.05	0.02-0.04
Forested land	2.7-11.6	0.3-1.8	0.03-0.8	0.01-0.11
Cropland runoff	0.1-11.6	9	0.05-2.6	0.02-1.7
Irrigated cropland in western U.S. (surface flow)	2.7-24.1	0.6-2.2	0.9-3.9	0.2-0.4
Urban land drainage	6.3-8.0	3	1.0-5.0	0.2-1.1
Feedlot runoff	89.3-1430	920-2100	8.9-554	290-360

[1]Data do not reflect extreme values caused by improper waste management or extreme storm conditions.
[2]Parts per million
Source: Loehr, 1974.

Table 2.—Average annual nutrient yields in runoff from some pastureland.

Location	Management system	Total nitrogen lb/acre	Total phosphorus lb/acre
Nebraska	Rotation graz.	2.5	0.62
	Rotation graz.	1.7	0.17
Oklahoma	Continuous graz.	8.7	4.11
	Rotation graz.	1.9	1.16
	Rotation graz.	4.6	0.04
Ohio	Rotation graz.	0.5-2.9	0.3-1.15
Minnesota	Prairie	0.7	0.10

Source: Doran, Schepers and Swanson, 1981.

Livestock producers and farmers need to leave a vegetated buffer strip of 33 m (100 ft) or more while surface-applying manure near streams, lakes, or drainage structures to prevent direct runoff into a waterbody (Gilbertson, 1983). If land is frozen or snow covered, manure generally should be applied on predominantly flat ground to minimize direct runoff. In spreading manure, avoid permeable soils with high water table, shallow creviced bedrock, waterways, floodplains, wet soils, and excessive application rates.

BMP'S FOR CATTLE ON RANGE OR PASTURE

EPA's 1984 report to Congress recommended several BMP's for nonpoint source pollution control for unconfined cattle production. They include (U.S. EPA, 1984):

1. Adopt an effective erosion control program;
2. Tailor the grazing programs and stocking rates to the microclimate, soil, vegetation, topography, and geology of the particular area;
3. Locate necessary animal holding pens or high-density grazing at hydrologically remote places (away from streams);
4. Disperse feeding facilities, watering sites, and shelters to reduce manure accumulation, soil compaction, and erodible paths;
5. Maintain grass cover downslope from sites where animals congregate and along stream banks to provide a vegetative filter;
6. Maintain good forage and ground cover to decrease volume and rate of runoff, prevent erosion, entrap manure and other organic matter, and use fertilizer nutrients; and
7. In special situations, consider more drastic measures, including (a) using tillage to break up or incorporate manure deposits, (b) modifying runoff drainage pathways, or (c) restricting animal access to critical areas.

FEDERAL AND STATE PROGRAMS FOR NONPOINT SOURCE POLLUTION CONTROL

In a 1978 review of water pollution effects of unconfined animal production EPA recommended against any regulatory programs that would discourage or restrict livestock production on pasture or rangeland, because of the low level of water pollution associated with unconfined animal production (Robbins, 1978). Successful agricultural nonpoint source water pollution strategy requires clearly defining solvable problems within a specific watershed and targeting specific sites for BMP application (Duda and Finan, 1983).

The 1984 EPA report to Congress favored management of nonpoint source pollution control at the State level instead of a national strategy that cannot be flexible enough to identify priority water quality problems nor target management control efforts at those problems.

Barriers to BMP adoption by ranchers and farmers can be categorized as economic, educational, and institutional. Ways to increase BMP adoption include:

1. Demonstrate the economic viability of each practice;
2. Provide cost-sharing incentives for those water pollution control practices that are not economical. (19 States now offer their farmers cost sharing incentives to adopt conservation measures or BMP's);
3. Provide educational programs through existing agencies, such as the Agricultural Extension Service, Soil and Water Conservation Districts, and producer groups; and
4. Provide stable agricultural policies that encourage investment in pollution control and resource management projects.

SUMMARY AND CONCLUSIONS

Instead of producing surplus grain on marginal land with increased potential for erosion and water degradation, cattle operations recycle nutrients back to land to better manage the soil. Cattlemen can use alternative BMP's to increase forage and beef production while preventing nonpoint source water pollution. When good management is practiced, cattle production enhances environmental quality and is an important asset to this Nation's soil and water resources.

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APPLICATION OF NEW TECHNOLOGIES TO LIVESTOCK WASTE MANAGEMENT

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INTRODUCTION

Recycling livestock and poultry waste through biological refeeding systems or through energy recovery systems may provide an economic incentive for farmers to consider alternative waste management systems (Martin and Madewell, 1971). This paper briefly describes several refeeding/energy recovery systems including the use of poultry house waste (broiler litter) in several beef cattle production systems, and recycling swine wastes through an aquaculture production (algae–fish–water chestnut–biogas) system.

FEEDING BROILER LITTER TO BEEF CATTLE

Ruminant animals such as cattle have no parallel in the role of scavenging and, consequently, no parallel in resource recovery from agricultural wastes. Their unique digestive system includes a microbial fermentation stage that enables crop residues, certain industrial byproducts, and livestock and poultry wastes to be used as feedstuffs and converted into meat. The Food and Drug Administration leaves the regulatory responsibilities for this practice to individual States. However, those States that have approved livestock and poultry wastes as feedstuffs for cattle have developed regulatory standards similar to the model regulations for processed animal waste products as animal feed ingredients, available from the Association of American Feed Control Officials (Minyard, 1978).

Broiler litter is a mixture of broiler manure, bedding material, waste feed, and feathers. Wood shavings, sawdust, and peanut hulls are the main bedding materials used in broiler houses in the Southeast. The kind of bedding apparently does not affect the quality of litter removed from a broiler house. However, broiler litter from different houses and management systems varies in nutrient content.

The Alabama Cooperative Extension Service and the Tennessee Valley Authority collected and analyzed litter samples from 31 broiler houses in north and central Alabama (Table 1). Average crude protein content of litter samples was 23.9 percent, which is not as high as the percent quoted by other States (Fontenot, 1978). A greater loss of nonprotein nitrogen (NPN), caused by higher humidity and heat, may account for the lower average. NPN protein equivalent was 5.7 percent on a dry weight basis. Thus, the NPN makes up only 24 percent of the total crude protein. Litter is a rich source of calcium and phosphorus. Trace minerals are also present in more than adequate amounts for cattle when broiler litter is fed properly. When litter makes up more than 30 percent of a ration, minerals need not be added.

The Total Digestible Nutrients (TDN) found in broiler litter indicates a relatively low-energy feed (Ruffin and Martin, 1981). Calculated TDN values range from 26 to 64 percent. Even dry brood cows need more energy from such grain as corn and wheat when wintered on broiler litter. The average TDN level of litter is similar to average quality hay grown in the Southeast.

Broiler litter should be processed so that harmful agents like salmonella and coliform bacteria are destroyed (Ruffin and Martin, 1981). Processing litter will also increase its acceptability to cattle. Most on-farm processed litter is deep stacked in a shed or stored outside and covered with heavy duty polyethylene. It should be stacked at least 2 to 2.5 m (about 6–8 ft) deep so that heat will destroy potential pathogens. Usually after ensiling 4–6 wks the litter is ready for feeding. Properly stored litter will lose its typical manure smell and will be much more acceptable to the cattle. Broiler litter can also be processed in a pit or bunk silo.

Table 1.—Nutrient content of broiler litter from 31 broiler houses in north and central Alabama (Ruffin, 1978).

Composition	Average	Range
	%	
Dry matter	78.3	69–84
Composition of dry matter		
TDN (calculated)	55.0	26–64
Crude protein	23.9	13–31
Crude fiber	26.9	14–46
N-P-N (protein equiv.)	5.7	1.0–11
Ash	21.5	10–47
Calcium	2.1	1.0–3.5
Phosphorus	1.6	1.1–1.9
Potassium	1.7	1.3–2.1
Magnesium	0.44	0.3–2.1
Sulfur	0.21	0.1–0.41
Copper	0.036	0.0011–0.060
Arsenic	0.0036	0.0018–0.0062

Table 2.—Suggested rations including broiler litter.

Ingredients	Ration Number 1	2	3	4
	kg			
Broiler litter	364	300	227	157
Cracked yellow corn	90	154	227	295
Ground limestone				2
% Corn/% litter	20/80	34/66	50/50	66/34
	calculated analysis[1]			
Dry matter	80.5	82.2	83.8	85.4
TDN	62.6	68.3	73.8	78.9
Crude protein	18.1	16.4	14.7	13.1
Crude fiber	21.2	17.2	13.6	9.9
Calcium	1.60	1.27	0.96	0.78
Phosphorus	1.30	1.11	0.93	0.74

[1]Based on data presented in Table 1.

Table 2 suggests rations of varying broiler litter–corn mixtures. These should be used only as a guide because the nutrient levels in broiler litter vary (Ruffin and Martin, 1981). Ration No. 1 is calculated for use as the major ration for dry beef cows. Hay or some other roughage should be provided to maintain normal rumen function. About 1 kg (2.2 lbs) of long hay fed every 2 or 3 days will be adequate. A 454-kg (1,000-lb) dry brood cow will need about 9–11 kg (20–24 lbs) of ration No. 1 for maintenance during winter months. Corn mixed with broiler litter should be cracked or ground.

The No. 2 ration is formulated for lactating brood cows. About 11 kg (24 lbs) daily will furnish adequate nutrients during the winter months. Some long hay, as with ration No. 1, will be needed for normal function of the rumen.

The No. 3 ration is formulated for growing stocker cattle. Stocker cattle weighing about 227 kg (500 lbs) will consume abut 6.3 kg (14 lbs) of this ration. Healthy stockers that have been wormed, vaccinated, implanted, and otherwise managed as recommended by the Alabama Extension Service should gain 0.9 kg (2 lbs) or more daily consuming this ration.

The No. 4 ration can be fed to cattle weighing about 341 kg (750 lbs) or more. Consumption should be about 11–13 kg (25–28 lbs) daily for maximum gain. Long hay or a small amount of oat or wheat straw will maintain normal rumen function for cattle consuming finely ground rations such as the No. 4 mixture.

EFFECTS OF FEEDING SYSTEMS ON CHEMICAL CONTENT OF CATTLE MANURE

The precise composition of cattle manure varies according to the type of cattle operation and particular feeding system. Broiler litter contains much higher concentrations of elements such as phosphorus, potassium, and calcium than are required by cattle; therefore, its use in feeding generally increases the fertilizer value of the cattle manure.

Nine typical on-farm feeding systems (five of which include broiler litter for four different types of cattle operations) are given in Table 3 (Ruffin and Martin, 1983). Manure samples from these farms were air-dried to simulate pasture drying conditions, then oven-dried and analyzed for nitrogen, phosphate, potash, calcium, and magnesium.

In three of the systems on Farms 1 through 7 representing brood cows, replacement dairy heifers, and growing stocker cattle, the manure was deposited on the land by the grazing animals. Results in Table 4 indicate that manure from cattle on rations containing broiler litter contributed more to the fertility of a pasture than did manure from conventional rations. Obviously, part of the manure was concentrated in loafing areas. Within each system, manure from cattle consuming broiler litter contained more phosphate than did the manure from cattle on hay or silage. For example, manure from brood cows on a 20 percent corn plus 80 percent broiler litter ration (Farm 1) contained more than double the amount of phosphate than did the manure from cows fed good quality coastal bermudagrass hay (Farm 3) and three times more phosphate than the manure from cows fed low-quality fescue hay (Farm 4). The phosphate content of manure from feedlot cattle on a 66 percent corn plus 34 percent broiler litter ration was 2.98 percent; the phosphate content of feedlot manure from a conventional corn silage ration was 1.53 percent.

Table 4.—Effects of different cattle feeding systems on plant nutrient content of manure.

Farm Number	Composition of dry cattle manure, % N	P_2O_5	K_2O	Ca	Mg
	Brood cow maintenance				
1[1]	1.45	2.13	0.71	1.76	0.30
2[1]	1.31	1.17	0.84	1.20	0.30
3	1.12	1.01	0.84	0.83	0.22
4	1.32	0.66	1.07	0.92	0.31
	Replacement dairy heifers				
5[1]	1.21	1.19	0.61	1.20	0.33
	Growing stocker cattle				
6	1.84	1.28	1.16	0.82	0.52
7[1]	1.72	1.65	1.70	0.85	0.27
	Finishing slaughter cattle				
8[1]	1.93	2.98	2.56	1.49	0.51
9	2.03	1.53	1.97	0.71	0.43

[1]Contained broiler litter.

Table 3.—Cattle feeding systems in north and central Alabama.

Farm Number	Type of Cattle Operation	Feeding Systems
1	Brood cow maintenance	20% corn + 80% litter
2		20% wheat + 80% litter + wheat pasture + coastal bermudagrass hay
3		Coastal bermudagrass hay (good quality)
4		Fescue hay (poor quality)
5	Replacement dairy heifers	50% corn + 50% litter + hay + fescue pasture
6	Growing stocker cattle	Wheat pasture + cottonseed + hay
7		50% corn + 50% litter + fescue pasture
8	Finishing slaughter cattle	65% corn + 35% litter
9		Corn silage + cottonseed meal

INTEGRATED AGRICULTURAL/AQUACULTURAL/LIVESTOCK WASTE MANAGEMENT SYSTEMS

A 5-year study was conducted at Muscle Shoals, Alabama, of the recovery of plant nutrients from swine manure in an integrated algae–fish–water chestnut production system (Behrends et al. 1982, 1983; Maddox et al. 1982). Swine manure fertilizes the algae; filter-feeding fish consume the algae; and effluent from the fish pond supplies nutrients to a water chestnut bed. One phase of this study also included biogas production from swine manure in an anaerobic digester; the digester waste then fertilized the aquatic farming system.

The swine manure is flushed directly into the fish–algae culture ponds with virtually no odor because enough oxygen is maintained by the growing algae. A specified level of manure loading rates assures proper oxygen levels for growing and maintaining fish. In static water systems where water is added only to replace evaporational/seepage losses, manure loading rates should not exceed 40 kg/ha/day (dry matter basis). The flowing water system should maintain a waterflow rate sufficient to replace all fish water in 10 days, giving a flow rate of 655 L/ha (70 gal/acre) min continuously. The waste from 5,000 kg of pigs applied to a hectare 91 cm deep (11,000 lb/acre at 3-ft depth) at this flow rate should stimulate a lush growth of algae which will provide adequate feed for filter-feeding fish.

Fish such as tilapia (*Tilapia* spp.) can be grown in this type system. They should be stocked into the aquatic farming system at a density equivalent to 10,000 to 15,000/ha (3,240 to 4,080/acre) with fish weighing 30–60 g (1–2 oz) each. Accessory species, such as silver carp (*Hypophthalmichthys molitrix*) and bighead carp (*Aristichthys nobilis*), can be stocked at a rate equivalent to 2,500/ha (1,000/acre). Silver carp can be substituted for tilapia in this stocking ratio if they are the principal fish grown in the system, and bighead carp can be stocked up to 25 percent of the total population. Annual fish yields of 5,600–7,850 kg/ha (5,000–7,000 lb/acre) can be expected from this system if the proper size fish are stocked and grown for 150–180 days. Tilapia cannot survive water temperatures below 13°C (55°F) but may be overwintered in power plant water with raceway facilities or in artesian springs where water temperature is at least 15°C.

Wide diurnal fluctuations in dissolved oxygen and pH make survival impossible for many of the pathogenic bacteria such as *Salmonella* spp. (Baker, 1981). Thus fish grown in manure-fertilized systems are free of many of the pathogenic bacteria associated with the manure.

Water discharged from the fish pond can be irrigated onto a sand bed filter to grow Chinese water chestnuts (*Eleocharis dulcis*) with an area equal to approximately one-half the water surface area of the fish system (1:2 ratio). Chinese water chestnuts should be planted on 51-cm (20-in) spacings early in the spring, and the bed should be flooded 5–10 cm (2–4 in) deep. Plant tops (shoots) can be cut and baled for hay after the first frost. The water chestnuts can be harvested with modified root harvesting equipment from the dry fields. Yields of 15 metric tons/ha (6.7 tons/acre) of dry hay and nearly 40 metric tons/ha (17.8 tons/acre) of water chestnuts can be expected. The quality of the water leaving the sand beds would meet tertiary wastewater treatment standards during the growing season, thus minimizing the pollution potential of the swine wastes.

The water chestnut hay is suitable for cattle feed and the water chestnuts can be sold for gourmet cooking. Also, the water chestnut is a sugar and starch crop suitable for animal feed or use as a possible source of carbohydrates for alcohol fermentation.

Anaerobic digester waste has proved to be suitable as an aquatic fertilizer. Reduced oxygen demand of the waste as a result of the pretreatment process permits higher waste loading to the aquatic system and reduces the land area required to recover and treat a given amount of swine waste.

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