Attachment A

Comments on Tentative Waste Discharge Requirements General Order for Existing Milk Cow Dairies, submitted by Lawyers for Clean Water on January 16, 2007.

LAWYERS FOR CLEAN WATER INC

VIA United States Mail and Electronic Mail January 16, 2007

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RE: Comments on Tentative Waste Discharge Requirements General Order for Existing Milk Cow Dairies

Dear Ms. Lowry:

These comments to the Tentative Waste Discharge Requirements General Order for Existing Milk Cow Dairies ("Tentative WDR") are submitted on behalf of Baykeeper, Waterkeeper Alliance, Inc., Sierra Club, California Sportfishing Protection Alliance, Center on Race Poverty and the Environment, the Community Water Center, and Lawyers for Clean Water, Inc.. Many of these groups have submitted additional comments. Rather than repeat those comments here, we will simply state our support for and adopt those comments in this letter by reference. Questions regarding the issues addressed in these comments should be directed to Drev Hunt at Lawyers for Clean Water, Inc.

We'd like to first thank staff and the Regional Water Quality Control Board for the Central Valley Region ("Regional Board") for taking on the monumental, though essential, task of issuing a cohesive set of waste discharge requirements to an industry that has gone largely unregulated in California. The costs of this lack of regulation are abundant and widespread as evidenced by the many reports considered by staff in developing the Tentative WDR and the Information Sheet and the Findings in the Tentative WDR itself. The time and effort staff has put in developing the Tentative WDR is respected and nothing in these comments is intended to disparage the hard work that they have put in over the last several years.

These comments identify the requirements of the Federal Water Pollution Control Act ("Clean Water Act") and the Porter-Cologne Water Quality Control Act ("Porter-Cologne Act") that the Regional Board is obligated to comply with when issuing a permit that regulates discharges to surface waters. Addressed below are the legal requirements set forth in both Federal and State law that compel the Regional Board to issue an NPDES permit that builds upon the foundation developed by the Tentative WDR. Following the legal analysis, we present the facts that demonstrate that milk cow dairies in the Central Valley discharge to waters of the united States, as well as the many examples of how the effluent limitations and other regulation of discharges to surface waters contained in the Tentative WDRs which require the Regional Board to issue an NPDES permit. Finally, a comparison to the correct decision to issue an NPDES permit to regulate milk cow dairies made by the Regional Water Quality Control Board for the Santa Ana Region is offered as guidance of what this Regional Board must do. However, we begin with an explanation of how the course that the Regional Board proposes to take does a disservice to the dairymen – the very people the Regional Board must work hand-in-hand with to solve the grave threats to water quality in the Central Valley – by failing to insure that a dairyman who follows the letter of this Tentative WDR will be in compliance with the law.

I. The Tentative WDR Does a Disservice to Dairymen by Failing to Provide Them with Adequate Permit Coverage Required by State and Federal Law

From a practical standpoint, we are concerned that the action the Regional Board is proposing will leave the dairymen throughout the Central Valley without the safe harbor of knowing that if they comply with the Tentative WDR, they will be in compliance with the law. The consequences of this uncertainty are significant since a failure to obtain a necessary NPDES permit exposes the dairymen to liability under the Clean Water Act for up to $32,500 per day per violation for unpermitted discharges.[1] During the workshop held by the Regional Board on December 7, 2006 regarding the Tentative WDR, the Regional Board and staff indicated that they liked using the authority under sections 13260 *et seq.* of the Porter-Cologne Act, rather than the NPDES authority in sections 13370 *et seq.* of the Porter-Cologne Act because of the flexibility they perceive it provides in taking on the monumental task of industry-wide regulation of a largely unregulated industry. While the Regional Board may like the flexibility it believes non-NPDES permitting provides, it is unacceptable for the Regional Board to use this process when it fails to provide the requisite legal coverage to the dairymen of California.[2]

As will be explained in detail in these comments, the Clean Water Act and the Porter-Cologne Act require all owners and operators of concentrated animal feeding operations that discharge or propose to discharge pollutants to waters of the United States obtain an NPDES permit that allows for this discharge. *See* 33 U.S.C. §§ 1311(a), 1342; Cal. Water Code §§ 13370 *et seq.* However, although this Tentative WDR requires all dairy owners and operators to comply with its terms, it is not an NPDES permit and thus any discharge from any dairy to a water of the United States, whether allowed by this WDR or not, will be a violation of the Clean Water Act. A couple quick examples to make this point follow.

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[1] 33 U.S.C. § 1319(d).

[2] We are aware of at least one dairy that intends to file, or already has filed, an application for an NPDES permit. We suspect that many other dairies will follow suit, recognizing that only by obtaining and complying with an NPDES permit will they have done everything required to allow themselves to discharge, including discharge storm water runoff, to waters of the United States.

A. Discharges of Storm Water Will Subject Dairymen to Liability for Unpermitted Discharges in Violation of the Clean Water Act

The Tentative WDR requires that all dairymen develop and implement a Nutrient Management Plan ("NMP") for their facility.[3] The NMP must be developed and implement to "prevent adverse impacts to surface and groundwater" that may be caused by the application of wastewater, manure, and other waste products generated at the facility to land owned or under control of the facility owner or operator.[4] The Tentative WDR also prohibits the discharge of storm water runoff to surface waters from these land application areas unless the facility is managed pursuant to the NMP.[5] The Tentative WDR provides a compliance schedule for the development and implementation of the NMP of five years and thus storm water discharges from the land application areas are incapable of causing a violation of the Tentative WDR for five years.[6] The Regional Board has included this NMP requirement in the Tentative WDR to, among other reasons, allow facility owner and operators to take advantage of the agricultural storm water exemption from the definition of point source required by the Clean Water Act and not have to obtain an NPDES permit for these discharges.[7] However, the Tentative WDR fails to provide this assurance.

The agricultural storm water discharge exemption in the Clean Water Act only applies to those facilities that are managed in accordance with a certified NMP.[8] In cases where the facility is not managed pursuant to an NMP, storm water discharges from concentrated animal feeding operations ("CAFOs"), including many of the milk cow dairies in the Central Valley, violate the discharge prohibition of the Clean Water Act. These discharges are only allowed when covered by, and in compliance with an NPDES permit.[9] Because the Tentative WDR does not require that the facility be managed consistent with the NMP for 5 years, which not accidentally is the life of this WDR, facility owners and operators will be required to either seek additional coverage under a separate NPDES permit for these discharges or be exposed to liability under the Clean Water Act. Thus, as proposed this WDR fails to provide dairymen with assurance that compliance with the WDR is compliance with the Clean Water Act.

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[3] Tentative WDR § C.1
[4] Tentative WDR, Attachment C at 1
[5] Tentative WDR § A.12
[6] Tentative WDR, Table 1 ("Schedule for Submittal of Existing Conditions Report, Waste Management Plan, Nutrient Management Plan, Salinity Reports, and Annual Reports.
[7] *Public Workshop, Tentative Waste Discharge Requirements General Order for Existing Milk Cow Dairies*, Staff of Regional Water Quality Control Board for Central Valley Region, Slide 37 (December 7, 2006) (hereinafter "Staff Presentation").
[8] *See Waterkeeper Alliance, et al. v. United States Environmental Protection Agency,* 399 F.3d 486, 508-09 (2d Cir. 2005) ("*Waterkeeper*"); 40 C.F.R §§ 122.42(e)(1)(vi)-(ix), 40 C.F.R. § 412.4(c).
[9] *See* 33 U.S.C. § 1311(a).

B. Discharges in Violation of the WDR Is Also an Unpermitted Discharge in Violation of the Clean Water Act and thus Carries Penalties of Up to $47,500 Per Day of Violation

A second example involves the situation of a discharge from the facility which is prohibited by the Tentative WDR – such as a discharge of wastewater from the production area to surface waters in violation of Tentative WDR § A.2. As the Tentative WDR states, a violation such as this is subject to penalties of up to $15,000 per day of violation.[10] However, in this case, since the discharger does not have an NPDES permit, the discharger is also exposed to liability under the Clean Water Act for for unpermitted discharges and failing to obtain and comply with a required NPDES permit.[11] As noted above, these violations of the Clean Water Act carry a penalty of up to $32,500 per day per violation.[12] In essence, a facility operator who discharges in violation of the Tentative WDR is subject to double liability under both State and Federal law with a potential exposure to penalties of up to $47,500 per day per violation.

By failing to make the Tentative WDR an NPDES permit, the Regional Board is doing a terrible disservice to dairymen throughout the Central Valley. Rather than providing a permitting program that will allow the dairymen to get back to doing what they know best, dairy farming, the Tentative WDR requires the dairymen to make difficult decisions about whether their discharges require them to seek additional permit coverage. The simple and logical solution is for the Regional Board to issue an NPDES permit that builds upon many of the requirements and management practices that it proposes to include in the WDR.[13]

II. The Clean Water Act and the Porter-Cologne Act Require the Board to Issue an NPDES Permit

Not only is the issuance of this WDR a disservice to the permittees, it is illegal under the Clean Water Act and the Porter-Cologne Act. The Regional Board must issue Waste Discharge Requirements also in the form of an NPDES permit. As explained below, both the Clean Water Act and the Porter-Cologne Act explicitly require the Regional Board to regulate discharges from point sources to waters of the United States with NPDES permits. Following the explanation of legal requirements, these comments highlight the facts in the Regional Board files, as well as in the Tentative WDR fact sheet and findings, that demonstrate the dairies in the Central Valley discharge pollutants to waters of the United States and thus must be regulated with an NPDES permit. Finally,

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[10] Tentative WDR, Standard Provisions and Reporting Requirements § E.1.
[11] *See* 33 U.S.C. § 1311(a).
[12] 33 U.S.C. § 1319(d).
[13] There are certain aspects of this WDR that would have to be modified to meet the federal NPDES regulations for concentrated animal feeding operations. Because this is not an NPDES permit, technical comments regarding changes to the permit compelled by the federal regulations are not provided. If the Regional Board decides to issue a general NPDES permit for milk cow dairies, we will provide appropriate comments at that time.

we provide an explanation of and comparison to the decision of the Santa Ana Regional Board to regulate dairies with a general NPDES permit as an example of the course of action this Regional Board is obligated to take.

A. **When regulating discharges to waters of the United States, the Regional Board must regulate with an NPDES permit**

Under the Clean Water Act, the discharge of pollutants from a point source to waters of the United States is unlawful unless the discharge is in compliance with, among other things, the effluent limitations established under Section 301 of the Clean Water Act and a permit issued under Section 402 of the Clean Water Act.[14] Section 402 of the Clean Water Act, 33 U.S.C. § 1342, establishes the system by which the Regional Board may allow the discharge of pollutants to waters of the United States. In pertinent part, Section 402 provides

> the [Regional Board] may, after opportunity for public hearing issue a permit for the discharge of any pollutant, or combination of pollutants, *notwithstanding section 1311(a) of this title*, upon condition that such discharge will meet either (A) all applicable requirements under sections 1311, 1312, 1316, 1217, 1318, and 1343 of this title, or (B) prior to the taking of necessary implementing actions relating to all such requirements, such conditions as the [Regional Board] determines are necessary to carry out the provisions of this chapter.[15]

All NPDES permits must ensure compliance with section 301 of the Clean Water Act, which means that all permits must include the appropriate effluent limitations and guidelines[16] Accordingly, the Clean Water Act only allows for the discharge of pollutants to waters of the United States if done so pursuant to an NPDES permit. A careful examination of (1) the NPDES requirements as applied to delegated States, (2) the representations California's Attorney General made to the EPA when seeking delegation, and (3) the decision reached by the Second Circuit in the *Waterkeeper* case leads to the conclusion that the Regional Board must modify the Tentative WDR to also be an NPDES permit. Each of these topics will be discussed in turn.

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[14] 33 U.S.C. § 1311(a).

[15] 33 U.S.C. § 1342(a)(1) (emphasis added); *see* 33 U.S.C. § 1342(b) (providing for the delegation of permitting authority to a State authority, such as the Regional Board, provided certain conditions are met).

[16] *See* 33 U.S.C. §§ 1311(b) and 1342(a).

1. <u>The Clean Water Act Specifically Requires that All Delegated States Regulate Discharges to Waters of the United States with NPDES Permits</u>

A delegated State such as California has a continuing obligation to implement the NPDES permit program consistent with the requirements set forth in the Section 402(b) of the Clean Water Act.[17] In implementing its NPDES program, a delegated state must "issue permits which apply and ensure compliance with any applicable requirements of section[] 1311."[18] If a State fails to follow its obligations when implementing the delegated NPDES permitting program "the [EPA] shall withdraw approval of such program."[19] As such, the onus is on the delegated State to regulate the discharge of pollutants from point sources to waters of the United States pursuant to Section 402. Stated another way, a delegated State may not regulate discharges from point sources to waters of the United States in a manner other than with an NPDES permit.

The Clean Water Act's implementing regulations also require that delegated states regulate discharges to waters of the United States with NPDES permits. Specifically, in setting forth the scope of the NPDES permitting program, 40 C.F.R. § 122.1(b)(1) states, "the NPDES program requires permits for the discharge of 'pollutants' from any 'point source' into 'waters of the United States.'" The regulations also state, "[a]ll State [NPDES] Programs … must be administered in conformance with [EPA NPDES regulations] except that States are not precluded from omitting or modifying any provisions to impose more stringent requirements."[20] The EPA NPDES regulations provide that CAFOs, including most if not all of the milk cow dairies regulated by the Tentative WDR, are point sources.[21] As explained below, there is ample evidence that milk cow dairies discharge pollutants and that these pollutants are discharged to waters of the United States. As such, the Clean Water Act's implementing regulations require that delegated states regulate these discharges with NPDES permits.

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[17] 33 U.S.C. § 1342(c)(2).
[18] 33 U.S.C. § 1342(b)(1)(A).
[19] 33 U.S.C. § 1342(c)(3).
[20] 40 C.F.R. § 123.25(a).
[21] *See* 40 C.F.R. § 122.23(a) (2002) ("Concentrated animal feeding operations are point sources subject to the NPDES permit program."); *see also Revised National Pollution Discharge Elimination System Permit Regulation and Effluent Limitations Guidelines for Concentrated Animal Feeding Operations in Response to Waterkeeper Decision*, United States Environmental Protection Agency, 71 Fed. Reg. 37744, 37784 (June 30, 2006) ("Concentrated animal feeding operations, as defined in paragraph (b) of this section, are point sources.").

2. The Porter-Cologne Act and Attorney General's Statement Accompanying California's Request for NPDES Delegation Demonstrate that the Tentative WDR Must Also Be an NPDES Permit

In addition to the directives contained within the Clean Water Act and its implementing regulations, the Porter-Cologne Act and Attorney General's interpretations of the Porter-Cologne Act's scope and authority mandate that regulation of point source discharges to waters of the United States be done with NPDES permits. Addressing the Porter-Cologne Act first, when California sought delegation of the NPDES program authority from EPA, it submitted, as required by all States seeking delegation, proof that it had the authority to implement an NPDES program that would meet the federal requirements. California's submission included a copy of the Porter-Cologne Water Quality Control Act, Cal. Water Code §§ 13000 *et seq.*, which provides the State Board and regional boards with NPDES implementing authority. In pertinent part, the Porter-Cologne Act states that the Regional Board "shall ... issue waste discharge requirements ... which apply and ensure compliance with all applicable provisions of the [Clean Water Act]."[22] As explained above, the Clean Water Act requires the permitting authority to issue NPDES permits when regulating discharges to waters of the United States. It follows that the Regional Board's obligation under the Porter-Cologne Act is to regulate discharges to waters of the United States with NPDES permits.

The Clean Water Act and its implementing regulations require a State seeking delegation to submit a statement from its attorney general that explains that the laws of the State seeking delegation provide adequate authority to carry out the NPDES permit program.[23] California's attorney general submitted a statement in 1973 when California first sought delegation and again in 1987[24] In conducting the analysis of California law and the authority it provides to implement the NPDES permit program, the Attorney General stated that "whenever an NPDES permit is required under the Clean Water Act, waste discharge requirements are required under Chapter 5.5 of the Porter-Cologne Act."[25] Chapter 5.5 of the Porter-Cologne Act establishes the process and authority for issuing waste discharge requirements that are the equivalent of NPDES permits[26]. The directive here is unmistakable – when the Clean Water Act requires NPDES permits, which it does for discharges to waters of the United States, California law mandates that the Regional Board regulate those discharges with NPDES permits.

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[22] Cal. Water Code § 13377
[23] 33 U.S.C. § 1342(b); 40 C.F.R. §§ 123.21(a)(3) and 123.23(a)
[24] *See generally, Attorney General's Statement of Legal Authority to Implement a State National Pollutant Discharge Elimination System Program and a State Pretreatment Program*, State of California, Department of Justice (May 11, 1987) ("AG's Statement").
[25] AG's Statement at 19.
[26] *See* Cal. Water Code 13370(c).

The disclaimer in the Tentative WDR that

> [t]his Order is not a National Pollutant Discharge Elimination System Permit issued pursuant to the Federal Clean Water Act. Any facility required to obtain such a permit must notify the Central Valley Water Board,[27]

is not adequate to fulfill the Regional Board's duty to issue NPDES permits when regulating discharges to waters of the United States. Though the obligation to apply for the appropriate permit lies with the discharger, it is the Regional Board's obligation to make the appropriate permits available for those seeking permit coverage. To this end, the AG's Statement provides that the Regional Board has the authority to issue general waste discharge requirements that will govern point source discharges only if "that issuance of general waste discharge requirements for point source discharges would be consistent with the requirements of the Clean Water Act.[28] As demonstrated in these comments, most if not all CAFOs in the Central Valley are point sources and many if not all discharge to waters of the United States. However, the Tentative WDR seeks to regulate point source discharges without complying with the Clean Water Act. This directly contradicts the assurances the attoney general provided the EPA when California sought delegation to implement the NPDES in California.

To be consistent with the Attorney General's assessment of the Regional Board's NPDES authority, the Regional Board should issue a general WDR that is also an NPDES permit. In so doing, the Regional Board will be able to ensure that those dairymen who are obligated to obtain NPDES permits will be appropriately covered. Likewise, should a dairyman believe that his operation does not require NPDES coverage he will be able to seek coverage under individual waste discharge requirements. This will also ensure for the Regional Board that it has made every effort to meet its obligation to regulate all point source discharges with NPDES permits.

Of course there will be dairymen who refuse to obtain coverage under a general NPDES permit, but this is no reason to make the exception – those dairymen who may not need NPDES permit coverage – the rule. The Regional Board now has a report of waste discharge on file for over 95% of the dairies in the Central Valley, so those dairies that refuse to comply, either by submitting to coverage under the general NPDES permit or filing for an individual WDR, should not be difficult to find. Under the scheme that the Regional Board currently proposes, it will be next to impossible for the Regional Board to efficiently identify those facilities that are not complying with their obligations under the Porter-Cologne Act and the Clean Water Act. Only by making a general NPDES permit available will the Regional Board be able to meet its legal obligations.

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[27] Tentative WDR, General Findings ¶ 44.

[28] AG's Statement at 58; *see* Cal. Water Code § 13372

3. The Second Circuit Decision in the *Waterkeeper* Case Does Not Restrict the Regional Board's Authority to Issue a General NPDES Permit

The section of the Information Sheet for the Tentative WDR discussing applicable regulations provides the only explanation for why the Tentative WDR are not an NPDES permit. At page 16 of the Information Sheet, in the one paragraph explanation of how this proposal meets the applicable regulations found in Title 40 of the Code of Federal Regulations, the Regional Board states that "2nd Circuit Court of Appeals … vacated the requirement for all CAFOs to either apply for an NPDES permit or demonstrate they have no potential to discharge." Apparently, the Regional Board believes that the *Waterkeeper* decision stripped the Regional Board of its authority to issue a general NPDES permit for milk cow dairies in the Central Valley. Provided below is a summary of the *Waterkeeper* decision demonstrating this is not the case.

First, the *Waterkeeper* decision did nothing to change the Regional Board's obligations as a delegated State. Specifically, whether the Regional Board must use NPDES permits when allowing discharges to waters of the United States is a separate issue from whether the EPA properly justified its decision requiring all large CAFOs to seek permit coverage. As set forth herein, the Regional Board is obligated to require NPDES permits for discharges from point sources to waters of the United States.

Second, once that basic principle is understood, while the *Waterkeeper* Court articulated that there are limits on the EPA's authority to require NPDES permits, even when faced with significant, known pollution problems, these limits do not absolve the Regional Board of its responsibility to regulate milk cow dairies with an NPDES permit. In fact, the *Waterkeeper* decision limited EPA's ability in <u>only one respect</u> – namely that the EPA could not require a facility seek permit coverage simply because it has a "potential" to discharge.[29] The court suggested that the EPA could, and seemingly had, marshaled evidence that "such a prophylactic measure may be necessary to effectively regulate water pollution from Large CAFOs, given that Large CAFOs are important contributors to water pollution and that they have, historically at least, improperly tried to circumvent the permitting process."[30]

In this case, as summarized below, the evidence before the Regional Board justifies just such a prophylactic measure to effectively control water pollution from milk cow dairies in the Central Valley. In fact, Findings 21-24 of the Tentative WDR summarize the substantial impact dairy operations have on water quality.[31] Finding 24 concludes that "[t]he waste management systems at these existing dairies are commonly not capable of preventing adverse impacts on waters of the state either because of their outdated design or need for maintenance or both. Historic operation of these dairies has presumptively resulted in an adverse effect on the quality of waters of the state." In

[29] *Waterkeeper*, 399 F.3d at 505.
[30] *Id.* at 506 n. 22.
[31] Tentative WDR, Findings 21-24.

response to the documented impacts that milk cow dairies have on the waters of California, the Regional Board has issued a prophylactic measure to resolve the problem. Inexplicably however, the Regional Board proposes to take this action without meeting its obligations under the law and issuing an NPDES permit.

Further justification for the Regional Board to issue an NPDES permit in this case is found in the NPDES regulations. The NPDES regulations, which the Regional Board must implement, require that facilities that "propose" to discharge are obligated to obtain permit coverage - the *Waterkeepers* Court did not disturb this duty.[32] There are several ways in which milk cow dairies "propose" to discharge. First, as the Tentative WDR states:

> In land applications areas where groundwater is shallow, some Dischargers have installed subsurface (tile) drainage systems to maintain the groundwater level below the crop's root zone. Drainage from these systems may be discharged directly to surface water bodies or to drainage ditches that discharge to surface water bodies. Some of these systems discharge to evaporation basins that are subject to waste discharge requirements. Discharges from these systems have elevated concentrations of salts, including nitrates and other nutrients. This Order requires Dischargers who have these systems to identify their location and discharge point and to monitor discharges from these systems.[33]

Each of these facilities discharges from a point source to a water of the United States (except maybe those that discharge to evaporation ponds). As such, each of these is either an actual or proposed discharge that the discharger must cover with an NPDES permit, and which the Regional Board is required to regulate with an NPDES permit. A second "proposed" discharge that requires an NPDES permit is any discharge to groundwater that has a substantial nexus with surface waters.[34] Together, these discharges, whether actual or proposed, combined with the evidence of facilities that do discharge discussed below demonstrate that the milk cow dairies in the Central Valley discharge to waters of the United States and must be regulated with an NPDES permit.

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[32] *See* 40 C.F.R. § 122.21(b).
[33] Tentative WDR, Finding 37.
[34] *Compare Northern California River Watch v. City of Healdsburg*, 457 F.3d 1023 (9th Cir. 2006) (significant nexus between groundwater and surface water confer Clean Water Act jurisdiction over groundwater) and *Idaho Rural Council v. Bosma*, 143 F.Supp.2d 1169, 1180 (D. Idaho 2001) (upholding groundwater connection as basis for CWA protection) *with Village of Oconomowoc Lake v. Dayton Hudson Corp.*, 24 F.3d 962, 965-66 (7th Cir.) (finding EPA's rules do not assert authority to reach discharges to groundwater), *cert. denied*, 513 U.S. 930 (1994).

B. The Facts Available to the Regional Board Compel Regulation with an NPDES Permit

1. Considerable information available to Regional Board demonstrates that milk cow dairies discharge pollutants to waters of the United States

The Tentative WDR Information Sheet states that there are approximately 1600 milk cow dairies in the Central Valley.[35] These dairies are large industrial operations and as the Tentative WDR states "[e]ach facility represents a significant source of waste discharge with a potential to affect the quality of the waters of the State."[36] Presented below are the facts the Regional Board has before it or in its files and that it must consider when evaluating whether these facilities should be regulated with an NPDES permit or, as is proposed here, waste discharge requirements. These facts include: (1) the 2002 Clean Water Act List of Impaired Waterbodies ("303d List"), which identifies the serious impact dairies have on surface water quality in the Central Valley; (2) the information in files the Regional Board maintains – files it turns over to the Dairy Task Force for enforcement – that catalogue hundreds of dairies which discharge pollutants to waters of the United States; and (3) the General Industrial Storm Water Permittee Database which identifies hundreds of dairies that have voluntarily sought coverage for their discharges of storm water associated with industrial activity to waters of the United States.

First, the 303d list demonstrates that dairies discharge to waters of the United States. A water body is required to be identified and placed on the 303d List when the water body is so polluted that it cannot support its beneficial uses.[37] When listing a water body, the listing agency is required to identify those pollutants causing the impairment as well as the source of those pollutants.[38] The State Water Resources Control Board ("State Board") has tasked the regional boards with identifying those water bodies within each region that are impaired. This Regional Board has identified 8 water bodies in the Central Valley that are impaired by pollutants associated with dairy operations.[39] In 3 of those 8, the Regional Board has identified dairies as the sole cause of the impairment.[40] For the remaining 5, the Regional Board lists activities such as agriculture and grazing, aspects of dairy operations, as the source of the impairment. From this information, the Regional Board is aware that, in general, dairies discharge pollutants to waters of the United States.[41]

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[35] Tentative WDR, Information Sheet at 2.
[36] Tentative WDR, Finding 12.
[37] 33 U.S.C. § 1313(d).
[38] *Id.*
[39] *2002 CWA 303(d) List of Water Quality Limited Segments*, State Water Resources Control Board, pages 130-151 (2003) (approved by EPA July 2003).
[40] *Id.* (identifying Lone Tree Creek, Temple Creek, and Avena Drain as impaired by discharges from dairy operations).
[41] A dairy which meets certain threshold requirements, such as size or proximity to surface water bodies, is a CAFO and as such is a point source for purposes of the Clean Water Act. *See* 40 C.F.R. § 122.23(b).

Second, files developed and maintained by the Regional Board identify some of the many dairies in the Central Valley that discharge to waters of the United States. A recent file review[42] yielded the following information – information which demonstrates that the Regional Board has knowledge of some, though not all, of the dairies which discharge pollutants to waters of the United States. The Regional Board maintains files on those dairies that have been issued a notice of violation for off-property discharges of wastewater or other waste.[43] Each of the files maintained by the Regional Board identifies a dairy that is required to obtain an NPDES permit since it discharges pollutants to waters of the United States. Based on our file review, there are at least 56 dairies within the purview of the Sacramento Division of the Regional Board that discharge to waters of the United States. Many of the discharges from these facilities are due to inadequate waste storage capacity at the CAFO, technical failures, or shortcomings in design such as inadequate tailwater return systems. Though these discharges may be sporadic or intermittent, their character as such does not absolve the facilities owners from needing to obtain NPDES permit coverage. *See Carr v. Alta Verde Industries, Inc.*, 931 F.2d 1055, 1063 (5th Cir. 1991) (a CAFO that discharges on a "sporadic or intermittent" basis without an NPDES permit remains in a continuing state of violation until it obtains a permit). We must speculate that there are many more dairies that discharge in the Fresno Division since the Fresno Division oversees operations in the most populous dairy counties in the State. Further, the files maintained by the Redding Division undoubtedly identify additional dairies that discharge to waters of the United States. Each of these dairies is obligated to obtain an NPDES permit and the Regional Board is obligated to regulate these dairies with NPDES permits, not the proposed WDR.

Third, the Industrial Storm Water Permit database maintained by the State Board identifies dairies that discharge to waters of the United States. The Industrial Storm Water Permit requires that all facilities subject to effluent limitations and guidelines ("ELGs") set forth in Subchapter N of Title 40 of the Code of Federal Regulations obtain permit coverage.[44] A dairy is subject to ELGs if it contains more than 700 mature dairy

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Thus, the water bodies that list dairies as source of impairment are impaired by point source discharges – discharges which are subject to permitting under the section 402 of the Clean Water Act.

[42] This file review was limited, on suggestion by the Regional Board staff due to resource limitations in collecting all the files from all three divisions, to those dairies under the purview of the Sacramento Division that have been issued NOV's for off-property discharges. According to Regional Board staff, the Sacramento Division only maintains files related to dairies operating in Lake, Colusa, Sutter, Yuba, Yolo, Sacramento, Amador, Calaveras, San Joaquin, Stanislaus, and Tuolumne Counties, as well as parts of Sierra, Nevada, Placer, Napa, Solano, Alpine, Contra Costa, Alameda Counties.

[43] These files are incorporated in these comments by reference. As the files demonstrate, these discharges occur at dairies throughout the Central Valley. These files are readily accessible to both the Regional Board and staff and must be considered by the Regional Board when determining how to properly regulate the dairies.

[44] *See* Attachment 1 ¶ 1 of *Waste Discharge Requirements for Discharges of Storm Water Associated with Industrial Activities, excluding Construction Activities*, Water Quality Order No. 97-03-DWQ, National Pollution Discharge Elimination System (NPDES) General Permit No. CAS000001, State Water Resources Control Board (1997) ("Industrial Storm Water Permit").

cows.[45] In the Central Valley over 200 dairies have sought coverage under the Industrial Storm Water Permit.[46] Presumably, since the number of dairies with more than 700 mature dairy cattle exceed the number of permittees, those dairies that have obtained coverage did so because they admit that their discharges are to waters of the United States and thus must be covered under an NPDES permit. In any event, that over 200 facilities have sought coverage under the Industrial Storm Water Permit indicates that at least this many facilities discharge to waters of the United States and must continue to maintain NPDES permit coverage even if they are regulated by the Tentative WDR.

The dairies the Regional Board files identify as discharging to waters of the United States represent only a limited number of those dairies that actually discharge. Due to self-proclaimed resource limitations, the Regional Board staff can neither investigate each dairy in the region nor respond to every report or complaint it receives that a dairy is discharging.[47] However, the inability to identify each dairy that discharges, and thus is required to obtain an NPDES permit, is not a justification for failing to issue an NPDES permit to regulate these discharges. Understandably, the Regional Board would like to issue a general permit for dairies since the number of facilities in the region would make regulation by individual permit a burdensome process. However, as set forth in these comments, the proper method for streamlining the process is to issue a general NPDES permit as opposed to the Tentative WDR.

2. The Tentative WDR Regulates Discharges to Surface Waters

The Tentative WDR contains many examples of a regulation of the discharge from milk cow dairies to surface waters. In the section titled "Prohibitions," Section A of the Tentative WDR Order beginning on page 10, the following paragraphs impose limitations on discharges from the milk cow dairies to waters of the United States:

> 2. The direct or indirect discharge of waste and/or storm water from the production area to surface waters is prohibited [note included in WDR: Discharges of pollutants from the production area to waters of the United States may not lawfully occur except in compliance with a National Pollutant Discharge Elimination System (NPDES) permit. NPDES permit coverage is not provided by this Order, but must be obtained separately.]
>
> 3. The discharge of waste from existing milk cow dairies to surface waters which causes or contributes to an exceedance of any applicable water quality objective in the Basin Plans or any applicable state or federal water quality criteria, or a violation of any applicable state or federal policies or regulations is prohibited.

---

[45] *See* 40 C.F.R. § 412.30.
[46] See Database on active Industrial Storm Water Permittees available at http://www.swrcb.ca.gov/stormwtr/industrial.html.
[47] Personal Communications with Board Staff by commenters.

4. The discharge or disposal of waste from existing milk cow dairies that results in pollution or nuisance is prohibited.

7. All animals shall be prohibited from entering any surface water within the animal confinement area (Title 27 CCR Section 22561).

10. The discharge of wastewater to surface waters from cropland is prohibited. Irrigation supply water that comes into contact or is blended with waste or wastewater shall be considered wastewater under this Prohibition.

11. The application of process wastewater to a land application area before, during, or after a storm event that would result in runoff of the applied water is prohibited.

12. The discharge of storm water to surface water from a land application area where manure or process wastewater has been applied is prohibited unless the manure has been incorporated into the soil and the land application area has been managed consistent with a certified Nutrient Management Plan.

Each of these regulations mimics, or is an exact restatement of effluent limitations guidelines applicable to CAFOs promulgated by EPA and found in Part 412 of Title 40 of the Code of Federal Regulations. The requirement to develop and implement a certified Nutrient Management Plan that ensures, among other things, that wastewater and manure are applied to land application fields at agronomic rates so that excess nutrients do not runoff into area surface waters or infiltrate and pollute groundwater is also an effluent limitation on discharges from these dairies.[48] Other examples of effluent limitations on discharges from milk cow dairies in the Tentative WDR include, but are not limited to, the General Specifications,[49] the Land Application Specifications,[50] and the Provisions.[51] In each of these instances, the Tentative WDR impose regulations on how, when, and under what conditions the milk cow dairy owner or operator may discharge pollutants from the facility to surface waters. These examples all demonstrate that this Tentative WDR regulates discharges to waters of the United States and, as explained herein, when the Regional Board acts to regulate discharges to waters of the United States, it must do so with an NPDES permit.[52]

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[48] *See Waterkeeper*, 399 F.3d at 502-503.
[49] Tentative WDR § B.1-B.3, B.5, B.6, B.12, B.14. B.16-B.18.
[50] Tentative WDR § C.1, C.7 – C.10.
[51] Tentative WDR § E.3.
[52] We urge the Regional Board to compare this situation to the situation faced by its attempted Modification of the City of Roseville's Master Reclamation Permit in 2004. In that case, the Regional Board issued waste discharge requirements, not an NPDES permit, that included effluent limitations on discharges to waters of the United States. Several environmental groups, including some of those submitting comments today, filed an appeal of this decision with the State Board and ultimately filed a petition for writ of mandate in State Court. After lengthy negotiations, the Regional Board acknowledged that it may not regulate discharges to waters of the United States unless it does so with an NPDES permit. As a result, the Regional Board had to reissue the Master Reclamation Permit at great expense to California taxpayers and staff time.

C. <u>Faced with the Same Issue, the Santa Ana Regional Board Took the Appropriate Path and Issued a General NPDES Permit</u>

The Regional Board for the Santa Ana Region ("Santa Ana Regional Board") faces a similar threat to water quality from dairies. Like this Board's files, the Santa Ana Regional Board's files contain evidence that dairies throughout that region discharge to waters of the United States. The Santa Ana Regional Board is also faced with resource constraints that limit its ability to investigate each dairy and each discharge. However, despite these constraints and while faced with information much like that before this Regional Board, in 1999 the Santa Ana Regional Board issued a General NPDES permit for discharges from dairies and related facilities.[53] In the Fact Sheet for the Santa Ana Dairy CAFO NPDES Permit, the Santa Ana Regional Board stated:

> The Federal Clean Water Act (CWA) states that all concentrated animal feeding operations (CAFOs) are point sources and are subject to NPDES permitting requirements. The CWA defines a CAFO as any AFO [animal feeding operation] that has more than 1,000 animal units[54] .... About 70% of the AFOs in the Region have over 1,000 animal units, and are, therefore, considered CAFOs under the CWA. However, the CWA states that smaller facilities can be designated as CAFOs by the permitting authority ... after considering certain criteria. These criteria include, in part, the location of the AFO relative to surface waters, the slope, rainfall, and other factors that increase the likelihood and frequency of discharges, and the impact of the aggregate amount of waste from many small operations in the watershed that exceed that of larger operations. Board staff has determined that all dairies, heifer ranches and calf nurseries in the Region meet one or more of these criteria, and therefore, should be designated as CAFOs under the CWA. [This Order] designates all dairies, heifer ranches and calf nurseries in the Region as CAFOs, and makes them subject to NPDES requirements.

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[53] *See General Waste Discharge Requirements for Concentrated Animal Feeding Operations (Dairies and Related Facilities) within the Santa Ana Region*, Order No. 99-11, NPDES No. CAG018001, California Regional Water Quality Control Board, Santa Ana Region (August 20, 1999) ("Santa Ana Dairy CAFO NPDES Permit") and associated *Cease and Desist Order No. 99-65 for Violations and Threatened Violations of Requirements Specified in Order No. 99-11, NPDES No. CAG018001.*

[54] Since the adoption of the Santa Ana Dairy CAFO NPDES Permit the regulatory definition of a CAFO has been modified as set forth in EPA regulations - regulations that the Regional Board is obligated to comply with. *See* 40 C.F.R. § 122.23(b)(2), (4), and (9); *see, supra*, p. ??-??. The full text of these regulations is attached hereto as Exhibit ?? and incorporated herein by reference. These modifications do not alter the conclusion that most, if not all, of the milk cow dairies in the Central Valley are CAFOs.

Santa Ana Dairy CAFO NPDES Permit, Fact Sheet at 3. The evidence before this Regional Board leads to the same conclusion. Whether a dairy houses the minimum number of animals or is otherwise a CAFO based on consideration of factors set forth in the EPA regulations at 40 C.F.R. § 122.23(b), the proper and legal method for regulating discharges from these facilities is through an NPDES permit. Further, as explained throughout these comments, there is ample evidence before the Regional Board that demonstrates that some, if not all of these facilities discharge to waters of the United States. Since these facilities are point sources and they discharge to waters of the United States, the Regional Board is obligated to regulate them with an NPDES permit.

III. Conclusion

We would again like to thank the Regional Board for applying the extraordinary effort necessarily to develop a laudable set of waste discharge requirements that should go a long way towards solving the substantial pollution problems related to dairy farming in the Central Valley. However, for the reasons stated above, the Regional Board is required to undertake this task with an NPDES permit that builds upon this Tentative WDR. We thank you for the opportunity to comment on the Tentative WDR and look forward to working with the Regional Board to develop an NPDES permit that achieves the same goals – the protection and enhancement of water quality in the Central Valley of California.

Respectfully Submitted,

/s/ Drevet Hunt
Drevet Hunt
Lawyers for Clean Water, Inc.

Jeffrey Odefey
Waterkeeper Alliance, Inc.

Deb Self
Baykeeper

Dale Stocking
Mother Lode Chapter of Sierra Club

Bill Jennings
California Sportfishing Protection Alliance

Laurel Firestone
Community Water Center

Ingrid Brostrom
Center on Race Poverty and the
Environment

Attachment B

Comments on Draft of Waste Discharge Requirements for Dairy CAFOs, submitted by Lawyers for Clean Water on June 12, 2006.

LAWYERS FOR CLEAN WATER

VIA U.S. MAIL and ELECTRONIC MAIL June 12, 2006

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Re: Draft of Waste Discharge Requirements for Dairy CAFOs

Dear Ms. Lowry,

Baykeeper's Deltakeeper Chapter, the Waterkeeper Alliance, Sierra Club's Mother Lode Chapter, the Center for Race, Poverty, & the Environment, and Lawyers for Clean Water, Inc. thank you and the other staff members of the California Regional Water Quality Control Board, Central Valley Region (hereinafter "Regional Board") for meeting with us to discuss the Draft Waste Discharge Requirements ("WDR"), Monitoring and Reporting Program, and associated documents (hereinafter "Draft Order"). We appreciate the effort staff has put into the Draft Order, and the challenge to regulate a growing industry that has gone unregulated for decades. However, as discussed at the May 24th meeting, the Draft Order essentially continues to authorize Concentrated Animal Feeding Operations (CAFOs) to operate without any requirement to actually implement pollution prevention measures.

Further, the Regional Board's "policy" of conducting numerous meetings with industry representatives for informal backdoor review and negotiation of the Draft Order, while the public is left out, is not only inappropriate but is also against the policy and purpose of requiring full public review and participation for all parties. During the May 24th meeting, we provided staff with considerable substantive comments on the Draft Order, including the failure to comply with the state's antidegradation policy and to protect groundwater quality. However, we believe it is appropriate to provide formal written comments only when there is full disclosure to the public as is required by the applicable statutes. This letter, therefore, only reiterates our principle comments that: (1)

the Draft Order violates the California Environmental Quality Act (hereinafter "CEQA") because it is not exempt from CEQA review and (2) the WDR violates the Federal Water Pollution Control Act (hereinafter "Clean Water Act") because it regulates surface water discharges but is not a NPDES permit.

1. The Draft Order violates CEQA.

The WDR, in Paragraph 13, states that "[t]he adoption of this Order is categorically exempt from CEQA because, consistent with the 'existing facility' exemption in Title 14 CCR Section 15301, eligibility under this Order is limited to milk cow dairies that were existing facilities as of 17 October 2005." Title 14 CCR Section 15301 clarifies, "The key consideration is whether the project involves negligible or no expansion of an existing use." For example, there is no condition placed on the CAFOs to maintain dairy herd sizes at current levels. This may allow future new and expanded facilities beyond the baseline of existing facilities. As such, the WDR does not guarantee that there would only be negligible or no expansion of existing uses.

The existing facilities exemption would not apply to the WDR, but in the alternative, as was pointed out at the May 24th meeting, there is a cumulative impact exception to the exemption for existing facilities. The CEQA regulations (Title 14 CCR Section 15300.2(b)) provide an exception to all exemptions "*...when the cumulative impact of successive projects of the same type in the same place, over time is significant.*" As I am sure you are aware, there is an abundance of evidence that the estimated 1,600 Milk Cow Dairy CAFOs operating in the Central Valley are creating cumulative impacts on our air and waterways that are significant.

In addition, there is another exception to the categorical exemptions for activities that pose "*a reasonable possibility that the activity will have a significant effect on the environment due to unusual circumstances.*" (Title 14 CCR Section 15300.2(c)). There is definitely more than a *reasonable* possibility of significant effects on the environment. As the WDR acknowledges, each of the estimated 1,600 CAFOs "represents a significant source of waste discharge". The categorical exemptions were put in place to exempt from CEQA those projects that do not have significant effects on the environment. Hence, the purpose of the exemption is not fulfilled and the exemption would not apply to the CAFOs.

Therefore, the adoption of this Order is not categorically exempt from CEQA as alleged in Paragraphs 12 and 13 of the WDR, hence, issuing the Draft Order without full and adequate CEQA review constitutes a violation of CEQA.

2. The Draft Order violates the Clean Water Act

The Draft Order regulates discharges to surface waters in numerous ways. For example, the WDR prohibitions include:

> The discharge of waste from existing milk cow dairies to surface waters which causes or contributes to an exceedance of any applicable water quality objective in the Basin Plans or water quality criteria set forth in the California Toxics Rule and the National Toxics Rule is prohibited. (Prohibition A.3)
>
> The discharge of wastewater to surface waters during or following application to cropland is prohibited. Irrigation supply water that comes into contact or is blended with waste or wastewater shall be considered wastewater under this Prohibition. (Prohibition A.10)
>
> The application of process wastewater to a land application area before, during, or after a storm event that would result in runoff of the applied water is prohibited. (Prohibition A.11)
>
> The discharge of storm water to surface water from a land application area where manure or process wastewater has been applied is prohibited unless the land application area has been managed consistent with a certified NMP. (Prohibition A.12)

Paragraph 14(a) of the WDR even references the fact that an NPDES permit is required for discharges of pollutants to surface waters when it states:

> This Order prohibits discharges of: (a) Waste to surface waters from the production area unless the facility is in compliance with Title 40 Code of Federal Regulations Section 122.21(a)(1) [United States Environmental Protection Agency (USEPA) National Pollutant Discharge Elimination System (NPDES) Regulations for Concentrated Animal Feeding Operations].

The WDR is clearly regulating discharges of pollutants to waters of the U.S. without complying with the Clean Water Act. The Regional Board must draft and issue the Draft Order as a NPDES permit as required by the Clean Water Act and the Porter-Cologne Water Quality Control Act (California Water Code Division 7).

As the state water pollution control agency, the Regional Board is not only authorized to act under the Clean Water Act but is *required* to issue WDRs which ensure compliance with the Clean Water Act. California Water Code Division 7 Section 13377:

> Notwithstanding any other provision of this division, the state board or the regional boards shall, as required or authorized by the Federal Water Pollution Control Act, as amended, issue waste discharge requirements and dredged or fill material permits which apply and ensure compliance with all applicable provisions of the act and acts amendatory thereof or supplementary, thereto, together with any more stringent effluent standards or limitations necessary to implement water quality control, or for the protection of beneficial uses, or to prevent nuisance.

Action taken by the Regional Board under California Water Code Division 7 requires compliance with the Clean Water Act. Specifically, Section 13372(a) makes certain that, above all else, there is compliance with the Clean Water Act:

> This chapter shall be construed to ensure consistency with the requirements for state programs implementing the Federal Water Pollution Control Act and acts amendatory thereof or supplementary thereto. To the extent other provisions of this division are consistent with the provisions of this chapter and with the requirements for state programs implementing the Federal Water Pollution Control Act and acts amendatory thereof or supplementary thereto, those provisions apply to actions and procedures provided for in this chapter. The provisions of this chapter shall prevail over other provisions of this division to the extent of any inconsistency.

When this point was brought up at the meeting, Regional Board staff responded that the Regional Board can legally regulate surface water discharges without issuing a NPDES permit. We respectfully request to be notified of what authority the Regional Board relies on to support the claim that the draft WDR, which regulates discharges of pollutants to surface waters, does not violate the Clean Water Act.

Please do not hesitate to contact me with any questions or follow-up on the Draft Order. As we stated at the May 24th meeting, we expect to be included in any subsequent informal review and negotiation with the dairy industry and any further review, which we noted should be conducted during full public review.

Thank you for your time.

Sincerely,

/s/

Layne Friedrich, Attorney
Phoebe Hyun, Law Clerk
Lawyers for Clean Water, Inc.

/s/

Carrie McNeil
Deltakeeper Chapter of Baykeeper

/s/

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Attachment C

Geohring, L.D., P.E. Wright, T.S. Steenhuis. 1998. Preferential Flow of Liquid Manure to Subsurface Drains. Drainage in the 21st Century: Food Production and the Environment. Proceedings of the Seventh International Drainage Symposium. Orlando, Florida.

Drainage in the 21st Century: Food Production and the Environment

Proceedings of the
Seventh International Drainage
Symposium

8-10 March 1998
Orlando, Florida

Larry C. Brown, Symposium Proceedings Editor

Published by
American Society of Agricultural Engineers
2950 Niles Rd., St. Joseph, Michigan 49085-9659
USA

Preferential Flow of Liquid Manure to Subsurface Drains

Larry D. Geohring, Peter E. Wright, and Tammo S. Steenhuis[1]

ABSTRACT

The land application of liquid manure can result in bacterial contamination of the effluent from subsurface drains. This contamination appears to occur rapidly during a precipitation event and may cause significant environmental impacts. A field study was initiated to better understand the preferential flow processes and to quantify the degree of tile effluent contamination from liquid manure. Two different initial soil moisture conditions were established in replicated plots prior to the application of liquid manure. A similar amount of liquid manure (47 m^3/ha) was applied to all the plots using a slurry tank wagon. Within 40 minutes after the start of irrigation , the tile began flowing from the wetter plots and was discolored and smelled of manure. A peak concentration of 110,000 colonies/100 ml of fecal coliform was measured. Although the tile discharge from the drier plots did not occur as rapidly, similar fecal coliform concentrations and preferential flow responses evolved. Fecal coliform peak concentrations were reduced by 1/3 when the irrigation was delayed 1 week after the application of the manure. The timing of the precipitation event after the manure application had a significant effect on the magnitude of fecal coliform concentration in the drain effluent. The primary influence of the initial soil moisture content was the length of time which elapsed prior to the observance of the peak fecal coliform concentrations and drain discharge.

Keywords: Preferential Flow, Subsurface Drain, Manure, Bacteria

INTRODUCTION

The USGS National Water Quality Assessment data for the Northeast indicate animal manure was the primary source of nitrogen (N) and phosphorus (P) inputs to the watersheds (about 3.7 and 0.85 t/km^2, respectively). Manure source inputs of N and P exceeded fertilizer, atmospheric and other point sources of these nutrients. Manure N accounted for 36% of the total N inputs, slightly higher than the N inputs from the atmosphere, the next highest source. However, manure P accounted for 64% of the total P inputs, more than double that from fertilizer, the next highest source (US-GAO, 1995). It is believed that most of these nutrient inputs to watersheds will be absorbed (cycled) by land based plants or bound up in the soil, and will not likely end up in the surface and groundwaters. However, the fate and transport mechanisms of nutrients from manures is more complex than those from inorganic fertilizers and are still not well understood. The N in fresh manure is primarily in the ammonia form and is mineralized and nitrified to nitrate which is subject to leaching. The organic fraction of manure P for the dairy cow is about 40% (Barnett, 1994). According to Gerritse and Zugec (1977), the organic P compounds are generally more water soluble than the inorganic phosphate, causing the organic form to be more subject to leaching. In soils with shallow water tables, accumulations of soil N and P can lead to early breakthrough and the leaching of N and P in significant concentrations.

Much attention has been focused on water quality contamination from rapid surface runoff of manured areas (Brockamp, 1993). However, information on the water quality from tile beneath manured sites, and especially the portion attributable to preferential flow, is inadequate. A better understanding of these processes would be beneficial to improving manure application management decisions which maximize the nutrient benefits of manure while minimizing the contamination of receiving water bodies.

[1] Authors are Sr. Extension Associate, Sr. Extension Associate , and Professor, respectively, Dept. of Agricultural & Biological Engineering, Cornell University, Ithaca, NY.

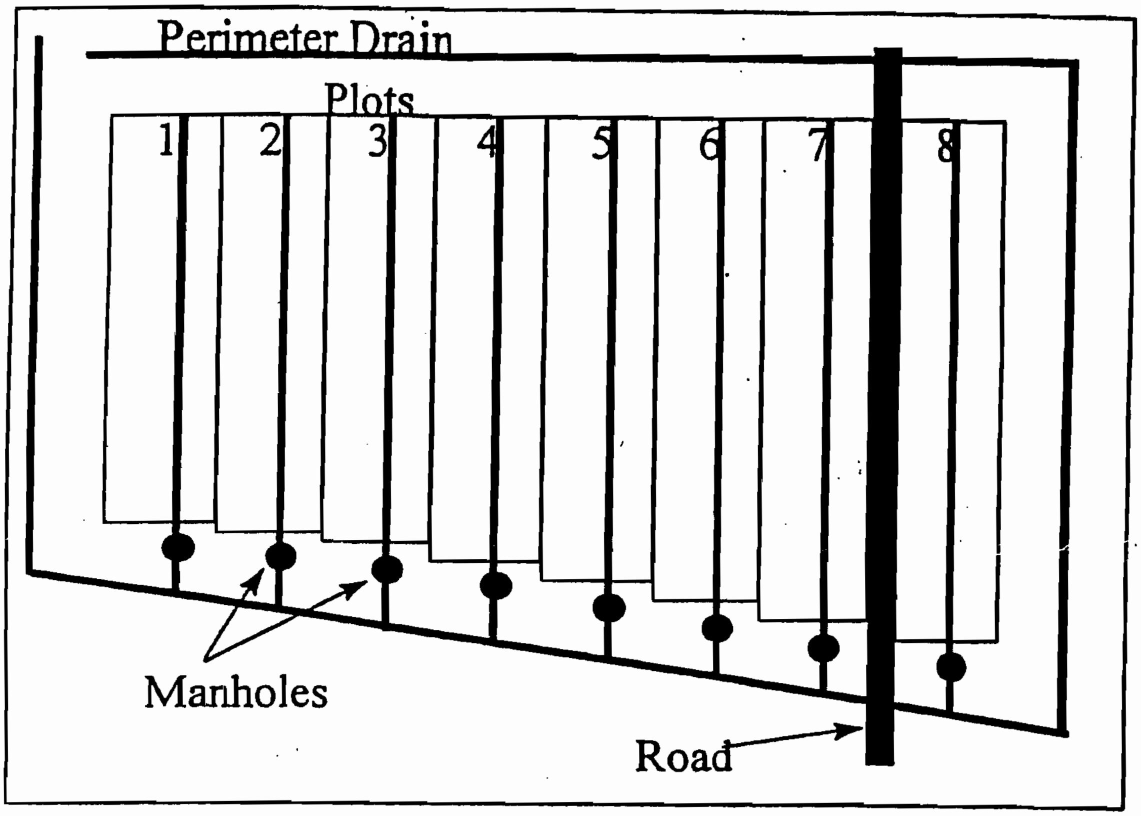

Figure 1. Schematic layout of experimental plot area at Cornell University Willsboro Research Farm.

commenced. Since no manure had been applied previously to these plots, no water samples for bacterial analysis were collected at this time to determine any background level for fecal coliform. A total of 78 mm of water was applied during the pre-wetting process in two separate irrigation events, which raised the gravimetric water content about 8 % on a dry-weight basis above that in Plots 1,2, 7 and 8.

Liquid dairy cow manure from an adjacent farm was applied with a Wic 3200 model bulk tank spreader at a rate of 47 m^3/ha (5000 gal/acre) across all 8 plots. Manure application uniformity measurements were taken several times as shown in Fig. 2, which resulted in an average uniformity coefficient of 0.66. Ten manure samples were drawn from the spreader and analyzed for its nutrient value. The liquid manure contained 6.7% solids and had a density of 1.028 g/cm^3. The nutrient content of this manure was 0.22% Nitrogen of which 0.09% was Ammonia-N, 0.07% Phosphorous, and 0.23% Potassium. The manure application rate was typical of what farmers in the area would normally spread and was selected to meet part of the nitrogen needs of the next year's corn crop.

Irrigation was initiated on Plots 1, 2, 3, and 4 within hours of manure application and before the manure had dried on the surface. The remaining four plots (Plots 5, 6, 7, and 8) were irrigated 1 week later, after the manure had an opportunity to dry on the surface. Irrigation was carried out with Rainbird 30H sprinklers which were set in a 12.2 m grid pattern providing an average application rate of 11.5 mm/hr. During and following irrigation, the drain discharge was measured and sampled using a grab sampling technique at 15 minute intervals. Irrigation was continued until all the plots exhibited drainflow. Water samples for bacterial analysis were refrigerated immediately and analyzed within 24 hours using standard water/wastewater techniques. Water samples for nitrogen and *phosphorous* compounds were frozen to - 4° C and analyzed at a later time. Soil sampling was again carried out following the completion of the irrigations to assist in quantifying effects on nutrient movement.

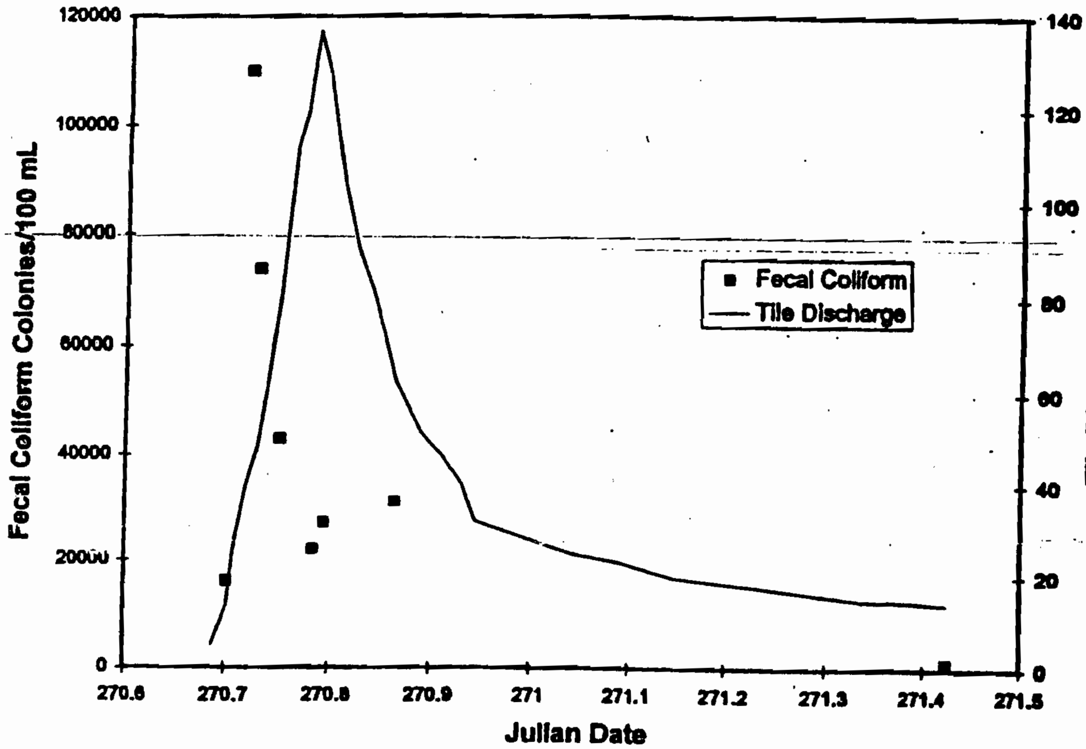

Figure 3. Fecal coliform discharge concentrations in relation to the tile discharge hydrograph for Plot 4.

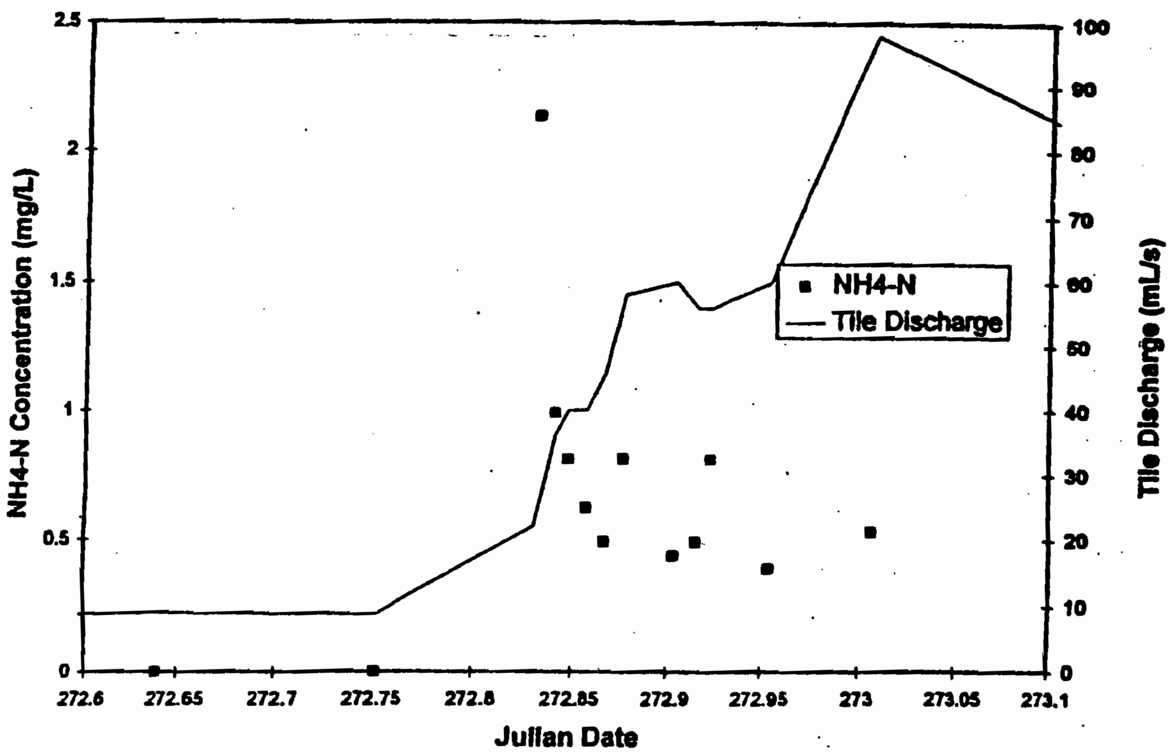

Figure 4. NH_4^+-N discharge concentrations in relation to the tile discharge hydrograph for Plot 4.

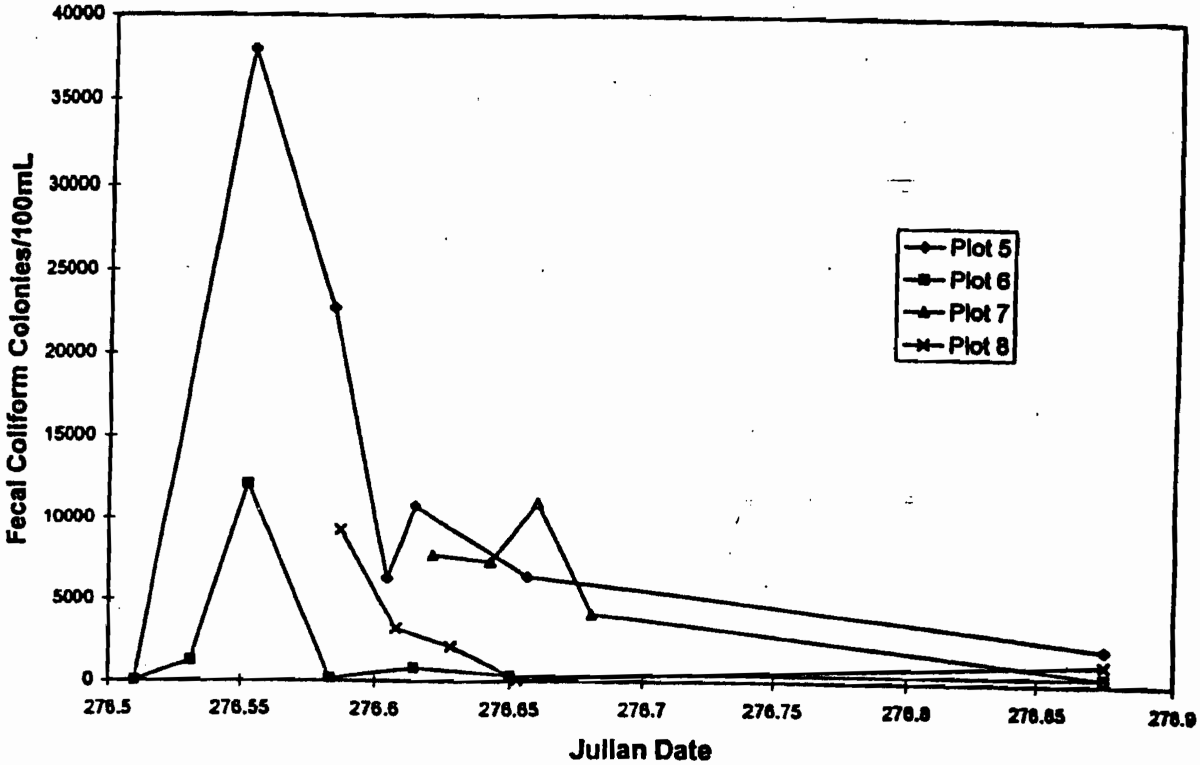

Figure 6. Fecal coliform discharge concentrations with respect to time for the pre-wetted plots (5 & 6) as compared to the dry plots (7 & 8) during the irrigation event 6 days after the manure application.

CONCLUSION

Liquid manure applied to the soil surface at nominal rates, and followed by a precipitation event, can result in bacterial contamination of a subsurface drain in soils which exhibit preferential flow characteristics. The timing of the precipitation event following the liquid manure application will influence the magnitude of the peak concentrations of bacteria such as fecal coliforms. Liquid manure which had dried on the surface did not eliminate the further risk of fecal coliform transport upon rewetting within a 6 day period. An irrigation event on the same day of liquid manure application resulted in a peak concentration of 110,000 colonies/100ml, and an irrigation 6 days after the manure application still resulted in a peak concentration of 38,000 colonies/100ml.

Given a constant precipitation rate, the initial soil moisture content at the time of a precipitation event will influence the length of time which elapses before preferential flow occurs. Liquid manure application to the soil surface when the drain is flowing will result in rapid movement (within minutes) during a precipitation event. For the case when the soil is drier and there is no drain flow, preferential movement of fecal coliform still occurred during a precipitation event when the event was extended for several hours. The peak concentration of fecal coliform did not appear to be affected by the initial soil moisture content.

Attachment D

Geohring, L.D., S. Lee, P.E. Wright, T.S. Steenhuis, and M.F. Walter. 2005. Drainage Water Quality Response to Liquid Manure Application. American Society of Agricultural Engineers. ASAE Paper 05-2065. St. Joseph, Michigan.

The Society for engineering in agricultural, food, and biological systems

An ASAE Meeting Presentation

Paper Number: 05-2065

Drainage Water Quality Response to Liquid Manure Application

Larry D. Geohring[1] Sr. Extension Assoc. **Susie Lee**[1] Student **Peter E. Wright**[2] State Engineer **T. S. Steenhuis**[1] Professor **M. F. Walter**[1] Professor & Head

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Written for presentation at the 2005 ASAE Annual International Meeting

Abstract. Increasing concentrations of nitrate-N (NO_3^-- N) in surface and subsurface water resources are a major concern where livestock manures are being land applied. A five year field experiment to examine NO_3^-- N losses to subsurface drains was carried out, and two applications of liquid dairy manure under different conditions were examined. The first surface application of liquid manure increased NO_3^-- N concentrations in the subsurface drains from an average of 7 mg L^{-1} prior to the manure, to 9.6 mg L^{-1} after the manure was applied. However, when the liquid manure was incorporated immediately after a surface application, no increases in NO_3^-- N concentrations were observed following this manure application. Preferential flow processes were observed to influence the forms of nitrogen lost and the initial amounts. When the liquid manure was surface applied, the NO_3^-- N concentration in the drainage effluent increased rapidly to a concentration similar to that in the liquid manure, and provided the majority of the initial N load. Plow incorporation of the liquid manure had the greatest effect on reducing ammonium-nitrogen concentrations in the drainage effluent.

Keywords. Drainage, water quality, nitrates, liquid manure, manure management

Introduction

Increasing concentrations of nitrate-N (NO_3^-- N) in surface and subsurface water resources are a major concern where livestock manures are being land applied. The land application of livestock manure is a common agricultural practice, and recycling manure provides a valuable source of plant nutrients and other soil conditioning benefits in addition to providing an economical means of handling and disposing of manure. Since manure has nitrogen (N) primarily in the organic form, several N-transformation processes are necessary prior to plants being able to utilize the N, or for N to be transformed into the mobile form of NO_3^-- N. Thus, manure should respond as a slow-release form of N, and be less subject to NO_3^-- N leaching. For agronomic purposes in nutrient management plans, the plant available N from manure is often discounted over a period of years. As a result, additional inorganic fertilizers are still applied to meet the N requirement of successive crops, or greater amounts of manure are applied. Tan et al. (2002) suggested that currently recommended N fertilization practices lead to NO_3^-- N concentrations in drainage water that are typically above drinking water guidelines (10 mg L^{-1} NO_3^-- N), resulting in substantial accumulated N losses and potentially polluting the environment with nitrates. Since agro-ecosystems are inefficient and leaky systems, the additional application of manure applied N, once transformed into the soluble NO_3^-- N form, may further enhance the leaching of NO_3^-- N from the crop root zone.

It has long been known that subsurface drainage is effective in lowering the water table and increasing the aeration of soil, facilitating both N mineralization and nitrification processes (Lyon and Bizzell, 1918; Van Horn, 1958; Schwab et al., 1966; Jones and Zwerman, 1972; Feddes and van Wijk, 1977; Oosterbaan, 1994). Haghiri et al. (1978) found that a one-time application of beef cattle manure increased the NO_3^-- N concentration in the drainage water leachate, with concentrations increasing with increasing manure application rates, and this effect carrying out over several years. However, after observing the accumulation of ammonium-N (NH_4^+- N) in the subsoil where manure was applied to poorly drained soils, Kuo (1981) concluded that better drained soils were still more suitable for manure applications. In more recent studies, Cheatham et al. (2004) found that poultry manure applied at the same rate of N as urea ammonium nitrate did not significantly increase NO_3^-- N concentrations in drain flow, unless a higher rate of N was applied. Other studies found that liquid swine manure applications resulted in significantly greater flow weighted average NO_3^-- N concentrations in tile drainage water (Stratton et al., 2003; Bakhsh et al., 2005).

It has long been known that the quality of drainage water depends on whether water flows through the soil as preferential or matrix flow (Lawes et al., 1882). The loss of NO_3^-- N to drain discharges has been usually attributed to matrix flow. However, manure can be applied at different solid contents, and can be applied to the surface or the subsurface. These variations in manure application methods on different soils at varying soil water contents can influence manure N transformations and leaching processes. Studies have shown that liquid manure applications on soils exhibiting preferential flow can result in rapid contamination and elevated levels of nutrients and bacteria in the drain discharge (Dean and Foran, 1992; Cook and Baker, 1998; Geohring et al., 1998). The nutrient losses of concern from preferential flow are primarily phosphorus (P) and NH_4^+- N. Nevertheless, it is less clear how liquid manure applications on soils subject to preferential flow may affect the short and long term loss of NO_3^-- N. Unlike manure containing a lot of solids and taking years for complete N transformations to occur, liquid manure slurries may be subject to much more rapid (within months) N transformations. Consequently, this paper summarizes the N data obtained from field studies where liquid manure was observed to flow preferentially to subsurface drains.

Materials and Methods

Two intensive field experiments were conducted to examine nutrient delivery to tile drains following liquid manure applications. In the first experiment during the fall of 1996, the effect of wet vs. dry antecedent soil moisture content was overlaid on plots having two different tillage treatments prior to the surface application of liquid manure. For the second experiment in the fall of 1998, the affect of manure incorporation into the soil via disking and plowing was evaluated. After the manure applications, the plots were irrigated and drain effluent was collected. Drain discharge was also monitored extensively in these plots over a period of years before and after the two manure applications. These plots had no previous history of manure application prior to these experiments.

The field study was carried out at a site consisting of 8 tile-drained plots at the Cornell University Willsboro Research Farm located near Willsboro, NY (44•22'N, 73•26'W) adjacent to Lake Champlain. The soil is a very deep, somewhat poorly drained Kingsbury silty clay loam (very-fine, illitic, mesic *Aeric Epiaqualfs*). The drainage characteristics of this soil are similar to numerous other estuarine-formed soils in New York, and represent more than 450 thousand hectares of somewhat poorly drained soils commonly used for agriculture and the land application of livestock manure. This site was used previously to obtain a better understanding of preferential transport of fecal coliforms and P (Geohring et al., 1999; Geohring et al., 2001), other non-adsorbed chemicals (Kung et al., 2000), and pesticides (Steenhuis et al., 1990).

The field site was developed in 1984 with the installation of subsurface drains spaced 18.5 m apart. The site was subdivided into eight plots, each having a subsurface drain (Fig. 1). The plots are 18.5 m wide and vary in length from 96 m (plot 1) to 158 m (plot 8) to provide set-back from a surface waterway. The plots are surrounded with a perimeter drain placed at 1.5 m depth to minimize seepage from the adjacent undrained area. The subsurface drain in each plot was placed about 1 m deep and discharges into a manhole where the discharge can be monitored. A 22.5• •V-notch weir equipped with a water level pressure transducer and connected to a data recorder was used to monitor flow. Drain effluent samples were obtained manually as grab samples. Starting in 1995, the drain effluent was typically collected at weekly intervals, but during the manure application experiments, samples were collected at 15 minute intervals during high flow periods and at 4, 12, 24, or 84 hour intervals as flow subsided. The cropping management of the plots for the previous 20 years consisted of a corn/grass-legume mix rotation, and no manure had been applied. Starting in the fall of 1991, glyphosate was applied to the existing grass-legume sod, and four plots were randomly established as 'conventional' tillage with fall moldboard plowing (FP). Corn was planted in all plots in 1992, and the other four plots were planted and established as no-till (NT). Corn was planted every year (1992-1999), and the tillage integrity of the plots was maintained. The annual inorganic N fertilizer application rates were 118 kg ha^{-1} during 1992 and 1993, 136 kg ha^{-1} for 1994 to 1996, 113 kg ha^{-1} in 1997, 140 kg ha^{-1} in 1998, and 106 kg ha^{-1} in 1999. The N fertilization rate was varied to account for residual N from the sod (1992-1993), and the two manure applications (1997 and 1999). About 20 percent of the ammonium nitrate fertilizer was applied through the planter in early May, and the remainder was side-dressed (liquid Nitan) with a knife (injector) applicator around mid-June.

The 1996 summer was relatively dry and the drains were not flowing prior to the first manure application experiment. The average volumetric soil water content of the plots was 0.30% in the top 1 m of soil (based on three cores per plot). Thus, immediately after corn harvest, plots 3 to 6 were pre-wetted until the drains flowed to create a 'wet' antecedent soil moisture condition. The average initial 'wet' volumetric soil water content was raised to 0.38% in the top 1 m. Plots 1, 2, 7, and 8 did not receive any pre-wetting, and served as the 'dry' plot treatment. The liquid manure was broadcast on the soil surface and was not immediately incorporated into the soil.

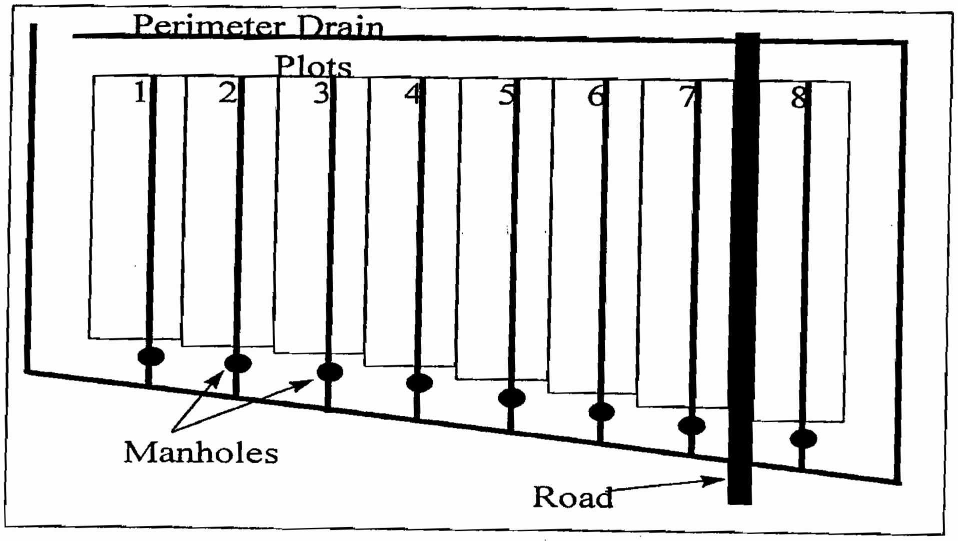

Figure 1. Experimental plot layout at Willsboro Research Farm.

For the FP plots, the plowing was delayed by about 45 days. The liquid manure added 4.7 mm water equivalent which did not induce or increase tile flow in any plot. Immediately following manure application, irrigation was initiated on two dry plots (1 and 2) and two wet plots (3 and 4). Irrigation added 35.6 mm of water at a rate of 11.0 mm hr^{-1}. All the drains in the four plots (1 to 4) flowed as a result of this irrigation. Plots 5 to 8 were irrigated six days later with 29.3 mm of water at a rate of 7.5 mm hr^{-1}, but plots 1 to 4 did not receive any additional water during this irrigation. Between the two irrigation cycles, 23 mm of natural rain also occurred. The natural rain influenced drain flow in plots 1 through 6. All the drains in plots 5 to 8 produced flow as a result of the water added in the second irrigation. Drain discharge was sampled at 15 minute intervals during the irrigation events and the samples were frozen for later NO_3^-- N analysis in the lab using standard techniques for water and wastewater.

Although inorganic N fertilizer was applied for the corn crop during 1997 and 1998, no additional manure was added to the plots until the fall 1998 experiment. In the fall of 1998, the drains were flowing in all the plots at the time of the manure application. Liquid manure was surface applied after corn harvest in a similar manner as in 1996, and incorporated the same day. The manure was incorporated into plots 4 and 5 with conventional plow, and into plots 3 and 6 using a tandem disk harrow. The FP treatment inverted a 15 cm thick slice of soil and completely buried the manure and other surface residue. Since the disk was used on the established NT plots, the disk incorporation only produced shallow furrow slices about 5 cm in width at the disk edge, but left much of the remaining soil area between the 18 cm spaced disks undisturbed. As a result, the disk treatment only partially mixed the manure and soil, and any incorporation was typically less than 8 cm depth. After the manner was incorporated, the four were irrigated with 55.6 mm of water at a rate of 7 mm hr^{-1}. Three rainfall events of 14, 13, and 8 mm also occurred during the sampling period between 40 and 65 hours after manure application. Drain discharge was grab sampled at 15 minute intervals during the irrigation events and samples were collected and frozen for later analysis.

For both manure application experiments, the liquid dairy cow manure was applied to the soil surface with a Wic 3200 model bulk tank spreader at a rate of 47 m^3 ha^{-1} (5000 gal $acre^{-1}$). A uniformity coefficient of 0.66 was measured for this spreader using multiple transects of buckets placed every 1.5 m across the spreading width. Nine manure samples (five in 1996 and four in 1998) were collected during spreading for nutrient analysis. The total N in the applied manure averaged 2020 mg L^{-1} (17.3 lbs/1000 gal), or 97 kg ha^{-1} applied, of which 40.1% was in the NH_4^+- N form. The manure samples had less than 5% variation between samples and years. The liquid manure contained 5-7% solids at a density of 10.3 mg cm^{-3}. A NO_3^-- N analysis of the manure showed a concentration of 13.8 mg L^{-1}, or about 0.26 kg ha^{-1} applied as NO_3^-- N.

The irrigation water source was Lake Champlain with a concentration of 0.13 mg L^{-1} NO_3^-- N. The irrigation system used Rainbird 30H sprinklers with 3.2 mm by 3.2 mm - 20••(1/8" x 1/8" - 20•) spreader nozzles set on a 12.2 m spaced grid pattern covering about 1400 m^2 $plot^{-1}$, and was only capable of irrigating a four plot width set. Eight rain gauges were placed within the plots to monitor the application amounts and uniformity.

Soil Test N

The soils in the plots were sampled at five depths (0-5, 5-15, 15-30, 30-60, and 60-90 cm) for pH, organic matter (OM, loss on ignition), NO_3^-- N (Morgan's extraction), and total Kjeldahl N prior to the first application of manure in 1996, immediately after the manure application and irrigation experiment in 1996, and then in June 1997. Three soil cores two inches in diameter were extracted from each plot and a composite sample was frozen, and later analyzed for each depth. Table 1 shows the average values of four plots, based on the no-till (NT) and fall plowed (FP) treatments, and for each depth and sampling period. It should be noted that the manure was surface applied to all the treatments and the POST manure sampling was done prior to plowing in the fall of 1996.

Climate Data

An automated weather station was located within 250 m of the site. Precipitation amounts during the course of this study are shown in Table 2. The long term average annual precipitation for this area is about 870 mm (34.3 inches). Several rain and snowfall samples were also collected for NO_3^-- N analysis, and contained an average of 0.43 mg L^{-1} NO_3^-- N.

Discussion

The average drain discharge NO_3^-- N concentrations observed for the FP and NT tillage treatments are shown in Figure 1. Overall, the concentrations are not significantly different between the tillage treatments. However, the NT treatment produced higher concentrations for a brief period during the summer of 1997 (following the first manure application in the fall of 1996), and then again once the NT plots were fall plowed at the end of the corn rotation in 1999. The latter affect of increasing NO_3^-- N concentrations following the plow-down and rapid mineralization and nitrification of an established residue was also reported by Sogbedji et al. (2000). The higher concentrations that occurred in the NT treatments during the late summer of 1997 are less clear, but are also likely the affect of more favorable mineralization conditions of the organic-N residual from the surface applied manure. The soil sampling data in Table 1 indicate that the organic matter and total N available in the top 5 cm of NT soil after (POST) manure application are higher than in the FP treatment, although these differences appear to be negligible by early summer of 1997. The NO_3^-- N concentrations typically increased following fertilizer applications, and were the highest at around 15 to 20 mg L^{-1} NO_3^-- N following the first (and surface) manure application, and the first fertilizer application after this manure application. It's interesting to note that the second manure application, which was incorporated and done about three weeks later in the fall than the first one, did not produce the same response. One explanation for this may be that the drains were flowing all summer in response to the higher than normal precipitation (note Table 2), so much of the soil available NO_3^--N was depleted, and

Table 1. Soil analysis data before and after the first liquid manure application experiment.

Sampling Period:	PRE Manure Application, 1996							
Treatment by Depth, cm	pH		OM, %		NO_3^-- N, mg kg^{-1}		Total N, %	
	NT	FP	NT	FP	NT	FP	NT	FP
0-5	7.0	7.3	6.7	7.5	13.7	7.2	0.315	0.310
5-15	6.9	7.2	6.3	7.3	13.1	8.8	0.263	0.315
15-30	7.2	7.2	4.1	4.1	3.4	0	0.135	0.123
30-60	7.8	7.6	2.6	2.0	0	1.9	0.063	0.050
60-90	8.1	7.9	1.6	1.1	0	1.8	0.038	0.028
Sampling Period:	POST Manure Application, 1996							
0-5	7.2	7.4	8.0	7.4	20.6	11.9	0.330	0.293
5-15	7.2	7.3	7.3	7.3	11.6	12.3	0.295	0.298
15-30	7.3	7.4	3.9	4.1	0	2.3	0.118	0.125
30-60	7.6	7.7	2.2	1.9	0	0	0.050	0.043
60-90	8.1	7.9	1.6	1.5	0	1.6	0.038	0.030
Sampling Period:	Following Spring June 5, 1997							
0-5	7.1	7.3	7.0	6.9	17.2	16.1	0.288	0.285
5-15	7.2	7.2	6.4	7.2	2.3	5.2	0.253	0.290
15-30	7.3	7.3	3.9	4.5	1.8	1.6	0.128	0.153
30-60	7.7	7.6	2.5	2.1	1.6	2.5	0.055	0.053
60-90	8.1	7.7	1.5	1.4	0	2.3	0.035	0.030

Table 2. Monthly precipitation (mm) for the Willsboro Research Farm study site.

Year	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Total
1995	66	38	33	40	33	44	120	138	60	166	69	54	861
1996	77	5	14	102	98	80	129	31	50	79	131	80	876
1997	18	27	58	42	43	75	88	131	64	37	136	3	722
1998	114	31	35	36	61	231	135	112	132	55	24	5	971
1999	87	33	95	15	37	36	49	45	183	48	71	54	753

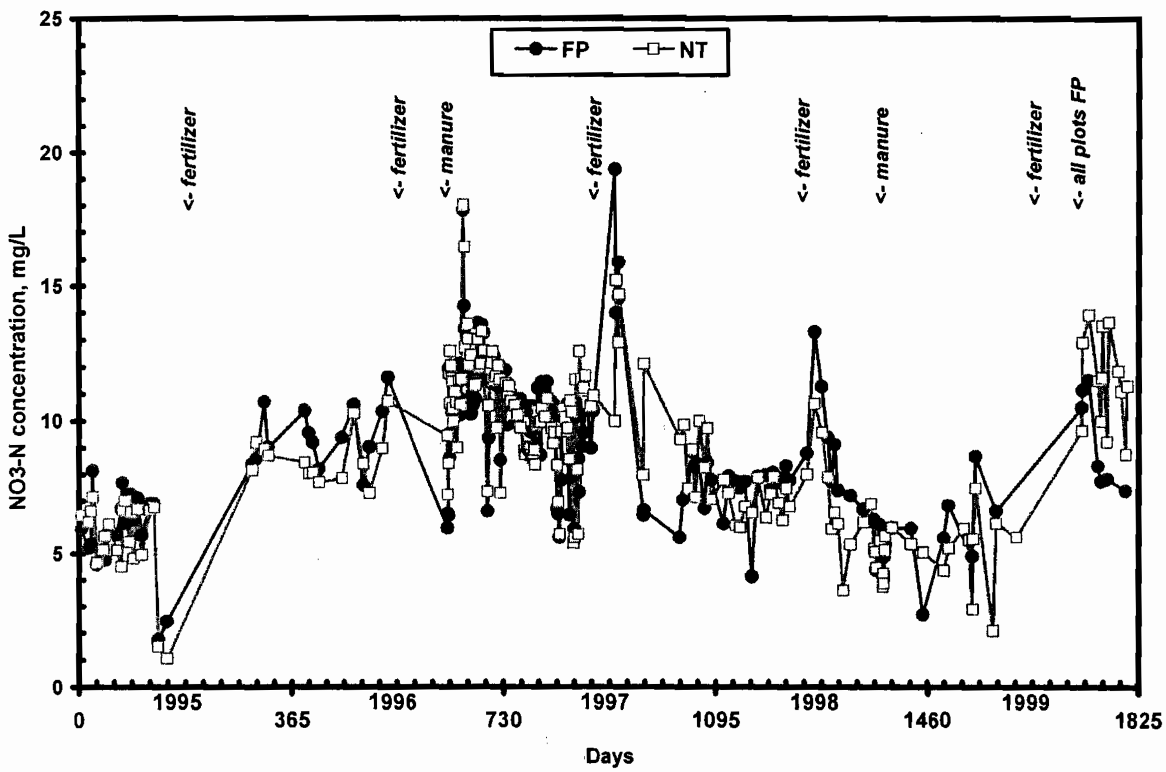

Figure 1. Average NO_3^-- N concentrations in drain discharge for 1995 to 1999 in response to different tillage and manure application treatments.

and mineralization and nitrification conditions were not very favorable for the manure-N incorporated into the wetter and cooler soil.

In contrast to the negligible affect of the second manure application, the NO_3^-- N concentrations were significantly higher after the first manure application (fall 1996 to fall 1998) for all plots when compared to prior years (1995 to fall 1996). The mean concentration increased from 7 to 9.6 mg L^{-1} NO_3^-- N (significant at $\alpha = 0.05$ using students *t*-test). Figure 2 shows the total N, NO_3^- - N, and NH_4^+- N concentrations for the FP and NT treatments in more detail just prior to and after the first manure application. Prior to this manure application, the drains were not flowing. A 36.4 mm (1.44 in.) irrigation on Julian Day 264 to establish a 'wet' treatment on four plots did not produce any drain discharge. Another pre-wetting irrigation of 41.6 mm (1.63 in.), however, did initiate drain flow (Fig. 2). The NT plots began flowing first, and the FP plots started to flow 1.5 hours later. The NT plots not only began to flow first, but also initially produced somewhat higher NO_3^-- N concentrations. The higher available soil NO_3^-- N in the NT plots (see Table 1 PRE data), a result of warm and dry pre-existing conditions for mineralization, would confirm this first leaching response. During the irrigation after the manure was applied, the NO_3^-- N concentrations in both treatments are similar, and show some effect of dilution from the irrigation. The NO_3^-- N concentration in the FP plots eventually increases, whereas the NT treatment concentration levels and drops off, partly in response to dilution resulting from the 23 mm (0.9 in.) rain that occurred on Day 272. The concentrations are similar at later times, although the NT concentration again shows a drop in response to rain on Day 277. When comparing the PRE and POST soil sample data in Table 2, it's interesting to note that the OM

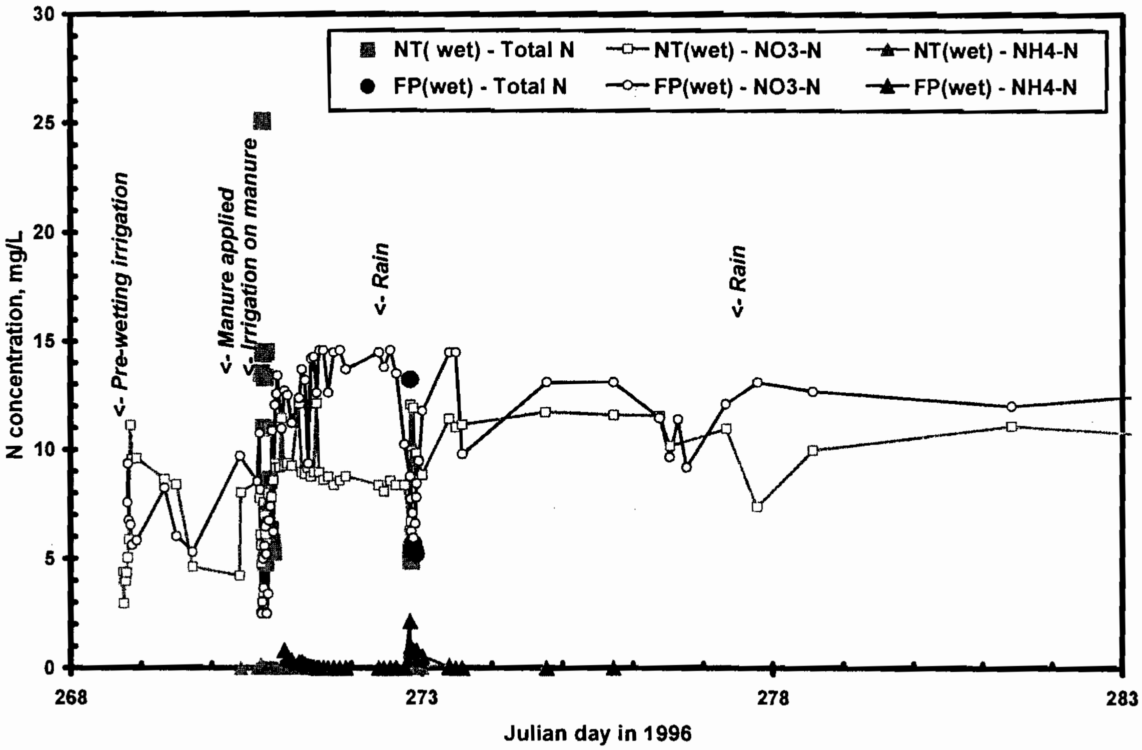

Figure 2. Various N concentrations immediately before and after the first surface applied manure application on the four pre-wetted plots.

and Total N concentrations increased substantially in the top 15 cm of the NT plots, compared to virtually no change in the FP plots. The surface applied liquid manure application may have filled some of the structure pores, partially reducing the NO_3^-- N leaching concentration. The affect of preferential flow is observed first in the NT plots with the early breakthrough of total N and NH_4^+- N, although concentrations seem to subside quickly. The preferential breakthrough of total N and NH_4^+- N occurs later in the FP plots in response to the next rain event, and then at higher concentrations than in the NT plots.

The accumulated NO_3^-- N discharged to the tile drains immediately following the first manure application and irrigations, and in response to the overlay of 'wet' vs. 'dry' treatments is shown in Figure 3. Although the concentrations were essentially similar between FP and NT treatments and between the pre-wetted and dry plots, the accumulated loss was ultimately affected when manure was applied to the pre-wetted plots. The NO_3^-- N loss occurred quickly on the wetter plots where the drains were now flowing in response to the irrigation and rain event. The initial accumulated loss is about the same as the 0.26 kg ha^{-1} of NO_3^-- N content in the applied manure. It appears that the loss of N is somewhat higher from the two pre-wetted NT plots then from the wet FP plots. The 23 mm (0.9 in.) rain that occurred on Day 272, two days after the manure application, was adequate to generate more drain flow and produce a similar loss from the two pre-wetted plots that had not been irrigated right after the manure application. This rain also increased the loss from the two wet plots that were irrigated two days earlier. During the 2nd irrigation of the last four plots (plots 5-8) six days after the manure had been applied, additional NO_3^-- N was leached to the drain from the pre-wetted plots, and slightly more from the NT plot.

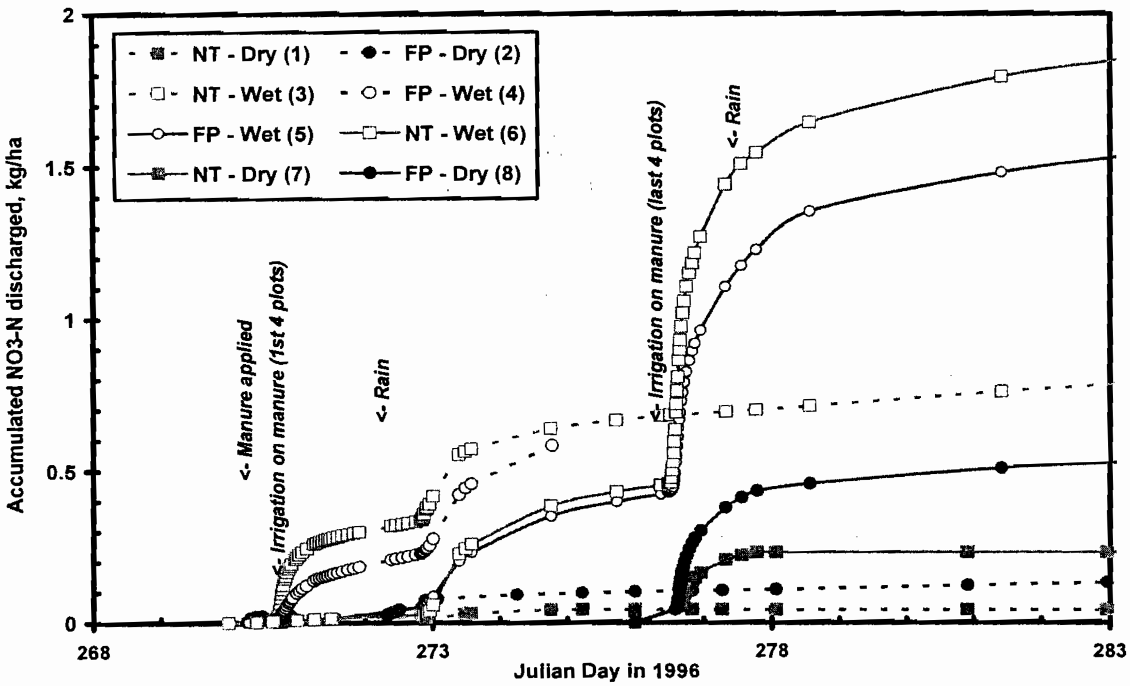

Figure 3. Accumulated NO_3^-- N loss from the drain in response to tillage treatment and the surface application of manure to soil at different antecedent moisture conditions.

The 2nd irrigation on the dry plots resulted in more N loss than the first irrigation of the dry plots, probably a result of the previous rain, but was still similar to the amount of available NO_3^-- N in the applied manure. The data in Figures 2 and 3 suggest that all forms of N may be lost via preferential flow. The NO_3^-- N concentration and amount was similar to that in the manure. Since the accumulated loss of NH_4^+- N over this same time period was only about 0.01 kg ha^{-1}, the loss as nitrate represented the largest loss of N. The accumulated losses were slightly higher when the manure was applied to wetter soil, but this was primarily the result of faster leaching response to a rain event. The initial mass loss of N represents only about one percent of the N applied, but the NO_3^-- N concentration exceeded the drinking water standard.

As shown in Figures 1 and 4, the more deleterious affect to water quality appears to occur soon after the surface application of liquid manure, as some of the remaining organic N was apparently quickly transformed to nitrate. The NO_3^-- N concentration remained at around 10 mg L^{-1} and an average of 30 kg ha^{-1} of NO_3^-- N was discharged within 100 days of the manure application. The highest loss occurred on a dry NT plot. Since the plots had been relatively dry and the manure was applied early in the fall when the soil was still warm, N transformations must have been able to occur. The soil pH and organic matter in this soil would be conducive for mineralization and nitrification, and the preferential nature of this soil may have also enhanced the processes by providing aeration. Although one might assume much of the NH_4^+- N in the surface applied manure should have volatilized, the irrigation soon after the manure application may have carried the organic N into the soil. The soils data in Table 1 also indicates this may have happened.

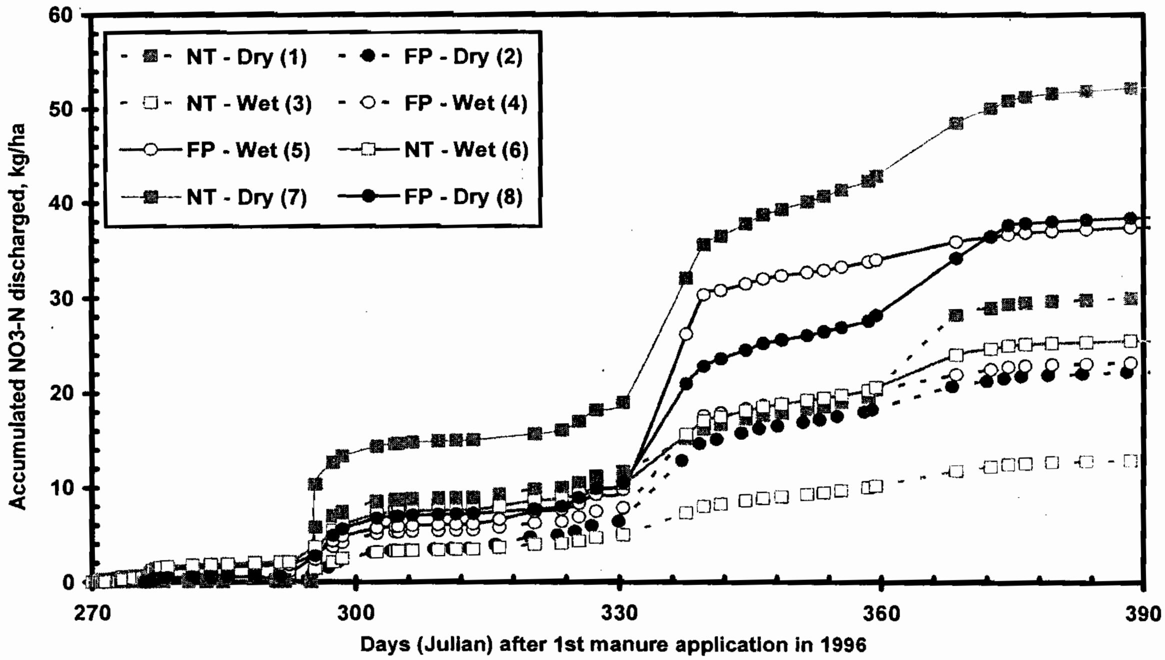

Figure 4. Accumulated NO_3^-- N loss in the drain discharge after the first manure application.

The second experiment, with manure incorporation, produced very different responses in N loss. Figure 5 not only shows lower overall NO_3^-- N concentrations at the time of the manure application, but the effect that plow incorporation had on further reducing the NH_4^+- N concentration in any preferential flow. Prior to this manure application in the fall of 1998, the soil was already wet and the drains had been flowing extensively. This likely explains the lower NO_3^- - N concentration prior to this manure application. The incorporation treatments further minimized differences in the previous NT and FP tillage treatments, as the NO_3^-- N concentrations were the same immediately following the manure application. In this 2nd experiment, the manure was also applied later in the fall compared to the first manure application. Thus, the wet, cool soil, and the mixing of the manure into the soil with the incorporation treatments must have minimized the opportunity for any rapid N transformations. Figure 1 shows that the NO_3^-- N concentrations were not sustained as they were following the first application, and combined with small drain flows, the accumulated losses were also small.

The ratio of the annual accumulated NO_3^-- N discharged per unit of drain flow is summarized in Table 3 for the NT and FP plot treatments. The ratio was lowest (at 0.639 kg ha^{-1} cm^{-1}) for the NT treatment in 1995 prior to any manure application. The 1st manure application in the fall of 1996 increased the ratio for both tillage treatments, and to a high of 1.03 kg ha^{-1} cm^{-1} for the FP treatment. Note that a ratio of one would imply a flow-weighted NO_3^-- N concentrations of 10 mg L^{-1}, thus showing that concentrations increased in the drain flow as a result of the manure application. The ratio remained high in the year following the manure application, with the higher

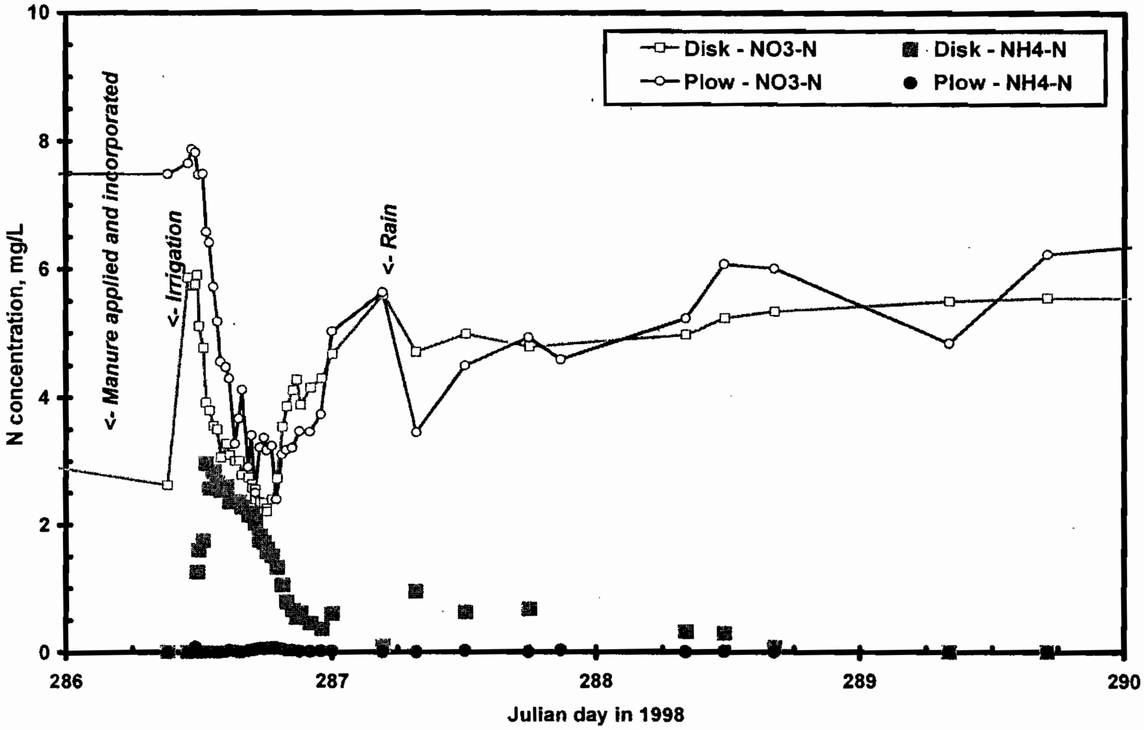

Figure 5. Nitrogen concentrations in the drain discharge following manure application and incorporation.

value now occurring in the NT treatments. The ratio dropped slightly in 1998, as the 2nd manure application later in the fall, and which was incorporated, resulted in little additional loss. However, the ratio increased again during 1999, probably the result of the organic N beginning to mineralize. It's interesting to note that the higher ratio value switched from the FP treatment to the NT treatment in the years following the 1st manure application.

Table 3. Ratio of average annual accumulated NO_3^-- N (kg ha^{-1}) to equivalent water depth (cm) discharged from the subsurface drains.

Treatment by Year	NT	FP
1995	0.639	0.723
1996	0.998	1.03
1997	0.911	0.886
1998	0.854	0.849
1999	0.866	0.761

Conclusion

The surface application of liquid dairy manure increased NO_3^-- N concentrations in subsurface drains from an average of 7 mg L^{-1} prior to the manure, to 9.6 mg L^{-1} after the manure was applied. When the liquid manure was incorporated immediately after a surface application, no increases in NO_3^-- N concentrations were observed following this manure application. The opportunity for more rapid mineralization and nitrification of the manure organic N when applied to the surface while the soil was dry and warm may have been the reason for the observed responses. Although NO_3^-- N concentrations were similar between NT and FP treatments throughout the five year duration of this study, the NT treatments appeared to lose more NO_3^-- N per unit of drain discharge after the manure had been applied. The preferential loss of N occurred at this site, with both organic and NO_3^-- N forms of N being observed in the drain effluent when irrigation followed the surface manure application. The NO_3^-- N concentration increased rapidly to a concentration similar to that of the liquid manure, and provided the majority of the initial N load. Different antecedent moisture conditions established just prior to the surface manure application did not influence the breakthrough concentrations, but breakthrough was more rapid from the NT treatment and wetter soil. Incorporation of the manure reduced the initial N breakthrough concentrations, with the plow (deeper) incorporation having a greater reduction than the disk incorporation. The NO_3^-- N concentration in the subsurface drainage effluent increased after each inorganic N fertilizer application, but the response was inconsistent following the liquid manure applications. The manure N transformations leading to NO_3^-- N loss are apparently influenced by a number of processes, which will require further research to better understand the impacts of manure application on drainage water quality.

Acknowledgements

This research was supported by New York State funding for the Agricultural Water Management Program and the Northern NY Agricultural Research and Development Program. The authors would like to thank the Willsboro Farm crew for their dedicated support collecting drain samples.

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Attachment E

Hoorman, J.J., J.N. Rausch, T.M. Harrigan, W.G. Bickert, M.J. Shipitalo, M.J. Monnin, S.R. Reemer, F.E. Gibbs, M.I. Gangwar, L.C. Brown. 2004. Liquid animal manure application on drained cropland. Preferential Flow Issues and Concerns Workshop Summary. Columbus, Ohio.

LIQUID Animal Manure Application on Drained Cropland:
Preferential Flow Issues and Concerns Workshop Summary

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The movement of manure to surface water from artificially drained cropland is a concern. A Liquid Animal Manure Application on Drained Cropland: Preferential Flow Issues and Concerns workshop was held in Columbus, Ohio (November, 2004). The objectives were to: (1) integrate state guidelines into regional guidelines for mitigating liquid manure discharges from artificially drained cropland; (2) identify/prioritize research needs related to the downward movement of animal manure on artificially drained cropland; and 3) identify/prioritize extension and outreach needs related to manure application and pollution of water resources. Recommended regional guidelines for drained fields include monitoring outlets/inlets; matching manure application rates with soil infiltration rates, water-holding capacity of the soil, and crop/soil nutrient needs; and not applying manure when subsurface drains are flowing. Avoid applying manure to flood prone fields, adjust application rates to environmental conditions and ability of the soil to store and utilize manure nutrients (based on nitrogen and phosphorous), and apply manure at a uniform rate and volume to avoid ponding and manure runoff. Future research is needed on pathogen transport and fate; soil preferential flow characteristics; evaluating manure management and equipment application; total manure characteristics (% solids, viscosity, nutrients, pathogens, color); and developing liquid manure testing methods, quick tests, and sensors. Extension activities include developing simple rules for manure application and management; requiring producer certification/education for manure application; developing web based fact sheets, video clips, photographs and demonstrations for preventing manure runoff; promoting partnerships with agencies and animal industry; and educating agency personnell on manure runoff issues.

Keywords: preferential flow, liquid manure, subsurface drainage, macropores, manure runoff

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Subsurface drainage improves crop growth and soil productivity, but can have detrimental environmental effects by increasing the movement of agri-chemicals and nutrients to surface water supplies (Kladivko et al., 2001). Frequently, this increased movement is attributed to preferential flow in soil macropores. Factors such as high intensity rainfall, dry soil, and conservation tillage, because it can contribute to the formation and preservation of soil macropores, increase the potential for preferential flow processes to occur (Shipitalo et al., 2000).

Liquid animal manures are a valuable source of nutrients and organic matter for crop production and can be applied by a variety of methods including spray irrigation, surface spreading, and subsurface injection. Because of their low solids and nutrient content, liquid animal manures are usually applied at relatively high volumes, but it is generally recommended that it not be applied at rates that would exceed the amount needed to bring the soil to field water holding capacity (Johnson and Eckert, 1995). Nevertheless, even when similar guidelines are followed, contamination of drain line effluent has been reported in soils with subsurface drainage due to macropore flow (Geohring et al., 2001).

Application of liquid animal manures to soils with subsurface drainage has been linked to contamination of the effluent with nutrients (Cook and Baker, 2001; Geohring et al., 2001; Stamm et al., 2002), particulate organic matter (Barkle et al., 1999), estrogens (Burnison et al., 2003), bacteria (Bicudo and Goyal, 2003; Cook and Baker, 2001; Dean and Foran, 1992; Jamieson et al., 2002; Joy et al., 1998), and veterinary antibiotics (Kay et al., 2004). These findings are not universal, however, as liquid animal manures can be applied without any detectable adverse effects on water quality. For instance, Randall et al. (2000) noted no difference in nitrogen, phosphorus, or fecal indicator bacteria losses in drainage water when they compared plots that received liquid dairy manure to plots that received equivalent amounts of mineral fertilizer. The fact that liquid animal manures can be safely land applied in some instances, but can cause contamination of subsurface drainage water under different circumstances suggests that the properties of the soil such as soil texture, initial water content, and tillage history as well as the amount of manures applied, application method, water content of manures, and the amount of rainfall after application may all play a role in determining the fate of the applied material.

Materials and Methods

A workshop on Liquid Animal Manure Application on Drained Cropland: Preferential Flow Issues and Concerns was held in Columbus, Ohio on November 9-10, 2004. The objectives of this workshop were: (1) Integrate state guidelines and recommendations for mitigating liquid manure discharges from artificially drained cropland; (2) identify and prioritize extension and outreach needs related to manure application and pollution of water resources; (3) identify and prioritize research needs related to the downward movement of animal manure on artificially drained cropland. Preferential flow and the fate of liquid animal manure on drained cropland presentations were conducted and discussed the first day. The second day, participants divided into three groups and discussed developing regional guidelines, future research needs for preventing preferential flow of liquid manure on drained cropland, and possible extension and outreach programs that need to be conducted. Each participant then used a blue dot (highest priority, 2 points) and a red dot (second priority, 1 point) to score and rank ideas in the research and extension categories. All ideas were recorded and scored, however, similar ideas were grouped together before and after scoring.

Results and Discussions

The content for developing regional guidelines to prevent preferential flow of manure to subsurface drains were identified and discussed. Research and extension activities were also discussed, scored, and ranked.

Regional Guidelines:

Task: Integrate state guidelines and recommendations for mitigating liquid manure discharges from artificially drained cropland to develop regional guidelines. Four major recommendations are:

1) Observation and Monitoring of Tile Inlets and Outlets

Any field where subsurface (tile) drains discharge into ditches that flow to surface water should be considered a high-risk field that is monitored carefully before, during and after a manure application. Apply, observe and monitor tile outlets, evaluate the results, and make adjustments as needed to develop a site-specific manure application plan. Do not apply manure to subsurface (tile) drained fields when the drains/tiles are flowing.

A suggested schedule for observation and monitoring:

a) 10-20 minutes after start of any liquid manure application.

b) Once each 20,000 gallons. Once each hour, if application rate is >20,000 gal/hr. (Example based on Ontario, Canada guidelines.) State and regional rates may vary.

c) Stop application immediately if discharge and/or discoloration observed, implement contingency plan.

2) Liquid Manure Applied to Subsurface Drained Fields

The available water holding capacity of the upper 8 inches of soil (Table 1) provides the approximate volume of water and/or liquid manure that can be applied before water, manure and nutrients begin to move through the soil profile. Manure application rates may need to be adjusted the day manure is applied to avoid reaching and/or exceeding the available holding capacity of the soil. Soils are better able to absorb multiple smaller liquid manure applications than a single large volume application. Field/soil conditions the day of application will dictate the maximum application volume that can be applied. Liquid manure:

a) Should not to be applied on soils that are prone to flooding, as defined by the National Cooperative Soil Survey (or in the Flooding Frequency Soil List posted in Section II eFOTG), during the period when flooding is expected. Manure can be applied if incorporated immediately or injected below the soil surface during periods when flooding is not expected;

b) Application rates should be adjusted to consider the most limiting factor and include the ability of the soil to accept, store and hold liquid manure, water and nutrients and the ability of the plants to utilize these nutrient.

c) Should be applied in a manner that will not result in ponding or runoff to adjacent property, drainage ditches, or surface water regardless of crop nutrient need/requirement;

Should be uniformly applied at a known rate or volume. Do not apply at rates (volume) that exceed the lesser of the AWC in the upper 8 inches or an effective rate of 13,000 gallons/acre per application (Example based on Ohio guidelines). State and regional rates may vary. The effective rate is used for application equipment with concentrated flows. For example, an injection toolbar with four (4) nozzles on 30 inch spacing. Each nozzle has a concentrated flow over a small area. The effective rate is calculated as the volume of manure applied per area for one (1) nozzle;

d) Prior to manure application, use surface tillage to disrupt the continuity of worm holes, macropores and root channels (preferential pathways) to reduce the risk of manure reaching tile lines, or till the surface of the soil 3-5 inches deep to a condition that will absorb the volume of liquid manure being applied. This is especially important if shallow tile (drains) are present (< 2 feet deep). Any pre-application tillage should leave as much residue as possible on the soil surface to minimize soil erosion;

e) If injection is used, inject only deep enough to cover the manure with soil. Till the soil at least 3 inches below the depth of injection prior to application, or control outflow from all tile outlets prior to manure application;

f) Identify subsurface (tile) outlets, and control or regulate discharge prior to application, or have on-site a means of stopping the discharge from subsurface (tile) drains (e.g. tile plugs, tile stops, or control structures). Use caution not to back-up water where it may impair the functioning of an offsite subsurface drainage system;

g) For perennial crops (hay or pasture), or continuous no-till fields where tillage is not an option, all subsurface (tile) outlets coming from the application area should be identified and flow should be controlled or captured prior to application;

h) Repair broken tile and blowholes prior to application, and follow recommended/required minimum setback requirements (setback distances vary from state to state) for surface inlets;

i) Do not apply manure to subsurface (tile) drained fields when the outlets are flowing;

j) Should a discharge occur, have a plan for dealing with any manure that may reach subsurface (tile) drains, such as blocking outlets or blocking the flow once it reaches the ditch;

k) Avoid applying manure before or after a rain. Keep log of weather forecasts and actual weather conditions 24 hours before and after a manure application with manure application records;

l) Bare/Crusted soils may require some tillage to improve infiltration and absorption. Determine the most limiting application rate base on the field condition and other limitations (may vary from state to state).

<u>These criteria may be waived if the producer can verify there is no prior history of manure discharge via subsurface (tile) drains or discharge is captured. However, if there is a discharge, the producer is liable for damages and is at risk of being classified as a CAFO (Concentrated Animal Feeding Operation).</u>

3) Liquid Manure Applied to Systematic Surface Drained Fields

Fields or areas of fields that have systematic "surface drainage" systems (e.g. shallow surface drains spaced 100 – 200 feet apart – NRCS Surface Drainage-Field Ditch Practice Standard 607) are considered concentrated flow areas. However, if special precautions are taken, manure can be applied in the surface drains with minimal risk of surface runoff. This does not apply to the collector surface drains (mains) or drains bordering the fields. The following special manure application techniques shall be used:

a. Till the surface at least 3 to 5 inches deep prior to <u>liquid</u> manure surface application. Pre-till within 7 days of application.

b. Surface-apply liquid manure <u>uniformly</u> over the entire soil surface on the freshly tilled soil to allow the liquid manure to be absorbed into the soil surface.

c. For fields with no subsurface drainage, liquid manure can be injected directly without prior tillage.

d. Manure application rates should be adjusted to consider the most limiting factor and include the ability of the soil to accept, store and hold liquid manure, water and nutrients. The Nitrogen and Phosphorus Application Criteria for manure, Organic By-Products and Biosolids contained in NRCS Nutrient Management Standard 590 are to be followed to limit transport and leaching..

4) Other Management Criteria

a. Maximize liquid manure storage structures available holding capacity through frequent manure applications under optimal weather conditions. (Do not let manure storage structures get too full.)

b. Size manure application equipment to meet equipment and labor (time) constraints.

c. Calibrate equipment frequently and follow a regular repair/maintenance schedule.

d. Modify crop rotations to fully utilize manure nutrients during the growing season. Plant cover crops after harvest to hold available soil nutrients.

Research Activities:

Task: Identify and prioritize research needs related to liquid animal manure applied to artificially drained cropland. The following topics were listed as priority areas that needed to be researched:

1) Pathogen transport and fate. Score 26
2) Soil types (water holding capacity) and preferable flow characteristics. Score 23
3) Total Manure Characteristics: Particle size, fiber content, percent solids, nutrient content, viscosity, pathogens, color, tied to management systems and research to keep manure out of surface water. Score 17
3) Comparison of existing application methods and application equipment. Compare tillage methods before, during, and after manure application. Score 17
4) Liquid manure testing methods, sensors, quick tests, cost effectiveness. Score 15
5) Correlation of all factors from case file violation cases to identify the magnitude of preferential flow problems. Score 14
5) Research alternative treatment technologies and methods. Score 14
6) Changes in manure, additives to liquid manure, viscosity, value-added, alternative uses. Score 7
6) Precision application technology, mixing, on the go detection and variable rate application. Score 7
6) Socio-economic factors, who pays, adoption of new technology, what combination of educational, technical, financial assistance, and regulation policy is the best. Score 7
7) Water table controls: Compare in soil/in-line storage, site characterization, design, construction, management and duration of control, and management of structures. Score 5
7) Research what happens after liquid manure stored in soil and after it is absorbed. Research what is stored to what is applied to what is discharged. Score 5
8) Research surface water tolerances for manure nutrients, limits, performance standards, and risk assessment. Score 4
9) Alternative storage and handling technology methods. Research storage/handling versus application of manure versus site characteristics. Score 3
9) Portion applied and stored in soil to portion discharged (volume/concentration). Score 3
10) Variability of manure characteristics: species, storage system, and application to fields. Score 2
11) Research the water column and surface applications to the geography setting. Score 1
- What are the most important components to solve problems at a specific operation? No Score
- Systems approach – What is most cost effective for producers? No Score
- Watershed scale studies No Score

Extension Activities:

Task: Identify and prioritize extension, outreach and Technical Service Provider (TSP) needs related to liquid animal manure applied to artificially drained cropland. Seven major extension and outreach issues and educational programs were identified.

1) Keep all information simple and easy to use and integrate simple manure application rules into the whole farm plan. Score 35 points.

Animal manure producers are not utilizing comprehensive nutrient management plans or manure nutrient management plans because they are too complicated and difficult to understand. Need to develop a one-page fact sheet or check list for liquid manure application and one-page record keeping document for animal producers.

2) Required certification and continuing education credits for manure applicators to apply manure. Score 33

Discussion on various state education programs to educate producers about manure management and application. Specific programs mentioned included Livestock Environmental Assurance Programs and a program called Manure Management Issues, Challenges, & Solutions that taught agency personnell how to teach producers about proper liquid manure application techniques; preferential flow issues; winter application of manure; and water quality issues with liquid manure. Suggestions were to develop a notebook for each state on 1) Why liquid manure is a problem; 2) Guidelines on how to apply liquid manure safely, calibrating equipment, and manure application rates; 3) Management of manure storage; 4) State and federal regulations that apply; 5) Risk factors associated with weather, soil moisture conditions, and other environmental factors; and 6) Water quality issues and concerns. Livestock producers tend to apply manure at high rates and have little incentive to apply manure correctly. However, the environmental consequences of pollution from manure for drinking water, fish kills, and wildlife as well as neighbor relations, community perception and public perception may have negative effects on animal production.

3) Develop web based fact sheets, video clips, photos, slides for extension educators. Use demonstrations to educate livestock producers on preferential flow of liquid manure from drained cropland. Score 30

Fact sheets on different types of manure application equipment and how they can be used to apply manure safely. Utilize demonstration projects (e.g. smoking tile lines, monitoring tile outlets) to educate livestock producers on preferential flow issues. Develop workbook with research on applying manure to drained cropland. Recent survey in one state indicated web usage on educational material rated low, short fact sheets rated good, and demonstration and demonstration sites rated high.

4) Promote partnerships with Agencies, Industry, Producers, General Public, and Universities. Promote insurance rate reductions (as high as 30%) for producers who follow MNM plan and EMS procedures, developed by Wisconsin and Michigan. Score 27

Discussed the need to incorporate guidelines for manure application into NRCS technical guide. Need to educate dealers and manufacturers of liquid manure application equipment on how to design equipment that will reduce application rates and preferential flow problems. Agencies and livestock commodity groups should form partnerships and work together to simplify rules. Partnerships need to have a consistent message and should produce educational programs on manure management for livestock producers and grain producers who receive manure. In one program, a state used federal dollars to train consultants to manage manure storage facilities, hire custom manure applicators, develop GPS computer generated setback distances and manure application rates for individual fields, and flag and monitor tile lines for animal operations. Each operation was paid to hire a consultant to apply manure correctly..

5) Train Extension and Agency personnell (EPA, NRCS, SWCD) on Preferential Flow issues related to manure. Score 19

Need to have knowledgeable people at the county level who understand manure issues and who can handle a manure crisis. Need to have people who can deal with cultural differences with large dairies, integrated livestock operations, concerned citizen groups opposed to large operations, and the general public.

6) Develop an Interactive Computer Decision Support Program Model. Score 17

Develop a computer program that inputs 1) field data like soil type, soil moisture, and environmental setbacks, 2) total amount of manure on farm, and 3) climate data and generates output that identifies fields to apply manure and specifies a safe application rate. Could possibly be incorporated into Purdue Manure Nutrient Management Program.

7) Integrate Manure Management for Liquid Manure Application into other programs. Score 13

The issue was developing a comprehensive integrated system for managing and applying manure that addresses all issues. Liquid manure systems have been developed because they are healthier for livestock and manure from these systems is easier to handle, but these systems also generate large volumes of excess polluted water. There is a need to design systems that keep clean water separated from polluted water. Need to design systems that do not impact air quality or water quality. For example, injecting liquid manure may improve air quality by reducing odors but decrease water quality by increasing preferential flow problems. Need consistent recommendations that account for most environmental problems that may occur.

Conclusions

Good management is a key issue in preventing preferential flow of manure to surface water. While weather and some environmental conditions cannot be controlled, producers can control when and how they apply liquid manure. Producers need educational programs and guidelines based upon good research focusing on how to prevent the movement of manure to water resources. This paper outlines the content of recommendations for developing regional guidelines to prevent manure runoff. Future research needs and extension and outreach activities are identified to help producers apply liquid manure in a manner that minimizes the potential for impacting water resources through the downward movement of manure into subsurface (tile) drains. These recommendations incorporate the best available knowledge.

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Appendix

Table 1. Available Water Capacity (AWC) Practical Soil Moisture Interpretations for Various Soils Textures and Conditions to Determine Liquid Waste Volume Applications not to exceed AWC.

This table shall be used to determine the AWC (upper 8 inches) at the time of application and the liquid volume in gallons that can be applied not to exceed the AWC. To determine the AWC in the upper 8 inches use a soil probe or similar device to evaluate the soil to a depth of 8 inches.

Available Moisture in the Soil	Sands and Loamy Sands	Sandy Loam and Fine Sandy Loam	Very Fine Sandy Loam, Loam, Silt Loam, Silty Clay Loam, Clay Loam, Sandy Clay Loam	Sandy Clay, Silty Clay, Clay
< 25% Soil Moisture Amount to Reach AWC	Dry, loose and single-grained; flows through fingers. 20,000 gallons/ac	Dry and loose; flows through fingers. 27,000 gallons/ac	Powdery dry; in some places slightly crusted but breaks down easily into powder. 40,000 gallons/ac	Hard, baked and cracked; has loose crumbs on surface in some places. 27,000 gallons/ac
25-50% or Less Soil Moisture Amount to Reach AWC	Appears to be dry; does not form a ball under pressure. 15,000 gallons/ac	Appears to be dry; does not form a ball under pressure. 20,000 gallons/ac	Somewhat crumbly but holds together under pressure. 30,000 gallons/ac	Somewhat pliable; balls under pressure. 20,000 gallons/ac
50 - 75 % Soil Moisture Amount to Reach AWC	Appears to be dry; does not form a ball under pressure. 10,000 gallons/ac	Balls under pressure but seldom holds together. 13,000 gallons/ac	Forms a ball under pressure; somewhat plastic; slicks slightly under pressure. 20,000 gallons/ac	Forms a ball; ribbons out between thumb and forefinger. 13,000 gallons/ac
75% to Field Capacity Amount to Reach AWC	Sticks together slightly; may form a weak ball under pressure. 5,000 gallons/ac	Forms a weak ball that breaks easily, does not stick. 7,000 gallons/ac	Forms ball; very pliable; slicks readily if relatively high in clay. 11,000 gallons/ac	Ribbons out between fingers easily; has a slick feeling. 7,000 gallons/ac
100% Field Capacity	On squeezing, no free water appears on soil, but wet outline of ball on hand.	On squeezing, no free water appears on soil, but wet outline of ball on hand.	On squeezing, no free water appears on soil, but wet outline of ball on hand.	On squeezing, no free water appears on soil, but wet outline of ball on hand.
Above Field Capacity	Free water appears when soil is bounced in hand.	Free water is released with kneading.	Free water can be squeezed out.	Puddles: free water forms on surface

Attachment F

Mancl, K.M. and J.D. Slates. 2003. Farmer estimates of manure application rates. Proceedings of the Ninth International Animal, Agricultural, and Food Processing Wastes Symposium. Raleigh, North Carolina.

FARMER ESTIMATES OF MANURE APPLICATION RATES

K. M. Mancl and J. D. Slates

ABSTRACT

This study examined the capability of livestock producers and growers to make visual estimates of manure application rates. Manure spreader calibration was demonstrated to 101 farmers at 6 field days. At the beginning of each field demonstration, participants were asked if they had even seen this demonstration before, their occupation and their estimate of manure application based on their experience. Of the 101 participants 13% estimated at or near the actual application rate. Some (22%) estimated high application rates with 2 estimating four times the actual application rate. Most (65%) underestimated the manure application rate with 50% estimating less than one-half the actual application rate. If relying on visual estimates, 50% of the livestock producers and growers surveyed would have applied twice the desired application rate. The tendency to underestimate manure application and therefore over-apply manure reinforces the need to calibrate spreading equipment as a part of a manure management plan.

KEYWORDS. Animal waste management, environmental protection, livestock waste, waste disposal

INTRODUCTION

Livestock producers in Ohio and other states are being encouraged to develop manure management plans. Ohio law requires large livestock operation of over 1000 animal units to operate under a manure management plan (Ohio Revised Code section 903, 2002). Smaller livestock operations were encouraged, beginning in 1991, to develop plans (Ohio Revised Code sections 1511 and 1515, 1991).

Manure management plans include testing soil and manure for nutrients and matching the nutrients in manure to the needs of the crop where the manure is applied. Many testing labs and manure management specialist calculate the appropriate manure application rate for each farm and field. For example, several investigators (Levins et al. 1996; Quirke, et al. 2000) have produced computer programs for regulators and planners to determine appropriate application rates for farm operations.

The agronomic benefits of manure applied to soil have long been recognized. The plant nutrients and organic matter in livestock manure improves soil tilth, increases water holding capacity, lessens erosion, improves soil aeration,and is beneficial to soil microorganisms (Loehr, 1968). However, if not applied carefully, nutrients can be lost through volatilization, leaching or runoff.

The first step in determining manure application rates is testing the manure for it's nutrient value. A survey of 390 Minnesota farmers (Schmidt, et al. 1996) showed that 20% test manure for nutrient value. The survey also found that 37% kept records of manure application.

To apply manure at the desired rate can be problematic. Manure spreading equipment typically used have not been calibrated to apply manure at the desired rate. Schmidt and others (1996) found that only 16% of Minnesota farmers had their application equipment calibrated. Hoban and others (1997) interviewed over 1000 North Carolina livestock producers. They found that 38% tested manure and 36% have calibrated their spreading equipment.

With all the effort to analyze manure and determine appropriate application rates, the next step is to ensure that the manure is applied at that rate. However, with survey results showing fewer than 40% of livestock producers calibrating their equipment the question arises as to the potential for over or under applying manure by estimating the application rate. This study examined the capability of livestock producers and growers to make visual estimates of manure application rates.

METHODS

Livestock producers, growers and others were invited to six field demonstrations scheduled throughout Ohio. A 30 minute demonstration of manure spreader calibration techniques was presented at each field day. The demonstration followed instructions presented by Woodward (1985).

At each demonstration a commercially available manure spreader was loaded with solid livestock manure. Three sheets of plastic measuring 3 meters by 3 meters were weighed and laid out in an agricultural field. The spreader applied manure in the field, including the areas covered by the plastic sheets. The plastic was carefully gathered and weighed to determine the amount of manure applied to each sheet. Based on the size of the sheet and the average weight of manure, the application rate was determined as:

$$\frac{\text{Kg of manure} * 10}{\text{Size of sheet in m}^2} = \textbf{Metric tons of manure per hectare}$$

Example: Average weight of manure on the sheets was 5.2 kg

$$\frac{5.2*10}{1\ \text{m}^2} = 52 \text{ metric tons of manure per hectare}$$

After manure application in the field demonstration, participants completed a survey (Figure 1). They were asked if they had even seen this demonstration before, their occupation and their estimate of manure application based on their experience.

• Estimate of Application Rate _____ tons/acre

• Have you attended a field demo like this before?

__ No __ Yes

• Which or the following best describes your occupation?

__ Livestock Producer

__ Grower

__ Government Agency

__ Equipment Supplier

__ School/University

__ Other ___________________

Figure 1. Observational survey for manure calibration field demonstrations.

RESULTS

A total of 101 livestock producers and growers responded to the survey at the six field days. Actual application rates varied at the demonstrations ranging from 7 to 36 metric tons per hectare. The manure application estimates are presented in Table 1.

Table 1. Estimates of manure application rate from 101 farmers attending one of six Ohio field demonstrations.

Estimated	Number of Farms	%
Application rate (±2 ton/hectare)	13	13%
Overestimated	22	22%
Underestimated	66	65%
1/2 or less actual rate	51	50%

An estimate was considered if the participant reported the actual application rate plus or minus 2 metric tons per hectare. Of the 101 participants 13% estimated at or near the actual application rate. Some (22%) estimated high application rates with 2 estimating four times the actual application rate.

Most (65%) underestimated the manure application rate. Of the 101 participants 50% estimated less than one-half the actual application rate.

CONCLUSION

Using visual estimates of manure application, without training, will likely result in over-application of manure. If relying on visual estimates, 50% of the livestock producers and growers surveyed would have applied twice the desired application rate. The tendency to underestimate manure application and therefore over-apply manure reinforces the need to calibrate spreading equipment as a part of a manure management plan.

Manure spreader calibration is quick, simple and inexpensive. Taking steps to calibrate spreading equipment can increase the value of a manure management plan without placing a hardship on livestock producers or growers. Extension offices and Soil and Water Conservation Service offices can work with producers to facilitate calibration by having scales and calibration tables available for farmers. A short demonstration at a local field day can reinforce the need for calibration and demonstrate how quickly and easily it can be done.

Acknowledgements

Salaries and research support provided by state and federal funds appropriated to The Ohio State University Extension and Ohio Agricultural Research and Development Center.

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