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Pipestone County
Holland Wellfield Survey

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General Information:

Water quality in Southwest Minnesota is a significant concern to both private well users and public water suppliers. Aquifers in this region are often shallow and have a high potential of contamination from nitrate leaching. Deeper aquifers in this area may not be suitable for water supplies due to natural occurring contaminants, such as sulfur, or because of slow well recharge. Agricultural practices can be a source of contamination and adoption of environmentally sound practices can be highly beneficial in protecting the area's aquifers.

In September of 1997 a steering committee was formed to address water quality problems in Southwest Minnesota. Agencies participating in this effort included the Department of Health, Department of Natural Resources, Board of Water and Soil Resources, Pollution Control Agency and the Department of Agriculture. The steering committee then developed a technical committee to determine sources of pollution in ground water, specifically nitrate, and to determine possible solutions or preventive actions.

One of the first actions of the technical committee was to address specific nitrate problems with the Lincoln-Pipestone Rural Water. This system serves over 10,000 individuals in Southwest Minnesota. During the summer of 1997, water supplied to some of its customers exceeded 10 PPM nitrate-N (the U. S. Environmental Protection Agency recommended allowable limit for nitrate in drinking water). Lincoln-Pipestone Rural Water pumps water from three major wellfields: the Holland wellfield located between Lake Benton and Pipestone; the Verdi wellfield, located west of Verdi; and the Burr wellfield, located west of Canby. Some customers receiving water from the Holland wellfield were notified in 1997 that the water they received exceeded the limit for nitrate and could be dangerous to infants under six months of age. Nitrate-N levels in both the Holland and the Verdi wellfields have been over 5 PPM nitrate-N during 1997.

One of the first steps taken was to coordinate interviews with farmers in the potential recharge area of the wellfields. Farmer interviews conducted by the Minnesota Department of Agriculture (MDA) took place in September, 1997 for the Verdi wellfield and interviews took place in February of 1998 for the Holland wellfield. This report will address only the Holland wellfield.

Local Soil and Water Conservation District personnel, Extenuation Educators, and Natural Resources Conservation Services personnel were contacted in January 1998 informing them of the specifics of the farm surveys and the overall goals. The SWCD, NRCS and MES served as an important link between the farmers and the MDA staff. Local agency staff made personal telephone calls to the farmers after an initial letter, signed by the commissioner was sent from the Department of Agriculture . The letter's intent was to identify: the overall project; the purpose of the nutrient assessment; why they were selected; and what types of information and amount of time necessary to successfully complete the project.

Farmers were interviewed through a technique called FArm Nutrient Management Assessment Program (FANMAP). In the past five years, over 500 farmers have volunteered 2 to 4 hours of their time to share information about their farming operations. Letters were sent to thirty-seven farmers in the Holland Wellfield area (Figure 1). The local SWCD then contacted farmers to inform them of the local involvement in the surveys. The MDA then contacted the farmers to inquire if they would be involved in the survey process. Twenty-eight farm operations were involved in the interview process.

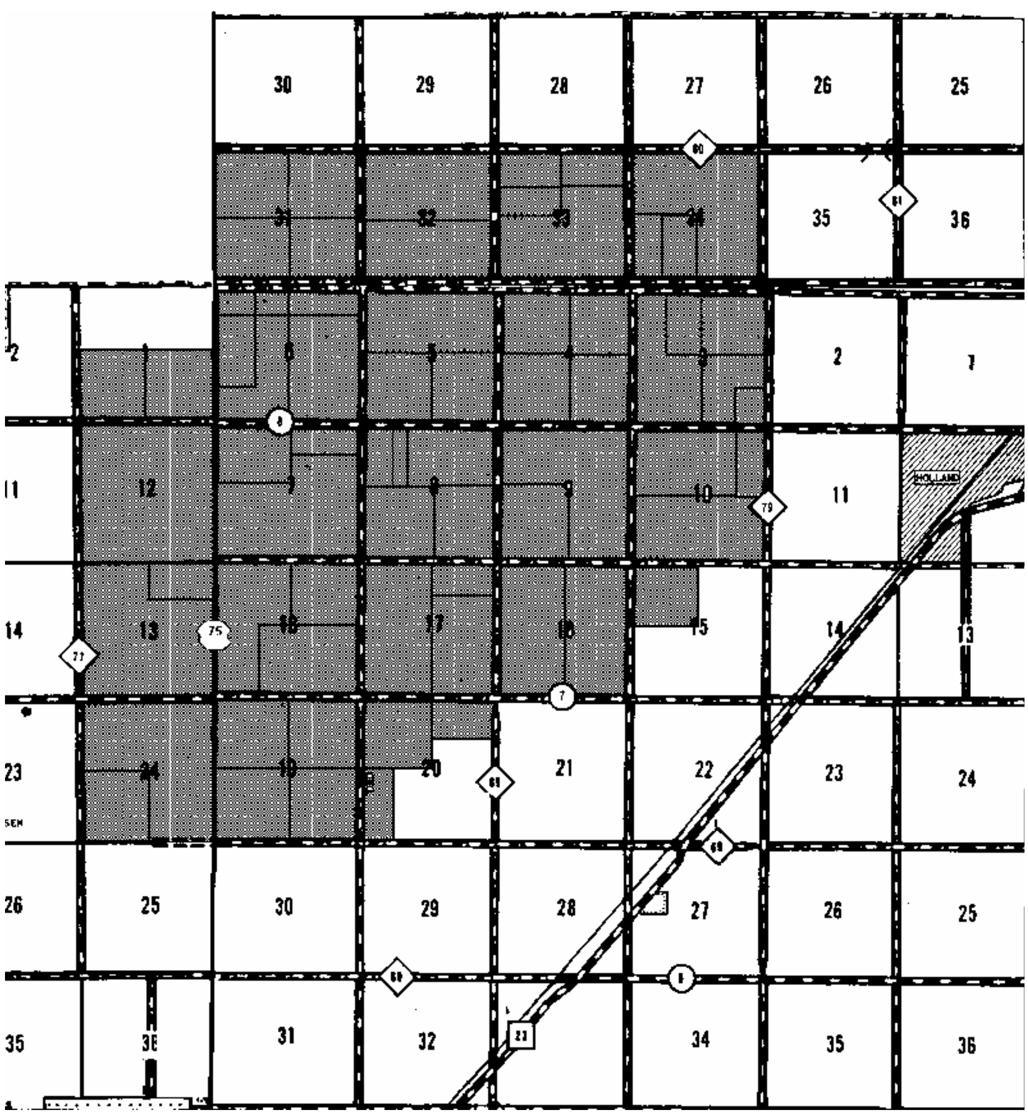

Figure 1. Area of Holland wellfield involved in the FANMAP process.

The majority of the soils in the Holland wellfield area are silty clay loams with slopes between 0% and 4%. The aquifer supplying water to the Holland wellfield may be inter-connected with surface water due to shallow depth to the aquifer, 5 to 20 feet, and below surface gravel areas that exist in the Holland watershed.

Nutrient Management Data Collection:

Inventory forms and database design were patterned after a previous successful project[1]. Timing, rates, and method of applications were collected for all nitrogen (N), phosphate (P_2O_5), and potassium (K_2O) inputs (fertilizers, manures, and legumes) on **a field-by-field basis for all acres within the wellfield area.** Soil and manure testing results were also collected if available. Nutrient inputs and yields were specific for the 1997 cropping season. Crop types and manure applications (starting in the fall of 1996) were also collected for the purpose of 1997 nitrogen crediting. Long term yield data generally reflected the past 3 to 5 years. Livestock census and other specifics for the entire farm (i.e. types of manure storage systems, total farm sizes) were also recorded. Information was gathered from the farmer or the fertilizer dealer if it kept the farmers records.

Farm Size, Crop and Livestock Characteristics of the Selected Farms in the Holland Watershed:

Twenty-eight farmers were interviewed in February of 1998. Some of the "farmers" were actually a combination of farmers such as a father and son who farmed together. The average age of the farmers in the Holland wellfield area was 48 years old.

A total of 9,983 acres of farmland were inventoried in the Holland wellfield. Approximately, 2,000 additional acres were not inventoried. Farm interviews covered over 80% of all agricultural acres in the recharge area.

Livestock appears to play a significant role in the Holland wellfield. Several farmers have recently quit raising livestock in the last 10 years. Eleven (39%) of farms had some form of livestock, but the nitrogen generated form the manure accounted for only 9% of all N inputs. Livestock will be further discussed in the Livestock Section of this report.

Corn acres occupied approximately 47% of crop land. Soybeans covered approximately 38% and the other crops totaled 15% (Figure 2, Table 1).

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[1]Effective Nitrogen and Water Management for Water Quality Sensitive Regions of Minnesota, LCMR 1991-93

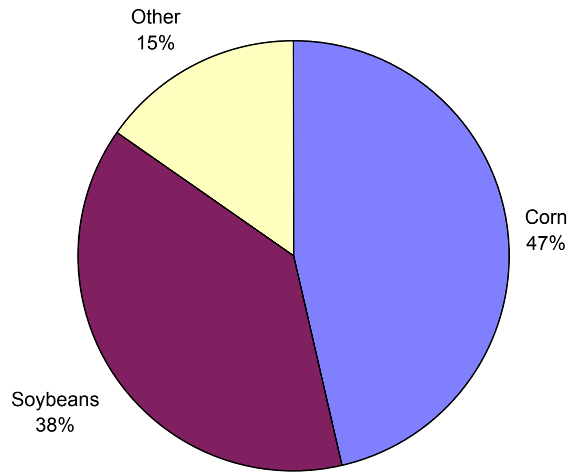

Figure 2. Crop type distribution across all cropland acres of all 28 farms.

Table 1. Type and Acres of Crop in the Watershed	
Crop	Acres
Corn	4,781
Soybean	3,928
Alfalfa	503
Small Grains	12
Pasture	182
Grasses	319
CRP	232
Other	26
Total Acres	9,983

Commercial Fertilizer Use Characteristics on Selected Farms: Holland Watershed

Corn accounted for 96% of all N commercial fertilizer use. Ninety-six percent (96%) of the total corn acreage received commercial N fertilizer (Table 3). Average fertilizer N rate on corn acres was 88 lb/A[2]. This rate is calculated as the means across all commercially N fertilized corn acres regardless of past manure or legume N credits. Total N inputs will be discussed later in the "Nitrogen Balances and Economic Considerations" section. Approximately 16% of the soybean acreage received N fertilizer. The average N rate on N fertilized soybeans was 13 lb/A (Table 2).

Table 2. Distribution of commercial nitrogen applications on cropland - 1997.

Crop	Acres Receiving N Fertilizer	Total N Applied	Percent of Total Commercial Nitrogen
Corn	4,577	402,486	96%
Soybeans	612	8,054	2%
Alfalfa	165	2,880	1%
Grasses	264	5,472	1%
Small Grains	7	217	0%
TOTALS	**5,625**	**419,109**	**100%**

Timing of N fertilizer applications is an important consideration in maximizing fertilizer use efficiency and minimizing environmental effects. Spring preplant applications of nitrogen in the form of anhydrous ammonia or urea are recommended for Southwest Minnesota[3]. Approximately 92% of commercial nitrogen fertilizer was applied in the spring on acres planted to corn (Table 3). Anhydrous ammonia supplied 49% of the total amount of commercial N applied to corn (Figure 3).

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[2] Average commercial fertilizer rate across all corn acres, fertilized and non-fertilized, was 84 lb/A.

[3] M.A. Schmitt and G.W. Randall 1993. Best Management Practices for Nitrogen Use in Southwest MN. AG-FO-6128-B.

Table 3. Timing of fertilizer applications for nitrogen on fertilized corn acres.			
Growth Stage	**Average Date of N Application**	**Total Acres Applied**	**Total N Applied**
Fall	11/2/96	404	17,359
Spring Preplant	4/29/97	4,943	345,620
Starter	5/5/97	2,255	26,323
Side Dress	6/15/97	239	13,184
TOTALS			**402,486**

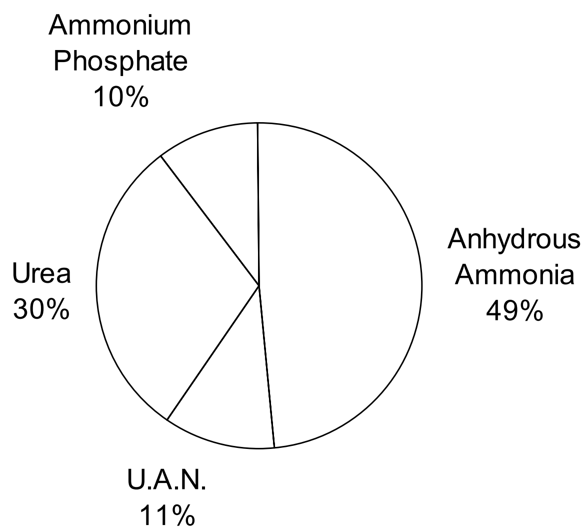

Figure 3. Types and relative contributions of N fertilizer sources used on corn.

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Fall application of nitrogen for corn in Southwest Minnesota is recommended if the proper source (anhydrous ammonia) is selected and proper soil temperature is reached. Research indicates anhydrous ammonia is the most efficient source of nitrogen when used for fall fertilization in Southwest Minnesota[4]. Producers applied only 4% of the total nitrogen for corn during fall applications of 1996 for the 1997 growing season. In this survey, two thirds of fall-applied nitrogen for corn was in the form of anhydrous ammonia and one-third as ammonium phosphate. Average fall application date of anhydrous ammonia November 9.

Fall applications of anhydrous ammonia should be delayed until the soil temperature is below 50° F at the 6-inch depth. Long-term climatic data from the Lamberton Experiment Station indicate that soil temperatures will generally remain below 50° F after October 29. Timing of fall applications of anhydrous ammonia in this survey were two weeks after October 29.

Only 1,048 (20%) acres of the 5,222 acres planted with crops other than corn received N fertilizer. Soybeans accounted for one-half of “non-corn” commercial N and grasses accounted for one-third.

Farmers were also asked how they determined the amounts of N fertilizer to apply. Several choices were offered as to who assisted in the recommendations of fertilizer amounts. Those choices included: farmer knowledge; fertilizer companies; crop consultant; seed companies; extension agents; University of Minnesota data or brochures; other (with an open blank where the farmer could describe the source of recommendations).

Ten farmers (36%) relied solely on “farmer knowledge” or information from past years, talking to neighbors, or other sources to adjust the amount of N applied in the past (Figure 4). Ten other farmers (36%) relied solely on the fertilizer companies for their recommendations of amounts of fertilizer to apply. These farmers generally followed fertilizer company recommendations. Three farmers (11%) used their knowledge and the fertilizer dealers recommendation to come to an agreement as to the amount of fertilizer to apply. Three farmers (11%) used recommendations from crop consultants. Two farmers used the recommendations for N from soil test reports. None of the farmers used seed companies, extension agents, University of Minnesota data or brochures, or other sources for recommendations of fertilizer amounts.

[4] M.A. Schmitt and G.W. Randall 1993. Best Management Practices for Nitrogen Use in Southwest MN. AG-FO-6128-B.

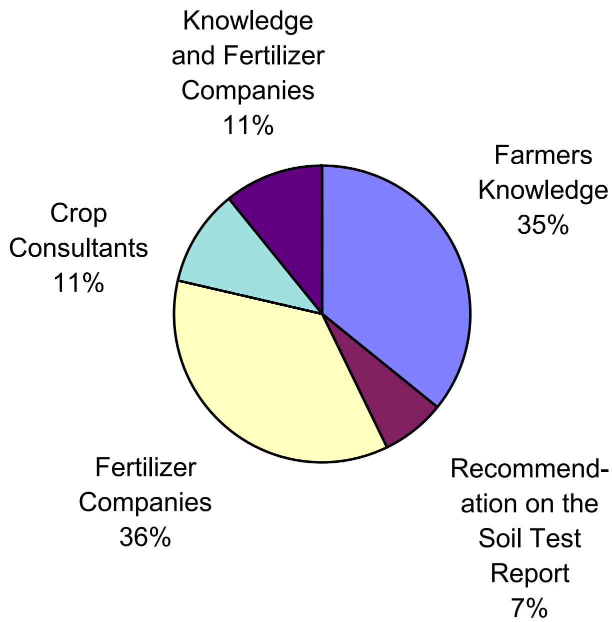


Figure 4. Sources of information for N rate decisions on fertilizing corn for 28 farms.

Livestock and Manure Characteristics of the Selected Farms:

Factors directly affecting crop nutrient availability from land applied manure (including manure storage, types, manure amounts being generated, application methods, incorporation factors and rates) were also quantified to complete the "whole farm" nutrient balance. Table 4 includes a complete animal inventory, including estimates of N, P_2O_5 and K_2O produced[5] and collected in various types of manure systems for spreading on acres in the survey (manure collected but not spread on acres specified in the survey are not considered in the collected amounts). Cattle manure not collected is usually due to time spent on pastures and large lots where manure is not collected, or, manure that was spread on land that was not within the Holland wellfield area. Livestock numbers represent the livestock on hand from the fall of 1996 to the summer of 1997. This would be the livestock that would contribute manure to the 1997 crops.

[5] Livestock Waste Facilities Handbook, Midwest Plan Services, Iowa State University, Ames, Iowa. 1993.

Table 4. 1997 livestock numbers, and manure N, P_2O_5 and K_20 produced and collected by livestock types in sample population.

Livestock Type	Livestock Number	Manure Nitrogen Produced	Manure Nitrogen Collected	Manure P_2O_5 Produced	Manure P_2O_5 Collected	Manure K_2O Produced	Manure K_2O Collected
			Pounds		Pounds		Pounds
Dairy Cows	236	51,212	41,881	20,768	16,984	41,300	33,750
Dairy Calves	35	2,730	683	1,155	289	2,170	543
Replacement Heifers	30	4,650	1,162	1,860	465	3,720	930
Boars	2	66	66	46	46	46	46
Sows	120	3,600	3,600	2,280	2,280	2,280	2,280
Slaughter Hogs[6]	4,850	41,940	41,940	29,825	29,825	32,153	32,153
Beef Bulls	12	1,884	393	1,356	282	1,668	347
Beef Cows	453	59,343	12,445	45,300	9,500	51,642	10,830
Beef Feeders Under a Year	467	28,954	5,911	21,949	4,481	25,685	5,243
Beef Feeders Over a Year	35	4,340	4,340	3,185	3,185	3,850	3,850
Sheep Rams, and Ewes	945	14,175	4,325	6,615	2,018	12,090	3,562
Feeder lambs	1,725	23,600	5,967	11,025	2,785	22,050	5,571
TOTAL	**8,910**	**236,494**	**122,712**	**145,364**	**72,141**	**198,654**	**99,130**

Manure collection varied by type of livestock in the Holland wellfield area. One hundred percent of the manure from the hogs was collected. In contrast, approximately 25% of the manure was collected from the beef operations and sheep operations. Both types of livestock were on pasture much of the year. Some winter pasturing did occur and some of the livestock were pastured, or raised, out of the wellhead area. Approximately 75% of the manure from the dairy operations was collected. Liquid manure collection in hog and dairy operations also increased the amount of manure collected. Liquid manure systems were either partial or total confinement.

Dairy livestock generated approximately one-third and hogs generated approximately one-third of the N collected (Figure 5).

[6] Slaughter Hogs are the number of animals sold per year. All other numbers are animals on hand per year.

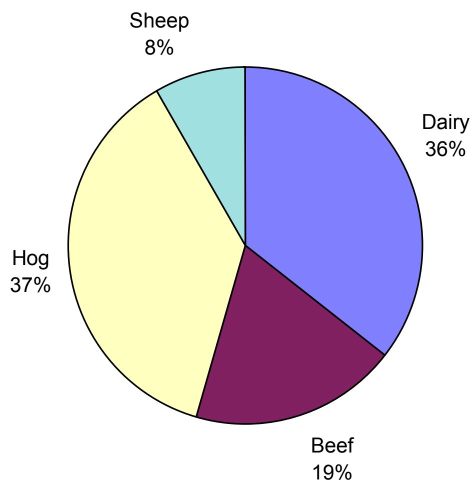


Figure 5. Amounts of nitrogen (total) collected by animal types across all farms.

Types of storage systems available for producers is an important consideration in efficiently retaining nutrients and allowing enough storage to field apply the manure in an environmentally safe manner. Twelve farms produced or applied manure. Of these, three applied some liquid manure while the other nine applied only solid manure.

Nutrient losses from collection and storage were estimated from accepted guidelines[7] for each individual storage system. Losses as a function of application methods and timing factors were calculated on a field-by-field basis. Solid manure systems were most often cleaned on a as needed basis both in the barns and lots. Liquid systems were generally cleaned in the fall. Ninety percent of fall application was incorporated and 10% of non-fall applied manure was incorporated based on manure N applied.

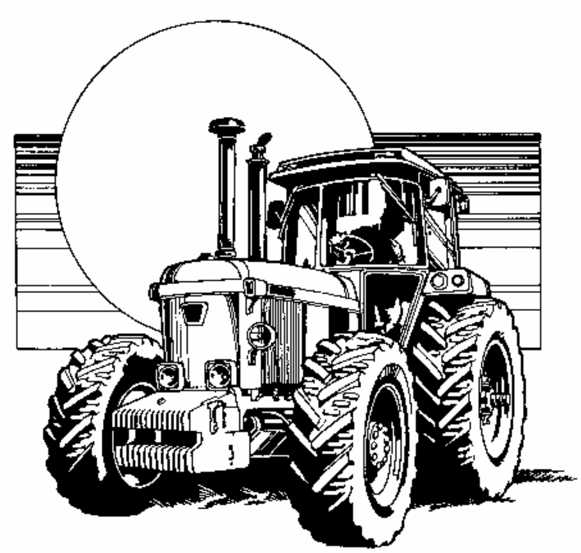
Amounts of N and P_2O_5 collected, lost in storage, and amounts retained for land application are summarized by collection systems in Table 5. Based on the amount of N collected, collection systems of livestock producers on Southwest Minnesota farms are equally divided between solid and liquid manure.

[7] Livestock Waste Facilities Handbook, Midwest Plan Services, Iowa State University, Ames, Iowa. 1993.

System Type	Number of Systems	Manure Nitrogen Collected	Retained N After System Losses	Manure P_2O_5 Collected	Retained P After System Losses	Manure K_2O Collected	Retained K After System Losses
			Pounds		Pounds		Pounds
Solid Manure	13	59,922	43,856	37,341	29,872	49,552	39,641
Liquid manure	2	62,790	50,232	34,800	27,840	49,578	39,662
TOTALS	**15**	**122,712**	**94,088**	**72,141**	**57,712**	**99,130**	**79,304**

Table 5. Manure N, P_2O_5 and K_2O collected and storage losses by all livestock on all farms in 1997.

The fate of manure-N has been summarized in a simple flow diagram (Figure 6). This diagram simplifies the complexities associated with N from excretion to "plant available". Due to the large amount of pasture and little incorporation of solid manure, only 17% of the total amount of N produced was available for the first year crop on non-imported manure. Two farmers also had manure from other sources than their own livestock. An additional 61,000 lbs of additional N was applied from imported sources, although application losses must be subtracted.



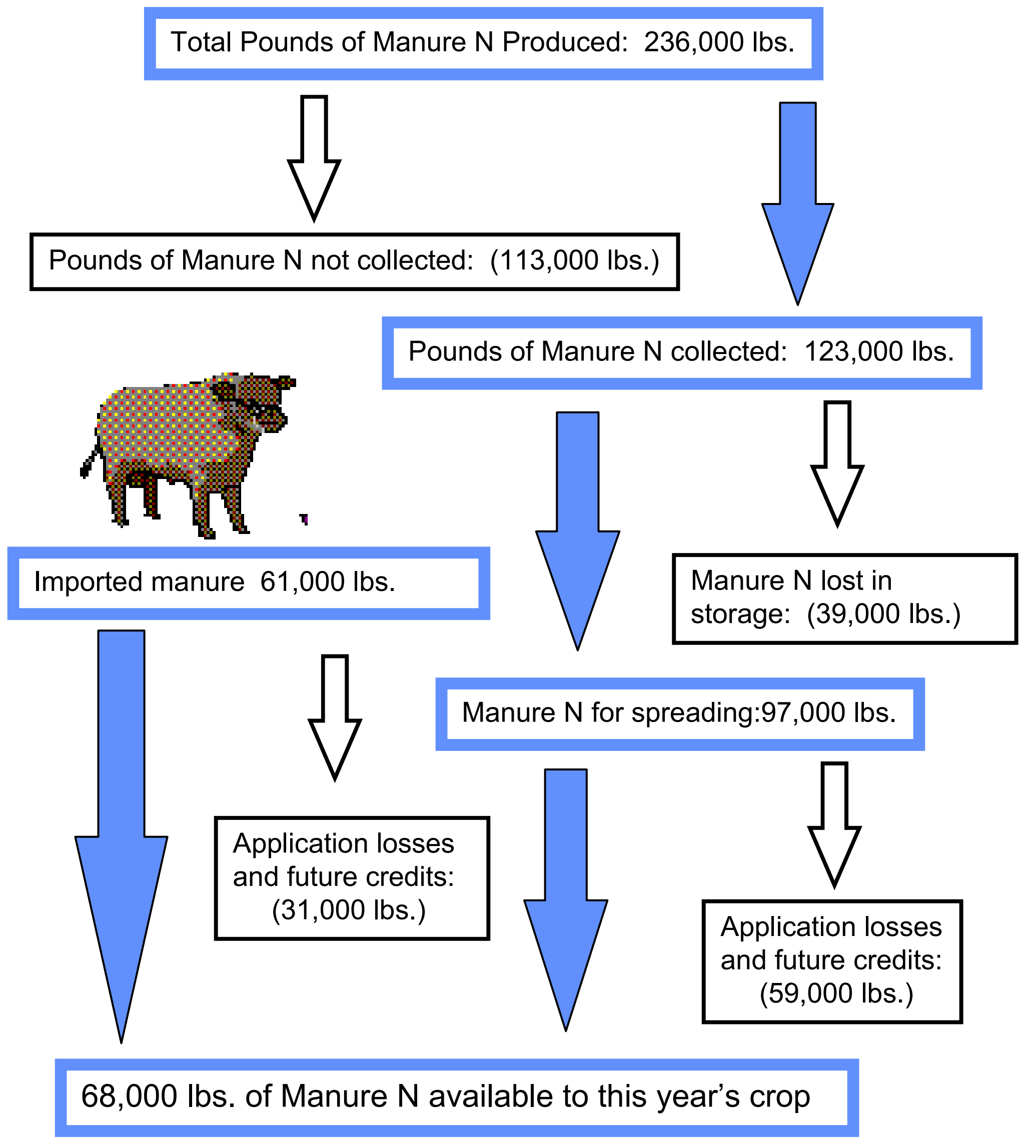


Figure 6. Fate of farm-generated and imported manure-N across all storage and management factors.

Manure supplied 60,000 lbs of N to the 1997 corn crop. Twelve percent (12%) of the farm generated manure on corn acres was applied as a broadcast with no incorporation. Incorporation of broadcast manure within 4 days would double the retained N available for crop use. Thirteen percent (13%) of the manure was incorporated within 4 days and 75% of the manure was injected (Figure 7).

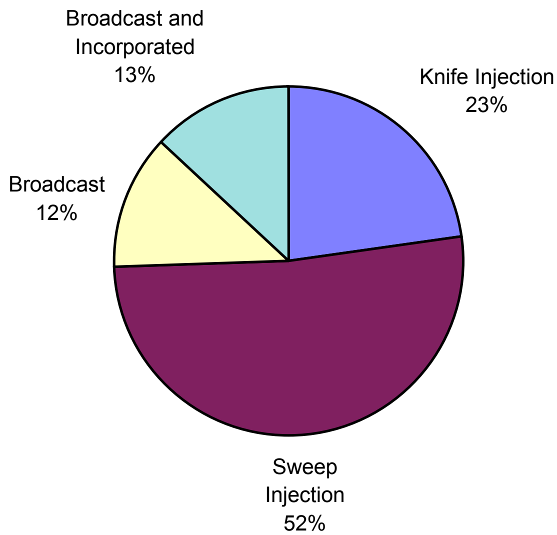


Figure 7. Type of manure application used for all manured corn acres based on manure-N available to the 1997 corn crop.

Most of the manure (87%) applied, based on N available, to the 1997 corn crop was applied in the fall. The rest (13%) was applied throughout the year generally based on field availability. In addition to the 60,000 lbs of N applied to corn, an additional 9,000 lbs of N were applied to soybeans and less than 1,000 lbs of N were applied to grasses.

Relative Importance of Nitrogen Sources on the Selected Farms:

University of Minnesota (UM) recommendations for nitrogen provide N credits from legumes. In the Holland watershed, legume credits only involved soybeans for the 1997 growing season. Soybeans provided a 40 lb/A N credit. A total of 181,000 lbs of N was contributed to the corn acres from the previous crop of soybeans.

Commercial fertilizer (63%), manure (9%), and legumes (28%) contributed a total of 644,000 lb. of "first year available N" to **corn acres** (Figure 8). Proper crediting for these sources is critical in maintaining economic and environmental balances.

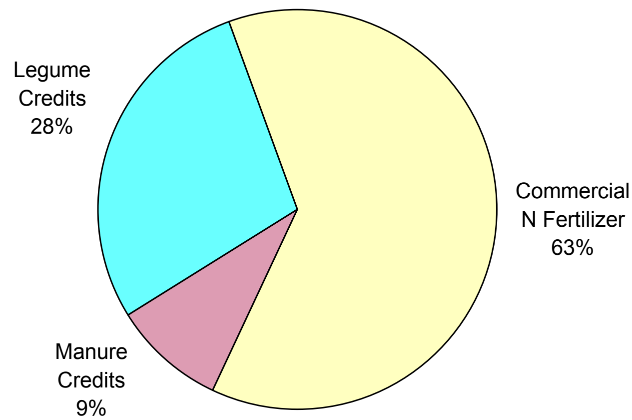


Figure 8. Relative N contributions from fertilizers, manures and legumes across all corn acres. N inputs totaled 644,000 for all sources.

Nitrogen Balances and Economic Considerations:

The corn yield goal across all farms and corn acres was 126 bushels per acre. University of Minnesota N recommendations (based on yield goal, crop history, and soil organic matter level) were compared to actual amounts of fertilizer and manure applied to each field. Approximately 2,700 acres had recent soil test information with soil organic matter data. The average field had 4.9% organic matter and all fields were in the medium to high range (greater than 3%) in regard to organic matter. University of Minnesota N recommendations to fulfill this goal averaged 67 lb/N/A (Figure 9). Actual amounts of N applied from commercial fertilizer and manure averaged 84 lb N/A and 12 lb/A respectively across all corn acres. Factoring in all appropriate credits from fertilizer, legumes and manures, there was an over-application rate of 29 lb/N/A.

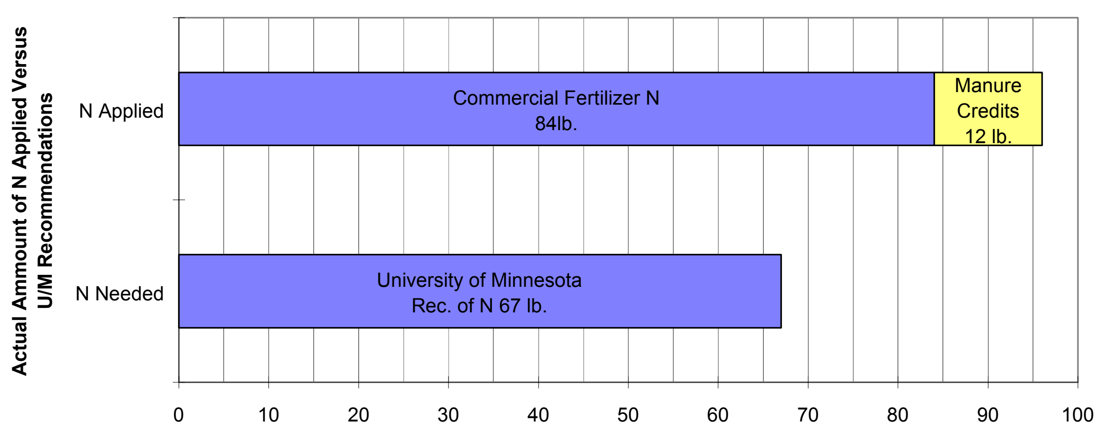


Figure 9. Crop N requirements based on UM recommendations in comparison to actual N inputs (fertilizer and manure) across all corn acres. Total corn area in this analysis was 4,781 acres. Legumes also provided 37 lb/A N across all acres and is already calculated into the UM recommendations.

Over 95% of the corn acres followed soybeans in the Holland watershed for the 1997 crop year. Because 95% of all corn acres followed soybeans, comparisons between corn following corn and corn following other crops were not made.

Factoring in manure N inputs into the process on a acre-by-acre basis, the amounts in excess of 1997 UM recommendations are illustrated in Table 6. One of the huge advantages of the technique developed through the nutrient assessment process is the ability to examine in great detail the nutrient balances and make some inferences on where the biggest gains in water quality can be obtained through focused educational programs. Manured corn acres accounted for 23% of all corn acres. However, manured corn acres accounted for 46% of the excess N applied across all corn acres.

Table 6. Excess Nitrogen on Corn Acres

Crop N Sources	Total Acres	Excess N[8] Average lb/A	Excess N Total lb
Commercial N Only	3,682	21	76,886
Manure[9]	1,099	58	64,227
Totals	4,781	29	141,113

Manured corn acres were divided by whether the manure was applied as a liquid or a solid. In this survey all manure applied as a liquid was incorporated and all solid manure was broadcast with no incorporation within four days. Cornfields applied with liquid manure were over-applied with N by 81 lbs/A. and solid manure fields were over-applied by 45 lbs/A (Table 7). Liquid manure accounted for 88% of all available first year N from all manure.

8 Excess N averages and totals include N from both commercial fertilizer and manure for the manure total. Excess acres also include in averages acres below the UM recommendations.

9 Manure acres include all corn acres with manure regardless of whether commercial N was also added.

Table 7. Excess Nitrogen on Manured Corn Acres			
Crop N Sources	Total Acres	Excess N[10] Average lb/A	Excess N Total lb
Solid Manure[11]	689	45	31,201
Liquid Manure	410	81	33,026
Totals	1,099	58	64,227

Farmers in the Holland wellfield are averaging 29 lb/A over-application of N. The largest reductions in N could be made on those acres with the largest excess of N applied. Fifty-nine percent (59%) of the total corn acres were applied with N amounts that were more than 30 lbs above UM recommendations (Figure 10).

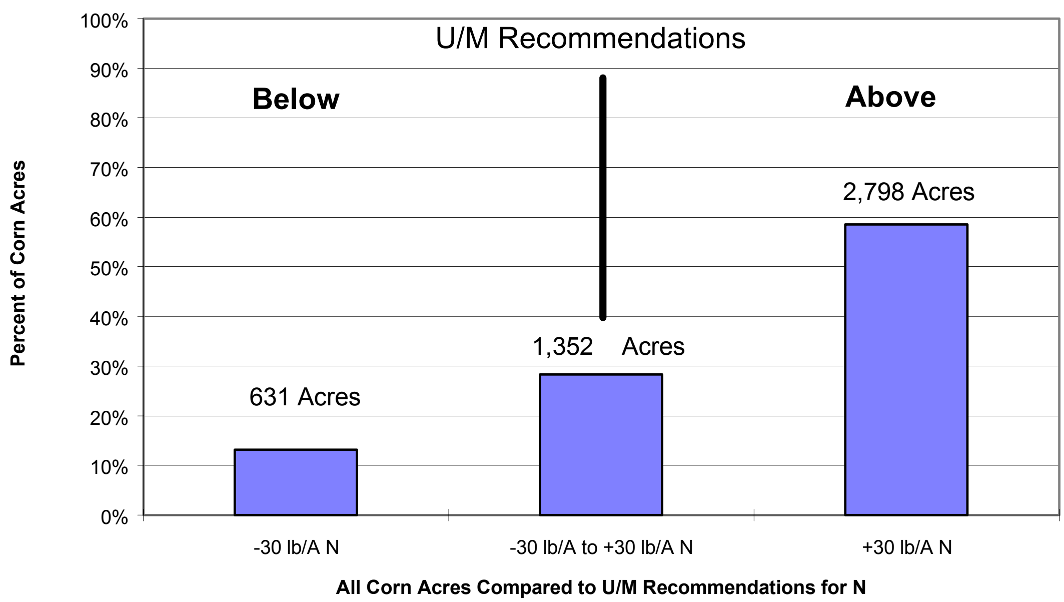


Figure 10. Percentage of corn acres either below, at, or in excess of UM nitrogen recommendations.

University of Minnesota recommendations are based on economic and environmental factors. Research at both the Southwest Experiment Station (Lamberton) and the Southern Experiment Station (Waseca) has shown that the

[10] Excess N averages and totals include N from both commercial fertilizer and manure for the manure total. Excess acres also include in averages acres below the UM recommendations.
[11] Manure acres include all corn acres with manure regardless of whether commercial N was also added.

recommendations are based on sound economic decisions and, in the long term, generally result in the most economic profit. If all corn acres were applied using UM recommendations, the annual amount of N would be reduced by 141,000 lbs. Reduction of nitrogen on corn acres to within 30 pounds of the UM recommendations would reduce 80,000 of lbs nitrogen from the farmers interviewed. By including the additional 20% acres of corn not in the survey process, an additional 15,000 lbs of nitrogen could be reduced for a total of 95,000 lb reduction of nitrogen for Holland watershed. UM recommendations are based on economic factors, so the reductions in N should lead to substantial savings with little or no yield loss to many of the farmers in the Holland watershed.

Conclusions and Summary of the Current Nutrient Management Practices for the Holland Watershed

Twenty-eight farms, covering about 10,000 acres, participated in the FArm Nutrient Management Assessment Program (FANMAP) with staff from the Minnesota Department of Agriculture. Producers volunteered 2-4 hours of their time to share information about their farming operation. The overall purpose of the program was to develop a clear understanding of current farm practices regarding agricultural nutrients and utilize this knowledge for future water quality educational programs.

Over 90% of commercial N used on corn was applied in the spring and anhydrous ammonia was the dominant source of N for all applications (49%). Manure (first year available) accounted for only 9% of the N while legumes and commercial N accounted for 28% and 63%, respectively. Soybeans was the dominate source of legume N credits. Twenty-three percent (23%) of corn acres received applications of manure leaving ample land available for manure application, if based on N inputs.

Producers appeared to be applying approximately 29 lbs/A of nitrogen above UM recommendations. Corn following soybean acres accounted for most of the excess N in this survey. Reducing the average amount of N applied and accounting for soybean credits could save farmers approximately $5 an acre if N was valued at $0.18 per pound. Fifty-nine percent (59%)of all corn acres were in excess of UM recommendations by more than 30 pounds for nitrogen.

There were some very positive findings from this study. There is strong evidence that producers are voluntarily adopting the educational materials and strategies developed by the UM. Fall application of N was very limited in the Holland watershed. Most manure was fall applied and most of the manure was incorporated. It is also evident that promotional activities need to continue and be specifically targeted to deliver the most recent technology and recommendations. Soybean and manure crediting are areas where there is a strong need for more education in this study area. Strong similarities exist in all existing FANMAP projects: producers are generally managing commercial N inputs successfully (although frequently using outdated recommendations) but continually under-estimate the N credits associated with manure and legume inputs.