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Are Water Quality Regulations Giving Manure a Bad Name?

Richard A. Levins

The most contentious issue in Minnesota agriculture is the location and operation of large livestock farms. The Minnesota Pollution Control Agency, many counties, some townships, and even the Attorney General's office are all trying to influence how farmers manage manure.

The state has initiated a generic environmental impact statement (GEIS) to look at all aspects of livestock farming in Minnesota. Within the complex of regulations created by these bodies is the basic presumption that water quality protection is a matter of keeping plant nutrients that occur naturally in manure out of surface water and groundwater.

It goes without saying that the state's policy of protecting water quality is important and proper. But, we need to look at some unintended consequences of this policy. In Minnesota, we regulate nutrients from manure, but we largely ignore nutrients from other sources. The consequence is that our regulations give manure a bad name.

Is there another way to accomplish the state's water quality goals without unduly discouraging livestock production in Minnesota? Regulating farm nutrients from all sources, not just from manure, offers an intriguing possibility.

The Current Program

Broadly speaking, water quality regulations and livestock come together in two ways. The first is in regulations on the handling and storage of manure to prevent leakage or direct discharge from degrading water quality. Such regulations are, at least conceptually, straightforward. It's all a matter of proper engineering and instruction.

With the second part of the feedlot program—the application of manure to farmland—effective regulation is more complicated.

Thousands of livestock farms of all types and sizes are required to submit manure land application plans for approval. The principal requirement of these plans is that manure nutrients, especially nitrogen, be spread at what are called "agronomic rates."

Agronomic rates match plant nutrient requirements and nutrient applications in such a way that excess nutrient levels do not unduly compromise water quality. An approved plan must show that there are enough acres available to spread manure at agronomic rates and indicate what those rates are for each farm field covered by the plan.

*(See **Water** page 2)*

Managing Minnesota's Drainage System

Steven J. Taff

There exists a very common feeling that to bring unused land into use is good—at all times, in all places, and without reference to the relation between costs and returns.

—Ray Teele, 1927

The sentiments reflected by Teele, a long-time USDA water resource expert (who by the way did not agree with them), capture well the ethos of water management in this country until the very recent past. Drainage is an unalloyed Good Thing.

But there was another aspect of this ethos:

The problems of drainage, highway construction, improvement of natural waterways, and the conservation of the state's natural resources are so intertwined that the solution of each must be worked out with due regard for the other.

—State Drainage Commission, 1913

This recognition of the complexity of the state's drainage System, as I'll call it, permeates Minnesota laws over the decades. Drainage is a management decision that cannot be considered alone.

It's a simple fact that much of Minnesota's agriculture was built on drainage. A 1985 study estimated that the state had nearly 5 million acres of drained land. Only 20% of that was drained by tiles, subsurface perforated pipes that convey excess water from fields to collection ditches. The rest was drained directly by ditches.

*(See **Drainage** page 3)*

University of Minnesota Extension Service

(*Water* *continued from page 1)*

Nitrogen has been the nutrient of most concern in these plans because of its potential to leach into groundwater. Phosphorus has received a lot of attention recently since it can pollute surface waters and cause algae blooms. But in either case, nitrogen *from manure* and phosphate *from manure* have been targeted.

Problems with Enforcement and Fairness

Enforcement problems are one reason we might want to look at other ways to regulate land application of manure. It is one thing to require feedlot operators to submit a plan; it is quite another to ensure that the plans are followed.

As daunting as checking land application plans for virtually every feedlot in Minnesota might at first appear, the challenge becomes even greater upon reflection. Almost all of these farms will spread manure during a relatively short time in the spring and fall. A sizable army of regulators would be hard pressed to see that manure is applied to the proper fields. And what if they also had to ensure that rates of application were according to plan?

Fairness is an even bigger problem. Farmers without livestock have the option to apply manure, which is heavily regulated, or commercial fertilizer, which is not regulated at all. Commercial fertilizer is easier to handle than manure and is less likely to draw nuisance complaints from neighbors. Yet if we want to have both an expanding livestock industry and high quality water resources, it is these farmers without livestock that must somehow be induced to use the growing supply of livestock manure.

You don't have to be around a lot of farmers to predict the answer to the question, "Would you rather use commercial fertilizer without regulations or use manure and have the Minnesota Pollution Control Agency and a host of other agencies looking over your fence?" Yet this is exactly the policy environment in which we are trying to encourage proper land application of manure. The incentives are all wrong.

Too Much Manure?

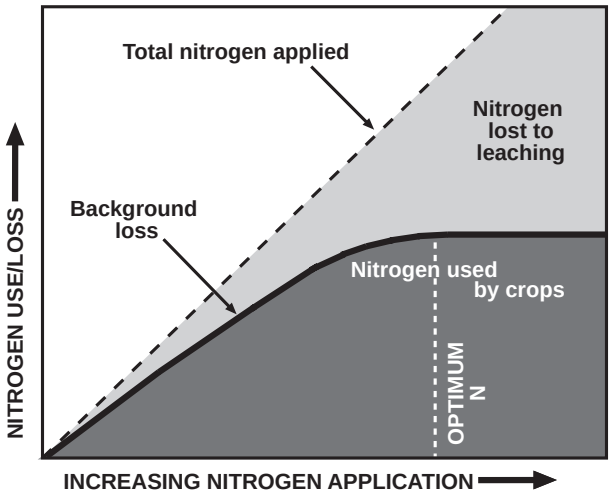
Use of nutrients from manure cannot be separated from use of nutrients from commercial fertilizer sources. Manure is a locally produced source of plant nutrients. Commercial fertilizer, on the other hand, is imported. Furthermore, the livestock industry adds value to feed crops and is an important part of the economy of rural Minnesota. But in listening to most feedlot debates, you come away with the impression that we have "too much manure."

Consider the case of Martin County, a leading hog-producing area in southern Minnesota. The county is also in the watershed of the Minnesota River, for which studies have shown substantial concern for water quality degradation due to agricultural nutrients. One of our graduate students studied the balance between nutrient use and nutrient requirements in the county. Her results are thought provoking.

First, she estimated the nutrients available from manure produced by livestock in Martin County. She compared that nutrient supply to the nutrient requirements of crops grown in the county. During 1988-1992, nitrogen from manure could have supplied no more than 22 percent of the nitrogen required by corn grown in the county. In most years, it would have been less than that.

She did the same type of analysis for commercial fertilizer sold in the county. In each of those years, there was enough nitrogen sold from commercial sources to meet at least 90 percent of the crop requirements. In one year, there was enough sold to meet 147 percent of requirements.

Figure 1. The impact of N rate on crop yield and nitrate loss.



She also found that, because of increasing concentration, livestock farmers have increasing difficulty in using manure on land they farm. It is more typical that animals are fed on specialized farms, while crops are grown on other specialized farms. If manure is to be applied at agronomic rates, it frequently must be applied to land operated by farmers with no livestock.

Although individual farmers in Martin County may have "too much" manure, the county is actually short of nitrogen from manure by a factor of four or five. From the county perspective, Martin County is better viewed as using "too much" commercial fertilizer.

Economic Incentives

From an economic perspective, one might be tempted to assume that regulatory problems arise simply from the fact that commercial fertilizers are underpriced. If these nutrients were more expensive, farmers would be more likely to instead use nutrients from manure.

Two principal ways of addressing the overall problem of excess nutrient application, regardless of source, are manipulating the price of nutrients and placing restrictions on the amount that can be used. Economists tend to consider price manipulation more efficient than quantity restrictions while permitting more individual freedom of choice.

There are exceptions, including nitrogen on Minnesota corn. Research by another graduate student

found that the commercial price of nitrogen is so low in comparison to the value of the corn it is used on that we would have to raise the price of nitrogen dramatically to achieve significant reductions in its use.

But the substantially larger fertilizer bill has the unintended consequence of reducing farm profits. In fact, we could achieve the same reduction in use by restricting quantities of nitrogen and have a smaller negative effect on farm profits than we get by raising prices.

For example, for nitrogen fertilizer applied in the form of ammonium nitrate, a 100 percent increase in the price of nitrogen decreased use by 25 pounds per acre. Increasing the price of nitrogen from urea by 100 percent reduced usage by 16 pounds per acre.

On the other hand, directly restricting nitrogen as ammonium nitrate to a level 25 pounds lower could be achieved at a cost to the farmer of $2.39 per acre. Achieving the same reduction with a 100 percent tax reduced profits by $24.99 per acre.

In the urea example, reducing use by 16 pounds per acre through restrictions cost the farmer $6 per acre while the 100 percent tax method cost $21.84 per acre in lost profits.

It seems clear that, if manure is to be considered an essential part of a comprehensive nutrient management program, direct restrictions on use may well have economic advantages over taxation schemes. The question becomes: Direct restrictions on what?

An Alternative

The current approach to regulation of manure use provides some incentives that work against its intent—manure is made less attractive to crop farmers. Making nutrients more expensive is a costly and possibly ineffective way to increase manure use.

The option of direct restriction of nutrient use, however, shows promise. In fact, a program of direct restriction is what we now have under Minnesota feedlot law.

Unfortunately, the use of nutrients from manure is restricted instead of the use of commercial fertilizer.

Here is one way such restrictions might work. When a livestock facility permit is applied for, a land application plan of the type now used would be developed. The extra commercial fertilizer needed for all land to which manure is to be applied would then be determined. Operators of that land would be given rights to buy only that amount of commercial fertilizer.

Clearly, such an approach would work best if all commercial fertilizer sales were regulated to cover only agronomic rates. Each farmer would initially be permitted to buy enough commercial fertilizer to cover all crops at agronomic rates. But these amounts would later be lowered when manure permits came into play. The farmers would essentially trade their commercial fertilizer rights for nutrients from manure.

Conclusion

Current feedlot regulatory practices have the undesirable side effect of making nutrients from manure less attractive than those from commercial sources. The regulations therefore discourage livestock production, a major source of economic activity for rural areas. The regulations also discourage local production of plant nutrients and encourage the import of these nutrients.

Regulating feedlots indirectly by limiting use of commercial fertilizer shows promise. The permitting system suggested here would have the immediate advantage of "leveling the playing field" for livestock producers and is possibly more enforceable than current regulations.

The final reason to consider a more comprehensive approach to regulating application of plant nutrients might be the most beneficial. Some studies have shown that nitrogen leaching can be a serious problem even when agronomic rates are followed. Significant improvement in water quality may therefore ultimately require nutrient application rates that are lower than current recommendations. Bringing about these changes cannot be done with feedlot regulations. A comprehensive nutrient management system would then not only be desirable—it would be necessary.

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*(**Drainage** continued from page 1)*

"Reclaiming" swamps and floodplains was one of the first official policies of state government. The titles of early legislation are suggestive. "An Act to encourage the drainage of land" was passed in 1858, followed in 1883 by "An Act to enable the owners of lands to drain and reclaim them when the same cannot be done without affecting the lands of others." A major reworking in 1887 has remained the core of the state's drainage laws ever since.

For over a century it was our stated policy to enable, indeed to encourage, landowners to drain land for agricultural and other economic development. This emphasis has changed only in the past few decades (and then not completely), as our attention shifted toward the environmental services that were said to come from what we drained—wetlands—and from the rivers and streams that we drained to.

This article is a first cut at an analysis of large-scale drainage system decisions. It will show that I can raise questions better than I can answer them—but I hope that even the asking can be instructive. My principal concern is the public management of private drainage systems, particularly the problems that arise from cumulative and interconnected individual decisions.

The Situation Today

Minnesota has over 90 thousand miles of watercourses, some 27 thousand miles of which are constructed ditches. These are interconnected in a complex hydraulic web, constituting a major civil works structure comparable to the road system in many areas. (Fig. 1)

Many times, the visual distinction between ditches and natural watercourses is slight: only legal distinctions are noticeable. We manage different parts of this hydraulic system differently.

Streams and rivers are under the purview of the state, while ditches are largely under the control of counties. Streams and rivers have water quality

standards applied against them; ditches are largely free of such regulation. We have private ditches, county ditches, judicial ditches, and (at times during our history) state ditches. And within the 7-county Twin Cities Metropolitan Area, we have yet another set of drainage rules.

Why Drain?

It is not my purpose here to examine the claims that environmental services from wetlands and rivers are disrupted by excessive or ill-managed drainage. Nor will I take up the question of whether continued or increased drainage is in the landowner's interest. I simply accept that drainage can influence environmental service flows and that drainage remains a financially prudent investment decision for many Minnesota landowners. (On the latter, see V. Eidman, *Minnesota Farmland Drainage: Profitability and Concerns*, **Minnesota Agricultural Economist**, Spring 1997.)

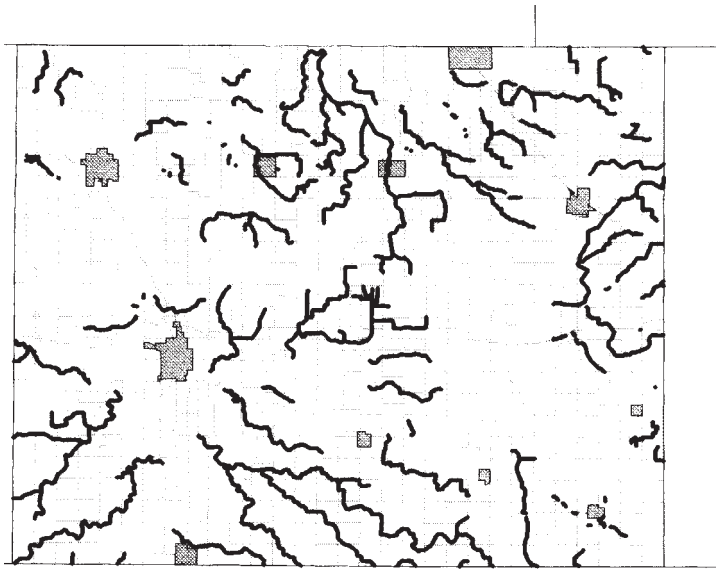
Well-drained land exhibits higher yields, more consistent yields from year to year, and higher sales value. Drained land is also more convenient to manage, because planting and tillage don't have to wait long after spring runoff or summer rains. Farmland drainage, because it improves farm profits, aids local economies and increases property tax bases.

At the farm level, little has changed since 1913, when the State Drainage Commission observed that …*the prices for drainage work throughout the state have reached the lowest mark in its entire history. The best and most improved types of excavating machines are now extensively used…and very active competition takes place whenever contracts of any magnitude are offered.*

With recent changes in tiling technology, landowners are improving existing installations (tiling at closer distances) and draining new lands at an ever increasing pace. In many cases, these new installations are overwhelming the capacity of existing ditch systems to handle the flow of water at peak periods.

The 1997 floods and recent publicity over the so-called "dead zone" in the Gulf of Mexico (attributed by some to farmland drainage and runoff throughout the Mississippi Valley) only highlight a problem that has been simmering for a number of years. The events have called attention to the way we design drainage structures and to the way we manage them.

Figure 1. The Ditches of Faribault County.



Only the public ditches (dark lines) and road network (light lines) for this southern Minnesota county are shown. Ditches are the dominant water mover in the county, extending for 310 miles. Streams and rivers (not shown) add another 270 miles to the county's watercourse system.

The Problem

Our current drainage laws, based on 1880's institutions and 1920's technologies, will inevitably fail. It's only a matter of time.

So what can we do about it? Can we redesign a drainage management framework that better balances the interests of landowners, local management authorities, and the public at large?

Let's consider how we organize drainage now, where the problems lie, and a few broad institutional schemes that might improve upon our situation.

In this article, when I talk about "the drainage System," I mean the multi-owner and even multi-watershed set of drainage installations. Drainage Districts, the current management entity, cover several score farms at most. The System is made of myriad districts, counties, and watersheds. It is this System that requires attention.

Current Organization

In Minnesota, and in most other states, drainage is essentially a "right." Landowners, if they meet certain minimal conditions, can expect to be allowed to keep their fields drained under all weather regimes. It is the responsibility of local authorities to keep the ditches open and to make sure the system works as designed.

The state's drainage laws, developed and elaborated upon over the past 150 years, have four prongs: legal, engineering, environmental, and economic. The first establishes the framework within which we make decisions about drainage management. There is a complex series of procedures, documentation, and decisions that try to ensure that all interests are represented.

Engineering and environmental concerns are linked by design specifications such as ditch profiles, buffers, and outlet sizing. The economics consist of fairly specific allocation of construction and maintenance costs and a generalized balancing of societal costs and benefits. (I'll return to the economics portion later.)

Drainage Districts, geographic (but not institutional) subdivisions of the drainage System, are essentially private organizations managed by public bodies, somewhat akin to public utilities. There may be several such districts in any given county. Overall responsibility rests with a county drainage authority, usually the county board of commissioners. (Multi-county drainage authorities are permitted but rarely employed.) Their task is to maintain the infrastructure already in

place and to oversee construction of new facilities.

Drainage may no longer be encouraged as a matter of state policy, but it is clearly still enabled. If a ditch is inadequate to handle current or anticipated water flows, it is the right of the landowner to petition the drainage authority for help.

This has led to a complex of levels of decision making about drainage infrastructure changes, outlined in Table 1. (I draw from the Association of Minnesota Counties briefing book on drainage law.) For each type of "project," I list the procedure necessary to activate county ditch authority action. Don't worry, you won't be quizzed on the specifics. They're shown simply to give you a flavor of the various actions considered under drainage law in Minnesota.

Policy Concerns

Let's consider two of the many drainage issues that Minnesota policy makers will have to grapple with soon. One is a question of science, the other is a question of politics.

The purpose of drainage law and, especially, the drainage authority, is to coordinate action among individual landowners, to reduce transaction costs, and to assign costs to all benefited parties. It seeks a balance among public and private interests, or financial and environmental concerns.

Such balancing has never been easy, but it has become even more difficult in recent decades. Public support for private drainage has increasingly become conditioned upon assurances that it will not adversely affect downstream parties or nonparticipating landowners. This concern about "externalities," unintended consequences of farmland drainage investments, drives recent criticism of existing drainage law.

To what extent are claims of downstream damage backed by science? Can we measure the cumulative effects of decisions that are largely based on individual farm or drainage district considerations? Can drainage technology be changed so that it accomplishes its goal—getting water off of fields—without seriously affecting downstream living conditions?

Such questions can be addressed only through further research, some of it under way at the University's experiment stations and some of it still in the proposal stage. It turns out that we have considerable analytic capability to examine questions of water movement through the field and through the soil, less capability to examine questions of water movement through tile and ditch complexes, and very little at all when it comes to issues at the System level.

The second policy concern is the seemingly more mundane one of cost allocation. Under current Minnesota law, Repairs and Improvements are charged against lands that "benefit" from drainage changes. This is the job of Viewers, "three disinterested residents of the state qualified to assess benefits and damages."

Benefits are traditionally calculated on the basis of improvements in crop productivity. (Implicitly, the Viewers are estimating increases in land values, but they tend to couch their reports in terms of annual revenue increments.)

But what about landowners whose lands will be drained more but who claim that they have no intention of taking advantage of these agronomic improvements? Is it fair that they be charged for ditch modifications that they don't want or need?

Traditionally, the answer has been yes. Recall the title of the 1883 law noted earlier. Or note the comments of Teele, our 1920's drainage expert:

Drainage is of greater public interest than irrigation in that the reclamation of swamps has a marked effect on public health, as well as on the improvement of highways and other public property. In addition, it is not possible to limit its benefits to particular tracts of land….Because of this greater public interest, the drainage

Table 1. Procedures to activate county ditch authority action.

Project	Petition signed by or decision by:
New System	Majority of landowners that system passes over **Or** Owners of at least 60% of property that system passes over
Improvement of System	At least 26% of owners of affected property **Or** Owners of at least 26% of affected property
Improvement of Outlets	County board **Or** At least 26% of owners of adjoining overflowed property **Or** Owners of at least 26% of adjoining overflowed property
Laterals	At least 26% of property owners **Or** Owners of at least 26% of property laterals pass over
Impoundment and Diversion	A person, public or municipal corporation, governmental subdivision, state or a department or agency of state, the United States or any of its agencies
Redetermination of Benefits	Drainage authority **Or** Majority of owners benefited or damaged
Use of Outlet	A person
Repair	Individual or any entity interested in or affected by the drainage
Consolidation or Division	Any person interested in or affected by the drainage
Abandonment	At least 51 % of property owners assessed for construction of the system **Or** Owners of at least 51% of the property assessed for the system

Source: Association of Minnesota Counties

district laws give less attention to protecting the rights of the minority and give more authority to public officials to include land in drainage districts regardless of the wishes of its owners.

Today, that grant of public authority over private preferences may be less supported. There are several drainage districts in the state that count very few active farmers among their landowners. How much of the cost of ditch and outlet maintenance are they likely to agree to?

If the law were more permissive, we could see as many petitions for Abandonment in some parts of the state as we now see petitions for Improvement. But existing law was designed to increase drainage, not to reduce it. Is our management structure adequate to handle a partial decommissioning of the drainage inventory?

These two issues, in my judgement, cannot be handled by the current drainage management structure. Counties really have no way to adjudicate among the interests of competing drainage districts or among the interests of different kinds of landowners than those presumed when our legal procedures were devised. Nor can they readily measure the perhaps considerable downstream effects of it. Existing law does not serve well the needs of county drainage authorities as they struggle to manage the System.

Change the Law?

In drainage circles, the complex of laws, rules, and procedures that govern drainage in Minnesota are called "ditch law." The possibility of reforming, revising, or repealing these activities is referred to as "opening up" ditch law.

The allusion to Pandora's box, I think, is not unintended. Many parties are concerned that once opened, ditch law could be so transformed that it would be unrecognizable (or at least undesirable) once it was closed up again.

Some observers suggest that we just open up the law a little bit, just enough for some tweaking, not for transforming. But everybody seems to have identified a different element they'd like to tweak. What should we focus on—Abandonment? Viewing? Access to outlets? Can all these diverse interests be served through minor adjustments?

I don't think so. I think we need to consider some more dramatic changes in the way we manage the drainage System in Minnesota. I see two broad options, one that requires detailed intervention in individual drainage decisions and one that permits extensive individual landowner autonomy subject to broad policy guidance. I'll call the two modes "command" and "market."

The Command Model

In this world, we would re-cast ditch law into, something that looks more like western irrigation law. When you think about it, drainage and irrigation really aren't that different from each other. Both involve the wrong amount of water on particular pieces of land. Both involve large engineering works and big expenditures. Where they differ is in how we've decided to manage their operations.

In the west, irrigation water use is managed by controlling access. Every drop is metered out. This institutional structure works because it is relatively simple: property rights are clearly specified, monitoring is extensive, and the systems management task has been well studied by economists and engineers.

Could Minnesota's drainage System be organized like the western irrigation System, with managers controlling access to outlets rather than to inlets?

Not right now. We really have no idea how much water is moving through the tile lines and ditches, when it moves, or what's in it.

Drainage, as now managed, doesn't require extensive day-to-day management decisions. Gravity does all the work. The principal management tasks are initial design and periodic cleanout. Ditches are usually built with no control structures, because the design task was to clear the land of water as quickly as possible, not to monitor and meter its volume and quality.

Had we the appropriate flow control and monitoring equipment, however, we could, under a full command management model, essentially declare that every ditch is to be managed just as we now manage natural watercourses. Each would have flow restrictions, ambient water quality standards, and clear lines of management authority. Control structures would be built so that full hydraulic control over the System could be maintained.

The Market Model

In this world, every landowner would be assigned (or would purchase) a certain number of drainage rights, pieces of paper that permit the holder to discharge a certain amount of water to a public watercourse (including ditches) at certain times of the year. No paper, no drainage. The number of permits would be set by the capacity of the ditch and outlet structures themselves.

These permits could be freely exchanged. If you want to improve your farm's drainage, you'd need to buy some more permits from neighbors or from the ditch authority. If you don't intend to exercise your allocated rights, you could sell them to someone who does. And if you want to reduce the amount of drainage in a watershed, you could buy up existing rights and just sit on them.

Clearly, this option would require extensive investment in monitoring and control equipment. And we wouldn't want to jump into it right away. But none of this is new to economists. We've been studying (and advocating) such arrangements for decades.

Any Place for Economics?

Drainage System management is a social science question, not a physical science question. We coordinate drainage decisions through the economics system (by prices) and through the legal system (by policies).

Economists have been largely silent when it comes to the management of the drainage System. We have helped calibrate the financial incentives presented to farmers, and we've done considerable work in estimating economic values for such natural amenities as wetlands.

But few economists have worked closely with Viewers in helping them apportion ditch system costs. We haven't advised drainage authorities on how to conduct proper benefit-cost studies for system improvements. We don't usually give ideas to regulators trying to reduce transaction costs for agencies or individuals. Nor have we an extensive track record with local authorities in devising management

structures that effectively deal with large system aspects of drainage, or with downstream parties estimating the cumulative effects of individual decisions.

Some of this neglect is due to the failure of economists to impress upon people that economics can be a useful tool in many areas of management, not just in business and finance. And some is due to the tradition of drainage being the province of engineers and lawyers—but not of economists.

I think this is unfortunate, because economics really does have something to say about drainage management. Economists need to more actively insert themselves into drainage debates, and local ditch authorities need to more frequently solicit the help of economists as they work through their increasingly complex responsibilities.

A GEIS on Drainage?

Minnesota law permits the preparation of occasional generic environmental impact statements (GEIS) that examine the environmental, social, and economic aspects of far-ranging issues and to recommend appropriate legislation and research investments. The Legislature just initiated a GEIS on feedlots, and one on timber harvesting was completed a few years ago.

Doesn't management of the state's drainage System seem like a likely candidate for Minnesota's next GEIS?

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An early cost-benefit analysis of Minnesota drainage policy.

Tabulated Statement Of
County & Judicial Ditches In The Several Counties
Of Minnesota

Name Of County	No Of Miles Constructed	Total No Of Cubic Yards In Ditches	Total Est. Benifits	Total Acres Benefited	Total Cost Of Ditches Constructed
Aitkin	280.46	3890067.56	$ 1037379.05	226141.32	$ 470620.55
Anoka	253.95	973401.03	247574.10	58041.62	154190.29
Becker	20.00	108331.50	21506.75	3569.65	16267.89
Beltrami	463.19	4645635.93	1207936.52	370039.67	685235.91
Benton	29.50	187757.88	68562.00	4196.00	31506.56
Big Stone	55.00	646969.09	150749.63	12098.58	120772.71
Blue Earth	51.50	370702.30	127453.70	10659.44	72968.71
Brown	227.50	2000000.00	300000.00	18572.00	274956.62
Carlton	6.96	75896.00	13051.69	4666.00	13488.47
Carver	21.30	283521.00	52503.50	2403.00	26904.72
Cass	15.24	193475.30	30921.91	10000.00	24737.53
Chippewa	229.75	208143.69	317643.00	23247.00	252777.00
Chisago	71.50	425291.03	114384.91	19281.75	74576.27
Clay	186.80	2242092.30	347337.64	284717.13	328224.91
Clearwater	16.12	84834.41	86585.00	23219.00	15500.00
Cook					
Cottonwood	5.25	183698.00	50184.77	2088.00	32098.00
Crow Wing	81.65	345458.50	74047.85	15307.56	59927.06
Dakota	16.00	160156.36	62245.50	3381.63	23060.58
Dodge	28.50	557889.00	51970.57	13853.00	55235.49
Douglas	89.25	637906.00	90511.88	15360.90	90511.88
Faribault	59.00	1348737.60	297302.42	12337.05	121349.66
Fillmore					
Freeborn	99.40	3070497.00	681470.15	23545.03	335221.98
Goodhue					
Grant	56.30	655228.00	194423.00	53621.00	77432.00
Hennepin	55.30	482433.86	214366.61	10419.60	109600.00
Houston					
Hubbard	8.50	30000.00	19221.00	2179.10	4375.87
Isanti	50.06	462587.05	79882.08	11094.00	63010.72
Itasca	4.06	22804.80	8469.00	4700.00	5828.45
Jackson	200.00	798044.10	279523.08	135115.50	398195.00
Kanabec	42.50	126130.30	34861.75	7471.50	22201.13
Kandiyohi	283.50	3189087.86	467862.99	44462.00	366531.30
Kittson	159.50	1765577.00	600000.00	258618.00	236290.00
Koochiching	85.08	471209.90	409728.50	127749.22	139757.00
Lac Qui Parle	252.34	1063936.00	425899.15	20823.50	315391.34
Lake					
Le Sueur	223.15	770837.00	171015.39	20000.00	210450.00
Lincoln	64.62	479513.00	171406.05	7072.00	116776.40
Lyon	39.75	351092.24	129487.80	7295.07	74177.24
McLeod	66.15	770220.00	222177.20	7842.80	69115.02
Mahnomen					
Marshall	920.56	11116911.67	2562825.49	1349064.79	1496708.09
Martin	118.00	150000.00	327519.42	23527.50	327519.42
Meeker	74.75	451761.43	182413.64	12310.77	92551.06
Mille Lacs	47.65	161541.60	32109.41	6553.90	32780.21
Morrison					
Mower					
Murray	52.00	595713.00	110466.50	14000.00	80986.00
Nicollet	149.30	1135946.10	300000.00	24216.00	136167.77
Nobles	32.00	456305.00	127805.00	6500.00	61894.94
Norman	134.00	1000133.41	177450.68	164463.50	172053.64
Olmsted					
Otter Tail	191.75	1151438.38	302307.46	49000.00	182000.00
* Pennington	237.00	2205286.00	621651.00	284945.10	390022.60
Pine	16.10	77630.78	40102.66	4886.78	12858.69
Pipestone					
Polk	616.50	5447031.51	1459349.60	997341.00	816035.57
Pope	110.00	1047171.10	290989.50	46516.70	139422.65
Ramsey	18.06	60140.00	24384.90	2019.00	24994.90
Red Lake	172.56	1581298.00	433643.60	241568.90	276731.97
Redwood	354.80	2266965.00	762961.00	127254.70	417000.00
Renville	310.00	2533086.40	739188.20	48618.70	311109.57
Rice	18.65	125387.44	27463.81	2727.53	17966.75
Rock					
Roseau	147.10	1420057.13	448987.25	168470.42	221344.92
St. Louis					
Scott	8.00	47719.50	10877.20	671.85	6870.24
Sherburne	69.50	358511.85	89503.32	11081.00	54915.69
Sibley	148.10	953301.00	276247.00	16838.00	114938.88
Stearns	162.00	856013.10	284815.39	19861.69	148615.23
Steele	48.40	681798.46	142261.50	9091.92	58525.65
Stevens	50.55	563851.71	185405.00	8933.14	71896.49
Swift	50.77	508896.68	102923.97	19420.00	64283.06
Todd	153.11	675467.74	242983.00	31947.00	124807.99
Traverse	32.75	567601.50	201365.00	89090.59	57180.58
Wabasha	25.00	119055.00	14691.52	6704.20	14694.31
Wadena	152.00	656934.10	93725.00	28383.85	93725.00
Waseca	72.70	834702.73	204620.24	12295.30	81935.48
Washington	11.50	212996.00	25033.72	6076.96	25033.72
Watonwan	48.00	290000.00	246448.00	4062.70	106269.67
Wilkin	196.60	1772103.80	637900.64	198183.59	265690.96
Winona	3.25	35000.00	21354.35	1487.00	4480.97
Wright	51.13	390893.29	135622.99	7848.27	68913.39
Yellow Medicine	60.00	410070.00	97000.00	31276.00	71238.72
Totals	8941.68	76937882.00	$20844223.10	5846126.17	$12131075.74

* Estimated, Records Not Obtainable

Source: Report of the State Drainage Commission on Drainage Work in Minnesota, 1913

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