

**USDA EQIP Education Assistance
Grant Program**

***Environmental Impacts and Economic
Comparison of Alternative Dairy Systems***

Final Report

December 30, 2004

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INTRODUCTION

This document reports on progress to from 2000 through the end of 2004 on the U.S. Department of Agriculture's Natural Resources Conservation Service (NRCS) Environmental Quality Incentives Program (EQIP) grant for "Environmental Impacts and Economic Comparison of Alternative Dairy Systems" (USDA Agreement Number 74-6322-0-3). This is the final report for the project, and fulfills grant-reporting requirements as per the agreement. This multi-year project (2000-2004) is designed to gather and distribute critical information needed by dairy producers throughout Minnesota on the environmental impacts and economic viability of various manure handling systems. A conventional dairy manure handling system, a manure handling system with an anaerobic digester (Haubenschild Farms near Princeton), and a pasture dairy will be compared. A series of workshops and educational events will be combined with fact sheets to educate farmers about these issues. The project is split into three main areas:

- A. Manure/soil/crop interactions.** Comparison information on the soil quality, crop response, and nutrient uptake of: 1) commercial fertilizer; 2) liquid manure; and 3) anaerobically digested dairy manure will be gathered and disseminated.
- B. Economic evaluation of alternative manure management systems on dairy profitability.** In order to help farmers make decisions about choosing a manure management system, this project will: 1) determine the economic value of manure nutrients of undigested dairy manure and anaerobically digested manure; and 2) compare the financial performance of farms with three different farm/manure management systems. This information will be disseminated in the form of a final report and fact sheets.
- C. Weed seed survival as affected by manure handling.** The type and quantity of viable weed seeds in anaerobically digested manure will be documented and compared to stored liquid manure. The current body of knowledge and additional analysis will be summarized, and educational materials, fact sheets and visual aids will be developed and disseminated. Both a field and a laboratory characterization will be done of the demonstration project manure impact on weed seeds.

The Minnesota Project is the project coordinator, with input provided by a project advisory group. Much of the project work is being sub-contracted by The Minnesota Project to cooperators from the University of Minnesota. These cooperators include, for each of the three project areas:

- A. Deborah Allan, U of M, Department of Soil, Water and Climate and
Michael Schmitt, U of M, Associate Dean for Extension
- B. Margot Rudstrom, U of M, West Central Research and Outreach Center and
Bill Lazarus, U of M, Department of Applied Economics
- C. Roger Becker, U of M, Department of Agronomy and Plant Genetics and
Jeanie Katovich, U of M, Department of Agronomy and Plant Genetics

SUMMARY

This section provides a summary of final conclusions for the three project areas, per the agreement (pg. 3, Subpart D).

Manure/soil/crop interactions

- Field plots were fertilized with raw manure digested manure or inorganic fertilizer and planted with silage corn,
- Soil variability was high at this site, but results suggest that the use of digested manure will produce yields equivalent to undigested manure or fertilizer, while simultaneously allowing the capture of bioenergy,
- Neither potentially mineralizable Nitrogen, total Carbon, total Nitrogen, nor microbial biomass differed in soil samples taken from field plots treated with fertilizer amendments,
- Laboratory incubations showed differences in Nitrogen related at high application rates with less nitrogen available from raw compared to digested or lagoon-stored manure during and eight-week incubation,
- Microbial respiration rates in the incubation experiment were higher in the raw manure treatment than for the other amendment at all application rates.

Economic evaluation

Part 1: Capital budgeting analysis of the digester and related manure handling and electricity generation equipment.

- The performance of the case farm's anaerobic digester system to date looks profitable, which can be attributed partially to careful management by a motivated and detail-oriented manager who has achieved outstanding digester and generator performance, and partially to favorable electricity pricing by the local utility along with assistance from various government agencies due to the demonstration status of the system,
- Future installations will not be eligible for the grants and zero-interest loan the case farm received and will likely not receive as high an electricity price,
- At the electricity prices currently being discussed, a smaller new operating subsidy would not be quite enough to assure profitability if performance is comparable to the case farm's performance,
- Even without the non-energy benefits a digester may still be cheap "insurance" against odor complaints and lawsuits even if operating at a loss.

Part 2: Whole-farm comparison of the Haubenschild confinement dairy operation to a different dairy farm that is using rotational grazing.

- Comparisons of major income statements are done on a per cow basis rather than absolute dollar amount,
- Rate of return on assets (ROA), rate of return on equity (ROE) and asset-turnover rather are on a percentage basis and can be compared directly,
- Haubenschild's farm had a higher ROE than the low-input grazing farm,
- The ROA at the low-input grazing farm was higher,
- The low-input grazing farm has less invested in assets on the farm because of the nature of the operation,

- Lower revenue on the gazing operation was offset by the lower asset values resulting in a higher ROA,
- The asset-turnover ration is higher on the low-input dairy farm.

Weed seed survival

- The majority of the freshly harvested weed seed were dormant at the time the seeds were exposed to the manure storage treatments,
- Seeds of wild proso millet, giant foxtail and ladythumb smartweed did not germinate during the course of the experiment and were most likely killed as a result of the rumen and simulated stomach treatment used prior to the manure storage treatments,
- Although higher numbers of velvetleaf seed germinated during the first year of both trials, there were no cumulative differences in weed seed germination among the anaerobic or conventional manure storage or the inorganic fertilizer treatment for any weed species tested,
- Anaerobic digester temperatures ranging from 95 to 105 F may have been too low to kill the weed seed during the period when the weed seeds were suspended in the digester,
- The majority of common lambsquarters, pigweed spp. and velvetleaf seed had not germinated after two seasons and most likely remained dormant in the soil,
- Although anaerobic manure digestion has many advantages, such as odor control and production of electricity via methane production, our results did not document a reduction on viability of weed seed after anaerobic manure digestion.

Other

- Eight advisory team meetings have been held over the course of four years, two each year,
- Three field days have been held at the Haubenschild Farm during the last four years and an estimated 1000 people have visited the farm during the course of the field days,
- Twenty project presentations have been given by members of the advisory team to diverse audiences.

ADVISORY GROUP

An advisory group was formed in 2000 to help guide the project, and generally meets twice a year. The advisory group met in the fall and spring of 2003. It is comprised of the project cooperators for this project and other interested stakeholders, including staff from the University of Minnesota, NRCS, Soil and Water Conservation Districts (SWCD), Resource Conservation and Development (RC &D) councils, and other interested parties. The current membership list is attached (Attachment B). An email list of these members has been set up for providing project updates.

FIELD DAYS

A field day was held on September 30, 2004 at the Haubenschild Farm. Three education presentations were given and attendees traveled between two separate stations. Fact sheets were produced summarizing educational objectives being studied during the last four years (attachment C). Partially because of bio-security concerns, attendees parked their cars at a site off the farm and were bused between the town hall and the farm.

At the town hall adjacent to the Haubenschild Farm, a general overview of educational objectives including the EQIP grant and grant through the state legislature, digester economic and soil/crop interactions were presented to field day participants. At the town hall site, Amanda Bilek (The Minnesota Project) Bill Lazurus (University of Minnesota Dept. of Applied Economics) Deborah Allan (University of Minnesota Dept of Soil, Water and Climate) and Katie Clayton (Univeristy of Minnesota Graduate Student) presented information to field day participants.

After these presentations were given participants boarded the buses to travel to the farm and past the field test plot sites. While on the bus they heard another presentation from Jeanie Katovich (University of Minnesota Dept of Agronomy) about the weed seed destruction analysis conducted over the last four years. A combination of fact sheets and posters were used to disseminate the project results of the EQIP grants to field day participants.

Finally at the farm, Dennis Haubenschild, Phil Goodrich (University of Minnesota Dept of Biosystems and Agricultural Engineering) and Paul Burns (MN Department of Agriculture) covered general farm and digester operations and in additional alternative generation projects in start-up at the farm. A tour was given of the digester, engine building, free stall barn, and manure handling system.

Approximately 170 people attended the field day. The feedback from the event was overwhelmingly positive and people left feeling well-informed. The overwhelming majority of participants were dairy producers and farmers interested in installing digesters on their farms. The audience was also made up of legislative staffers, state officials, engineers, industry representatives and farm organization staff.

PROJECT PRESENTATIONS

Power-Gen International Renewable Energy Conference

Las Vegas, NV

Henry Fischer (East Central Energy) presented on March 2, 2004 to a breakout session for an international conference on alternative energy production. The audience was made up of approximately 50 people, primarily utility executives, renewable energy consultants, representatives of renewable energy trade publications and renewable energy equipment manufacturers and distributors, plus some regulators. The content of his presentation focused on the successful electricity production at the Haubenschild Farm, but also the educational objectives happening at the farm including the EQIP grant.

AgStar National Biomass/Digester Conference

St. Louis, MO

Henry Fischer (East Central Energy) presented on March 24, 2004 in St. Louis, MO to a general session about utility biomass projects throughout the upper Midwest. Attendees included utility representatives, biomass project consultants, state and federal officials, dairy farmers, equipment manufacturers and distributors, and other interested parties in promoting renewable biomass

energy projects around the United States. Henry's presentation gave a brief overview and history of the project and focused on education objectives being studied at the farm.

BioCycle, Renewable Energy from Organics Recycling National Conference

Des Moines, IA

Amanda Bilek (the Minnesota Project) presented to a breakout session of the BioCycle conference on November 10. The audience was made up of state and federal agriculture officials, industry representatives, engineers, and farmers. The presentation was divided into two parts. The first part focused on the educational objectives being studied at the farm and the second part of the presentation introduced the alternative generation project starting at the farm.

Rasmussen College, Environmental Seminar Day

Eagan, MN

Amanda Bilek (the Minnesota Project) presented to about 75 students at an environmental field seminar day held at Rasmussen College. The presentation focused on the economic analysis from the Haubenschild project as an example of growing economic analysis needed for environmental projects. The overwhelming majority of the students had not heard of anaerobic digester technology before and were fascinated by the system and that there was one in Minnesota.

PART A: MANURE/SOIL/CROP INTERACTIONS

Soil Amendment Effects on Soil Quality, Nutrients and Yield

Introduction

The project objective was to compare effects of anaerobically digested and undigested manure sources on soil properties and crop yields at this farm. Field plots were fertilized with raw manure, digested manure or inorganic fertilizer and planted with silage corn. Soil variability was high at this site, but results suggest that the use of digested manure will produce yields equivalent to undigested manure or fertilizer, while simultaneously allowing the capture of bioenergy. Neither potentially mineralizable N, total C, total N, nor microbial biomass differed in soil samples taken from field plots treated with these amendments. However, laboratory incubations showed differences in N released at high application rates, with less N available from raw compared to digested or lagoon-stored manure during an 8 week incubation. Microbial respiration rates in the incubation experiment were higher in the raw manure treatment than for the other amendments at all application rates.

Materials and Methods

Field Experiment

The field plots for this research were located at Haubenschild Farms, Inc. in Princeton, Minnesota (T36N R26W). Three fields with different cropping histories were selected at different locations at the Haubenschild's farm. Each of these fields was located on Zimmerman Fine Sand (Mixed, frigid Lamellic Udipsamments); a soil with weak structure, high permeability, low organic matter content, and low exchangeable nitrogen and potassium. These soils formed in glacial outwash composed of well sorted sand and fine gravels. Layers of coarser and finer particles can differ greatly in thickness and depth, causing these soils to have high inherent variability. The three fields were: (1) the Appel field, which was in corn for two years prior to this study and had a history of manure application; (2) Bruce, which was a CRP field for the two years before this study and had no history of manure application within 30 years; and (3) the Lilac field which had been in alfalfa for the two previous years and had a history of manure application. Three different histories were chosen in order to compare amendment effects on areas which did or did not have previous manure application, or which had manure application in association with a leguminous crop. Each of these fields had 18 plots, 6.08 meters wide and 60.8 meters long (plots in the Appel field were restricted to 53.2 meters). There were three input treatments (digested manure, raw manure, inorganic fertilizer), two application frequencies (annual or biennial) and three replications per field.

The Bruce and the Lilac fields were established in 2001 and treatments were imposed again in 2002 and 2003 (Figs. 1 and 2).

Figure 1 2001-2003 Haubenschild Bruce Plot

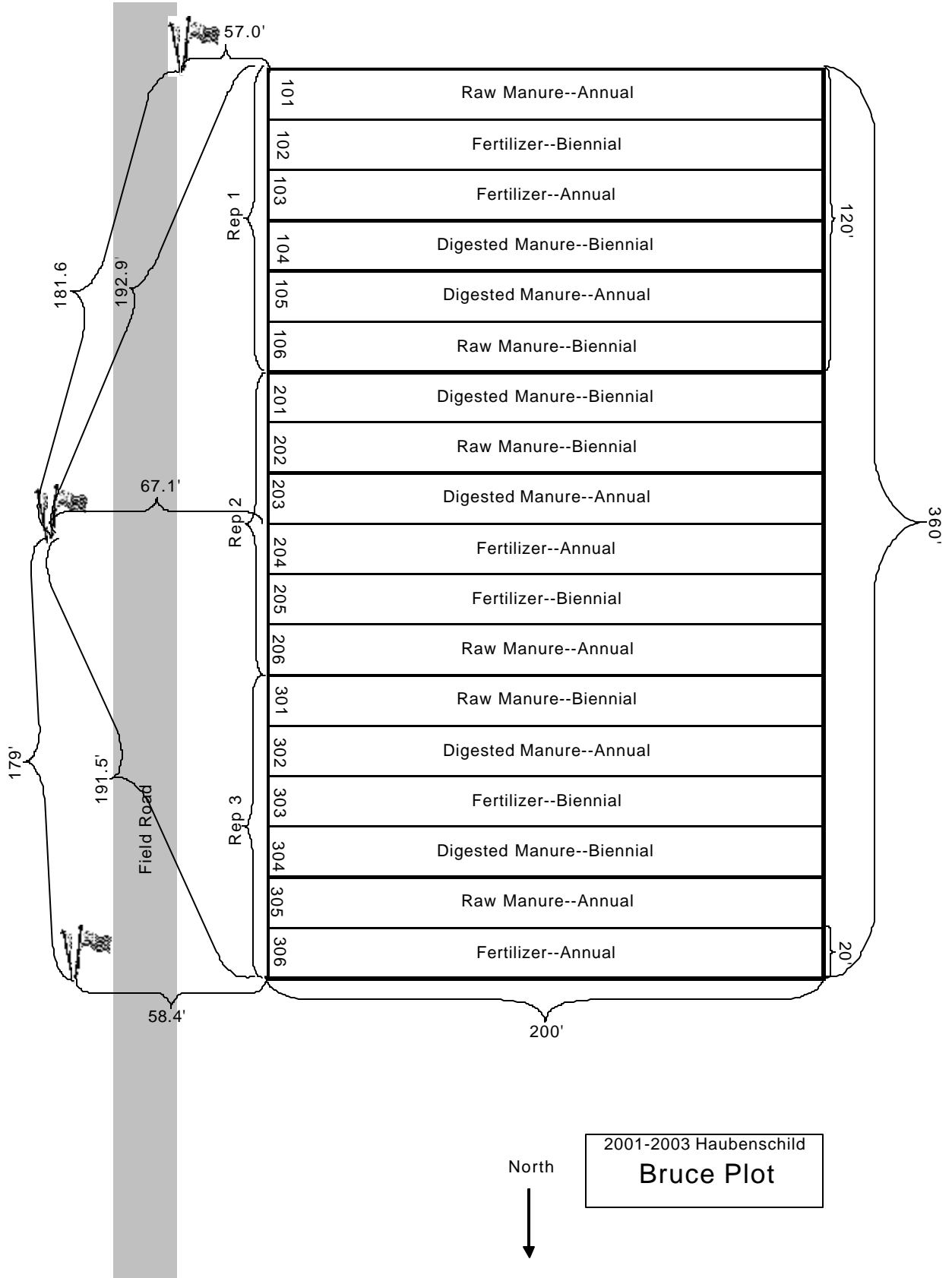
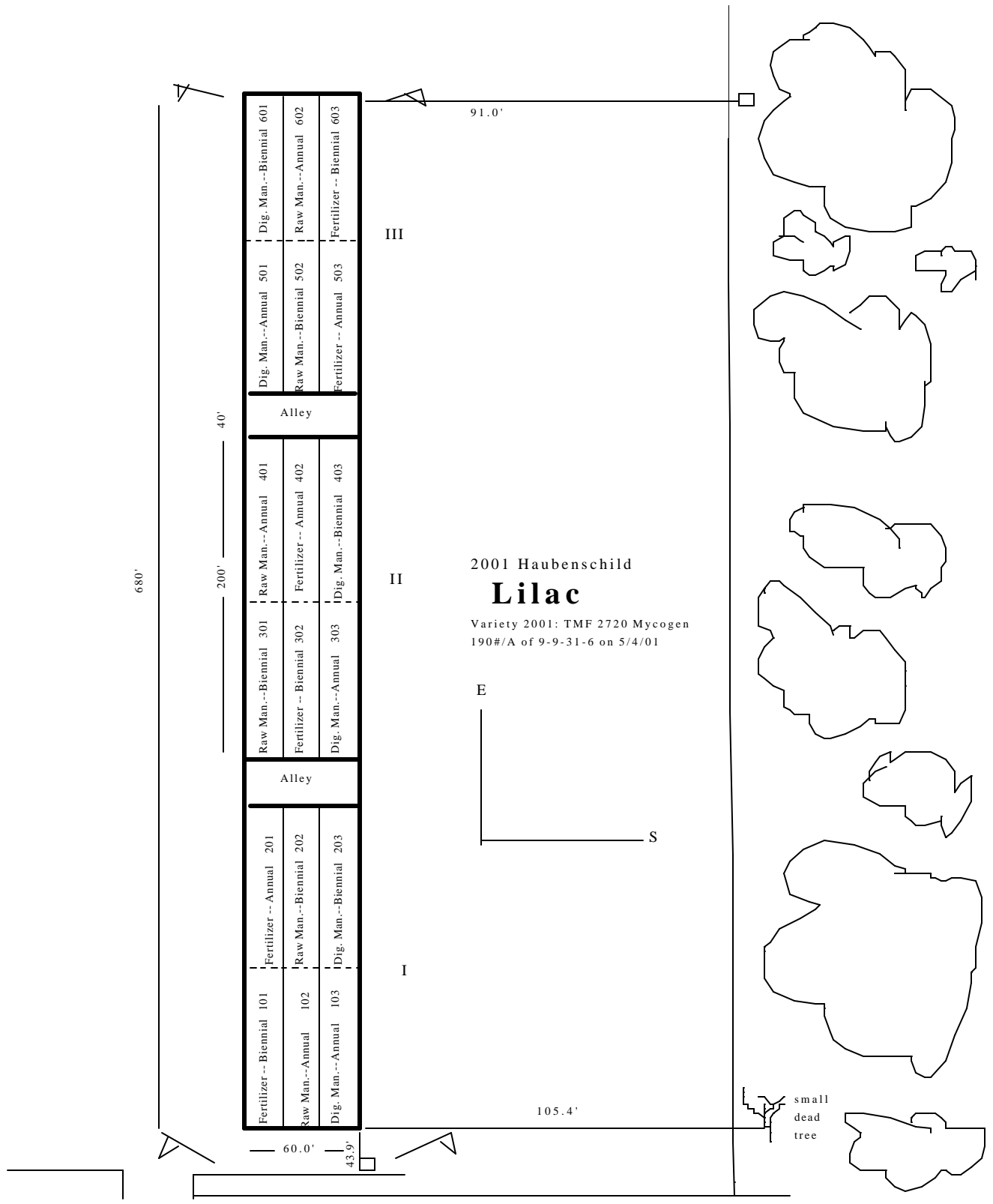


Figure 2 2001-2003 Haubenschild Lilac Plot



In 2003, plot 206 in the Bruce field mistakenly received two types of inputs; that plot was not used for analysis in 2003. The Appel field was also established in 2001; but the entire plot area was accidentally fertilized with digested manure after the 2001 growing season. These plots had to be reestablished in the spring of 2002 in a different location with the same management history (Figs. 3 and 4).

Figure 3 2001 Haubenschild Appel Plot

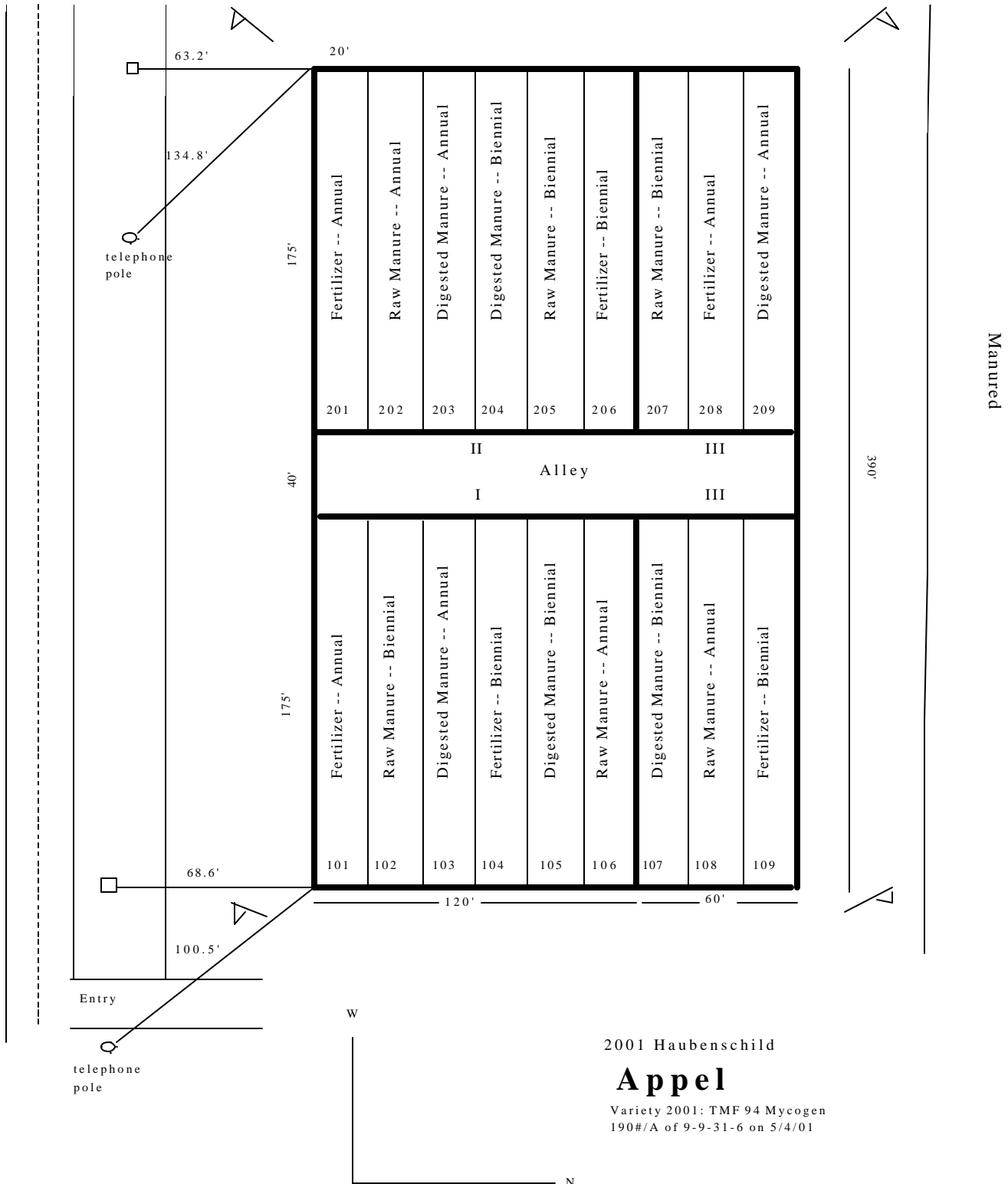
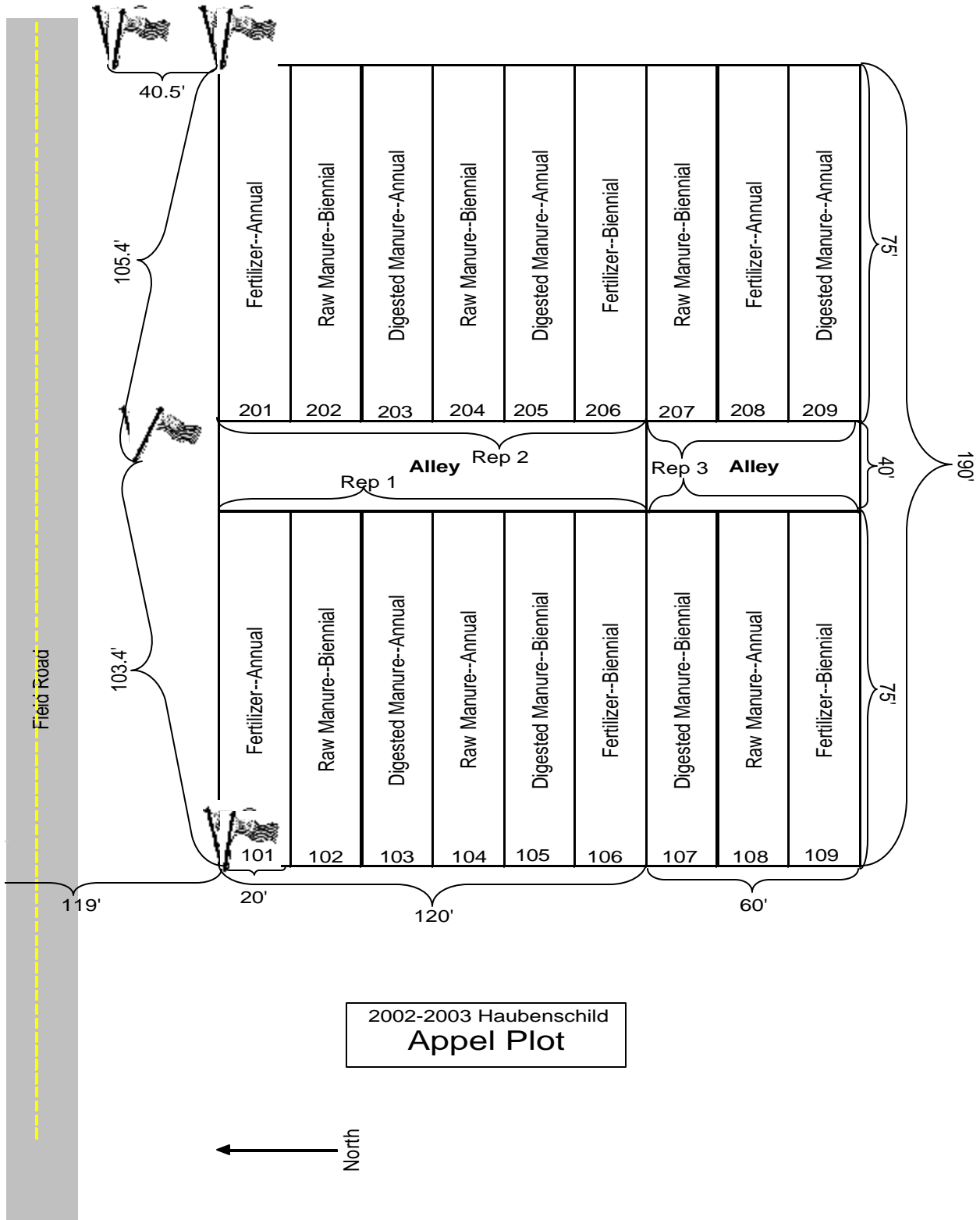


Figure 4 2002-2003 Haubenschild Appel Plot



2002-2003 Haubenschild Appel Plot

The Appel field was therefore a year behind in receiving manure application and in the annual/biennial determination. In 2003, manure was applied differently than the 2002 map indicates to two of the plots. Plot 202 became raw manure – Annual, rather than raw manure – Biennial and plot 203 became digested manure – Biennial, rather than digested manure – Annual. Soil pH, nitrate, phosphorus (P), and potassium (K) baseline values were tested for all three fields on April 18, 2001 (Table 1).

Table 1. Soil Test Values by Study Site Prior to Fertilizer Treatment Application, Haubenschild Farm, Princeton, MN 2001

Field	pH ¹	Bray-P	Potassium	Nitrate
		mg/kg		
Appel	6.9	108	210	24
Bruce	6.1	42	98	28
Lilac	6.2	112	74	7.0

¹ pH, Bray- P, and potassium were sampled to a depth of 15cm; Nitrate was sampled to a depth of 60cm.

Manure and inorganic fertilizer were applied by sweep injection to a depth of 20cm, with 76cm spacing. The plots received a lower than recommended rate of application in order to avoid masking potential differences among the fertilizer treatments. On April 26, 2001 raw and digested manures were applied at 28m³/ha (approximately 3000 gallons/acre or 84 kg N/ha) and urea fertilizer was applied at 84 kg N/ha on May 4, 2001. Potash (112 kg/ha) was also applied to the Bruce and Lilac fields at this time. On May 1, 2002 manure application was again 28m³/ha,

but urea fertilizer was applied at 112 kg N/ha (100 lbs/acre) on May 2, 2002. On April 28, 2003 manure was applied at the same rates as 2002 and 2001, but the urea fertilizer, also applied at the same rate as 2002, was applied as a side dress to the crop on June 9, 2003. In all three years starter fertilizer was applied according to the regular practice of the farm (213 kg/ha of 9-9-31-6).

Soil Sampling

Soil samples for determination of pre-plant N were collected before spring manure application at the 0-30cm and 30-60cm depths. Sampling occurred on April 23, 2001 (0-15cm samples for pH, Bray-P and potassium were also taken at this time); May 1, 2002; and March 1, 2003. These samples were composites of 10-15 samples taken the length of each plot, incorporating samples from in the row (site of banded manure injections) as well as between the rows. Cores were combined to give one sample at each depth per plot.

Soil samples were also collected for determinations of microbial biomass, potentially mineralizable N, total C and total N. These samples were taken at two depths (0-15cm and 15-30cm) and two times during the growing season each year: on July 3, 2001, July 18, 2002, and June 11, 2003 when the corn was in the V3 – V4 stage and again on August 23, 2001, August 27, 2002, and August 18, 2003 when the corn was in the early milk stage. Cores were taken at 19cm intervals across the third, fourth and fifth rows for a total of nine samples in different row positions; this was done twice in each plot. These samples were combined to give one 0-15cm sample and one 15-30cm sample per plot per sampling date. Soil samples were then taken back to the lab in a cooler, and stored at 4° C for analysis.

In the lab, soil samples were sieved to 4mm. Half of the sample was stored at field moisture content at 4° C. The other half was air dried and sieved to 2mm. Moisture content was determined by oven drying soils at 105°C overnight.

Laboratory Analysis

Microbial biomass C and an estimate of microbial biomass N were determined using the fumigation-incubation technique described by Jenkinson and Powlson (1976). Modifications from the procedure were the use of 25g of soil rather than 250g, fumigation of samples lasted 48 hours rather than 18-24 hours, and incubation of samples occurred in quart-sized Mason jars rather than confectionary jars (Rice et al., 1996). The samples were not inoculated before

incubation and they were incubated for 10 days (Rice et al., 1996). Sodium hydroxide (NaOH; 1M) traps were included in the Mason jars; 5mls were used rather than 100mls. The NaOH traps were analyzed for inorganic carbon on a Tekmar Dohrmann Phoenix 8000 Carbon Analyzer (Tekmar Corporation, Mason, OH) to determine biomass C. The calculation used to determine biomass C was:

$$\text{Biomass C} = \frac{[\text{C in fumigated sample} - \text{C in control sample}]}{0.45}$$

Biomass N was determined by 2 M KCl extraction of 3.5g of the sample and analysis was conducted on a Lachat Quick Chem AE Ion Analyzer (Lachat Instruments, Milwaukee, WI). The value for biomass N was calculated as the difference between the N content of the control and the fumigated samples. The constant of efficiency of extraction as described by Horwath and Paul (1994) was not calculated; therefore only the difference between fumigated and unfumigated samples is presented.

Potentially mineralizable nitrogen (PMN) was measured using the method outlined by Drinkwater et al. (1996). Modifications were made following the procedure in Bredja et al. (2000) as well as the following: 30g of soil were used instead of 40g and extractions were only performed on day zero (t_0) and 28 (t_{28}). From these 2 M KCl extractions, soil nitrate and ammonia were determined with a Lachat Quick Chem AE Ion Analyzer (Lachat Instruments, Milwaukee, WI) and used to calculate PMN. The calculation used to determine PMN was:

$$(t_{28} \text{NH}_4^+ + t_{28} \text{NO}_3^-) - (t_0 \text{NH}_4^+ + t_0 \text{NO}_3^-) = \text{PMN}$$

Total C and N were determined by ball milling air dried soil and analyzing a 0.25-0.4g sample on a Leco CN-2000 Elemental Analyzer (Leco Corp., St Joseph, MI). The pre-plant samples at the 0-30cm and 30-60cm intervals were dried at 60°C and ground. Nitrogen content as well as pH, Bray-P, and K were determined by analysis at the University of Minnesota Soil Testing Lab.

Yield

Corn yield samples were taken in the field on September 10, 2001; September 4, 2002; and September 3, 2003. Ears were hand harvested from 12.16m in rows at the center of the plot which were representative of the treatment area. Husks were removed and ears were weighed in the field and then dried at 77°C for one week to determine grain yield and field moisture content.

Results were reported as kg/ha of grain yield at 15.5% field moisture. The stover was measured from stalks cut from a 6.08m length of row. The stalks were chipped and weighed on the farm. A subsample of the chipped stover was taken back to the lab, dried at 77°C for one week and weighed to determine field moisture. These results were reported as total dry matter per hectare.

Manure Sampling and Testing

Raw and lagoon stored manure was sampled in the Spring of 2001 and 2002. Samples were also taken regularly from the Fall of 2002 to Summer of 2003. The raw manure was sampled in October 2002, and in March, twice in April, May, June, July, and August, 2003 from a holding tank that is located prior to the digester in the manure stream. The digested manure was sampled at these same times directly after digestion and before the manure was piped into the lagoon. The lagoon samples could only be obtained in October 2002, and both times in April, June, July and August 2003 when manure was being applied to the fields and therefore the lagoon contents had been mixed. Manure was sampled using a catch bucket on the end of a pole. The tank holding raw manure is regularly stirred before the manure is pushed into the digester, leaving a fairly homogenous mixture. After digestion the manure is free-flowing and also fairly homogeneous. The lagoon samples were taken when they would be as homogeneous as possible, as the manure was pumped from the lagoon into the spreader. All the manure samples were taken back to the lab and frozen until they could be analyzed.

For each date collected, an aliquot of the frozen sample was sent to the University of Wisconsin Soil and Forage Analysis Lab in Marshfield, Wisconsin to be analyzed for total N, total P, total K, and sulfur (S). The samples from 4/28/2003 were also analyzed for total C and the remainder was used for the manure incubations.

Manure Incubations

Three rates of manure application were selected to test for plant available N content of raw, digested and lagoon stored manure. The first rate was equal to the rate applied to the plots, 28m³/ha (3000 gallons/acre). The second rate was the rate the farmer usually applies (56 m³/ha or 6000 gallons/acre) and the third rate was a very high rate of 140 m³/ha (15000 gallons/acre) used as a comparison. To achieve these rates 10mls of manure was added to 1kg soil for the 28m³/ha rate, 20mls for the 56m³/ha rate and 50mls for the 140m³/ha rate. Soil collected from the Bruce field was sieved to 2mm and air dried; manure was added and mixed thoroughly.

This incubation procedure was modeled after the PMN procedure described previously, with the following modifications. Samples were extracted at the following times: 0, 14, 28, 42, and 56 days after experimental set up. The duration of the incubation was extended in order to capture the entire curve of activity as in Pilar Bernal and Kirchmann (1992) and Hadas et al. (1983). Manure was added to the soil and three repetitions of each type of manure and each time point were incubated in pint-sized Mason jars at 25°C. Samples were extracted with 2 M KCl and analyzed on a Lachat Quick Chem AE Ion Analyzer (Lachat Instruments, Milwaukee, WI) to determine total available N.

Soil blanks as well as urea controls were incubated along with the manure incubations. The amount of urea added to 1kg of soil was determined by measuring the NH₄ extracted from 25mls of manure with 1.0 L of double deionized water. The samples were shaken for 30 minutes, centrifuged and analyzed on a Wescan Analyzer (Wescan Instruments Inc., Santa Clara, CA). An amount of urea equivalent to the amount of NH₄ in the manure was added to soil and incubated for the same time periods and at the same temperature as the manure. These samples were also extracted with 2 M KCl and analyzed on a Lachat Quick Chem AE Ion Analyzer (Lachat Instruments, Milwaukee, WI). The total N values for the soil blanks were subtracted from the urea blanks to determine the effect of adding the urea to the soil. This value was then subtracted from the manure incubation value to determine the amount of N that becomes available to plants from the organic N fraction.

As with the biomass procedure, 5ml NaOH traps were placed in the Mason jars to monitor C respired per day during the incubation. These traps were placed, along with the samples, in the pint sized Mason jars and were not removed or changed until the samples were removed for extraction. The traps were analyzed for inorganic carbon on a Tekmar Dohrmann Phoenix 8000 Carbon Analyzer (Tekmar Corporation, Mason, OH). The calculation to determine respired C per day was:

$$\frac{\text{C collected in trap}}{\text{days incubated}} = \text{respired C per day}$$

As described in the previous paragraph, the C values from the soil blanks were subtracted from the urea controls, and that value was subtracted from the manure values. Thus respired C reported is solely the net effect of the given amendment.

Statistical analyses in this study were conducted using the GLM procedure of SAS using SAS V8 software (SAS Institute, 1999). Each soil quality and crop yield parameter was analyzed by grouping the three replicates of inorganic fertilizer or manure application within each field. Coefficients of variation (CVs) and LSD values for balanced data were reported in the output from the GLM procedure. P-values of 0.1 were chosen to increase the probability of detecting treatment differences. LSD values for unbalanced data were calculated by hand, using error and t-values generated by the SAS program. Unbalanced data resulted from missing values; in 2001 these occurred in the digested manure replications in both the Appel and Bruce fields. In 2003 missing data was from the raw manure replication in the Bruce field and from raw and digested manure and inorganic fertilizer replications in the Lilac field depending on the sampling time and variable tested. Coefficients of variation were high for all measured properties. This variability is due to two factors: (1) the inherent soil variability at this glacial outwash site; and (2) the fact that the variables measured were at very low levels on this naturally infertile, sandy soil, so that small differences between measured values resulted in large CVs.

Results and Discussion

Yield and Pre-Plant Nitrogen

A major concern for farmers when the fertilizer source is changed is the resulting crop yield. There were few differences in crop yield among the different amendments (Table 2).

Table 2. Effect of Fertilizer Type and Application Frequency on Grain and Stover Yield, Haubenschild Farm, Princeton, MN 2001-2003

Date of Sampling	Application Frequency	Nutrient Source	Grain Yield			Stover Yield		
			2001	2002	2003	2001	2002	2003
Field	Frequency	Nutrient Source	-----kg/ha @15.5% Moisture-----			-----TDM/ha-----		
Appel	Annual	Digested Manure	6951.40	6698.68	5647.66	2.05	2.38	1.39
		Raw Manure	6701.19	5733.57	2932.95	2.24	2.12	0.81
		Inorganic Fertilizer	6549.43	6920.05	6496.76	2.04	2.42	1.54
		LSD ¹	NS ²	NS	1839.91	NS	NS	0.42
Appel	Biennial	Digested Manure	--	--	1762.78	--	--	0.54
		Raw Manure	--	--	3864.82	--	--	0.99
		Inorganic Fertilizer	--	--	1836.77	--	--	0.43
		LSD	--	--	NS	--	--	NS
Bruce	Annual	Digested Manure	6973.35	6219.58	3846.00	2.17	1.88	1.02
		Raw Manure	7071.81	5149.74	4477.49	2.21	1.55	1.25
		Inorganic Fertilizer	6926.32	6382.62	3326.14	2.26	1.78	0.99
		LSD	NS	NS	NS	NS	NS	NS
Bruce	Biennial	Digested Manure	--	3519.28	3616.48	--	1.02	1.05
		Raw Manure	--	2393.01	3826.56	--	0.79	1.12
		Inorganic Fertilizer	--	3517.40	2522.82	--	1.04	0.81
		LSD	--	NS	NS	--	NS	NS
Lilac	Annual	Digested Manure	5393.69	4802.96	4746.52	2.17	1.94	1.20
		Raw Manure	5218.10	5159.15	4853.13	2.15	1.96	1.44
		Inorganic Fertilizer	4502.58	5000.49	3795.84	2.02	1.93	1.06
		LSD	NS	NS	NS	NS	NS	NS
Lilac	Biennial	Digested Manure	--	3970.80	4384.06	--	1.56	1.25
		Raw Manure	--	3568.20	3230.82	--	1.43	0.85
		Inorganic Fertilizer	--	4932.14	4323.85	--	1.75	1.21
		LSD	--	NS	NS	--	NS	NS

¹LSD ($p < 0.1$) refers to the three preceding nutrient sources within the indicated application frequency and field

²NS designates instances where results for the nutrient sources were not significantly different

The only differences observed in grain or stover yield were for the annual application on the Appel field in 2003 where raw manure yielded less than the other two amendments. For all three fields, the lack of a pattern in the rank order of treatments, as well as the lack of treatment differences both suggest that there were no yield differences among the amendments. However, variability was quite high especially in 2002 and 2003. Grain yield CVs for 2001 were 11-17%, in 2002 17-37%, and in 2003 18-53%. In 2001, stover yield CVs were 11-16%, in 2002 23-46%, and in 2003 18-53%. Our yield results are similar to those of Susse and Wurzinger (1986) who applied stored pig and cattle manure to a grassland, as well as Dahlberg, et al. (1988) using digested dairy manure on wheat in a greenhouse. Neither study showed differences in crop yield for digested versus raw manure.

Pre-plant N measurements were also highly variable (CVs 2001: 19-38%, 2002: 14-28%, 2003: 10-22%). The large CVs resulted from high inherent soil variability and low nitrogen values at this field site. Again, there was no pattern of differences among the nutrient sources as measured by pre-plant N (Table 3). The only difference observed in 2001 was in the Lilac field (30-60cm) where digested manure had higher pre-plant N than inorganic fertilizer. In 2002, differences occurred at the 30-60cm depth in the biennial application of both the Bruce field (raw manure was greater than the other amendments) and the Lilac field (inorganic fertilizer was less than the other amendments). Differences in 2003 were in the biennial applications (both depths) on the Appel field and annual (30-60cm) and biennial (0-30cm) applications on the Bruce field. Of the six cases where differences occurred, raw manure had the highest pre-plant N values twice and the lowest values once, inorganic fertilizer was highest once and lowest once, and digested manure was lowest once. This lack of consistent differences in pre-plant N among the treatments suggests that amounts of N supplied to the crop were generally similar for each of the nutrient sources.

Table 3. Effect of Fertilizer Type and Application Frequency on Pre-plant Nitrogen, Haubenschild Farm, Princeton, MN 2001-2003

Date of Sampling Depth in cm			Pre-plant Nitrogen					
			2001		2002		2003	
Application			0-30	30-60	0-30	30-60	0-30	30-60
Field	Frequency	Nutrient Source	-----mg/kg-----					
Appel	Annual	Digested Manure	5.37	3.38	4.07	2.73	4.30	3.90
		Raw Manure	6.40	3.33	4.42	2.82	3.47	3.23
		Inorganic Fertilizer	5.32	3.40	4.33	2.73	3.87	3.70
		LSD ¹	NS ²	NS	NS	NS	NS	NS
Appel	Biennial	Digested Manure	--	--	--	--	3.63	3.23
		Raw Manure	--	--	--	--	4.13	3.47
		Inorganic Fertilizer	--	--	--	--	3.40	2.87
		LSD	--	--	--	--	0.41	0.50
Bruce	Annual	Digested Manure	3.38	3.37	2.63	2.40	3.73	2.73
		Raw Manure	4.07	2.73	2.70	2.00	4.56	3.25
		Inorganic Fertilizer	2.78	2.70	3.27	1.90	4.13	3.53
		LSD	NS	NS	NS	NS	NS	0.73
Bruce	Biennial	Digested Manure	--	--	2.23	1.63	3.70	2.77
		Raw Manure	--	--	2.53	2.70	2.87	2.67
		Inorganic Fertilizer	--	--	2.40	1.83	4.25	3.17
		LSD	--	--	NS	0.63	0.64	NS
Lilac	Annual	Digested Manure	7.58	5.17	4.50	4.13	4.68	3.50
		Raw Manure	6.30	5.18	3.70	3.43	4.77	4.07
		Inorganic Fertilizer	6.07	3.65	3.70	4.10	3.53	3.43
		LSD	NS	1.32	NS	NS	NS	NS
Lilac	Biennial	Digested Manure	--	--	4.57	5.33	3.67	3.47
		Raw Manure	--	--	4.47	5.50	3.93	3.43
		Inorganic Fertilizer	--	--	3.73	3.70	4.30	3.53
		LSD	--	--	NS	1.19	NS	NS

¹ LSD (p<0.1) refers to the three preceding nutrient sources within the indicated application frequency and field.

² NS designates instances where results for the nutrient sources were not significantly different

Total Carbon and Nitrogen

Total C results (Table 4) were highly variable (CVs 2001: 12-48%, 2002: 11-47%, 2003: 4-51%). In 2001, the only areas that exhibited treatment differences were the Appel (0-15cm) and Bruce (15-30cm) fields in July, with inorganic fertilizer having higher total C than digested manure in both cases. In July of 2002, the Bruce field was the only field showing differences. These differences occurred in both application frequencies and at both depths. Of these four cases, digested manure was lower than other amendments twice in the annual application and raw manure was lower than inorganic fertilizer twice in the biennial treatment. In the August sampling, only the annual treatment in the Bruce field showed differences, with digested manure having lower total C than the other amendments at both depths.

In August, 2003, the Appel field (annual treatment 0-15cm, biennial treatment both depths) exhibited three differences, while the Bruce field only showed one (biennial treatment, 15-30cm). Digested manure had greater total C than raw manure once and less total C than raw manure once. Raw manure was lower than the other nutrient sources once, and inorganic fertilizer was lower than the other sources once. In the 12 out of 56 possible cases where differences were detected, inorganic fertilizer has higher total C than the other amendments in 9 cases, raw manure in 6, and digested manure in 3. Digested manure had lower C in 7 cases, raw manure in 4, and inorganic fertilizer only once.

Table 4. Effect of Fertilizer Type and Application Frequency on Total Soil Carbon, Haubenschild Farms, Princeton, MN 2001-2003

Date of Sampling			Total Soil Carbon											
			July 2001		August 2001		July 2002		August 2002		June 2003		August 2003	
Depth (cm)			0-15	15-30	0-15	15-30	0-15	15-30	0-15	15-30	0-15	15-30	0-15	15-30
Application			g/kg											
Field	Frequency	Nutrient source												
April	Annual	Digested Manure	953	702	622	767	930	602	805	607	883	543	883	694
		Raw Manure	1045	679	741	607	844	607	877	564	833	506	781	616
		Inorganic Fertilizer	1099	749	732	702	807	576	792	536	817	524	860	711
		LSD ¹	130	NS ²	NS	NS	NS	NS	NS	NS	NS	NS	NS	064
April	Barrial	Digested Manure	-	-	-	-	-	-	-	-	784	412	672	603
		Raw Manure	-	-	-	-	-	-	-	-	826	525	874	613
		Inorganic Fertilizer	-	-	-	-	-	-	-	-	801	399	721	456
		LSD	-	-	-	-	-	-	-	-	NS	NS	171	1.17
June	Annual	Digested Manure	555	458	861	819	537	405	538	431	518	379	539	556
		Raw Manure	628	527	672	694	737	573	692	611	854	562	741	671
		Inorganic Fertilizer	692	622	946	681	734	651	717	625	710	588	684	632
		LSD	NS	144	NS	NS	194	183	126	121	NS	NS	NS	NS
June	Barrial	Digested Manure	-	-	-	-	576	458	637	481	629	461	606	573
		Raw Manure	-	-	-	-	454	376	513	401	572	365	489	420
		Inorganic Fertilizer	-	-	-	-	655	564	642	569	590	483	597	496
		LSD	-	-	-	-	183	162	NS	NS	NS	NS	NS	123
Late	Annual	Digested Manure	809	805	824	652	874	801	877	738	867	743	833	908
		Raw Manure	807	774	1059	800	885	822	841	809	897	672	876	835
		Inorganic Fertilizer	622	889	825	789	587	590	599	598	605	536	589	694
		LSD	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Late	Barrial	Digested Manure	-	-	-	-	673	639	665	664	606	589	589	678
		Raw Manure	-	-	-	-	584	538	571	605	511	450	529	584
		Inorganic Fertilizer	-	-	-	-	844	767	839	693	969	701	807	771
		LSD	-	-	-	-	NS	NS	NS	NS	NS	NS	NS	NS

¹LSD ($p < 0.1$) refers to the three paired nutrient sources within the indicated application frequency and field

Total N also did not differ much among treatments over the three years of sampling (Table 5), but again showed high variability (CVs 2001: 12-113%, 2002: 13-72%, 2003: 10-118%). Differences observed in total N generally paralleled the differences in total C. In 2001, differences were in the July sampling at 0-15cm in the Appel field, with inorganic fertilizer having higher values than digested manure, and the Bruce field, where inorganic fertilizer was higher than both the other amendments. In 2002, the Bruce field, annual treatment, was the only area that exhibited differences. The digested manure had less total N than the other amendments in both the July sampling (0-15cm) and the August sampling (both depths). The Appel field, biennial treatment, was the only field with any differences in 2003. The June sampling (15-30cm) and the August sampling (0-15cm) both show inorganic fertilizer differing from the other two amendments, in one case greater and the other less. In the 7 cases out of 56 possible where differences occurred, inorganic fertilizer was greater in 6, raw manure was greater in 4, and digested manure was greater in only one. Inorganic fertilizer had lower total N in only one case, raw manure in 2, and digested manure in 6 cases. Trends in the results for total C and N suggest that there may be less total C and N supplied by digested manure than by raw manure or inorganic fertilizer. However, differences occurred only 13% (total N) to 21% (total C) of the time. Parham et al. (2002) also found no differences in total C and N in plots fertilized with manure or inorganic fertilizer, though additions of either input increased total C and N over unfertilized plots.

Table 5. Effect of Fertilizer Type and Application Frequency on Total Soil Nitrogen, Haubenschild Farms, Princeton, MN 2001-2003

Date of Sampling			Total Soil Carbon											
			July 2001		August 2001		July 2002		August 2002		June 2003		August 2003	
Depth (cm)			0-15	15-30	0-15	15-30	0-15	15-30	0-15	15-30	0-15	15-30	0-15	15-30
Application			g/kg											
Field	Frequency	Nutrient source												
April	Annual	Digested Manure	953	702	622	767	930	602	805	607	883	543	883	694
		Raw Manure	1045	679	741	607	844	607	877	564	833	506	781	616
		Inorganic Fertilizer	1099	749	732	702	807	576	792	536	817	524	860	711
		LSD ¹	130	NS ²	NS	NS	NS	NS	NS	NS	NS	NS	NS	064
April	Biennial	Digested Manure	-	-	-	-	-	-	-	-	784	412	672	603
		Raw Manure	-	-	-	-	-	-	-	-	826	525	874	613
		Inorganic Fertilizer	-	-	-	-	-	-	-	-	801	399	721	456
		LSD	-	-	-	-	-	-	-	-	NS	NS	171	117
Blue	Annual	Digested Manure	555	458	861	819	537	405	538	431	518	379	539	556
		Raw Manure	628	527	672	694	737	573	692	611	854	562	741	671
		Inorganic Fertilizer	692	622	946	681	734	651	717	625	710	588	684	632
		LSD	NS	144	NS	NS	194	183	126	121	NS	NS	NS	NS
Blue	Biennial	Digested Manure	-	-	-	-	576	458	637	481	629	461	606	573
		Raw Manure	-	-	-	-	454	376	513	401	572	365	489	420
		Inorganic Fertilizer	-	-	-	-	655	564	642	569	590	483	597	496
		LSD	-	-	-	-	183	162	NS	NS	NS	NS	NS	123
Lac	Annual	Digested Manure	809	805	824	652	874	801	877	738	867	743	833	908
		Raw Manure	807	774	1059	800	895	822	841	809	897	672	876	835
		Inorganic Fertilizer	622	889	825	789	587	590	599	598	605	536	589	694
		LSD	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Lac	Biennial	Digested Manure	-	-	-	-	673	639	665	664	606	589	589	678
		Raw Manure	-	-	-	-	584	538	571	605	511	450	529	584
		Inorganic Fertilizer	-	-	-	-	844	767	839	693	969	701	807	771
		LSD	-	-	-	-	NS	NS	NS	NS	NS	NS	NS	NS

¹ LSD (p<0.1) refers to the three paired nutrient sources within the indicated application frequency and field

² NS designates instances where results for the nutrient sources were not significantly different

Labile C and N Pools

Measures of microbial biomass and PMN also exhibited high amounts of variability, but did not show differences among the nutrient sources. At the Haubenschild farm, the range of CVs for microbial biomass C (MBC) was 11-57% in 2002 and 10-56% in 2003 and for microbial biomass N (MBN) was 15-45% in 2002 and 13-48% in 2003. In these years only a few differences in microbial biomass were detected (Figure 5&6, Appendix A for data).

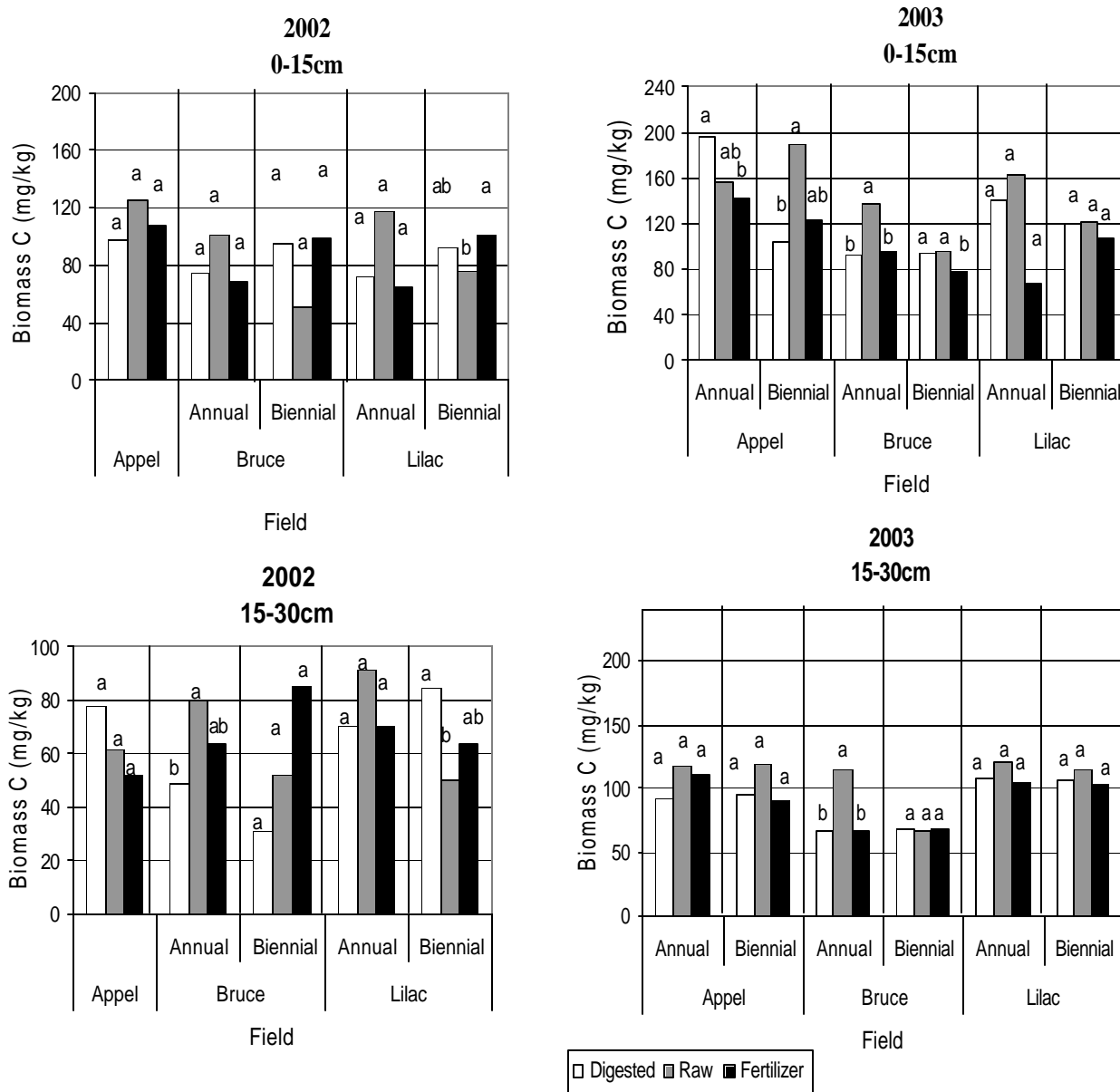


Figure 5. Nutrient Source Effect on Microbial Biomass Carbon, Haubenschild Farms, Princeton, MN 2002-2003
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In 2002, MBC exhibited differences in the Bruce and Lilac fields with MBC for digested manure greater than raw manure once, raw manure greater than digested manure once and inorganic fertilizer greater than raw manure once. In 2003, differences occurred in the Appel and Bruce fields where digested manure had higher MBC than inorganic fertilizer once, raw manure was greater than digested manure once, raw manure was greater than the other nutrient sources twice, and inorganic fertilizer was less than the other amendments once. In 8 out of 22 possible cases where differences occurred, raw manure resulted in higher MBC in 5 cases, digested manure in 3, and inorganic fertilizer only once. Raw manure had less MBC only twice, and digested manure and fertilizer were lower in 4 cases each.

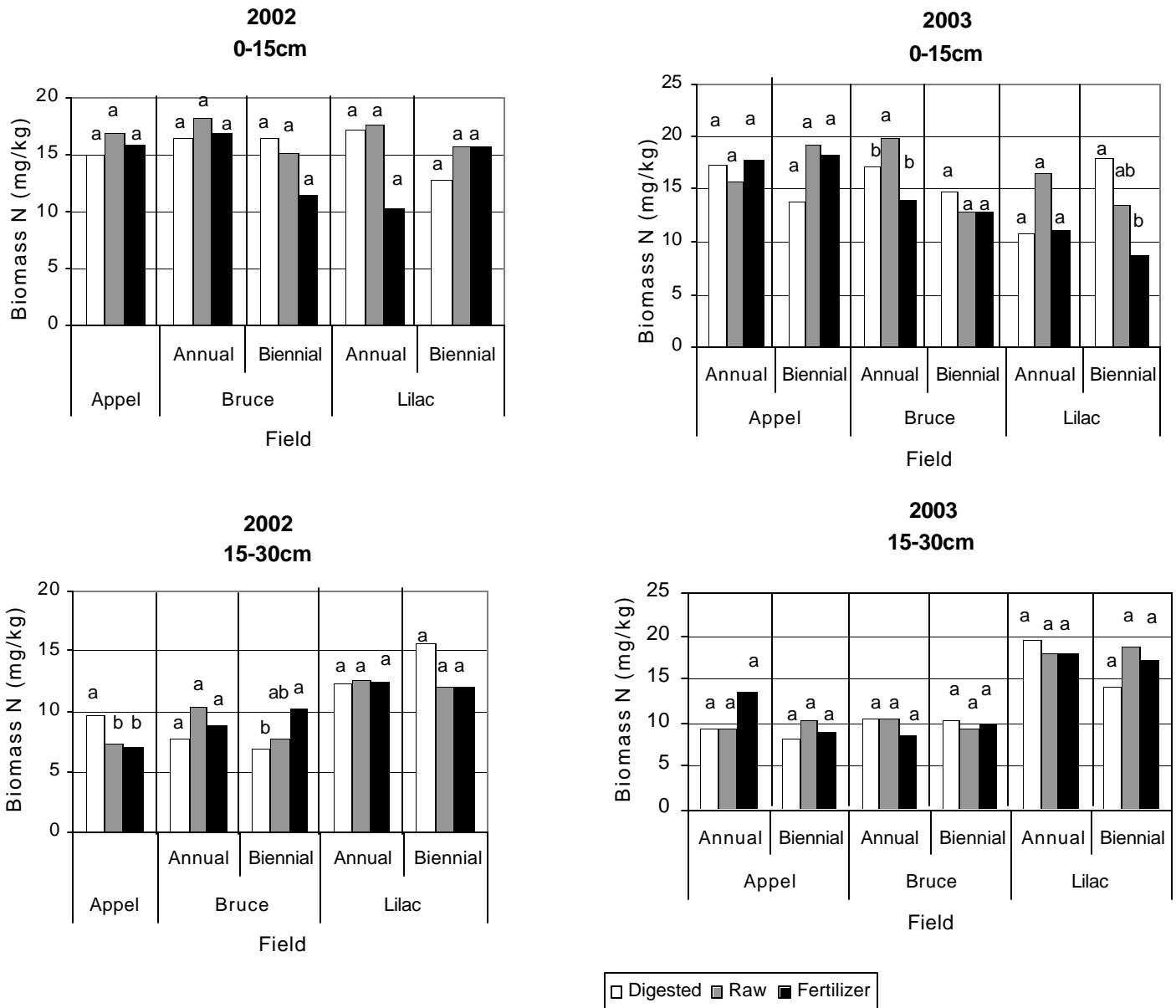


Figure 6. Nutrient Source Effect on Microbial Biomass Nitrogen, Haubenschild Farms, Princeton, MN 2002-2003

In 2002, MBN revealed differences in the Appel and Bruce fields (both at 15-30 cm) with digested manure MBN greater than the other nutrient sources once and digested manure less than inorganic fertilizer once. In 2003, the differences occurred in the Bruce field (0-15 cm), with raw manure MBN greater than the other amendments, and in the Lilac field (0-15 cm), with digested manure greater than inorganic fertilizer. MBN differed in only 4 out of 22 possible cases, with digested manure amounts greatest twice, raw manure once and inorganic fertilizer once. Raw manure MBN was less than the others only once, while digested manure was lower twice and inorganic fertilizer 3 times. Where differences occurred, it appears that manure sources were better than inorganic fertilizer for increasing MBC and MBN.

The Lilac and Appel fields both tended to have higher amounts of microbial biomass C and N than the Bruce field. This difference may be due to the lack of historical manure application in the Bruce field, and therefore limited substrate for microbes. Others have shown that manure additions to a site will increase the microbial biomass (Friedel et al., 1996; Parham et al., 2002; Peacock et al., 2001). The Lilac field and Appel field had relatively equal amounts of microbial biomass C and N which could be attributed to the long history of manure application prior to this study.

PMN is a test to determine how much N could become available to plants over the growing season. Robbins et al. (1997) determined that amounts of PMN are greater in unfermented manure than in inorganic fertilizer. Friedel et al. (1996) showed that anaerobically fermented manure, which is similar to digested manure, had higher amounts of PMN than unfermented manure. Results from the plots at the Haubenschild's farm exhibit a high degree of variability (CVs 2001: 13-62%, 2002: 9-30%, 2003: 6-142%), but show few differences in PMN for the different amendments (Figure 7&8, Appendix B for data).

In July, 2001, PMN was greater in the Bruce field (0-15 cm) for the fertilizer treatment than the digested manure treatment. In August, 2001, PMN was greater for raw manure than for digested manure in the Appel field and was greater for raw manure than either of the other two sources in the Bruce field (15-30 cm). In 2002, the Bruce field showed three differences: digested manure PMN less than the other two amendments, inorganic fertilizer greater than the other amendments, and inorganic fertilizer greater than digested manure. Other differences in 2002 included the Appel field (15-30 cm), with digested manure greater than inorganic fertilizer,

and the Lilac field (15-30 cm), with raw manure greater than digested manure. In 2003, the Appel and Bruce fields were the areas where differences occurred. Raw manure was greater than inorganic fertilizer twice and inorganic fertilizer was less than both the other amendments once. Based on the cases where differences were evident, raw manure application resulted in greater amounts of PMN than digested manure, but differences occurred in only 11 out of 56 possible cases.

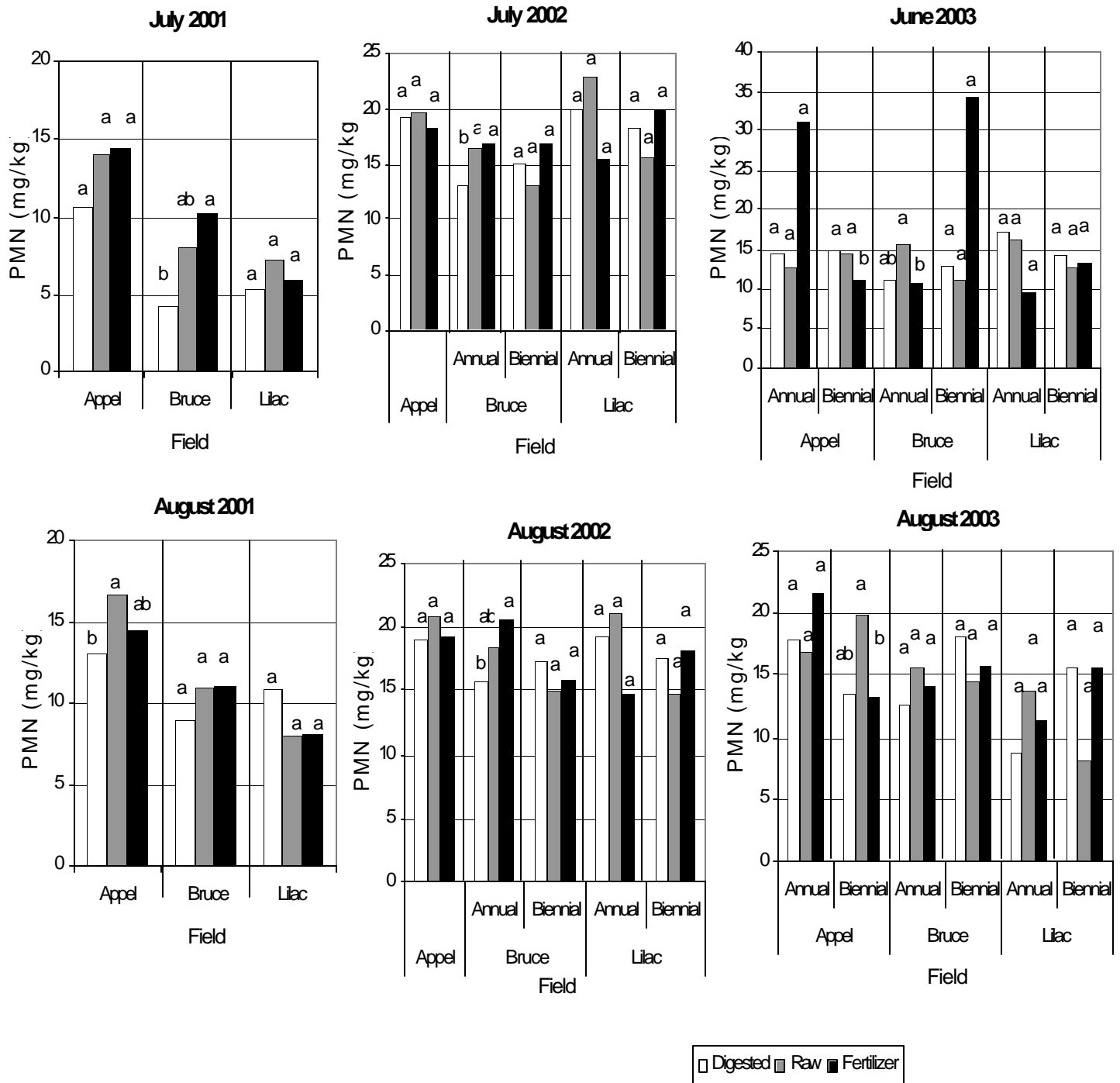


Figure 7. Nutrient Source Effect on PMN at 0-15cm depth during a 28 day Incubation, Haubenschild Farms, Princeton, MN 2001-2003

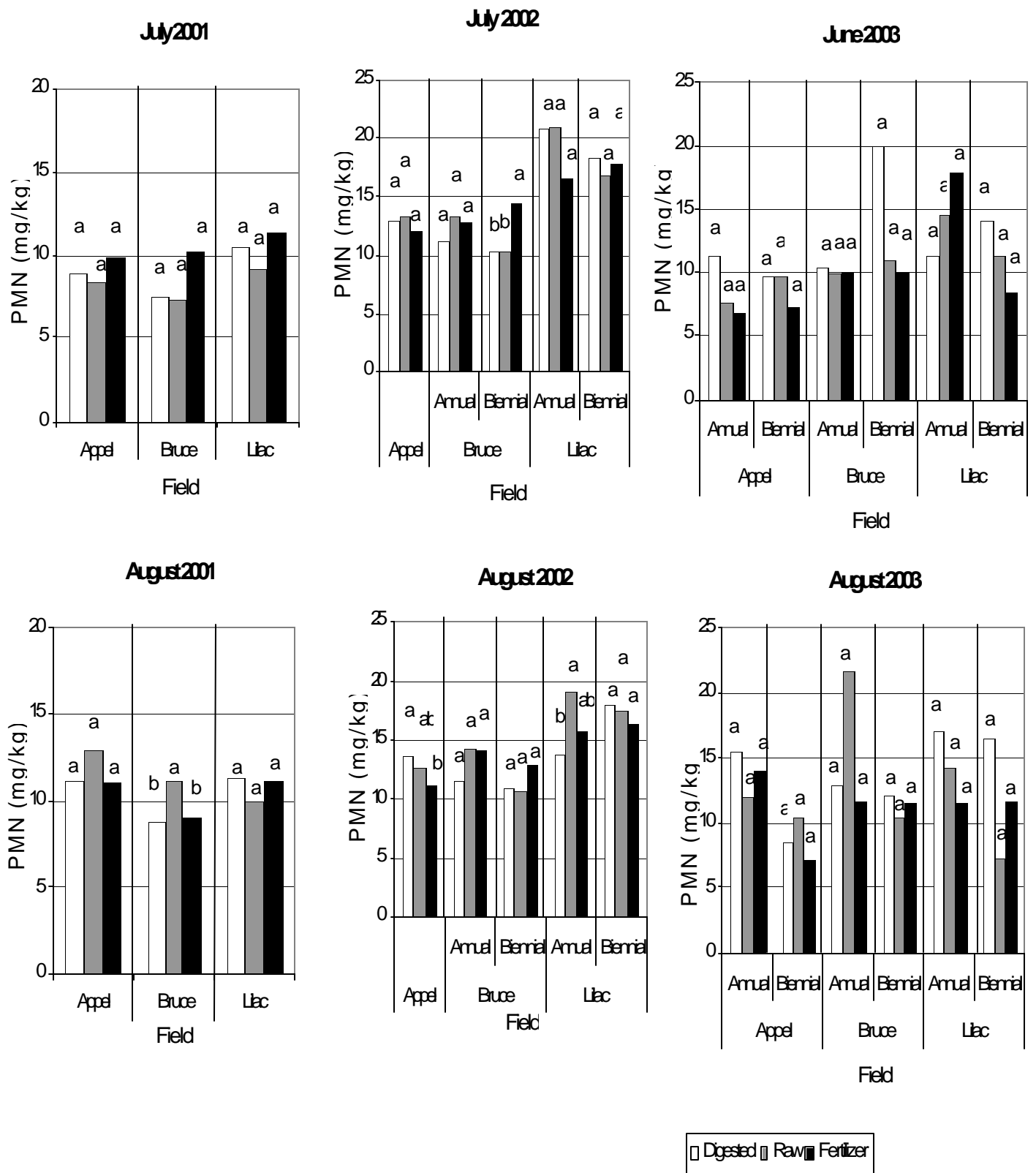


Figure 8. Nutrient Source Effect on PMN at 1530m depth during a 28 day incubation, Hubenschuld Farms, Pinceton, MN 2001-2003

Nutrient Pool Changes over Time

Other researchers have shown that manure additions continue to build soil C and N over a long period of time. This accumulation occurs even if small amounts of manure are applied (Peacock et al., 2001; Rochette and Gregorich, 1998). During the three years of this study, total C stayed fairly constant, but three years may not be long enough to see increases and smaller amounts of manure were applied than the usual farm practice. Nitrogen did not increase from 2001-2003 in the Lilac or Appel fields, but since these fields had a history of manure application, levels were already relatively higher in the 2001 samplings. In the Lilac field, where alfalfa preceded the corn crop planted in 2001, pre-plant N decreased over the three years of the study. By the third year there was a slight increase in the total N of the Bruce field, a field with no history of manure application.

Other nutrient levels in the three fields stayed constant or slightly decreased over the three years (Table 6), possibly due to the purposeful application of amendments at levels below those recommended for optimum corn yield. Potassium increased in the Bruce and Lilac fields after application of 112 kg/ha of potash in 2001 and starter fertilizer containing K each year. Extra K was applied to these fields to increase previously low levels determined by soil tests. After an initial increase these higher levels of K were maintained throughout the study.

Table 6. Soil pH, Bray-P and Potassium, Haubenschild Farms, Princeton, MN 2003 (0-30cm)

Table 5 Soil pH, Bray-P and Potassium in 2003 (0-30cm)

Field	Application Frequency	N Source	pH	Bray-P (ppm)	Potassium (ppm)
Appel	Annual	Digested Manure	6.83	65.00	139.67
		Raw Manure	7.00	55.33	136.33
		Inorganic Fertilizer	6.86	63.16	148.33
		LSD ¹	NS ²	NS	10.31
Appel	Biennial	Digested Manure	6.96	54.33	142.00
		Raw Manure	6.93	66.00	138.66
		Inorganic Fertilizer	7.00	57.00	137.00
		LSD	NS	NS	NS
Bruce	Annual	Digested Manure	6.33	36.33	96.66
		Raw Manure	6.36	28.66	118.00
		Inorganic Fertilizer	6.20	28.83	102.33
		LSD	NS	NS	11.83
Bruce	Biennial	Digested Manure	6.20	30.33	99.66
		Raw Manure	6.17	37.33	87.33
		Inorganic Fertilizer	6.00	28.33	93.66
		LSD	NS	7.85	NS
Lilac	Annual	Digested Manure	6.20	74.33	123.33
		Raw Manure	6.10	85.66	123.33
		Inorganic Fertilizer	5.96	73.00	95.67
		LSD	0.18	NS	NS
Lilac	Biennial	Digested Manure	6.03	70.67	108.67
		Raw Manure	6.27	75.16	113.50
		Inorganic Fertilizer	6.07	80.33	117.67
		LSD	NS	NS	NS

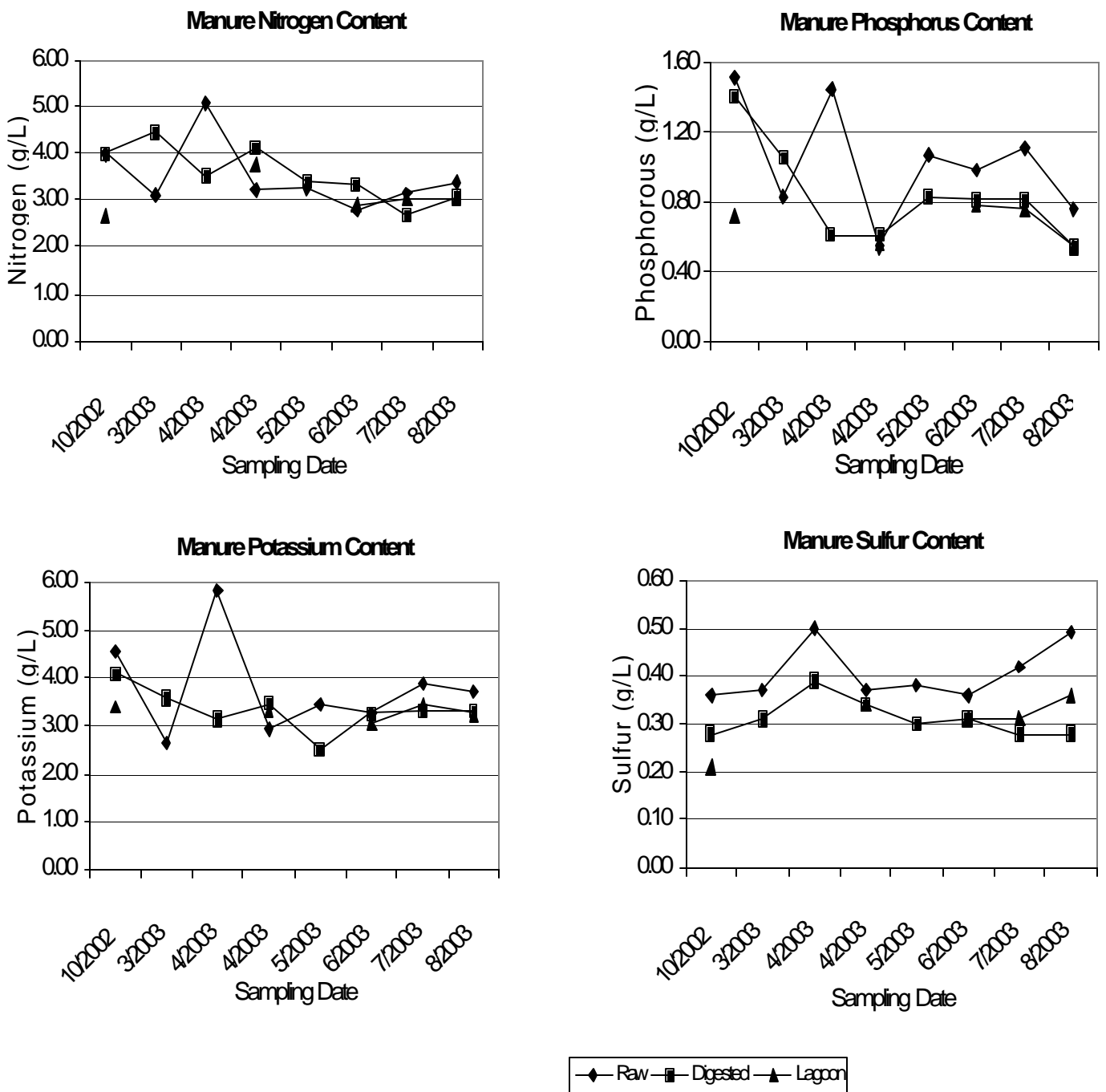
¹LSD (p<0.1) refers to the three preceding N sources within the indicated application frequency and field

²NS designates instances where results for the nutrient sources were not significantly different

Manure Nutrient Concentrations

Manure was collected from three different locations on the Haubenschild's farm (raw manure from a holding tank before the digester, digested manure as the manure came out of the digester, and lagoon manure as the manure was pumped into the spreader) and was analyzed for N, P, K, and S. Nitrogen, K and S were relatively stable and N and K were at similar concentrations during this one year period, except for the first April sampling date, when the raw manure had increases of 22-54% over average values (Figure 9, Appendix C for data).

Figure 9. Raw, Digested and Lagoon Manure Nutrient Concentrations over Time, Haubenschild Farms, Princeton, MN



Raw and digested manure exhibited high P values in the October, 2002 sampling, decreasing to lagoon levels throughout the rest of the sampling dates. Sulfur also appeared to increase in July and August 2003; otherwise the three different manure sources differ little over the sampling period. When averaged over time, S was the only nutrient showing a difference between raw and digested manure (Table 7). Manure collected in the Spring of 2001 and 2002 had concentrations of N, P, and K that were similar to the Spring samples in 2003.

Table 7. Average Raw, Digested and Lagoon Manure Nutrients over Time, Haubenschild Farms, Princeton, MN

Manure Type	Nitrogen -----	Phosphorus -----g/L--	Potassium -----	Sulfur
Raw	3.50a	1.03a	3.78a	0.41a
Digested	2.58a	0.83a	3.34a	0.31b
Lagoon*	3.08	0.67	3.29	0.31

*Because only a few lagoon samples could be collected, they were not included in the ANOVA and LSD calculation

These results agree with Van Horn et al. (1994) who determined that N, P, and K levels are consistent between raw and digested manure. Nitrogen is the nutrient most easily lost from storage and DeLuca and DeLuca (1997) estimate that losses are between 30% and 60% of the N from feedlot manure in open lot storage; however, Thomsen (2000) found that N lost from anaerobically stored sheep manure is only about 18%. These studies agree that only small differences are detected in the total nutrient concentrations for digested versus raw manure. At the Haubenschild farm manure handling and storage practices seem to be conserving nutrients quite well, even in the lagoon.

Manure Incubations

Unlike the field results, manure incubations in this study did show differences in net rates of N mineralization among different manure types. Differences in KCl-extractable N were most pronounced at the highest rate of application (Figure 10).

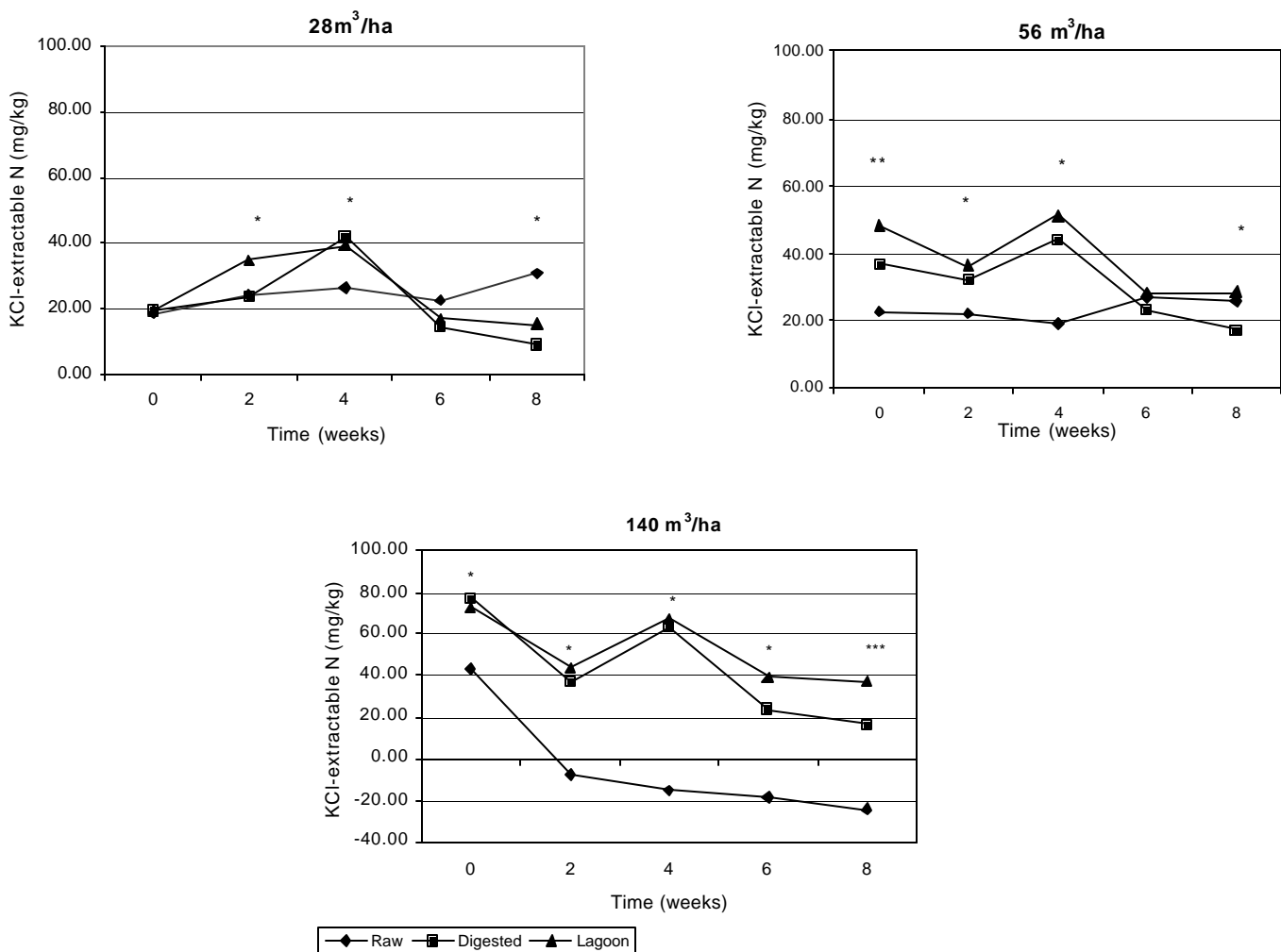


Figure 10. Net Extractable Nitrogen Attributable to Manure Source by Application Rate during 8 week Incubation

* Indicates a time point where one manure source differs from the other two

** Indicates a time point where only the largest and smallest values differ

***Indicates a time point where all three differ

This rate of 140 m³/ha, which is 2.5 times the usual practice on the farm, shows a difference at every time point with raw manure always having less available inorganic N than digested or lagoon manure. After the initial time point, results for the raw manure are negative because there was more KCl-extractable N in the urea and soil controls than in the soil from the manure incubation. There were fewer differences at the low rate of manure application (28m³/ha) and these differences were not consistent. At the 28m³/ha rate, available N attributable to the lagoon manure source was significantly higher than for the other types (week 2), but by later in the incubation, N attributable to raw manure was significantly higher (week 8). Until 6 weeks, the 56 m³/ha rate KCl-extractable N was greatest in the digested and lagoon samples, but by 8 weeks, extractable N from digested manure was lower than raw or lagoon manure. Generally, these results agreed with Pilar Bernal and Kirchmann's (1992) study, showing that anaerobically treated manure additions result in more N mineralization than raw manure.

Less extractable N was measured in the raw manure incubations because of greater N immobilization. Later in the incubations, in the 6th and 8th week, available N increased at the lower rate (28m³/ha) for raw manure. At both the higher rates of manure application, raw manure was markedly lower in extractable N than digested or lagoon sources during the first two weeks. At the lower rate (28m³/ha) this decrease was not observed. This could be because there were not enough available C added to trigger a decrease in extractable N, or the decrease may have occurred before the first sample was taken at two weeks and was not captured by the sampling times. Again, these incubations follow the pattern observed by Pilar Bernal and Kirchmann (1992) and Serna and Pomares (1991).

Although total C was scarcely different among the three manure types (raw: 400 g/kg, and digested and lagoon both 383 g/kg), there were significant differences in respired C (Figure 11). In these incubations, respired C attributable to raw manure was greater at every application rate and every time point except one, the final time point at 56 m³/ha.

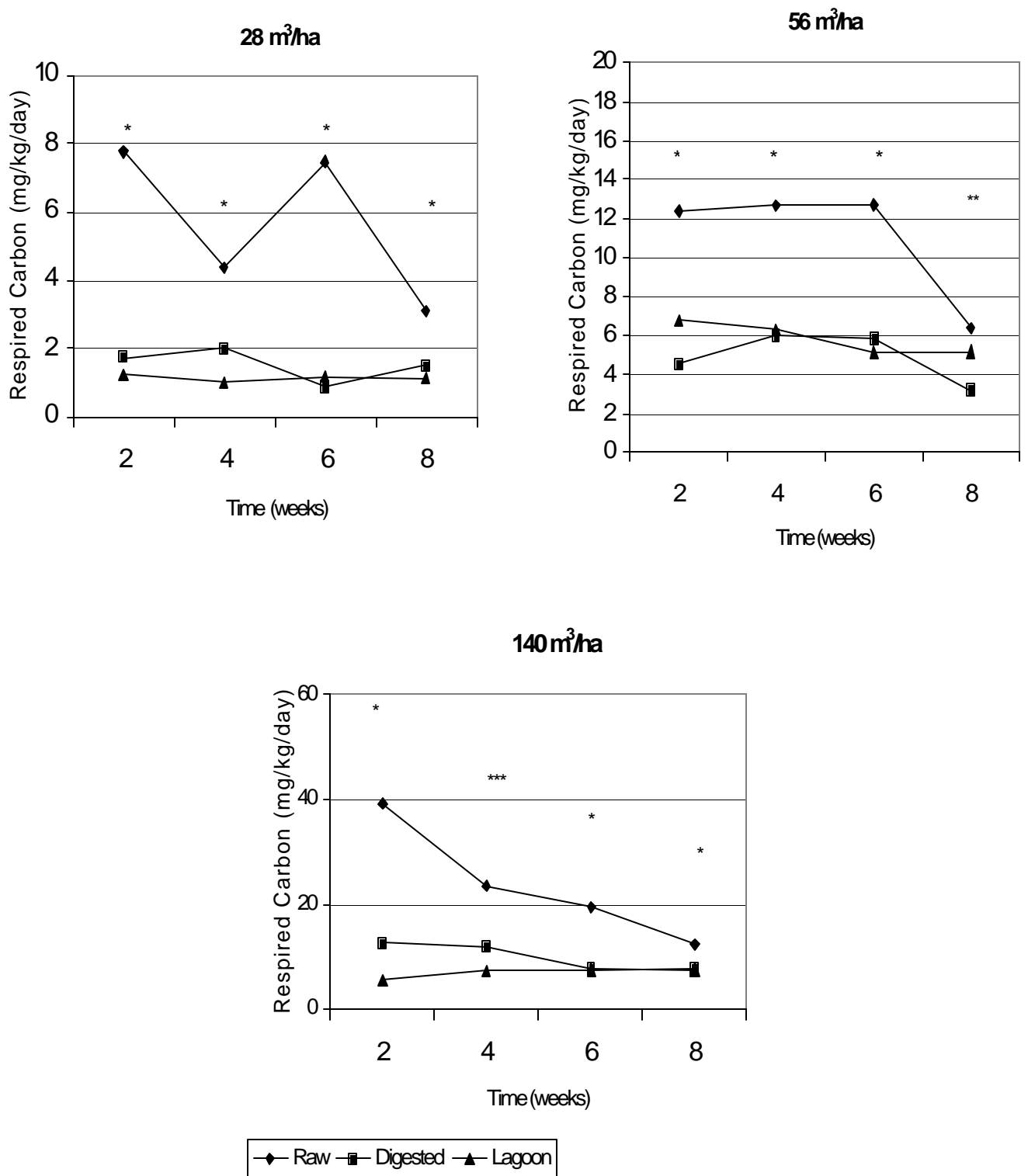


Figure 11. Net Respired Carbon Attributable to Manure Source by Application Rate during an 8 week Incubation

* Indicates a time point where one manure source differs from the other two

** Indicates a time point where only the largest and smallest values differ

*** Indicates a time point where all three differ

The major difference between the manures tested in this study is the digestion process. This could account for the differences in mineralizable C and N. Digested and lagoon manure could have lower C values because the easily digestible C has been used by the microbes in the digester. This easily digestible C includes the volatile solids which cause odor. Petersen (1992) determined that even a small decrease in the volatile solids will reduce odor. Odor reduction is one of the benefits attributed to the digestion process. The raw manure has not gone through the digestion process; therefore the microbes have a more abundant source of decomposable C substrates and a higher respiration rate thus can immobilize N for longer periods of time.

Conclusions

Inherent soil variability and low nutrient status resulted in high coefficients of variation at this field site. This variability may have masked differences among the types of amendments applied. However, the low rates of N applied to our plots should have maximized the differences we observed. Therefore, our results suggest that digested manure produced equivalent yields to raw manure and inorganic fertilizer, as well as increased soil N over unfertilized areas. In terms of other soil quality parameters, digested manure was equal to raw manure and inorganic fertilizer in sustaining or increasing soil quality over the duration of this study.

While 8 week laboratory incubations did indicate that raw manure had less available N than either digested or lagoon stored manure, these differences were not observable in the field. Until late in the incubation, digested and lagoon manure released more available nitrogen than the raw manure. These differences were most dramatic at high rates of application and resulted from greater immobilization of N in the raw manure treatment. Analysis of the three manures by the University of Wisconsin directly out of the mixing pit, digester and lagoon also did not show any significant differences among the different types of manures. Further study at a site with less inherent variability and more replication might allow more consistent differences in nutrient sources to be observed.

The results of this study suggest that anaerobic digestion does not decrease manure fertilizer value or resulting productivity. Environmental risks or benefits also need to be considered, but such measures were beyond the scope of this study. A digester can benefit the farm financially

from methane and heat production and odor reduction, and there was no loss in fertilizer value or soil quality from the digestion process at this site.

REFERENCES

- Brejda, J.J., et al. 2000. Distribution and Variability of Surface Soil Properties at a Regional Scale. Soil Science Society of America Journal **64**: 974-982.
- Dahlberg, S.P. et al. 1988. Effect of Anaerobic Digestion on Nutrient Availability from Dairy Manure. American Society of Agricultural Engineers **31(4)**: 1211-1216.
- DeLuca, T.H. and D.K DeLuca. 1997. Contemporary Issues: Composting for Feedlot Manure Management and Soil Quality. Journal of Production Agriculture **10**: 235-241.
- Drinkwater, L.E., et al. 1996. Potentially Mineralizable Nitrogen as an Indicator of Biologically Active Soil Nitrogen. Pg.217-229. In J.W. Doran and A.J. Jones (eds.) Methods for Assessing Soil Quality. Soil Science Society of America Special Publication 49. Soil Science Society of America, Madison, WI.
- Friedel, J.K. et al. 1996. Nitrogen Mineralization of Liquefied Anaerobically Fermented Cattle Manure in Soil. Agribiological Research—Zeitschrift fur Agrarbiologie Agrikulturchemie Okologie **49(1)**: 1-9. (Abstract Only).
- Hadas, A. et al. 1983. Effect of Pelleting, Temperature, and Soil Type on Mineral Nitrogen Release from Poultry and Dairy Manures. Soil Science Society of America Journal **47**: 1129-1133.
- Horwath W.R. and E.A. Paul. Microbial Biomass. In Methods of Soil Analysis Part 2: Microbiological and Biochemical Properties. Soil Science Society of America Book Series: 5. Weaver, R.W. et al. (eds.). Soil Science Society of America, Inc. 1994 Pg 753.
- Jenkinson, D.S. and D.S. Powlson. 1976. The Effects of Biocidal Treatment on Metabolism in Soil. V: A Method for Measuring Soil Biomass. Soil Biology and Biochemistry **8**: 209-213.
- Parham, et al. 2002. Long-term Cattle Manure Application in Soil: 1 Effect on Soil Phosphorous Levels, Microbial Biomass C, and Dehydrogenase and Phosphatase Activities. Biology and Fertility of Soils **35**: 328-337.
- Peacock, A.D. et al. 2001. Soil Microbial Community Responses to Dairy Manure or Ammonium Nitrate Applications. Soil Biology and Biochemistry **33**: 1011-1019.

- Petersen, S.O. 1992. Nitrification and Denitrification after Direct Injection of Liquid Cattle Manure. Acta Agriculturae Scandinavica, Section B, Soil and Plant Science **42**: 94-99.
- Pilar Bernal, M. and H. Kirchmann. 1992. Carbon and Nitrogen Mineralization and Ammonia Volatilization from Fresh, Aerobically and Anaerobically Treated Pig Manure During Incubation with Soil. Biology and Fertility of Soils **13**: 135-141.
- Rice, C.W. et al. Role of Microbial Biomass Carbon and Nitrogen in Soil Quality. In Methods for Assessing Soil Quality, Soil Science Society of America Special Publication Number 49. Ed by J.W. Doran and A. J. Jones. Soil Science Society of America, Inc., 1996 Pg 203.
- Robbins, C. W. et al. 1997. Improving Exposed Subsoils with Fertilizers and Crop Rotations. Soil Science Society of America Journal **61**: 1221-1225.
- Rochette, P. and E.G. Gregorich. 1998. Dynamics of Soil Microbial Biomass C, Soluble Organic C and CO₂ Evolution after Three Years of Manure Application. Canadian Journal of Soil Science **78**; 283-290.
- Serna, M.D. and F. Pomares. 1991. Comparison of Biological and Chemical Methods to Predict Nitrogen Mineralization in Animal Wastes. Biology and Fertility of Soils **12**: 89-94.
- Susse, A. and A. Wurzinger. The Effect of Anaerobic Digestion on Nutrient Value of Farm Manure. In Efficient Land Use of Sludge and Manure. Ed by A. Dam Kofoed, J.H. Williams, P. L'Hermitte. Elsevier Applied Science Publishers, 1986 Pg 47-55.
- Thomsen, I.K. 2000. C and N Transformations in ¹⁵N Cross-labeled Solid Ruminant Manure during Anaerobic and Aerobic Storage. Bioresource Technology **73(3)**: 267-274. (Abstract Only).
- Van Horn, H.H. et al. 1994. Components of Dairy Manure Management Systems. Journal of Dairy Science **77**: 2008-2030.

PART B: ECONOMIC VIABILITY OF ALTERNATIVE DAIRY SYSTEMS

Part 1: Capital budgeting analysis of the digester and related manure handling and electricity generation equipment

Introduction

The need to more fully understand questions posed by anaerobic digesters was spurred in Minnesota by the installation of an anaerobic digester system at Haubenschild Farms, an 800-cow, 1000-acre dairy farm an hour north of Minneapolis/St. Paul. In 1999, the farm installed a heated plug flow digester with a 130-kilowatt engine/generator to utilize the biogas. The successful operation of this facility (the generator has been running over 98% of the time since start-up) has resulted in much interest from policy-makers as to the applicability of digesters to other animal feedlot operations in the state. Also, there were claims by the digester industry of the superiority of digested manure, with only anecdotal evidence to support them, and there was a desire to more fully investigate these claims.

In 2000, The Minnesota Project, a non-profit environmental and rural development group, was the recipient of a 4-year U.S. Department of Agriculture, Natural Resources Conservation Service (USDA-NRCS) grant to look into several questions related to the environmental performance and financial feasibility of anaerobic digesters at dairy farms, as compared to alternative dairy systems. Specifically, the project had three objectives:

1. Compare effects of soil quality, crop growth and nutrient uptake for three nutrient sources – commercial fertilizer, undigested manure and digested manure;
2. Determine weed seed survival as affected by manure handling; and
3. Conduct an economic evaluation of alternative manure management systems on dairy profitability.

The Minnesota Project contracted with several partners from the University of Minnesota to conduct much of this work. More information on the Haubenschild Farm and this grant is available at www.mnproject.org.

Economic Analysis of the Digester System

This section presents one component of a two-part economic analysis being conducted under the EQIP project. The component is a partial, capital budgeting analysis of the digester and related manure handling and electricity generation equipment. The analysis is "partial" in that it assumes that the rest of the modern, confinement dairy operation (currently at 800 milking cows and 1,000 acres of cropland) would remain the same if the digester were absent. The analysis considers the investment requirements for the digester, financing, electricity sales and avoided purchases, LP gas avoided purchases, labor requirements, and repairs and maintenance

for the equipment involved. This analysis is based on performance data from the farm through October, 2003.

The other component of the economic analysis will be a whole-farm comparison of the Haubenschild confinement dairy operation to a different dairy farm that is using rotational grazing. The whole-farm comparison will look at profitability issues such as the impact on rates of return on assets, and liquidity and solvency measures, and will be carried out using the FINPACK farm financial analysis software.

The present capital budgeting analysis of the digester is implemented in an Excel spreadsheet template and has two general objectives. The first objective is to document the economics of the case farm's digester system, which is unique in certain respects. Its economics are affected by the fact that, as a demonstration facility, it was financed partially through grants that would not be available to later farms, and the electricity both no longer purchased by the farm and that sold back to the utility receives an advantageous price. Also, Mr. Haubenschild has taken a great deal of interest in managing the digester, and has recorded gas and electricity production levels that seem relatively high compared to similar digesters elsewhere.

The other objective is to compare the demonstration farm against scenarios representing the economics of a digester system that another farm might install in the future. Future installations may be able to match or surpass the demonstration farm's performance, or may be less successful. So, one of the future scenarios is based on the demonstration farm's production while the other two consider biogas performance at 80 and 60 percent of that level. The 60 percent level was based on averages calculated from the profiles of the 12 older dairy farm digesters profiled in Roos and Moser. LP gas savings and operating costs for the lower biogas production level scenarios are based on suggested planning numbers from Roos and Moser's Farmware software.

Case Farm Digester System Investment and Financing

The additional investment required for a digester system above and beyond a conventional manure system includes a mix tank and piping to control the flow of manure into the digester, the digester itself, the engine and electrical generator set, and miscellaneous costs such as engineering costs. The costs of these items amounted to \$355,000 or \$444/cow (Table 1, from Nelson and Lamb, 2000, p. 17). In the five years since this digester was installed (August 1999

to August 2004), the cost of building materials has increased by around 10% while farm machinery has increased by 17%, according to USDA's index of prices paid by farmers. By those measures, the cost of a similar digester system would have risen around 14% to \$506/cow or \$405,000 in 2004.

The case farm faced a certain amount of financial risk when they invested in the digester technology, and have had to devote a considerable amount of time to the planning, communications, and bureaucracy associated with serving as a demonstration site. These costs and risks have been offset at least to some degree by the financial and technical assistance they received from AgSTAR and state programs. The grants and in-kind assistance amounted to \$127,500, or 36 percent of the investment. In addition, the Minnesota Department of Agriculture provided a \$150,000 six-year, zero-interest loan.

Without the demonstration status of the case farm, other operations considering digester systems in the future will probably not receive as much financial assistance as the case farm has received. There are four financial incentives that apparently will be available to operations who install digesters in the future, however:

- The Minnesota Department of Agriculture has funds available to make additional zero-interest loans to three more pilot farms, with the maximum amount increased to \$250,000 per farm (Boerboom).
- An operating subsidy of 1.5 cents/kilowatt-hour (kwh) is available from the Minnesota Department of Commerce to be paid over a period of ten years, to producers who generate electricity from anaerobic digesters that have commenced operations after July 1, 2001 (de Fiebre).
- The renewable energy section 9006 of the 2002 farm bill is another USDA source of grant funding for farm digesters. A total of 47 grants were made in FY03 for biomass projects, totaling \$11.5 million. Grant availability under this program is for a maximum of 25 percent of the project cost, which would appear put a maximum of \$88,750 or \$120/cow for a project similar to the one discussed here. Funds are to be available through FY07 at \$23 million/year. Grants are also reported to be available from electric utilities to help defray the cost of the electrical generation equipment.
- A federal renewable energy tax credit of 0.9 cents/kilowatt-hour is available for digesters placed in service in 2005.

Table 1 shows three scenarios that might represent farms installing digesters in the future in addition to the case farm situation. In one scenario, the future farm receives \$200,000 in grant funding from sources such as the farm bill and a utility as well as the zero-interest loan, the state operating subsidy and the tax credit. The second scenario includes the zero-interest loan, the

state operating subsidy and the tax credit but omits the grants. The final scenario omits all of these financial incentives. As operating subsidies, the operating subsidy and the federal credit are not shown in Table 1 but are shown in later tables of operating performance.

The remainder of the investment would need to be provided by debt obtained from commercial lenders at market interest rates, or from the farm's equity capital. The financial analysis below assumes that 22 percent of the investment is paid from the farm's equity capital, as for the case farm. The remainder is financed from debt. An opportunity cost of 11 percent/year is charged on equity capital and a 7 percent interest rate is charged on debt borrowed from commercial lenders.

Energy Production Performance and Operating Costs

The financial performance of case farm's digester system has been attributed to several main factors:

- higher-than-expected methane gas production rates,
- little maintenance downtime on the engine-generator set,
- the farm had been paying a fairly high price on electricity it had been purchasing from the local utility, so it has saved quite a bit of money by avoiding those purchases, and
- it has also been able to sell its extra electricity back to the local electricity utility at the same high price as it had been paying.

The case farm manager has kept a weekly log of generator operation and gas and electricity production, which was used to calculate the summary numbers shown in Table The case farm's generator has been operating nearly all the time, averaging 98 percent over five years. A benchmark of 95% is used in the financial analysis for projecting the case farm's performance into future years.

Generator running time on other farms profiled by Roos and Moser appeared to average only 62 percent, based on rough calculations based on numbers provided on generator size and estimates of electricity production. On at least one farm, the generator was apparently operated only as needed to meet the farm's electricity needs, because the price offered by the utility was not high enough to make generation for sale worthwhile. Hence, a low runtime performance may be due to the economic situation rather than any unreliability or lack of maintenance. To reflect this history on other farms and the possibility that digester management on future farms

may be less intensive than here at the case farm, other scenarios were also analyzed assuming only 80 or 60 percent of this farm's electricity generation performance.

Table 1. Investment Requirements and Financing Arrangements on the Case Farm and Assumptions about Future Operations

Item	800-Cow Case Farm	Future Pilot Projects with Grants	Future Pilot Projects, No Grants	Post-Pilot Farms
<i>Capital Investment Items</i> (beyond what would have been required for a conventional manure handling system):				
Mix tank/manure collection	\$32,400	\$36,963	\$36,963	\$36,963
Digester	125,100	142,720	142,720	142,720
Energy conversion (engine and generator)	157,500	179,683	179,683	179,683
<u>Miscellaneous</u>	<u>40,000</u>	<u>45,634</u>	<u>45,634</u>	<u>45,634</u>
Total investment	\$355,000	\$405,000	\$405,000	\$405,000
<i>Financing:</i>				
<u>Grants</u>				
AgSTAR technical assistance	\$40,000	\$-	\$-	\$-
Minnesota Office of Environmental Assistance	\$37,500	\$-	\$-	\$-
Minnesota Department of Commerce	<u>\$50,000</u>	\$-	\$-	\$-
Possible utility subsidy on generator, \$400/kw		<u>\$200,000</u>	<u>\$-</u>	<u>\$-</u>
Total grants	\$127,500	\$200,000	\$-	\$-
Percent of investment covered by grants	36%	49%	0%	0%
Net investment required from farm equity or debt capital	\$227,500	\$205,000	\$405,000	\$405,000
<u>Equity Capital</u>				
Amount	\$77,500	\$77,500	\$77,500	\$77,500
Percent of investment paid out of equity capital	22%	22%	22%	22%
Opportunity cost interest rate on equity capital	11%	11%	11%	11%
<u>Loans</u>				
Percent of investment from debt	42%	29%	78%	78%
Subsidized MDA zero-interest loan	\$150,000	\$ 127,500	\$250,000	-
Unsubsidized from commercial lender		\$-	\$ 77,500	\$ 327,500
Interest rate on commercial loan		7%	7%	7%

SOURCES: The case farm data is from Nelson and Lamb, 2000. The data on MDA zero-interest loans for future pilot farms is from Boerboom.

Electricity generation is shown in Table 2 as kilowatt-hours (kwh) generated and either used on the farm or sold, per cow based on the 800 cow herd size reached in the third year of operation. The first electricity was generated in September, 1999, so the 1999-2000 number of 1,670 kwh/cow/year represents somewhat less than a full year. The first full year of operation was 2000-2001, when 2,063 kwh/cow was produced. Electricity generation per cow during 2000 calendar year was somewhat higher than the July-June averages shown, but the per cow average declined in 2001 probably as a result of reaching the maximum generator capacity as the herd grew, averaging 1,295 kwh/cow/year for 2001-2002. The output was down slightly in 2004 to 1,155 kwh/cow due to a repair, which works out to a five-year average of 1,253 kwh/cow. That average is projected to continue for the remaining 5 years of the 10-year planning horizon.

The generator runtime efficiency and particularly the electricity generation are above the benchmarks. Electricity generation is almost twice as great. The higher generator runtime efficiency accounts for most of the increase. The other main factor thought to explain the increased gas and electricity production is the additional volatile solids entering the case farm's manure system in the form of recycled newspaper that is being used to bed the farm's freestall barns. Maintaining an adequate volatile solids level of 10 percent can be challenging on many dairy farms.

The amount of LP gas purchases avoided through use of the methane gas and waste heat from the digester system is the most difficult performance number to estimate for the case farm. The farm manager is recording the amount of LP gas used as a backup heat source. Also needed is an estimate of the LP gas that would have been used if the digester were not in place, however, and that information is not available. The Farmware default benchmark is 10.8 gallons of LP gas/cow/year. The case farm manager was forced to use LP gas to heat the milking parlor and cow holding area for the month of January, 2002, because of a breakdown in the digester system's heat exchanger. On the basis of that one month's data, we estimate that the LP gas savings for the most recent year are 10.5 gallons/cow. The farm recorded more LP gas during the first two years than it did for 2001-02, so less savings are credited for those years for a ten-year average of 9.1 gallons. The avoided LP gas purchases are priced in the financial analysis at 75 cents/gallon for the case farm for the first five years. Global oil prices rose sharply in 2004,

however, so the “future farms” scenarios are based on a price of \$1.15/gallon in year one. The case farm LP price is also increased to that level in the sixth year. Prices for years later than 2004 are increased at three percent per year.

The farm manager estimates that the digester requires around one hour/day for monitoring and maintenance. The system has been so popular, however, that he also spends around two hours/week handling inquiries and giving tours. Those two time commitments then come to an average of 1.3 hours/day or 469 hours/year, which are factored into the analysis at an opportunity cost of \$20/hour placed on the manager’s time. The case farm’s 469 hours/year of operator labor was valued at an opportunity cost of \$20/hour for year 1 and inflated at the same 3 percent rate for the other years.

The case farm did not record any significant repair costs for the first two years, although engine oil and filters cost an estimated \$1,258/year. The third year saw repairs totaling \$13,150. Repair costs were less in the fourth or fifth years, so that operation and maintenance costs (or O&M, including both repairs and labor) averaged around \$15,000/year over the first five years of operation.

A coupling broke between the engine and generator early in the sixth year (2004-05). A new engine was installed at that time to avoid downtime later, although the original engine was still operating. That repair along with a pump replacement has cost around \$110,000 in addition to roughly 200 hours of operator labor. With the labor and normal maintenance, O&M costs will total around \$125,000 this year. The repairs also reduced the electricity output this year.

O&M costs for the remaining four budgeted years are projected at \$25,000, under the assumption that repairs will be more costly than in the early years but that nothing as costly as the engine will be required. Operation and maintenance costs averaged over the ten years and adjusted for inflation to 2004 dollars are 3.1 cents/kwh on the case farm. That average O&M cost could be as much as 3.5 cents/kwh if additional major repairs are required or as little as 2.7 cents if repairs over the remaining years are minimal.

The expected O&M cost for future farms would be about the same as for the case farm. Future farms may avoid the roughly two hours of extra time/week that Mr. Haubenschild estimates that he devotes to educational activities related to the digester, but inflation would likely make up the difference. So, the 3.1-cent rate is also used in the “Future Farms” scenarios.

Electricity Pricing

Electricity pricing and interconnection requirements for connecting small electricity production sites to utility grids are complicated issues which can “make or break” a project financially. Two sources of information about these issues are Helgeson and the Ratevision section of the handbook by Roos and Moser.

The case farm is producing roughly twice as much electricity as the farm consumes, with the excess (46% to date) sold to the local utility cooperative. The case farm was able to negotiate a favorable five-year contract with the utility whereby they were able to sell this extra electricity at the same 7.25 cents/kwh that they would have paid to purchase electricity in the absence of the digester system. The rate increased to 7.3 cents as of January 1, 2001 (Nelson and Lamb, 2002). That contract will expire in 2004.

Electricity pricing for future farms appears far from certain. The two utilities that provide electricity to most of rural Minnesota are Alliant Energy and Great River Energy. Speakers from both utilities spoke at an August, 2002 workshop in St. Cloud, Minnesota and described the purchase prices they were offering for biogas-generated electricity at that time. Alliant Energy serves parts of southern Minnesota, with Great River serving much of the rest of the non-metro parts of the state. The speaker for Alliant Energy mentioned a price of 6 cents/kwh (Johnson). In a later conversation, however, the speaker indicated that the 6-cent price is available to only a few Wisconsin demonstration digesters, due to state-mandated programs in Wisconsin. In the absence of a special regulatory arrangement, Alliant would arrive at a price for digester electricity based on what they are paying for conventional sources, which would currently be in the range of 1 to 1.5 cents/kwh.

The Great River presentation mentioned a choice of contracts of 5, 10, or 20 years in length. For each contract length, there are further choices of either a constant price or one which increases over time (Selander). For the sake of simplicity, the projections below are based on the 10-year, levelized constant price of 3.56 cents for both avoided purchases and sales offered by Great River Energy as of June 3, 2004.

In the projections below, scenario 1 assumes that the case farm will receive the 3.56-cent price for both avoided purchases and sales for years 6 – 10. Scenarios 2 and 3 are also based on

the 3.56-cent price. Scenario 2 also assumes a \$400/kw generator subsidy (\$56,000 total for a generator similar to the case farm's 140-kw unit), while scenario 3 omits that subsidy.

Table 2. Actual and Projected Performance and Operating Costs for the Case Farm's Anaerobic Digester, Compared to Benchmarks Based on Earlier Digesters^a.

	1999-2000	2000-01	2001-02	2002-03	2003-04	Projected		Older Installations ^c
						2004-05	2005-09	
Cows in milking herd, number	400	550	800	800	800	844	800	980
Biogas produced, ft ³ /cow/day	122	130	85	88	84	84	88	57
Electricity generated, cwh/ft ³ of gas	0.0393	0.0436	0.0418	0.0410	0.0410	0.0393	0.0410	0.0373
Generator running time, % of total	98.6%	99.0%	98.4%	99.1%	97.2%	93.4%	95%	62%
Electricity generated, cwh/cow/year	1,670	2,063	1,295	1,314	1,248	1,099	1,239	745
Reduced LP gas use, gal./cow/year	7.25	8.11	10.53	10.53	10.53	10.53	10.53	10.8
Extra Labor Required, hrs/day	1.3	1.3	1.3	1.3	1.3	1.8	1.3	1.6
Repairs and Maintenance Not Including Operator Labor, \$/year	\$1,258	\$1,258	\$13,150	\$5,563	\$5,247	\$110,000 ^b	b	-
Operations and Maintenance including Operator Labor, \$/year	\$10,638	\$10,919	\$23,101	\$15,929	\$16,114	\$125,514 ^b	b	\$10,677
Operations and Maintenance including Operator Labor, \$/kwh	\$0.0159	\$0.0093	\$0.0210	\$0.0139	\$0.0143	\$0.1232 ^b	b	\$0.0146

^aThe performance numbers are calculated based on a year running from July 1 to June 30, in order to provide a roughly 12-month yearly period for the cash flow calculations that includes the construction period of summer and fall, 1999.

^bRepair and maintenance cost for 2004-05 includes a new engine. Repairs and maintenance costs for the remainder of the planning horizon, 2005-09, are inflated using a projected inflation rate of 3%/year.

^c"Older installations" are averages for 12 dairy farms profiled in Roos and Moser, except for reduced LP gas use which is based on Farmware default data. Not all farms reported information on all parameters. Generator running time on the profiled farms of 62% is based on numbers provided on generator size and estimates of electricity production. Electricity generated on the profiled farms averaged 745 kwh/cow/year. On at least one farm, the generator was operated at less than full capacity because the price offered by the utility was not high enough to make generation for sale worthwhile.

The 3.56-cent price implies that if a future farm were to generate twice as much electricity as it uses, and if it paid 7.3 cents for the usage while receiving 3.56 cents for all of the generated electricity, the sales revenue would be less than the payment and it would end up still owing the utility a net payment despite the fact that it is generating twice its usage in physical terms. This may seem unfair from the producer's viewpoint, but the logic from the utility's point of view relates to the expected pattern of usage between peak and non-peak time periods. Much of the generated electricity is expected to occur during non-peak times, while usage is more likely during peak times. Actual pricing arrangements that future farms negotiate would likely consider load patterns explicitly and might result in an average price higher than the 3.56 cents assumed here.

Again, while the scenarios discussed below are based on the data from these two presentations by utility representatives, our understanding is that these prices and terms are subject to change and may be different by the time you read this. Check with your utility representative for the latest information before basing any decisions on this analysis.

Benefits of the Digester Other Than Energy Production

Economists who evaluate new technologies frequently must decide how reliable the purported benefits are and when they are sufficiently well-documented to include in the analysis. Proponents of the technology are often enthusiastic about performance, while others are more skeptical.

While the electricity production is the best-documented aspect of the digester system, the Haubenschields feel that their operation is also benefiting in several other ways. The main benefits that they have observed are:

- some digested manure is being sold to a neighbor,
- less agitation is required for the manure storage pit before starting to empty it,
- more flexible timing of manure application because part of the digestate is applied to alfalfa stubble with minimal risk of burning the plants,
- some manure is being sold to a neighbor,
- fewer broadleaf weed problems are occurring on the corn, making it possible to avoid a post-emergence herbicide application,
- Fewer complaints from neighbors about odor after spreading, and
- Possible future carbon credits

An explanation of each benefit is provided below:

Sales or Utilization of Digestate

Mr. Haubenschild has been selling digestate to a neighbor for several years. In 2002, he replaced a smaller tank applicator with a 4,000-gallon one. He charged \$100/load in 2000 which includes the digestate and applicator, with the purchaser supplying the tractor and operator. He sold 17 loads in 2000 for a total of \$1,700.

Mr. Haubenschild feels that he would not have been able to sell that as raw (undigested) manure, so he credits the entire \$1,700 to the digester. If one were to assume that a buyer could have been found to purchase the raw manure at its fertilizer replacement value, it would have been worth \$47/load at an analysis of 38-13-34, 75 percent availability, and N, P and K prices of \$0.20, \$0.28, and \$0.13. The value added by the digestion process would then have been \$53/load, or a total of \$901. But that is somewhat hypothetical if, as Mr. Haubenschild believes, the neighbor is not willing to buy raw manure, perhaps because of odor concerns. These calculations, then, suggest valuing annual digestate sales at between \$900 and \$1,700. Sales in 2004 were only \$200, however. So, a ballpark estimate of \$1,000/year is used in this analysis. The number used in the model is $(\$1,000/800 \text{ cows}) = \$1.25/\text{cow}$ for year 1, with later years inflated at 3%/year.

The other possible benefit cited in some digester studies is utilization of solids separated after digestion, composted and then used as bedding in the dairy barn free stalls (see, for example, Kramer). The case farm has access to paper for bedding so is not interested in this, but it was considered as a possible benefit in the future farm scenarios. Mr. Haubenschild has heard other farm operators estimate annual bedding costs of \$19/cow, which would amount to a savings of \$15,200/year for an 800-cow dairy operation. One concern about using composted solids for bedding is that enough pathogens might remain to cause increased mastitis problems. Aside from that, however, an additional investment would be required for the manure separator and composting site, which he estimates would be around \$80,000 for a fan-type separator. Additional operating expenses would also be involved. A University of Minnesota analysis found that a screen-type separator for a 500-cow dairy farm would cost around \$30/cow in annual capital ownership (\$17.41), operating (\$7.35), and labor (\$5.33) costs. Newer separator designs may operate more reliably and efficiently than the one considered in that study, but still

it appears that the benefits would need to be greater than \$19/cow for separation to be economical. So, the bedding option has not been included in the future farm scenarios.

Reduced Pit Agitation Before Emptying

Mr. Haubenschild feels that as a result of solids breaking down in the digester, the digestate develops less of a crust in the outside earthen manure storage pit than raw manure would. The lack of a crust allows him to begin loading the liquid digestate into his applicators without agitating first. If the pit had a normal crust, he would have to agitate with two 130-horsepower tractors and pumps (one at each end of the pit) over two 12-hour days before emptying. At an estimated cost of \$26/hour (from Lazarus and Selley), this amounts to an annual savings of \$1,248.

Digestate Application to Alfalfa

The crop mix on the case farm includes corn and alfalfa. In 2002, the acreage was 678 acres of corn and 277 acres of alfalfa, for a total of 955. Both the corn and the alfalfa have been receiving around 6,000 gallons of digestate per acre, with the alfalfa application being split into three separate applications each made within a few days of each cutting. Mr. Haubenschild feels that the digestate has less potential to burn the regrowing alfalfa than raw manure would. If he did not have the digester, he might still apply some manure to the alfalfa but would have to do it more quickly after each cutting to avoid problems.

Valuing this consideration is difficult. U of M agronomists feel that additional research is needed to determine how much difference in burning potential there really is. In the absence of that definitive research, we have done a rough calculation under the assumption that the 30 percent of the digestate now going on the alfalfa were instead sold to a neighbor for half of the application cost. He has estimated that his alfalfa fields are an average of 1.2 miles from the facility, slightly closer than his corn fields which average 1.8 miles away. One disadvantage of applying to the alfalfa is that the N in the digestate is basically wasted. Still, the P and K are needed on the alfalfa (assumed to require 50 pounds of P and 180 pounds of K per acre). Valuing the digestate at what it would save in commercial fertilizer minus its application cost at a 1.2-mile hauling distance comes to \$10,249/year, using the model from Lazarus and Koehler. If he were to haul it 1.8 miles instead and apply at the 6,000-gallon rate, the application cost is estimated at \$6.79/1,000 gallons. If he were able to sell it for enough to recover half of that

amount, it would come to \$3.40/1,000 gallons or \$5,349/year. So, the additional value resulting from the alfalfa application instead selling it, is the difference (\$10,249 - \$5,349) or \$4,900/year.

Agronomists are unsure about how much difference digestion makes when applying manure to alfalfa, and whether alfalfa should receive manure at all given that the N is not needed by that crop. Further research is needed to determine how likely these non-energy benefits are to occur in a typical installation. So, the magnitude of these non-energy benefits should be viewed cautiously for now.

Reduced Broadleaf Weed Problems

Mr. Haubenschild has observed that he has less severe weed problems on his digestate-receiving land than is the case on other cropland he farms or observes elsewhere in the area. Proso millet, in particular, seems to be less of a problem. Lambsquarters and velvetleaf are other weed species that may be affected, although he does not see much of the latter. His herbicide program includes a pre-emergence herbicide, and then if broadleaf weeds emerge later he comes back with a post-emergence herbicide that costs around \$30/acre. That second application was not necessary last year and may not be needed this year. Other land he rents at another location which does not receive digestate, has weed problems this year and will need the second herbicide application. He believes that the difference may be that the weeds may germinate more quickly in the spring on the digestate-treated land as a result of going through digestion, and be killed by the pre-emergence herbicide.

If the \$30/acre savings estimate is accurate, the benefit will be substantial. His 2003 corn acreage is 770 acres, so a herbicide savings of \$30/acre amounts to \$23,100/year in additional benefit. That is still less than the value of the electricity that the case farm is producing, but is almost as much as the electricity might be worth to future farms selling at a 3 cent/kwh rate or at a lower output rate. However, experiments have thus far shown that immersion of weed seeds in the digester does not have a statistically significant impact on germination rates of most weed species (see Nelson, Allen and Katovich). So, the possible herbicide savings are not factored into the economic comparison below, pending additional documentation.

Fewer Odor Complaints and Possible Carbon Credits

The desire to be a good neighbor and avoid odor complaints from residences near the facility was one of the main reasons for installing the digester. The scope of this project did not extend to valuing that benefit, however.

Credits for carbon sequestration or emissions reductions are another possible future benefit which has not been valued in this analysis. The Chicago Climate Exchange (CCA) has recently begun trading carbon dioxide futures contracts (see http://www.chicagoclimatex.com/trading/stats/monthly/st_0409.html for details). The contract prices are for reductions that the exchange members make in their CO₂ emissions relative to a 1998-2003 base. The exchange members agree to reduction targets. Then, if a member misses a target, that member could purchase the right to emit the extra amount from another member that has reduced an emission by more than their target. There are only a few members of that exchange at this time and they tend to be large corporations rather than farms. So, the idea of a dairy farm generating cash income by selling CO₂ reductions to exchange members who have missed targets is obviously speculative at this point. However, given the public interest in this topic, we have estimated the potential carbon credit value a future farm might generate based on the 2002 methane digester gas output recorded at the case farm, using the September 2004 average Chicago Climate Exchange CO₂ futures price for delivery in 2005 or 2006. The estimated value is \$825/year, assuming the farm were show a reduction in emissions compared to the 1998-2003 base or some other arrangement. Because the case farm's digester went into operation in late 1999, the present operation would not result in CO₂ reductions compared to a 1998-2003 base even if a marketing arrangement were to be set up. Future digester installations, however, might be able to document reductions required to potentially capitalize on this revenue source.

Biogas generated/day, 2002 average, cu. ft.	68,605
Biogas generated/year, 2002 average, 1,000 cu. ft.	25,041
Methane % in biogas	60%
Methane generated/year, 2002 average, 1,000 cu. ft.	15,024
Methane volume to wgt conversion, cu ft./metric ton	48,700 ^a
Methane generated/year, 2002 average, metric tons	309
CO ₂ greenhouse equivalent of methane	18.25
CO ₂ equivalent burned in 2002, metric tons	5,630
Futures price for delivery in 2005 or 2006 on the CCA, average for Sept. 2004, per metric ton CO ₂	\$ 0.96 ^b
Potential value of methane burned if sold on CCA	\$ 5,405

^a <http://www.eia.doe.gov/emeu/iea/tablec1.html>, assuming natural gas

^b http://www.chicagoclimatex.com/trading/stats/monthly/st_0409.html

Total Non-Energy Benefits

The total of the digestate sales (based on \$2.13/cow), the \$1,248 in avoided pit agitation, and \$4,900 in avoided alfalfa fertilizer is \$7,848/year for year 1. Later year values increase at the 3% inflation rate, plus the digestate sales amount is increased as the herd increases to 800 cows in year 3.

Tax Considerations and Capital Pricing

The economic analysis is carried out on an after-tax basis. A marginal tax rate of 35 percent is used for all scenarios, representing both U.S. and Minnesota income taxes. The digester system is assumed to be classified as a “single-purpose livestock structure” for depreciation purposes, except for the engine-generator set which is classified as “farm machinery”. The tax deductions for depreciation are based on a year 2001 declining-balance GDS schedule with a half-year convention, over seven years for the engine-generator and 10 years for the rest of the system.

A 10-year annual cash flow was calculated in the Excel template and compared against one calculated by the Farmware program. The cash flows compared very closely, with the exception of the depreciation expenses. Farmware allocated more of the depreciation to the first few years. Farmware was published in 1997, so we suspect that the discrepancy may be due to a change in the tax rules depreciation between 1997 and 2001. The Farmware documentation does not discuss their assumptions about depreciation, so we are not sure.

Taxability of government incentives for renewable energy such as the 1.5-cent state production subsidy is unclear at this time. The Internal Revenue Service has form 6497 for government agencies to use to designate energy grants or subsidized financing as nontaxable, apparently at the agency’s discretion. The form instructions state: “Grants are always taxable to recipients unless specifically exempted by the Federal statute authorizing the grants.” On that basis, the production subsidy is assumed to be taxable for the purposes of this report.

Comparative Economic Analysis

Three likely future scenarios are compared with the case farm’s economic performance in and Figure 1 and Table 3. They consider the values of the energy (electricity and heat) produced from the digester and the non-energy benefits discussed above (digestate sales, avoided pit agitation, and alfalfa application), if the possible herbicide savings are not considered.

Scenario 1 represents the case farm, with five years of actual performance and projections for another five years of a ten-year planning horizon, with both avoided electricity purchases and sales priced at 7.29 cents/kwh for the first two years, 7.3 cents for years three through six, and 3.56 cents for the last four years. When these prices are adjusted to 2004 levels based on recent inflation rates, they average 5.7 cents/kwh in 2004 dollar terms. The “Future Farms” scenarios 2 and 3 are based on Great River Energy’s projected 10-year constant price of 3.56 cents/kwh, but the real purchasing power of those prices in the later years will be less if there is inflation. Discounting those prices back to a 2004 present value at 3 percent/year results in an average of 3.1 cents/kwh in 2004 dollars. Electricity production for all four scenarios is as shown in Table 2, and averages 1,253 kwh/cow/year.

“Future Farms With Grants, Loans and Subsidies” scenario 2 includes the \$200,000 USDA and utility grant amounting to 49 percent of the total system’s investment. The remaining investment is assumed to be provided as 29 percent debt and 22 percent equity, which is the same ratio as for the case farm. The debt capital is in the form of a \$127,500 zero-interest loan from the Minnesota Department of Agriculture. The 11 percent opportunity cost is charged on the equity capital. This scenario also includes the 1.5-cent state production subsidy and the 0.9-cent federal renewable fuel tax credit.

The “Future Farms with Loans and Production Subsidies” Scenario 3 omits the grants but includes the other incentives. The MDA loan increases to the maximum \$250,000, with the remaining \$77,500 from a 7 percent commercial loan. Scenario 4 omits all of the financial incentives to reflect a situation that might prevail once the biogas concept moves beyond the pilot phase. It leaves out the utility generator grant and assume that all of the debt comes from a commercial lender at a 7 percent rate.

Several different decision criteria were examined in the analysis:

1. Simple payback period,
2. Internal rate of return (IRR) on assets and on equity capital, ignoring any value on the investment beyond ten years,
3. Net present value (NPV) on equity capital
4. NPV converted to a constant annual cash flow equivalent
5. Debt servicing cost, \$/cwt of milk
6. Additional capital debt repayment capacity resulting from the benefits, as a percentage of the amortized capital service cost of the investment, and
7. Change in the milk production cost, \$/cwt.

Brief explanations of these criteria are as follows:

The *simple payback period* is the expected years required to recover the original investment. The simplicity of this measure is appealing, but it is criticized by academic economists because it does not consider preferences that most people have for receiving money in the near future rather than later on (referred to as the “time value of money”). The IRR and NPV are preferable from that standpoint, but are more complex. The NPV is the sum of the cash inflows and outflows (CF) over expected n years of project life, discounted at the project’s cost of capital k,

$$NPV = CF_0 + \frac{CF_1}{(1+k)^1} + \frac{CF_2}{(1+k)^2} + \dots + \frac{CF_n}{(1+k)^n} = \sum_{t=0}^n \frac{CF_t}{(1+k)^t}$$

The IRR is that discount rate which equates the present value of a project’s expected cash inflows to the present value of the project’s costs. The IRR assumes that the cash flows are reinvested at the IRR. Some users like the internal rate of return (IRR) as a criterion because it is a percentage that can be compared to interest rates charged by lenders. The NPV of the return on equity shown in Table 3 is calculated based on the 11 percent opportunity cost of equity mentioned previously

The *Internal Rate of Return (IRR) on assets* ignores financing issues. That is, it assumes that all of the initial investment for the digester construction (net of grants) is paid for out of the farm’s equity capital, without borrowing. The reason for making this simplifying assumption is to separate the question of profitability of the digester investment, on one hand, from the question of how to finance it. This separation of the questions of profitability and

financing should make it easier for readers to generalize the results to other situations where the financing possibilities may be different. It should be noted that since financing is not considered, the IRR on assets is not affected by the availability of low- or zero-interest subsidized financing such as the case farm received from the Minnesota Department of Agriculture.

The *internal rate of return on equity capital* and the *net present value* and *annual cash flow equivalent (AECF)* measures shown below, on the other hand, do consider financing. That is, the annual cash flows used to calculate these measures include the \$77,500 in initial equity capital and the payments on the debt financing shown in Table 1 above. The IRR on equity capital tends to fluctuate more across the scenarios than does the IRR on assets, because the fixed debt payments are netted out of cash flows before calculating the IRR on equity capital. That is, we start with a varying net operating cash flow, and subtract a fixed debt payment. The difference, then, fluctuates more percentagewise than did the original cash flow. In this case, the debt payments are not quite fixed across the seven scenarios because the debt interest rate is zero for scenarios 1 – 4 and seven percent for scenarios 5-7. But, this difference is still much less than the difference in the operating cash flows, so in Table 4 the IRR on equity capital varies from 39% to less than -10%, while the IRR on assets only varies from 20% to -6%.

The NPV can be converted to a constant AECF, so this measure was added for the convenience of such readers who prefer annual dollar measures. An earlier version of this paper included only the IRR and NPV, but a reader then asked how the economics of the digester would compare to other odor control methods such as pit additives that don't require a major investment but do involve significant annual operating expenditures. The AECF is a constant annual amortization payment which, over the n years of project life, has a present value equal to the NPV of the project. is simply a constant amortization payment similar to what a borrower would typically pay on a mortgage loan, and is easily calculated using Excel's PMT function. The AECF measure is particularly useful for analyzing investment alternatives with unequal lives – ten years in the case of the digester and perhaps one year or less for the pit additive alternative.

Change in milk production cost per hundredweight is calculated from the AECF divided by milk production, with the milk production valued at an estimated long-run value of \$12.50 per hundredweight.

The annualized present values of the various benefits and the operating and total annual cost of the digester system are shown in Figure 1. The per-cow numbers are based on the current herd size of 800 cows, with the recognition that the herd size was smaller in the first two years of operation.

The general arrangement of the figures are that the operating and maintenance costs and total annual costs of owning the digester system are shown as lines, while the benefits are shown as bars. The total cost numbers are calculated as if the system were financed at market rates on capital – 7 percent on debt and 11 percent on equity. The grants and the interest subsidy on the zero-interest loan are then shown as offsetting benefits.

The components of the bars represent the benefits that were discussed above. The electricity and LP gas savings are shown at the bottom of the bars. The government and utility incentives (grants and the production and interest subsidies) are shown next. The non-energy benefits are shown at the top because they are thought to be more speculative at this point. Locating them at the top makes it easier to determine how important these non-energy benefits are to making the investment break even.

Figure 1 shows that the LP gas savings, electricity, and non-energy benefits would not have covered the total cost of the digester system on the case farm without the grants and subsidies. The second bar shows a similar future scenario but with the electricity priced at only 3.56 cents. At that lower price, even the subsidies are not quite enough to provide profitability. The third and fourth bars show reduced electricity generation performance of only 80 and 60 percent of what the Haubenschilds have achieved. The last three bars show that the unit would not be profitable without the subsidies.

figure 1.

Methane Digester Costs and Benefits at The Demonstration Farm and Possible Future Scenarios With and Without Government Subsidies

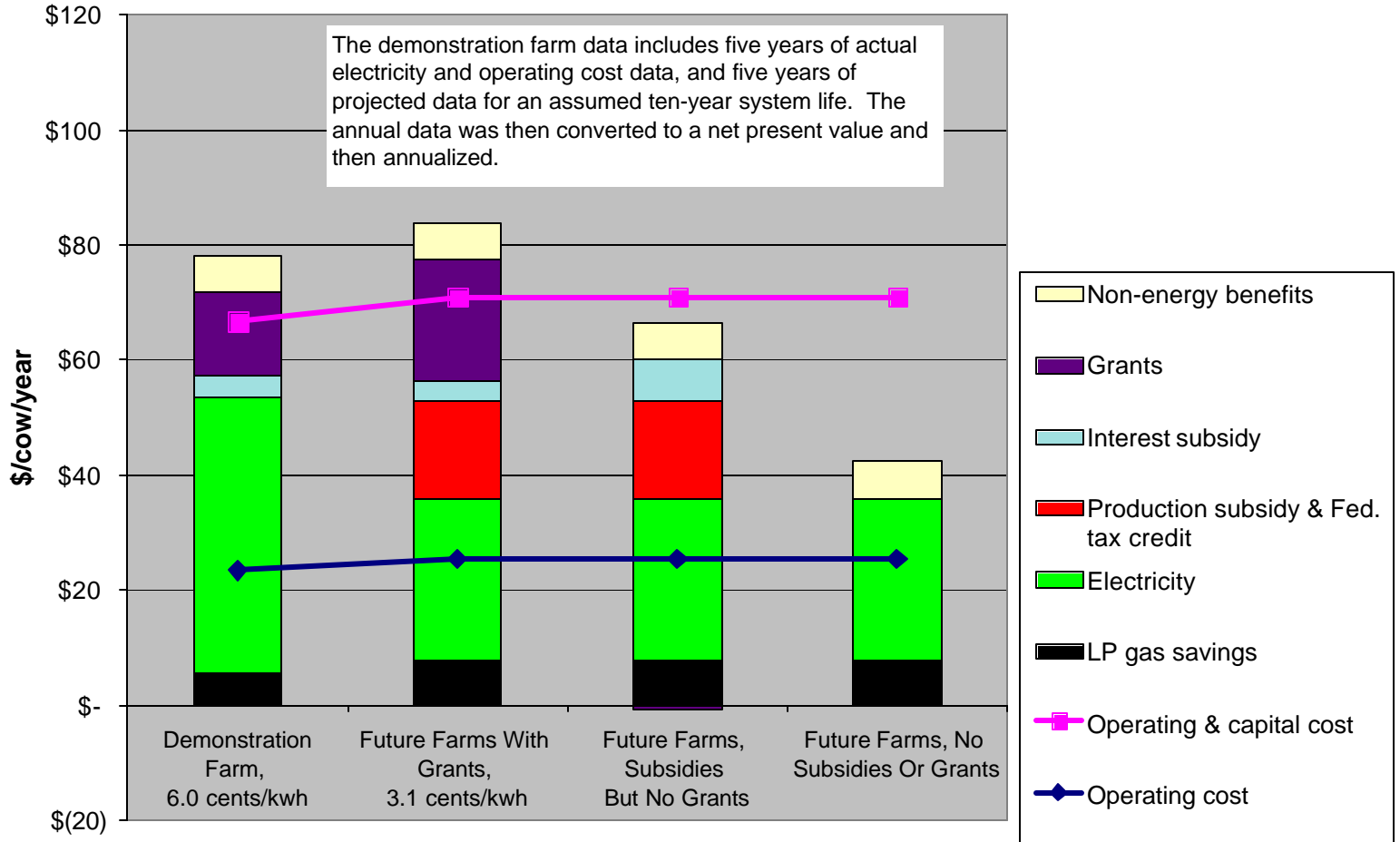


Table 3 provides additional details for the four scenarios. Scenario 1 shows that the case farm's system's payback period is 4 years, with a 11 percent return on the \$355,000 investment, or a 26 percent internal rate of return on the \$77,500 of equity capital after subtracting principal payments on the 6-year zero-interest loan. The payback period for Scenario 2 is only 3 years because nearly half of the investment has been covered by the \$200,000 in grants. The return on investment is 13 percent with a 30 percent return to the equity capital invested.

The payback period is over 10 years for the future farm scenarios without the grants, whether the loan and subsidies are included or not. The loan and subsidies bring Scenario 3 close to breakeven, with a negative 1% return on assets and an annualized net present value of \$-5,696. Without any incentives, Scenario 4 shows a substantial loss of an annualized \$-30,583. Scenario 4 would result in a 2% percent increase in the milk production cost. The net present values and annualized net present values in Table 3 are calculated using an after-tax capital cost of 5.6 percent on assets or 7.15 percent on equity.

Table 4 shows how the amount invested in a digester system would affect the cost-effectiveness of the investment, assuming the design and performance is similar to that of the demonstration farm but with the electrical prices and state and utility incentives that might be available to a farm installing a digester today, based on the “Future Farms With Grants, Loans and Subsidies” Scenario 2. The first column, “Annualized Capital Costs”, corresponds to the total cost line of the graph minus the value of the grants and interest subsidy sections of the graph bars. “Operating Returns” represents to the other benefits shown in the graph and corresponds to the height of the bar. “Annualized Net Present Value” is the difference between the returns and costs. The last column then puts this net on a rate-of-return basis. Returns go negative at an investment of \$500/cow or more.

Little data is available on the O&M costs of older digesters such as cleanouts of accumulated solids and scum. Moser and Langerwerf report that cleanout and maintenance of a sixteen-year-old digester on a 400-cow California dairy cost around \$50,000 in 1998. Given the uncertainty about future O&M costs on the case farm’s and future farms’ digesters, another calculation that was made in this analysis was to calculate a time-discounted net present value of the cash flows expected on the case farm over the remaining four planning years. That net present value gives the additional O&M expenditures that would be justified, over and above the \$25,000 currently projected, in order to keep the digester system operating that much longer. Present indications are that the digester will probably operate more than another four years, in which case the breakeven additional O&M estimates below are on the conservative side.

The projected after-tax cash flows and breakeven O&M costs by year are shown below. For example, it would be worthwhile to spend up to an additional \$123,495 at the beginning of 2005-06 in order to keep the digester running and generating four years of cash flows. By the

beginning of 2008-09, however, one would only be able to justify an expenditure of \$31,328 (on top of the currently budgeted \$25,000) in order to generate the final year's after-tax cash flow of \$21,819:

<u>Year</u>	<u>2005-06</u>	<u>2006-07</u>	<u>2007-08</u>	<u>2008-09</u>
After-tax net cash flows	\$ 26,530	\$24,244	\$21,951	\$21,819
Breakeven additional before-tax O&M justified by after-tax cash flows through end of year 10	\$ 123,495	\$91,510	\$60,754	\$31,328

Summary

The performance of the case farm's anaerobic digester system to date looks profitable to date, which can be attributed partially to careful management by a motivated and detail-oriented manager who has achieved outstanding digester and generator performance, and partially to favorable electricity pricing by the local utility along with assistance from various government agencies due to the demonstration status of the system. Future installations will not be eligible for the grants and zero-interest loan the case farm received and will likely not receive as high an electricity price. At the electricity prices currently being discussed, a smaller new operating subsidy would not be quite enough to assure profitability if performance is comparable to the case farm's performance. However, even without the non-energy benefits a digester may still be cheap "insurance" against odor complaints and lawsuits even if operating at a loss.

Table 3. Comparative Analysis of Benefits of Digester System Scenarios With Varying Electricity Prices and State and Utility Incentives, Compared to the Case Farm^a

	Demonstration farm	Future Farms With Grants, Loans and Subsidies	Future Farms With Loans and Production Subsidies	Future Farms, No Incentives
INVESTMENT PER COW	\$ 444	\$ 506	\$ 506	\$ 506
Grants as % of Investment	36%	49%	0%	0%
Debt as % of Investment	42%	29%	78%	78%
MDA zero-interest loan	\$ 150,000	\$116,600	\$250,000	\$ -
MN production subsidy	\$ -	\$ 0.015	\$ 0.015	\$ -
Federal energy tax credit (first 5 yrs)	\$ -	\$0.009	\$0.009	\$ -
Electricity generated, kwh/cow/yr	1,253	1,253	1,253	1,253
LP gas savings, gal./cow/yr	9.1	9.1	9.1	9.1
Electricity O&M cost w/labor (in 2004 dollars), \$/kwh	\$0.031	\$0.031	\$0.031	\$0.031
Breakeven electricity generation price (in 2004 dollars), \$/kwh	\$0.050	\$0.019	\$0.045	\$0.084
Average electricity price received (in current dollars), \$/kwh	\$ 0.058	\$ 0.036	\$ 0.036	\$ 0.036
Average electricity sale price received (in 2004 dollars), \$/kwh	\$0.057	\$0.031	\$0.031	\$0.031
Simple Payback Period, Years	4	3	10+	10+
Internal Rate of Return on Assets	11%	13%	-1%	-10%
Internal Rate of Return on Equity	26%	30%	-6%	<-12%
Net Present Value of Return on Equity	\$64,382	\$73,637	\$(39,730)	\$(213,319)
Annualized Net Present Value	\$9,230	\$10,557	\$(5,696)	\$(30,583)
Change in milk production cost	-0.6%	-0.7%	0.4%	2.0%

^a A 10-year planning horizon is assumed, starting on July 1, 1999 for the demonstration farm and January 1, 2004 for the other scenarios. The per-cow numbers are based on the current herd size of 800 cows feeding the digester. The herd size was smaller during the first two years of operation, so the ten-year average herd size is 735 cows. *Other* benefits include digestate sales, avoided pit agitation, and more flexible timing of manure application, but *not* herbicide savings or any value on odor control or carbon credits.

Table 4. Sensitivity Analysis of Financial Performance As Investment Varies, for a Future Digester with Current State and Utility Incentives, Per Cow Basis^a.

Investment	Annualized Capital Costs^b	Operating Returns^c	Annualized Net Present Value^d	Rate of Return to Equity
\$400	\$(18)	\$37	\$19	46%
\$500	\$(22)	\$37	\$15	31%
\$600	\$(27)	\$37	\$10	20%
\$700	\$(32)	\$37	\$5	12%
\$800	\$(36)	\$37	\$1	7%
\$900	\$(41)	\$37	\$(4)	2%
\$1,000	\$(45)	\$37	\$(8)	-2%

^a The values in this table correspond to Scenario 2, "Future Farms With Incentives, Performance 100% of Case Farm" in Table 3.

^b "Annualized Capital Costs" corresponds to the total cost line of the Figure 1 minus the value of the grants and interest subsidy sections of the graph bars.

^c "Operating Returns" represents to the benefits shown in the Figure 1 other than the grants and interest subsidy.

^d "Annualized Net Present Value" is the difference between the returns and costs and corresponds to the second line from the bottom of Table 1, converted to a per-cow basis.

REFERENCES

Boerboom, Jim. "Financing Your Project," presentation at Digesters for Managing Animal Waste: A Practical Workshop, August 21, 2002, St. Cloud, Minnesota.

Brigham, E.F. and J.F. Houston. Fundamentals of Financial Management. Hinsdale, Illinois: Dryden Press, 1997.

Chicago Climate Exchange, "September 2004 Monthly Market Summary, CCX Carbon Financial Instruments (CFIs, web site),"

http://www.chicagoclimatex.com/trading/stats/monthly/st_0409.html, accessed October 20, 2004.

de Fiebre, J., Minnesota Department of Commerce, St. Paul, Minnesota. Personal communication, July 25, 2002.

U.S. Environmental Protection Agency, "The AgSTAR Program," accessed 8/2/2002. <http://www.epa.gov/agstar/operation/index.htm>

Hagy, William F. Funding Assistance and Other Initiatives. Presentation at the AgStar National Conference. 3/24/2004.

Hawkins, R., R. Craven, K. Klair, R. Loppnow, D. Nordquist, and W. Richardson. FINPACK User's Manual, Center for Farm Financial Management, University of Minnesota, St. Paul.

Helgeson, P. "Utility Connect Issues," presented at the Wisconsin Manure Biogas Symposium, Plover, Wisconsin, April 4, 2002 (Proceedings available on CD from the University of Wisconsin Center for Dairy Profitability, Madison, Wisconsin).

Johnson, Bill. "Selling Your Electricity," presented at "Digesters for Managing Animal Waste: A Practical Workshop," St. Cloud, Minnesota, August 21, 2002

Lazarus, W.F. and R.G. Koehler. "Economics of Applying Nutrient-Rich Manure at Low Rates." Review of Agricultural Economics 24(2002):141-159.

Lazarus, W.F. and R. Selley. "Minnesota Farm Machinery Economic Cost Estimates for 2002." FO-6696, University of Minnesota Extension Service, September 2002, <http://www.apec.umn.edu/faculty/wlazarus/mf2002.pdf>.

Kosbab, Steve, Great River Energy. Personal communication, 7/30/02.

Kramer, Joseph M. "Agricultural Biogas Casebook." Resource Strategies, Inc., September 2002, available at <http://www.mnproject.org/>.

Moser, M.. and L. Langerwerf. Langerwerf Dairy Digester Facelift: What We Found When We Took Apart a 16 Year-old Dairy Plug Flow Digester. http://www.epa.gov/agstar/resources/lag_cons.html.

Nelson, C. and J. Lamb. Final Report: Haubenschild Farms Anaerobic Digester, The Minnesota Project, 1885 University Avenue, Suite 315, St. Paul, Minnesota 55104, December 2000, <http://www.mnproject.org/pdf/haubyfinal3.pdf>.

Nelson, C. and J. Lamb. Final Report: Haubenschild Farms Anaerobic Digester, Updated, The Minnesota Project, 1885 University Avenue, Suite 315, St. Paul, Minnesota 55104, August 2002, <http://www.mnproject.org/index-main.html>.

Nelson, C.; D. Allen; and J. Katovich. "Fertilizer Value and Weed Seed Destruction Potential of Digested Manure." Presented at Anaerobic Digester Technology Applications in Animal Agriculture: A National Summit, Raleigh, NC, June 2-4, 2003, <http://www.mnproject.org/pdf/Raleigh%20paper-%20nutrients&weeds.pdf>.

Roos, K. "Status and Issues Facing the Anaerobic Digester Industry Relative to the U.S. Livestock Market," presented at the Wisconsin Manure Biogas Symposium, Plover, Wisconsin, April 4, 2002 (Proceedings available on CD from the University of Wisconsin Center for Dairy Profitability, Madison, Wisconsin).

Roos, K.F. and M.A. Moser. AgSTAR Handbook: A Manual for Developing Biogas Systems at Commercial Farms in the United States. U.S. Environmental Protection Agency, Atmospheric Pollution Prevention Division.

Selander, Stan. "Selling Your Electricity," presented at "Digesters for Managing Animal Waste: A Practical Workshop," St. Cloud, Minnesota, August 21, 2002.

USDA National Agricultural Statistics Service, Agricultural Prices, August 1999 and August 2004, <http://usda.mannlib.cornell.edu/reports/nassr/price/pap-bb/>.

U.S. Energy Information Administration, "Voluntary Reporting of Greenhouse Gases Program, Fuel and Energy Source Codes and Emission Coefficients (web site)," <http://www.eia.doe.gov/oiaf/1605/coefficients.html>, accessed October 20, 2004.

Vincze, Zsolt. "Economic Evaluation of a Manure Separator System for Minnesota Dairy Farms," Plan B paper, Department of Applied Economics, University of Minnesota, July 1996.

Whole-farm comparison of the Haubenschild confinement dairy operation to a different dairy farm that is using rotational grazing

Introduction

Methane gas production on dairy farms has garnered a great deal of interest. Investment in anaerobic digestion and electricity generation is substantial. The returns to the farm need to be assessed over the long-term. Returns are a function of the amount of electricity generated, the price received for excess electricity, as well of the financing arrangements. All of these factors are examined in the context of whole farm financial performance.

Haubenschild Dairy, located in Princeton MN, provides a case study of an anaerobic digester on a dairy farm. Methane gas is collected from the manure and piped to a generator, where it is converted to electricity. Great River Energy purchases the electricity. In addition to producing electricity, capturing methane reduces manure odor. This aspect of the anaerobic digester is important for Haubenschild Dairy as it is located in close proximity to urban populations.

The computer program FINPACK was used for the analyses. A subroutine call FINLRB allows for long-range planning. Budgets for cropping, dairy and electricity production are developed based on Haubenschild Dairy information. These budgets are used with an initial balance sheet (base plan) to develop a number of 'what if' scenarios. For example, what if investment is made in a methane digester and electricity pricing and production mirror Haubenschild's current levels? The analyses show expected farm financial performance under different electricity pricing, production and financing scenarios.

Crop acreage and yield

Cropping and milk production parameters are based on the production history of Haubenschild Dairy. Table 1 provides a description of typical individual crop acres and average crop yields. Again, these are based on historic crop yield. There are 975 crop acres. The analyses are based on 929 dairy cows with an average annual milk production of 21,000 pounds per cow.

Table 3: Crop acreage and yield

<i>Crop</i>	Acres	Yield per acre
Corn Silage	262.2	17 tons
Feed Corn	431.1	120 bu
Alfalfa Haylage	181.3	9 tons
Mixed alfalfa/grass hay	100	4.5 tons

The capital cost of the Haubenschild Dairy methane digester is presented in table 2. The total cost of the methane digester system was \$355,000. The digester was financed through a

combination of grants, loans and equity provided by Haubenchild Dairy. There was a total of \$127,500 in grants, \$150,000 interest-free loan from the Minnesota Department of Agriculture and \$77,500 equity (cash) invested by Haubenchild Dairy. It is important to note, the capital costs are for a methane digester built in 1999. In addition, a significant amount of labor was provided by Haubenchild Dairy in the construction of the digester. This in-kind contribution is not included in the construction cost. The cost of anaerobic digesters is dependent on the type of digester built. It is possible the cost of a methane digester could exceed \$600,000 today.

Table 4: Capital Cost for Haubenchild Dairy Methane Digester

Item	Amount
Mix Tank and Collection	\$32,400
Digester	\$125,100
Energy Conversion	\$157,500
Miscellaneous	\$40,000
Total	\$355,000

Haubenchild Dairy With and Without Methane Digester

The base plan is a farm that was identical to Haubenchild Dairy in terms of cropping and milk production but does not have an anaerobic digester. An initial balance sheet for the base farm was created using Haubenchild Dairy's balance sheet with adjustments made to reflect a lower debt load and lower asset values by not investing in the methane digester. The base plan balance sheet is presented in Appendix D.

Crop and livestock budgets were developed using production and cost information from Haubenchild dairy. The budgets are presented in Appendix E. Chemical costs for feed corn and corn silage with the methane digester are one-half of the crop chemical costs without the methane digester. The lower chemical cost with the methane digester is based on Haubenchild Dairy's experience that one chemical pass provided sufficient weed control when digestate (manure that has passed through the methane digester) was applied to cropland.

Budgets were developed for electricity production. Electricity price for sales is 5.34 cents per Kwh and electricity production is 800 Kwh/cow annually. These are based on Haubenchild's current electricity production and pricing contract.

Table 3 presents the income statement for the base plan (no methane digester) and Haubenchild's current methane production situation. It is important to note from the outset that electricity sales represent a small portion of gross farm income. Under the current electricity price-production structure, electricity represents only 2% of gross farm income. As such, the whole farm impact of methane production is likely to be relatively small.

Table 5: Income statement with and without methane digester

	Base Plan	Haubenchild Dairy
Milk Sales	\$2,926,350	\$2,926,350
Electricity Sales		\$ 39,687
Gross Farm Income	\$3,295,492	\$3,335,179
Fuel and oil expense	\$ 34,032	\$ 30,032
Utilities	\$ 65,253	\$ 30,092
Other Cash Expenses	\$2,489,976	\$2,508,777
Total Cash Expenses	\$2,589,261	\$2,568,901
Depreciation	\$ 220,808	\$ 256,308
Net Farm Income	\$485,423	\$509,970

Net farm income is \$24,547 greater with the methane digester. Net farm income is just one measure of financial performance. Other profitability measures are available. **Rate of return on assets (ROA)** can be thought of as the average returned being earned by all farm assets, those owned by the farm and those owned by the bank. **Rate of return on farm equity (ROE)** is the returned earned on the investment or equity in the farm. **Asset-turnover ratio** is an efficiency measure showing the dollars being generated by the farm assets. Table 4 presents these financial measures for the base plan and Haubenchild dairy's methane production situation.

Table 6: ROA, ROE and asset-turnover with and without methane digester

	Base Plan	Haubenchild Dairy
Rate of return on Assets	13.5%	13.3%
Rate of Return on Equity	23.4%	23.2%
Asset Turnover Ratio	37.1%	35.9%

As was mentioned previously, electricity sales are a small part of gross farm income (2%). It is not surprising the methane digester has a small impact on farm profitability. Both ROA and ROE are slightly lower with the methane digester as is the asset-turnover. This is the result of a large investment in the methane digester (\$355,000) and the relatively low electricity sales. Given the level of annual electricity production and electricity sale price, the methane digester had little impact on the profitability of the farm.

Financing Considerations

Financing the methane digester was done via a combination of grants, loans and equity from the Haubenchild Dairy. The financing was presented in table 2. As methane digesters move beyond demonstration projects, the availability of grants might decline. If grants are not available, that portion of the construction cost would need to be financed by borrowing. Three different financing scenarios were examined.

1. No grants and 0% interest loan.
2. No grants and 7% interest loan.
3. Grants and 7% interest loan.

Each of the scenarios assumed the investment from Haubenchild Dairy was \$77,500. When no grants were available, the amount borrowed increased from \$150,000 to \$277,000.

Comparisons in this section are with the current electricity pricing (5.34 ¢/KwH) and production on the dairy.

Table 7: Income statement under alternative financing strategies

	Haubenchild Dairy	No grant 0% loan	No grant 7% loan	Grant 7% loan
Gross Farm Income	\$3,335,179	\$3,335,179	\$3,335,179	\$3,335,179
Interest Expense	\$229,127	\$229,127	\$247,571	\$243,849
Other Cash Expense	\$2,339,774	\$2,339,774	\$2,339,774	\$2,077,125
Total Cash Expenses	\$2,568,901	\$2,568,901	\$2,587,345	\$2,583,623
Depreciation	\$256,308	\$256,308	\$256,308	\$256,308
Net Farm Income	\$509,970	\$509,970	\$491,526	\$495,248

Differences in net farm income are the results of differences in interest paid. Under the scenario of no grants and a 7% interest loan, there is still a healthy net farm income, though it is \$18,444 less than the current financing arrangement. ROA and asset-turnover do not change under the different financing scenarios. ROE differs only slightly under each scenario (Table 6). In each case the ROE is higher under the alternative financing scenarios than the current financing scenario. The higher ROE with no grants and 0% interest loan is due primarily to lower equity or net worth position under this alternative financing strategy.

Table 8: ROE under alternative financing strategies

	Haubenchild Dairy	No grant 0% loan	No grant 7% loan	Grant 7% loan
Rate of Return on Equity	23.2%	24.6%	23.7%	23.2%

Financial performance under low electricity prices

In order to sell electricity to the grid, power-purchasing agreements are required. The agreements set out the price electric companies pay for putting electricity on to the power grid. Generally, this price is determined by the least cost alternative method of electricity production. Haubenchild's current power purchase agreement has electricity priced at 5.34¢ per Kwh. The impact on farm financial performance is examined using a lower electricity price of 3.56¢ per Kwh. Under the lower price scenario, electricity production, and financing arrangements are

assumed to be at the current level on the dairy. Table 7 provides a summary of farm performance under the current electricity price and the lower price of 3.56¢ per Kwh.

It must be noted that electricity sales represent a small portion of total gross revenue on the dairy. Therefore, its impact on whole farm financial performance is small. With the lower electricity price the financial performance of the farm declines slightly. ROA is 13.0% at the lower price compared to 13.3% under the current situation. ROE declines from 23.2% to 22.6% under the lower pricing scenario. Even though the financial performance declines, it is still reasonably strong. On the income side, electricity sales revenue is \$13,229 less at \$26,458.

Table 9: ROA, ROE and asset-turnover under different pricing scenarios

	Haubenchild Dairy 5.34¢ per Kwh	Low electricity price 3.56¢ per Kwh
Rate of return on Assets	13.3%	13.0%
Rate of Return on Equity	23.2%	22.6%
Asset Turnover Ratio	35.9%	35.7%

Financial performance under lower electricity production

The electricity generation on Haubenchild’s dairy is extremely efficient. It is important to assess the impact on whole farm profitability electricity generated was only sufficient electricity produced to meet the needs of the farm. The effect on farm profitability lies with lower gross farm income, because there are no electricity sales. Table 8 presents whole farm profitability for each of the 3 scenarios: 1) Current electricity production and 5.34¢ per Kwh; 2) current electricity production and 3.56¢ per Kwh; and 3) no electricity sales. Each of the scenarios assumes no change in how the methane digester was financed in terms of loans, grants and farm equity.

Table 10: ROA, ROE and asset-turnover under different pricing and electricity production scenarios

	Haubenchild Dairy 5.34¢ per Kwh	Low electricity price 3.56¢ per Kwh	No excess electricity sales
Rate of return on Assets	13.3%	13.0%	12.6%
Rate of Return on Equity	23.2%	22.6%	21.8%
Asset Turnover Ratio	35.9%	35.7%	35.2%

There are no differences in whole farm profitability between the low price and no excess sales scenarios. Again, this is due in large part to the small contribution electricity sales makes to total gross revenue. In the low electricity price scenario, electricity sales account for only 0.7% of gross revenue.

There is an additional measure of performance that looks at the rate of return on additional investment. Given the level of investment and the additional revenue generated, the rate of return on additional investment (methane digester) is calculated. For the three scenarios presented the return on additional investment are:

- Current price and electricity production: 8.8%
- Low price and current electricity production: 4.1%
- Low electricity production (no excess electricity sales): -5.5%

Alternative Dairy System

The anaerobic digester for large confinement dairy operations can have little negative impact on whole farm financial performance, as seen in the earlier analysis. An alternative dairy system is a grazing system and out-wintering of dairy cattle on bedding packs. Bedding packs are either partially or totally composted prior to spreading on cropland.

Grazing systems require less capital investment than confinement systems. This is especially true in terms of manure handling equipment and storage facilities. Appendix I contains a balance sheet for a low-input grazing dairy farm. This model farm has 260 cows and is based on an actual low-input dairy farm in Stearns County.

Comparisons of major income statement items are done on a per cow basis rather than absolute dollar amount. Larger herds will have more dollars of milk sold than smaller herds based solely on the fact they have more cows. Table 9 presents comparisons of net farm income on a per cow basis between the two systems. The pattern seen is fairly typical of well-managed confinement and low-input dairy farms. Confinement dairies tend to have higher gross sales, higher cash expenses, higher depreciation and lower net income per cow than low-input grazing systems.

Table 11: Income statement Haubenchild's Dairy and a low-input grazing dairy

	Haubenchild Dairy	Low-Input Grazing Dairy
Milk Sales	\$3,150.00	\$2,498.65
Electricity Sales	\$ 42.78	
Gross Farm Income	\$3,590.07	\$2,989.16
Fuel and oil expense	\$ 32.33	\$ 53.01
Utilities	\$ 32.39	\$ 53.23
Other Cash Expenses	\$2,700.51	\$1,901.39
Total Cash Expenses	\$2,761.23	\$2,007.63
Depreciation	\$ 275.90	\$ 79.26
Net Farm Income	\$ 552.94	\$ 902.27

The ROA, ROE and asset-turnover ratio are on a percent basis and can be compared directly. Haubenchild's farm had a higher ROE than the low input farm. When looking at ROA, the low-input farm was higher. The low-input farm has less invested in assets on the farm because of the nature of the operation. Its lower revenues are more than offset by the lower asset values or investment, resulting in a higher ROA. Similarly the asset-turnover ratio is higher on the low-input dairy farm.

Table 12: ROA, ROE and asset-turnover Haubenchild's Dairy and a low-input grazing dairy

	HAUBENCHILD DAIRY	Base Plan
Rate of Return on Assets	13.3%	15.8%
Rate of Return on Equity	23.2%	20.7%
Asset Turnover Ratio	35.9%	38.2%

PART C: WEED SEED SURVIVAL AS AFFECTED BY MANURE HANDLING

Introduction

The potential for weed seed introduction to cropland through the application of manure is a question faced by many farmers. The application of manure may increase the number of seeds already present in the weed seedbank or introduce seeds from a weed species not yet present in a field. Time of harvest and type of feed storage may affect weed seed dormancy and viability (Mt. Pleasant and Schlather 1994). Processes, such as ensiling or rumen digestion can also affect weed seed viability in manure by reducing the number of viable weed seed present (Blackshaw and Rode 1991). Anaerobic manure digestion may also reduce weed seed germination and viability. In a field study, this project determined the effect of anaerobic digestion on germination of weed seeds common to the Anoka sand plains region.

Materials and Methods

Because of changes in weed seed germination and viability that can occur during seed storage, newly matured weed seeds were collected from plants the fall of the initiation of the experiment. Weed seed were characterized for potential germination and viability to establish a baseline prior to inclusion in the study. Six weed species were chosen in part to reflect species typically found in manure in the region and to include representatives of weed seed 'groups'. Seed groups included were grass and broadleaf species, large and small seeded species, true seeds and achenes (smartweeds), and species with known impermeable, protective seed coats (velvetleaf). Weed species included in this experiment are as follows:

1. velvetleaf (*Abutilon theophrasti*)
2. common lambsquarters (*Chenopodium album*)
3. redroot pigweed. (*Amaranthus retroflexus*)
4. wild proso millet (*Panicum miliaceum*)
5. giant foxtail (*Setaria faberi*)
6. ladythumb smartweed (*Polygonum persicaria*)

Weed seed were collected from the Rosemount Experiment Station during the fall of 2002 and 2003 for the first and second trials of the experiment, respectively. Seeds were cleaned and stored at room temperature until used in experiments. Seed germination was tested by placing seed in a petri dish between moistened filter paper at 24 C for 14 days in the light. Seeds with emerged radicals were counted as germinated (Hartzler et al. 1999). Viability of 400 seed from each species was determined by placing seed in a petri dish between moistened filter paper

for a minimum of 48 hours in a germinator at 24 C, then treated with a 1% (w/v) solution of tetrazolium. Seeds were considered viable if the embryo stained red.

Tracking this seed lot through a farm-scale digester is like the “needle in a haystack” analogy. The seed needed to be contained and retrievable and so were placed in nylon mesh bags. For each treatment, all six species of weed seed were combined into one mesh bag. One hundred seed per species was added to each bag. Each treatment was replicated six times for a total of six bags. Since most, (but not all) of the weed seed in the system will pass through a dairy cow, we subjected seed to an *in vitro* rumen fermentation procedure (Marten and Halgerson, 1980) proven to simulate conditions of a cow’s digestive system. In this procedure, weed seeds were soaked in rumen fluid for 48 hours in an Ankom Daisy fermentor oven. Next, the seeds were immersed in a pepsin and hydrochloric acid solution for 24 hours to simulate passage through the stomach. Seed was then subjected to one of three manure or fertilizer treatments: 1.) anaerobic digested manure, 2.) conventional manure storage, and 3.) an inorganic fertilizer control.

For the two manure storage treatments, mesh bags were placed in either the anaerobic digester or in raw, undigested manure prior to its entering the digester. The mesh bags were placed into a larger mesh bag along with a temperature monitor and weighted with fishing sinkers to prevent the seed from remaining on the surface of the digestate. Seed bags were in manure treatments for 20 days (length of time for one batch of manure to pass through the digester though weed seeds may pass through at different rates depending on size, solution/suspension density, etc.). Seeds were placed in the end of the anaerobic digester where the manure exits prior to entering the storage lagoon, as this position was the only available access point from which to introduce the seeds and ensure they could be retrieved again. Though not ideal, we feel this approach most closely reflects anaerobic digester conditions, considering limitations of internal access to the digester and the need to track a seed lot know origin and viability in lieu of using a simulated digester.

To determine germination of seed once it was removed from the digester, seed were assayed in field boxes. Germination and emergence of the weed seed was monitored for two growing seasons. The experiment was placed in an area previously in sod as it was assumed that the *in situ* weed seed bank under sod would be low (Hartzler et al. 1999). The sod was removed and the soil worked to a depth of approximately 3 inches. The wooden frame field assay boxes

(15 by 18 inches) were placed 2 inches into the soil. In late November of 2001 and 2002, weed seeds were removed from the digester or conventional manure storage, placed in the appropriate wooden frame and incorporated with a small rake to a depth of approximately .5 inches into the soil. Digested or non-digested manure was added to the wooden frames at a rate of 6000 gal/A, a rate used by Dennis Haubenschild in fields where corn will be planted the following year. Each experimental treatment was duplicated without the addition of weed seed to determine the level of the *in situ* seedbank for a total of 12 assay boxes for each run of the experiment.

In mid-April of 2002 and 2003, ammonium nitrate (34-0-0) at a rate of 180 lb N/A as ammonium nitrate) was added to each plot requiring inorganic fertilizer, approximating the level of N available in the 6000 lb/A manure applications. Levels of P and K were found to be at acceptable levels based on a soil test conducted the fall of 2001. The number of germinating weed seeds was recorded on approximately a monthly basis throughout the growing season and weeds were hand pulled after counting. In April of 2003 and 2004, soil within each frame was mixed to a depth of two inches and germinating seedlings were again counted for the second season for each trial. To account for the number of possible weeds in the wooden assay frames that germinated from seeds already present in the soil at the initiation of the experiment, the number of “background” weeds was determined from assay boxes without added weed seed and were subtracted from the number of weeds that germinated in plots with added weed seed. Each treatment was replicated six times and the experiment was repeated in time. Results from the experiment were analyzed as a randomized complete block design and means were separated with a Least Significant Difference test at the 0.05 level of significance. Results did not differ between experimental runs and data was combined from both trials. Due to funding limitations, a non-rumen seed treatment check was not included, and viability of weed not expressed through germination in the field assay boxes was not determined.

Table 1.
Timing of experiment initiation and data collection.

	Trial 1	Trial 2
Date of experiment initiation	November 2001	November 2002
First season of field assay data collection	2002	2003
Second season of field assay data collection	2003	2004

Results and Discussion

Viability of weed seed used in Trials 1 and 2 ranged from 99% for velvetleaf to 82% for wild proso millet (Table 2). Results of the weed seed germination tests ranged from 11% for common lambsquarters to 0% for ladythumb smartweed, wild proso millet and velvetleaf. The low weed seed germination values compared to the high weed seed viability results indicate that the majority of weed seeds were dormant when placed into the anaerobic digester or conventional manure storage.

Table 2
Trials 1 and 2. Percent germination and viability of weed seed used in anaerobic digestion experiment, prior to rumen digestion, collected from Rosemount, MN, Fall 2001 or Fall 2002.

Species	Germination*		Viability*	
	(%)		(%)	
	2001	2002	2001	2002
redroot pigweed	2	5	92	100
common lambsquarters	11	12	88	100
wild proso millet	0	0	82	98
Ladythumb smartweed	0	0	95	88
velvetleaf	0	14	99	99
giant foxtail	0.8	0.8	88	87

* Mean of 4 lots of 100 seeds each.

In Trials 1 and 2, no giant foxtail, wild proso millet or ladythumb smartweed seeds germinated in plots from any treatment during spring or summer of 2002 through 2004. This is most likely due to destruction of the weed seed in rumen fluid and simulated stomach acid. Similar results were documented by Blackshaw and Rode (1991) who reported less seed survival of the grassy weeds, green foxtail, downy brome and barnyardgrass seeds compared to broadleaf weed seeds after rumen digestion.

During the first summer of data collection in each trial, there were no differences in number of broadleaf seeds germinating between conventional lagoon and anaerobic digestion manure treatments, with one exception. Velvetleaf seeds had higher rates of germination after the anaerobic manure treatment, with an average of 14 seeds germinating compared with nine seeds for the conventional manure treatment (Table 3). The increase in velvetleaf germination the first year of the study may have been due to scarification of the hard seed coat during anaerobic digestion. The scarification process may have enabled these velvetleaf seed to break seed dormancy and germinate sooner. During the second year of the study, the situation was reversed with the conventional and organic fertilizer treatments resulting in higher numbers of velvetleaf seed germinating compared with the anaerobic digestion treatment. In total, the same number of velvetleaf seed germinated over the course of two years of assay, but the number varied between the first and second season depending on manure treatment. After two years, it must be noted that the majority of velvetleaf seed did not germinate and were either destroyed by the initial rumen digestion treatment or remained dormant in the soil.

Table 3

First and second season data on numbers of velvetleaf seeds germinating in the spring and summer after 20 days of fall storage in different manure storage systems compared to seeding with inorganic fertilizer application. Trials 1 and 2 were combined. Haubenschild Farms, MN.

Manure/fertilizer system	Velvetleaf	
	First season	Second season
Anaerobic Digestion	14	2
Lagoon Storage	6	6
Inorganic Fertilizer	9	6
LSD (0.05)	3	3

When examining the timing of velvetleaf germination, most seed germinated between mid-May to mid-June (Julian dates of 130 to 170) (Figures 1 and 2). During the first season of both trials, more velvetleaf seed germinated from the anaerobic digester treatment during this time period (Figures 1a and 2a). In Trial 1, there were no differences in velvetleaf emergence among treatments during mid-May to mid-June for the second season (Figure 1b). However, in the second season of data collection in Trial 2, there were significantly more velvetleaf seed germinating at 126 Julian days (May 5) for the conventional manure storage treatment than for the anaerobic digestion treatment (Figure 2b).

There were no differences in the cumulative number of velvetleaf, common lambsquarters or pigweed spp. seeds germinating over two seasons among manure/fertilizer treatments in each trial. No ladythumb smartweed seed germinated in either trial (Table 4). Jayanayagam and Collins (1984) reported that dormant weed seed were less likely to be destroyed by anaerobic digestion than non-dormant seed. The weed seed used in our study was harvested a few months prior to the initiation of the experiment. Germination and viability tests indicated that 80% or more of the seed were likely to be dormant and less susceptible to damage caused by anaerobic digestion. Our results demonstrate that it is critical to characterize the age and dormancy of weed seed used to study the effect of anaerobic digestion on weed seed viability.

Table 4

Cumulative number of weed seed germinating in a field germination assay for two seasons following 20 days in different manure storage systems at Haubenschild Farms. Trials 1 and 2 were combined.

Manure/fertilizer system	Weed species					
	Vele ¹	Colq	Rrpw	Lasw	Gift	Wipm
Anaerobic digestion	16	12	1	0	0	0
Conventional storage	12	18	5	0	0	0
Inorganic fertilizer	14	11	4	0	0	0
LSD (0.05)	NS	NS	NS	NS	NS	NS

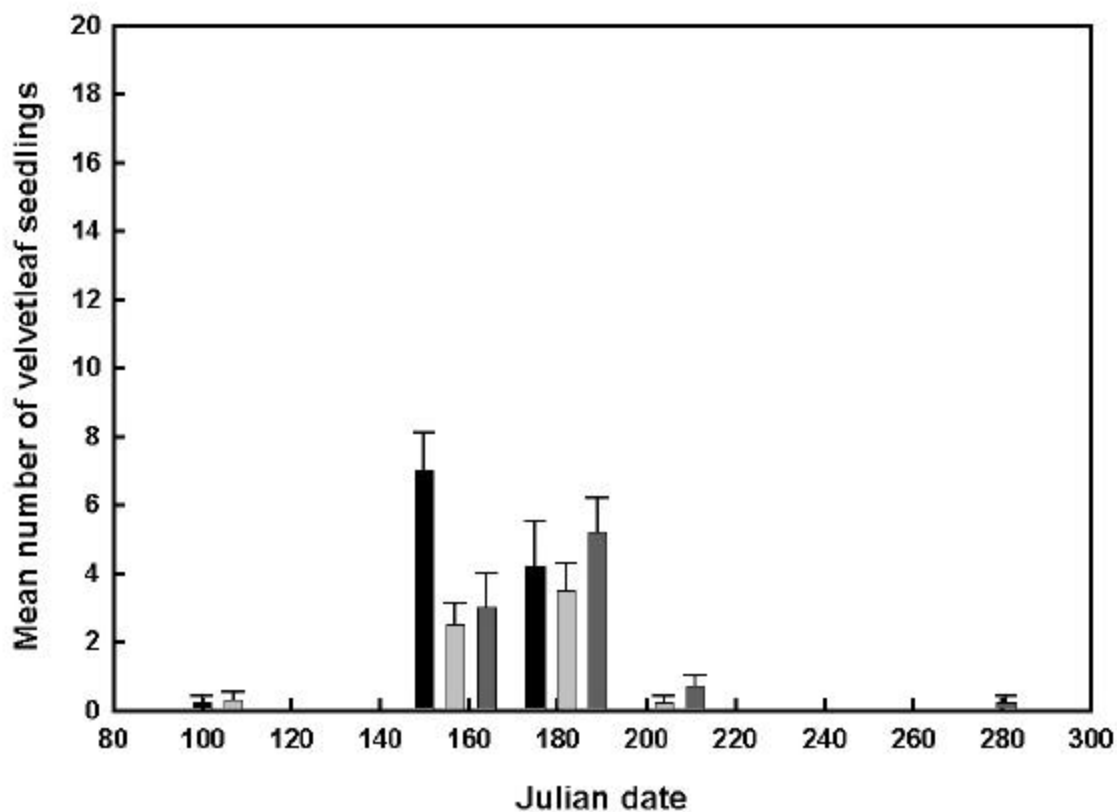
¹ Vele = velvetleaf Lasw = smartweed spp.
 Colq = common lambsquarters Gift = giant foxtail
 Rrpw = redroot pigweed. Wipm = wild proso millet

The temperature of the anaerobic digester during the 20 days that the weed seed were suspended in the anaerobic digester ranged from 95 to 105 F. The Haubenschild's digester is heated in the floor near the manure entry point such that temperatures most likely are higher near the floor near the entry area, with some convection and kinetic mixing occurring. However, overall, much of the manure and weed seed therein will not be exposed to temperatures significantly higher than the 95 to 105 F measured in the vicinity of the seed bags. This temperature is below the estimated 140 F required to kill the majority of weed seed in compost or manure piles (Larney and Blackshaw 2003). Some weed seed requires even higher temperatures to be killed. Wiese et al. (1998) reported that seven days of 180 F temperatures were necessary to kill field bindweed seed in a compost pile. Sarapatka et al. (1993) demonstrated that temperatures in a monitored anaerobic digester that ranged from 133 to 122 F were more effective in reducing weed seed viability than temperatures in the 86 F temperature range. From the results of our study, we concluded that temperatures in the anaerobic manure digester did not attain the level required to kill viable dormant weed seeds.

Conclusion

In conclusion, the majority of the freshly harvested weed seed were dormant at the time the seeds were exposed to the manure storage treatments. Other studies have documented that dormant weed seed are less likely to be destroyed by anaerobic digestion. Seeds of wild proso millet, giant foxtail and ladysthumb smartweed did not germinate during the course of the experiment and were most likely killed as a result of the rumen and simulated stomach treatment used prior to the manure storage treatments. Although higher numbers of velvetleaf seed germinated during the first year of both trials, there were no cumulative differences in weed seed germination among the anaerobic or conventional manure storage or the inorganic fertilizer treatment for any weed species tested. Anaerobic digester temperatures ranging from 95 to 105 F may have been too low to kill the weed seed during the period when the weed seeds were suspended in the digester. It may also be concluded that the majority of common lambsquarters, pigweed spp. and velvetleaf seed had not germinated after two seasons and most likely remained dormant in the soil. Although anaerobic manure digestion has many advantages, such as odor control and production of electricity via methane production, our results did not document a reduction on viability of weed seed after anaerobic manure digestion.

**Figure 1a. Seed Germination as Affected by Manure Storage
Trial 1, First Season of Data Collection**



■ Anaerobic digestion
■ Conventional manure storage
■ Inorganic fertilizer control

REFERENCES

- Blackshaw, R. E. and L. M. Rode. 1991. Effect of ensiling and rumen digestion by cattle on weed seed viability. *Weed Sci.* 39:104-108.
- Hartzler, R. G., D. D. Buhler and D. E. Stoltenberg. 1999. Emergence characteristics of four annual weed species. *Weed Sci.* 47:578-584.
- Jeyanayagam, S. S. and E. R. Collins Jr. 1984. Weed seed survival in a dairy manure anaerobic digester. *Trans. A. S. A. E. Am. Soc. Agric. Eng.* 27:1518-1523.
- Larney, F. J. and R. E. Blackshaw. 2003. Weed seed viability in composted beef cattle feedlot manure. *J. Environ. Qual.* 32:1105-1113.
- Marten, G. C. and J. L. Halgerson. 1980. A two-stage *in vitro* rumen fermentation technique for estimating the digestible dry matter of forages used in the Forage Quality Labs, Department of Agronomy and Plant Genetics, University of Minnesota.
- Mt. Pleasant, J. and K. J. Schlather. 1994. Incidence of weed seed in cow (*Bos* sp.) manure and its importance as a weed source for cropland. *Weed Tech.* 8:04-310.
- Sarapatka, B., M. Holub and M. Lhotska. 1993. The effect of farmyard manure anaerobic treatment on weed seed viability. *Biological Agriculture and Horticulture.* 10:1-8.
- Wiese, A. F., J. M. Sweeten, B. W. Bean, C. D. Salisbury and E. W. Chanault. 1998. High temperature composting of cattle feedlot manure kills weed seed. *Applied Engin. In Agric.* 14:377-380.

PART D: ADDITIONAL EDUCATIONAL NEEDS/IDEAS

Over the course of the last four years many educational objectives have been achieved. At the same time, additional ideas have been developed for further educational ideas. Also, additional needs have also been identified by the University of Minnesota scientists conducting this study. This section is an attempt to identify further education needs/ideas that would be very useful in continued study of anaerobic digester systems.

Manure/soil/crop interactions

The study over the last four years was limited by two factors:

1. High degree of inherent variability on the soils at the Haubenschild farm
2. Limited number of plots that were able to be treated, sampled and analyzed based on the project budget

A more homogenous site for field-testing would be desirable, or the variability issue could be avoided by performing a greenhouse study with homogenous, well-mixed soil and measuring plant response and nitrogen uptake over time in pot culture. With more treatments (low, medium and high rates of application) on a more homogenous site it might be possible to see differences in response curves to raw and digester manure and fertilizer application.

If there is more plant available nitrogen potentially released from digested manure earlier in the season, there is the potential for differences in nitrate leaching through the soil profile. To address this question, column studies in the greenhouse or installation of field lysimeters would be required.

Another avenue for further study is an attempt to answer Dennis Haubenschild's question about whether earlier nitrogen release from the digester manure results in an earlier weed flush and hence lower herbicide requirement. Dennis Haubenschild had observed decrease herbicide applications on his fields as a result from fertilizing the fields with digested manure. This particular observation was beyond the scope of the study.

Economic evaluation

Digested solids are a component of an anaerobic digester system that contain much potential for use in bedding or market as a garden amendment. Future economic evaluations should include avoided cost information for digested solids as bedding or additional revenue for sale as a garden amendment.

Another component of future economic evaluation should include cost information for smaller digester system or digesters in use in Europe and Asia. More thorough economic comparisons of varying digester sizes would equip producers with accurate economic information when considering installing a digester or not.

The electricity-pricing situation could be analyzed in more detail. Data on daily electricity usage patterns for case farms could be used to examine peak and non-peak electricity use. Digesters could also supply heat for nearby businesses, which presents an interesting economic model. For example, would it make sense to build a greenhouse complex near a digester and use the biogas to heat the greenhouse? How would this system effect the economics of the farm and the greenhouse or another business?

Weed seed survival

The current work conducted at the University of Minnesota explored the effects of anaerobic manure digestion on viability of weed seeds with a field assay to determine germination of seeds following rumen treatment. The work was conducted to answer as much as possible with limited funding. The questions left unanswered were to do a complete assay of viability and germination of seed after treatment (we relied on two seasons of stratification in the field to promote germination of seeds that were viable) and addressing the impacts of digestion on weed seeds that did not pass through a cow digestive tract (we pretreated all seeds with stomach and rumen digestion prior to insertion into the anaerobic digester). This is a considerable expansion of the workload considering the need to have duplicated seed lots to determine the viability of seed after passage through livestock compared to weed seed that would be in spilt-feed. There are numerous problems with determining the viability of seed following treatment. Thus, our approach was to monitor seed germination under natural conditions, which would hopefully stimulate the release of dormancy of weed seed through two years of cycling through Minnesota growing seasons. It would be helpful to assay a subset of seeds for viability following treatment in addition to performing germination tests. Additional tests would be tetrazolium to determine viability and artificial means in the laboratories to break dormancy. These procedures would require a triplicate set of seeds in the study, one for the field assay, one for laboratory germination tests, and one seed lot for viability tests. In essence the described work would double to triple the size of the project over that conducted on the previous grant and require at least double or triple the funding.

In the recently completed effort, the difference in the rate of dormancy break in a hard seeded species, velvetleaf, was detected. It appears that though anaerobic digestion did not kill velvetleaf seeds, the exposure to the manure digestion process did alter velvetleaf seed making them more prone to germination and emergence the first season following manure treatment. This could be beneficial in reducing long-term populations of hard seeded weeds in fields if a higher percentage of seed germinates the first season after manure spreading. If effective control measures can be applied to remove germinated, emerging seedlings, the build up of hard seeded species in the seed bank could be reduced. Conversely, if the particular season prevents effective management of the increased germination of hard seeded species such as velvetleaf the first season following manure application to the field, this could exacerbate weed problems. Regardless, a specific area of research would be to select more hard seeded species such as velvetleaf and to conduct further research to more accurately reflect the impacts of anaerobic digestion on hard seeded species that would survive manure treatment, but the management

effects of such treatment might be different than expected if the weed seed had not passed through anaerobic digestion.

Conducting on-farm field assays where manure is applied to field situations and resultant seed populations monitored likely would not be successful. A recent study in Wisconsin that attempted to track weed seed through manure with on-farm field applications is still under data analysis, but the indications are that field variability confounded the results to such a level that little meaningful information could be gleaned from the study. If this holds true as the final data analysis is completed, it would lend support to our previous supposition that conducting farm-scale trials in fields would be very difficult and would have to be conducted on an extremely high labor and intensity of study level that it does not seem economically feasible. This is mostly due to variability of *in situ* seed banks in the field and the variable nature of the expression of seed banks over time. This variable expression of seed banks and inherent variability of seed bank population densities over time confounds and exceeds the level of detection to discriminate among the effects of manure treatments that are being studied preventing any discernable effects of manure treatment on weed-seed viability from being detected.

Acknowledgments

We thank the USDA NRCS EQIP program for funding this project. Thanks to Haubenschild Farms for their kind assistance and use of their facilities.

Attachment A: Timeline of activities

Year	2000	2001	2002	2003	2004
Advisory Group meets	X	2X	2X	2X	2X
Field layout		X			
Crop demo		X	X	X	
Soil tests	X	X	X	X	
Field day planning meetings		X	X	X	X
Field days			X	X	X
Project Presentations				X	X
Weed seed tests		X	X	X	
Economic comparison		X	X	X	
Progress Report Contains					
Advisor Group progress	X				
Subpart work plan details	X				
Crop demo			X	X	X
Soil test		X	X	X	X
Field days			X	X	X
Project Presentations				X	X
Weed seed tests			X	X	X
Economic comparison		X	X	X	X

Attachment B: List of Advisory Committee members

Deborah Allan	U of M, Dept. of Soil, Water & Climate
Roger Becker	U of M, Dept. of Agronomy & Plant Genetics
Paul Burns	MN Department of Agriculture
Mark DeMuth	Water Plan Coordinator, Isanti SWCD
Matt Dreys	MN Department of Agriculture
Cliff Edblad	Isanti SWCD
Paul Flynn	USDA - NRCS
Wyatt Fraas	Center for Rural Affairs
Dennis Haubenschild	Haubenschild Farms
Marsha Haubenschild	Haubenschild Farms
Jeanie Katovich	U of M, Dept. of Agronomy and Plant Genetics
Loni Kemp	The Minnesota Project
Tim Koehler	USDA - NRCS
Bill Lazarus	U of M, Dept. of Applied Economics
Stephen Lutes	USDA - NRCS
Amanda Bilek	The Minnesota Project
Melissa Pawlisch	Regional Sustainable Development Partnerships
Larry Nelson	Onanegozie RC & D
Margot Rudstrom	U of M, West Central Research Station
David Schmidt	U of M, Dept. of Biosystems and Ag Engineering
Michael Schmitt	U of M, Associate Dean of Extension/COAFES
Jeff St Ores	USDA - NRCS
Scott Swanberg	USDA - NRCS
Denny Tressel	USDA – NRCS
Hao Vo	USDA – NRCS

ATTACHMENT C: SEPTEMBER 30, 2004 FIELD DAY MATERIALS

APPENDIX A

Effect of Fertilizer Type and Application Frequency on Microbial Biomass Carbon and Nitrogen, Haubenschild Farms, Princeton, MN 2002-2003

Date of Sampling	Microbial Biomass Carbon				Microbial Biomass Nitrogen					
	August 2002		August 2003		August 2002		August 2003			
Depth in cm	0-15	15-30	0-15	15-30	0-15	15-30	0-15	15-30		
Field	Application Frequency	Nutrient Source	mg/kg				mg/kg			
Appel	Annual	Digested Manure	98.51	78.08	196.35	91.86	15.04	9.82	17.45	9.52
		Raw Manure	125.85	61.64	155.96	117.75	16.82	7.35	15.74	9.48
		Inorganic Fertilizer	107.04	51.66	141.95	110.68	15.80	6.91	17.71	13.62
		LSD (balanced) ¹	NS ²	NS	52.73	NS	NS	2.36	NS	NS
Appel	Biennial	Digested Manure	--	--	103.50	95.39	--	--	13.73	8.15
		Raw Manure	--	--	189.15	118.79	--	--	19.17	10.28
		Inorganic Fertilizer	--	--	122.72	91.32	--	--	18.19	9.01
		LSD (balanced)	--	--	83.42	NS	--	--	NS	NS
Bruce	Annual	Digested Manure	74.82	49.15	91.75	67.27	16.39	7.57	17.17	10.61
		Raw Manure	100.19	80.34	137.59*	113.73*	18.04	10.34	19.91*	10.63
		Inorganic Fertilizer	68.47	63.52	95.29	66.40	16.77	8.84	13.96	8.62
		LSD (balanced)	NS	26.10	45.74	41.74	NS	NS	4.21	NS
		LSD (unbalanced) ³	--	--	51.14	46.67	--	--	4.70	--
Bruce	Biennial	Digested Manure	94.88	31.05	94.29	67.66	16.35	6.77	14.86	10.37
		Raw Manure	51.24	51.93	96.19	66.26	15.05	7.82	12.71	9.43
		Inorganic Fertilizer	99.12	84.90	77.73	67.98	11.51	10.25	12.75	9.95
		LSD (balanced)	NS	NS	15.58	NS	NS	2.77	NS	NS
Lilac	Annual	Digested Manure	71.34	70.18	140.92	108.31	17.14	12.24	10.89	19.67
		Raw Manure	116.56	91.43	163.23	120.53	17.53	12.63	16.45	17.78
		Inorganic Fertilizer	65.41	70.63	68.50	104.21	10.30	12.36	10.92	17.88
		LSD (balanced)	NS	NS	NS	NS	NS	NS	NS	NS
Lilac	Biennial	Digested Manure	92.14	84.15	119.43	106.08	12.79	15.53	17.96	14.12
		Raw Manure	75.54	50.29	121.18	114.28	15.56	12.11	13.53	18.72
		Inorganic Fertilizer	101.21	63.97	108.48	103.42	15.55	12.14	8.70	17.16
		LSD (balanced)	17.70	22.47	NS	NS	NS	NS	8.24	NS

¹LSD (balanced, $p < 0.1$) refers to the three preceding nutrient sources within the indicated application frequency at

²NS designates instances where results for the nutrient sources were not significantly different

³LSD (unbalanced, $p < 0.1$) refers to the three preceding nutrient sources within the indicated application frequency and field, where values were calculated by hand due to missing data points

* Category missing data point, so unbalanced LSD should be applied

APPENDIX B

Effect of Fertilizer Type and Application Frequency on PMN, Haubenschild Farms, Princeton, MN 2001-2003

Date of Sampling			Potentially Mineralizable Nitrogen											
			July 2001		August 2001		July 2002		August 2002		June 2003		August 2003	
Depth in cm			0-15	15-30	0-15	15-30	0-15	15-30	0-15	15-30	0-15	15-30	0-15	15-30
Application			mg/kg											
Field	Frequency	Nutrient Source												
Appel	Annual	Digested Manure	1064	889	1291	11.13	1919	1278	1899	1366	1447	1134	1793	1545
		Raw Manure	1404	841	1653	1295	1955	1341	2077	1267	1277	7.72	1698	1199
		Inorganic Fertilizer	1439	981	1444	1097	1821	1198	1930	1131	3095	6.72	2162	1409
		LSD (balanced) ¹	NS ²	NS	345	NS	NS	NS	NS	217	NS	NS	NS	NS
Appel	Biennial	Digested Manure	-	-	-	-	-	-	-	-	1483	9.78	1353	851
		Raw Manure	-	-	-	-	-	-	-	-	1432	9.67	1990	1047
		Inorganic Fertilizer	-	-	-	-	-	-	-	-	1120	7.45	1326	720
		LSD (balanced)	-	-	-	-	-	-	-	-	1.47	NS	658	NS
Bruce	Annual	Digested Manure	421	756	895	881	1312	11.15	1560	1158	11.11	1042	1255	1296
		Raw Manure	800	730	1094	11.07	1655	1344	1834	1429	1553*	9.90	1570	2169
		Inorganic Fertilizer	1029	1018	1104	9.02	1692	1273	2071	1421	1064	10.04	1408	1158
		LSD (balanced)	478	NS	NS	1.96	240	NS	453	NS	4.14	NS	NS	NS
		LSD (unbalanced) ³	-	-	-	-	-	-	-	-	4.63	-	-	-
Bruce	Biennial	Digested Manure	-	-	-	-	1512	1026	1736	1083	1303	1993	1816	1209
		Raw Manure	-	-	-	-	1323	1027	1491	1072	1121	11.05	1440	1049
		Inorganic Fertilizer	-	-	-	-	1676	1453	1587	1297	3447	10.13	1581	1148
		LSD (balanced)	-	-	-	-	NS	386	NS	NS	NS	NS	NS	NS
Liac	Annual	Digested Manure	538	1047	1086	11.31	2000	2064	1934	1391	1707	11.28	887	1709
		Raw Manure	723	911	800	9.99	2200	2088	21.14	1912	1618	14.42	1367	1433
		Inorganic Fertilizer	599	1127	807	11.05	1538	1657	1468	1574	9.57	17.93	11.27	1150
		LSD (balanced)	NS	NS	NS	NS	NS	NS	NS	464	NS	NS	NS	NS
Liac	Biennial	Digested Manure	-	-	-	-	1824	1825	1760	1792	1422	14.01	1557	1661
		Raw Manure	-	-	-	-	1570	1670	1476	1745	1263	11.32	828	731
		Inorganic Fertilizer	-	-	-	-	1999	1784	1824	1640	1328	8.52	1546	1159
		LSD (balanced)	-	-	-	-	NS	NS	NS	NS	NS	NS	NS	NS

¹ LSD (balanced, p<0.1) refers to the three preceding nutrient sources within the indicated application frequency and field

² NS designates instances where results for the nutrient sources were not significantly different

³ LSD (unbalanced, p<0.1) refers to the three preceding nutrient sources within the indicated application frequency and field, where values were calculated by hand due to missing data points

*Category missing data point, so unbalanced LSD should be applied

APPENDIX C

Manure Nutrient Concentrations over Time, Haubenschild Farms, Princeton, MN

Sampling Date		10/2002	3/2003	4/2003	4/2003	5/2003	6/2003	7/2003	8/2003
Nutrient	Manure	g/L							
	Type								
Nitrogen	Raw	399	312	507	322	326	279	315	339
	Digested	399	446	352	413	340	334	269	307
	Lagoon	267	-	-	376	-	290	303	303
Phosphorus	Raw	151	083	145	054	107	098	111	076
	Digested	140	105	061	061	083	081	081	055
	Lagoon	072	-	-	056	-	078	076	054
Potassium	Raw	455	264	582	294	344	326	388	372
	Digested	410	360	315	346	254	326	332	330
	Lagoon	341	-	-	331	-	305	345	325
Sulfur	Raw	036	037	050	037	038	036	042	049
	Digested	028	031	039	034	030	031	028	028
	Lagoon	021	-	-	034	-	031	031	036

Appendix D. Balance sheet for Haubenchild Dairy Without Methane Digester

CURRENT FARM ASSETS				Value	CURRENT FARM LIABILITIES			Balance
Cash & checking balance				-3,320	Farm accrued interest			-
Prepaid expense & supplies				-	Accounts payable and accrued expenses			-
Growing crops				-				
Accounts receivable				-		Int	P & I	Principal
Hedging accounts				-	Current Loans			Rate
Other current assets				65,000			Due	Balance
					Opr. loan - Operating	-	-	125,000
					Government crop loans			-
					Principal due within 12 months on term liabilities			-
Crops	Quantity	Value/Unit						
Soybeans	500	4.50/bu.		2,250				
Feed Corn	8,000	2.38/bu.		19,000				
Corn Silage	2,090	30.00/ton		62,700				
Alf/Gr Mixed	72	128.68/ton		9,265				
Alf Haylage	1,540	50.00/ton		77,000				
Straw	1,000	1.50/ton		1,500				
Rented Out	1	10000.00/\$		10,000				
Crops under govt loan				-				
Mkt Lvst	No.	Value/Unit						
Dairy Steers	36	- /cwt.		1,800				

Total Current Assets

245,195

Total Current Liabilities

125,000

INTERMEDIATE FARM ASSETS

INTERMEDIATE FARM LIABILITIES

	No.	Market Value		Int Rate	Principal Balance	P & I Due	Principal Due	Intermed Balance
Breeding Livestock								
Dairy show calves	7	4,500	8500 dairy cows	-	819,412	-	-	819,412
Dairy cows	929	1,151,044	8600 capital	-	185,458	-	-	185,458
Dairy bull calves	79	7,505	JD3970	-	5,514	-	-	5,514
Bull calves	3	600	JD4603	-	1,957	-	-	1,957
			Case 884	-	10,518	-	-	10,518
Farm machinery & equip.		1,005,806	Case 75X	-	10,677	-	-	10,677
Titled vehicles		-						
Other intermediate assets		-						
Total Intermediate Assets		2,169,455	Total Intermediate Liabilities					1,033,536

LONG TERM FARM ASSETS

LONG TERM FARM LIABILITIES

	Acre	Market Value		Int Rate	Principal Balance	P & I Due	Principal Due	Lg Term Balance
Land								
Feris/Enger	75	67,500	FCS Lagoon	-	36,526	-	-	36,526
Home Farm	390	297,600	FCS Real Estate	-	1,662,256	-	-	1,662,256
Porter 20	20	16,000	FCS:SBA	-	357,731	-	-	357,731
Porter 65	65	41,000						

Bldgs & improve.	2,404,562		
Other long term	48,011		
Total Long Term Assets	2,874,673	Total Long Term Liabilities	2,056,513
TOTAL FARM ASSETS	5,289,323	TOTAL FARM LIABILITIES	3,215,049
NONFARM ASSETS	-	NONFARM LIABILITIES	-
		TOTAL LIABILITIES	3,215,049
TOTAL ASSETS	5,289,323	NET WORTH	
2,074,274			

Appendix E: Budgets for Haubenchild Dairy
Crop Corn Silage

Unit	ton
	Long Range
Yield	17
Price	30.00
Product income	510.00
Gross income	510.00
Seed	42.45
Fertilizer	36.60
Crop chemicals	12.70
Crop insurance	
Drying fuel	
Irrigation energy	
Custom hire	
Hired labor	
Total direct expense	91.75
Return over direct expense	418.25
Labor hours	
Silage equivalents (ton)	17.0

Crop Corn, Feed

Unit	bu.
	Long Range
Yield	120
Price	2.25
Product income	270.00
Gross income	270.00
Seed	42.45
Fertilizer	36.60
Crop chemicals	12.70

Crop insurance
 Drying fuel 3.50
 Irrigation energy
 Custom hire
 Hired labor
 Total direct expense 95.25
 Return over direct expense 174.75
 Labor hours

Corn equivalents (bu.) 120.0

Crop Hay, Mixed Alfalfa/Grass

Unit ton
 Long Range

Yield 4.5

Price 100.00

Product income 450.00

Gross income 450.00

Seed 9.01

Fertilizer

Crop chemicals 5.24

Crop insurance

Custom hire

Hired labor

Total direct expense 14.25

Return over direct expense 435.75

Labor hours

Hay equivalents (ton) 4.5

Crop Haylage, Alfalfa

Unit ton

Long Range

Yield 9

Price 40.00

Product income 360.00

Gross income	360.00
Seed	9.01
Fertilizer	
Crop chemicals	5.24
Crop insurance	
Drying fuel	
Irrigation energy	
Custom hire	
Hired labor	
Total direct expense	14.25
Return over direct expense	345.75

Labor hours

Hay equivalents (ton) 4.5

Livestock Enterprise Dairy

Budget Unit Per Cow

Description Milk production

Long Range

Milk Quantity (lb.)	21000
Price (cwt.)	15.00
Product income	3150.00
Cull income	219.57
Miscellaneous income	74.15
Gross income	3443.72
Purchased feed	
Calf Feed	44.24
Corn	36.40
feed	740.31
hay	122.37
Silage bags	17.89
Breeding fees	34.04
Veterinary	132.74
Livestock supplies	
bedding	5.38

DHIA	8.26
Marketing	
ADA	10.06
MMP	0.54
Market exp	6.31
Milk haul	6.36
Total direct expense	1164.90
Labor hours	
Corn equivalents (bu.)	120.0
Hay equivalents (ton)	4.9
Silage equivalents (ton)	4.7
Feed expense	746.20
Return over budget expense	1532.62

Livestock Enterprise Dairy

Budget Unit	Per Cow
<i>Description</i>	<i>Biodigester</i>
	Long Range
Milk Quantity (lb.)	800
Price (cwt.)	5.34
Product income	42.72
Gross income	42.72
Labor hours	0.39
Return over budget expense	42.72

Appendix F. FINLRB for High Electricity Pricing

FINPACK

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PLAN DESCRIPTION	Base Plan	Alt. 1 current	Alt. 2 no grants no inter	Alt. 3 no grants interest 7%	Alt. 4 grants interest 7%
Total labor hours	-	362	362	362	362
Change in farm assets	-	277,500	277,500	277,500	277,500
Change in farm liabilities	-	150,000	277,500	277,500	221,500
Crop Plan					
	Yield/Acre	Share			
Corn Silage	17.0 ton	100 %	262.6	262.6	262.6
Corn, Feed	120.0 bu.	100 %	431.1	431.1	431.1
Haylage, Alfalfa	9.0 ton	100 %	181.3	181.3	181.3
Hay, Mixed Alfalfa/Grass	4.5 ton	100 %	100.0	100.0	100.0
Livestock Plan					
	Unit	Sales/Unit			
Dairy, Milk production	Cow	21000 lb.	929	929	929
Dairy, Biodigester	Cow	800 lb.	-	929	929
Corn equivalents (bu.)					
Produced	51,732	51,732	51,732	51,732	51,732
Fed	111,480	111,480	111,480	111,480	111,480
Balance	-59,748	-59,748	-59,748	-59,748	-59,748
Hay equivalents (ton)					
Produced	1,266	1,266	1,266	1,266	1,266
Fed	4,552	4,552	4,552	4,552	4,552
Balance	-3,286	-3,286	-3,286	-3,286	-3,286
Silage equivalents (ton)					
Produced	4,464	4,464	4,464	4,464	4,464
Fed	4,366	4,366	4,366	4,366	4,366
Balance	98	98	98	98	98
PROFITABILITY					
	Base Plan	Alt. 1	Alt. 2	Alt. 3	Alt. 4
			no grants	no grants	grants

INCOME STATEMENT (Typical Year)		current	no inter	interest	interest	
				7%	7%	
Silage equivalents	\$ 20.00/ton	1,958	1,958	1,958	1,958	
Milk	\$ 15.00/cwt.	2,926,350	2,926,350	2,926,350	2,926,350	
Milk	\$ 5.34/cwt.	-	39,687	39,687	39,687	
Cull breeding livestock		203,981	203,981	203,981	203,981	
Misc. livestock income		68,885	68,885	68,885	68,885	
CRP payments		54,615	54,615	54,615	54,615	
Other farm income		39,703	39,703	39,703	39,703	
(A) Gross farm income		3,295,492	3,335,179	3,335,179	3,335,179	
Seed		31,982	31,982	31,982	31,982	
Fertilizer		25,389	25,389	25,389	25,389	
Crop chemicals		10,284	10,284	10,284	10,284	
Drying fuel		1,509	1,509	1,509	1,509	
Purchased Corn	\$ 1.94/bu.	115,911	115,911	115,911	115,911	
Purchased Hay	\$ 99.00/ton	325,339	325,339	325,339	325,339	
Purchased feed		892,964	892,964	892,964	892,964	
Breeding fees		31,623	31,623	31,623	31,623	
Veterinary		123,315	123,315	123,315	123,315	
Livestock supplies		12,672	12,672	12,672	12,672	
Livestock marketing		21,618	21,618	21,618	21,618	
Interest		229,127	229,127	229,127	247,571	
Fuel & oil		34,032	30,032	30,032	30,032	
Repairs		109,776	128,576	128,576	128,576	
Hired labor		382,900	382,900	382,900	382,900	
Land rent		18,833	18,833	18,833	18,833	
Machinery & bldg leases		31,174	31,174	31,174	31,174	
Livestock leases		5,303	5,303	5,303	5,303	
Real estate taxes		8,232	8,232	8,232	8,232	
Farm insurance		98,008	98,008	98,008	98,008	
Utilities		65,253	30,093	30,093	30,093	
Dues & professional fees		11,957	11,957	11,957	11,957	
		Base Plan	Alt. 1	Alt. 2	Alt. 3	Alt. 4
			no grants	no grants	grants	
		current	no inter	interest	interest	
Miscellaneous		2,059	2,059	2,059	2,059	2,059
(B) Total cash farm expense		2,589,261	2,568,901	2,568,901	2,587,345	2,583,623

(C) Net cash farm income	706,231	766,278	766,278	747,834	751,556
Depreciation	220,808	256,308	256,308	256,308	256,308
(D) Net farm income	485,423	509,970	509,970	491,526	495,248

		Base Plan	Alt. 1	Alt. 2	Alt. 3	Alt. 4
			current	no grants no inter	no grants interest 7%	grants interest 7%
PROFITABILITY MEASURES (Market)						
Net farm income	(D)	485,423	509,970	509,970	491,526	495,248
Labor & management earnings	(D-E)	360,967	377,864	385,514	367,070	367,432
Rate of return on farm assets	(H/I)	13.5 %	13.3 %	13.3 %	13.3 %	13.3 %
Rate of return on farm equity	(J/K)	23.4 %	23.2 %	24.6 %	23.7 %	23.2 %
Rate of return on added investment	(L/M)		8.8 %	8.8 %	8.8 %	8.8 %
Operating profit margin	(H/N)	36.4 %	36.9 %	36.9 %	36.9 %	36.9 %
Asset turnover	(N/I)	37.1 %	35.9 %	35.9 %	35.9 %	35.9 %
(E) Interest on farm net worth	(K* 6%)	124,456	132,106	124,456	124,456	127,816
(F) Farm interest paid		229,127	229,127	229,127	247,571	243,849
(G) Value operators labor & mgt		-	-	-	-	-
(H) Return on farm assets	(D+F-G)	714,551	739,097	739,097	739,097	739,097
(I) Total farm assets		5,289,323	5,566,823	5,566,823	5,566,823	5,566,823
(J) Return on farm equity	(D-G)	485,423	509,970	509,970	491,526	495,248
(K) Total farm net worth		2,074,274	2,201,774	2,074,274	2,074,274	2,130,274
(L) Added return to added investment			24,547	24,547	24,547	24,547
(M) Added capital invested			277,500	277,500	277,500	277,500
(N) Value of farm production		1,961,278	2,000,965	2,000,965	2,000,965	2,000,965

LIQUIDITY

CASH FLOW (Typical Year)

Net cash farm income	(C)	706,231	766,278	766,278	747,834	751,556
Nonfarm income	(+)	-	-	-	-	-
Net cash available	(=)	706,231	766,278	766,278	747,834	751,556
Family living	(-)	-	-	-	-	-
Corporate income taxes	(-)	212,615	223,367	223,367	215,288	216,919
(R) Cash available for principal payments	(=)	493,616	542,911	542,911	532,546	534,637
Farm interest paid	(+)	229,127	229,127	229,127	247,571	243,849
Cash avail. for principal and interest	(=)	722,743	772,038	772,038	780,117	778,487
		Base Plan	Alt. 1	Alt. 2	Alt. 3	Alt. 4

		current	no grants no inter	no grants interest	grants interest	
8500 dairy cows		66,871	66,871	66,871	66,871	
8600 capital		23,959	23,959	23,959	23,959	
JD3970		5,514	5,514	5,514	5,514	
JD4603		1,957	1,957	1,957	1,957	
Case 884		10,518	10,518	10,518	10,518	
Case 75X		5,338	5,338	5,338	5,338	
FCS Lagoon		12,898	12,898	12,898	12,898	
FCS Real Eastat		150,922	150,922	150,922	150,922	
FCS:SBA		38,340	38,340	38,340	38,340	
MDA		-	7,500	13,875	-	
Loan 1		-	-	-	26,194	
Operating loan interest		5,938	5,938	5,938	5,938	
(S) Total scheduled principal and interest	(-)	322,255	329,755	336,130	348,449	
Cash available after loan payments	(=)	400,489	442,284	435,909	431,669	
Annual capital replacement		-	-	-	-	
Principal paid on intermediate debts		62,367	62,367	62,367	62,367	
(T) Cash required for replacement	(-)	-	-	-	-	
(U) Cash surplus or deficit	(=)	400,489	442,284	435,909	431,669	
		Base Plan	Alt. 1	Alt. 2	Alt. 3	Alt. 4
			current	no grants no inter	no grants interest	grants interest
					7%	7%
LIQUIDITY MEASURES						
Cash available for principal payments	(R)	493,616	542,911	542,911	532,546	534,637
Annual farm long term principal pymts	(-)	30,760	38,260	44,635	38,510	36,946
(V) Cash available for farm intermed. debt	(=)	462,856	504,651	498,276	494,036	497,692
(W) Farm intermediate debt to be served		1,033,536	1,033,536	1,033,536	1,033,536	1,033,536
Years to turnover farm intermed. debt	(W/V)	2.2	2.0	2.1	2.1	2.1
Surplus as a percent of payments	(U/(S+T))	124.3 %	134.1 %	129.7 %	123.9 %	126.9 %
Cash farm expense as % of income	(B/A)	78.6 %	77.0 %	77.0 %	77.6 %	77.5 %
Farm interest as % of value of prod.	(F/N)	11.7 %	11.5 %	11.5 %	12.4 %	12.2 %
Farm debt payments as % of value of prod.		16.4 %	16.5 %	16.8 %	17.4 %	17.1 %

SOLVENCY

BALANCE SHEET (Market)

Current farm assets		245,195	167,695	167,695	167,695	167,695
Intermediate farm assets	(+)	2,169,455	2,169,455	2,169,455	2,169,455	2,169,455
Long term farm assets	(+)	2,874,673	3,229,673	3,229,673	3,229,673	3,229,673
Nonfarm assets	(+)	-	-	-	-	-
(X) Total assets	(=)	5,289,323	5,566,823	5,566,823	5,566,823	5,566,823
Current farm liabilities		125,000	132,500	138,875	131,769	130,403
Intermediate farm liabilities	(+)	1,033,536	1,033,536	1,033,536	1,033,536	1,033,536
Long term farm liabilities	(+)	2,056,513	2,199,013	2,320,138	2,327,244	2,272,610
Nonfarm liabilities	(+)	-	-	-	-	-
(Y) Total liabilities	(=)	3,215,049	3,365,049	3,492,549	3,492,549	3,436,549
Net worth	(X-Y)	2,074,274	2,201,774	2,074,274	2,074,274	2,130,274

	Base Plan	Alt. 1	Alt. 2	Alt. 3	Alt. 4
		no grants	no grants	grants	
		current	no inter	interest	interest

SOLVENCY MEASURES

Current percent in debt		51.0 %	79.0 %	82.8 %	78.6 %	77.8 %
Current & intermediate pct in debt		48.0 %	49.9 %	50.2 %	49.9 %	49.8 %
Long term percent in debt		71.5 %	68.1 %	71.8 %	72.1 %	70.4 %
Nonfarm percent in debt		- %	- %	- %	- %	- %
Total percent in debt	(Y/X)	60.8 %	60.4 %	62.7 %	62.7 %	61.7 %

NET WORTH CHANGE (Typical Year)

Net farm income		485,423	509,970	509,970	491,526	495,248
Nonfarm income	(+)	-	-	-	-	-
Family living	(-)	-	-	-	-	-
Corporate income taxes	(-)	212,615	223,367	223,367	215,288	216,919
Net worth change per year	(=)	272,808	286,603	286,603	276,238	278,329

	Base Plan	Alt. 1	Alt. 2	Alt. 3	Alt. 4
		no grants	no grants	grants	
		current	no inter	interest	interest

FINANCIAL STANDARDS MEASURES

Liquidity

7% 7%

Current ratio	1.96	1.27	1.21	1.27	1.29
Working capital	120,195	35,195	28,820	35,926	37,292
Solvency					
Farm debt to asset ratio	60.8 %	60.4 %	62.7 %	62.7 %	61.7 %
Farm equity to asset ratio	39.2 %	39.6 %	37.3 %	37.3 %	38.3 %
Farm debt to equity ratio	155.0 %	152.8 %	168.4 %	168.4 %	161.3 %
Profitability					
Rate of return on farm assets	13.5 %	13.3 %	13.3 %	13.3 %	13.3 %
Rate of return on farm equity	23.4 %	23.2 %	24.6 %	23.7 %	23.2 %
Operating profit margin	36.4 %	36.9 %	36.9 %	36.9 %	36.9 %
Net farm income	485,423	509,970	509,970	491,526	495,248
Repayment Capacity					
Term debt coverage ratio	226.6 %	236.6 %	232.0 %	226.0 %	229.1 %
Capital replacement margin	400,489	442,284	435,909	431,669	435,324
Efficiency					
Asset turnover	37.1 %	35.9 %	35.9 %	35.9 %	35.9 %
Operating expense ratio	71.6 %	70.2 %	70.2 %	70.2 %	70.2 %
Depreciation expense ratio	6.7 %	7.7 %	7.7 %	7.7 %	7.7 %
Interest expense ratio	7.0 %	6.9 %	6.9 %	7.4 %	7.3 %
Net farm income ratio	14.7 %	15.3 %	15.3 %	14.7 %	14.8 %

CROP AND LIVESTOCK PRODUCTION

Corn Silage	ton	4,464	4,464	4,464	4,464	4,464
Corn, Feed	bu.	51,732	51,732	51,732	51,732	51,732
Haylage, Alfalfa	ton	1,632	1,632	1,632	1,632	1,632
Hay, Mixed Alfalfa/Grass	ton	450	450	450	450	450
Milk	lb.	19,509,000	19,509,000	19,509,000	19,509,000	19,509,000
Milk	lb.	-	743,200	743,200	743,200	743,200

Base Plan	Alt. 1	Alt. 2	Alt. 3	Alt. 4
	current	no grants no inter	no grants interest	grants interest

SENSITIVITY ANALYSIS

Effect Of A 2 % Decrease In All Enterprises					
Net farm income	415,140	438,893	438,893	420,449	424,171
Cash surplus or deficit	360,989	402,339	395,964	391,723	395,379
Net worth change per year	233,309	246,658	246,658	236,292	238,384

Effect Of A 10 % Decrease In All Enterprises

Net farm income	133,308	153,887	153,887	135,442	139,164
Cash surplus or deficit	212,685	251,221	244,846	241,527	244,997
Net worth change per year	85,004	95,540	95,540	86,097	88,002

Base Plan	Alt. 1	Alt. 2	Alt. 3	Alt. 4
	current	no inter	no grants interest 7%	grants interest 7%

INVESTMENT DETAIL

Capital Purchases

Biodigester	-	355,000	-	-	-
biodigester	-	-	355,000	-	355,000
dioidigester	-	-	-	355,000	-
Total new investments	-	355,000	355,000	355,000	355,000

Capital Sales

Cash Withdrawal	-	77,500	-	-	-
Grants	-	127,500	-	-	-
Cash Withdrawals	-	-	77,500	-	-
cash withdrawals	-	-	-	77,500	77,500
grants	-	-	-	-	56,000
Total capital sales	-	205,000	77,500	77,500	133,500

LOAN DETAIL

Current liabilities

Original principal balance	125,000	125,000	125,000	125,000	125,000
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8500 dairy cows

Original principal balance	819,412	819,412	819,412	819,412	819,412
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8600 capital

Original principal balance	185,458	185,458	185,458	185,458	185,458
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JD3970

Original principal balance	5,514	5,514	5,514	5,514	5,514
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JD4603

Original principal balance	1,957	1,957	1,957	1,957	1,957
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	Base Plan	Alt. 1 current	Alt. 2 no grants no inter	Alt. 3 no grants interest	Alt. 4 grants interest
Case 884					
Original principal balance	10,518	10,518	10,518	10,518	10,518
Case 75X					
Original principal balance	10,677	10,677	10,677	10,677	10,677
FCS Lagoon					
Original principal balance	36,526	36,526	36,526	36,526	36,526
FCS Real Estate					
Original principal balance	1,662,256	1,662,256	1,662,256	1,662,256	1,662,256
FCS:SBA					
Original principal balance	357,731	357,731	357,731	357,731	357,731
MDA					
Original principal balance	-	-	-	-	-
Other change	-	150,000	277,500	-	-
Resulting principal balance	-	150,000	277,500	-	-
Loan 1					
Original principal balance	-	-	-	-	-
Other change	-	-	-	277,500	221,500
Resulting principal balance	-	-	-	277,500	221,500

NOTES

Base Plan

Utilities are adjusted upward from Haubenchilds number to reflect the value of electricity used on farm. Fuel and oil are increased to reflect additional LP cost for heating the barn.

Depreciation is 10% on machinery & equipment and biodigester and 5% on buildings.

Alternative one is the current financing and price situation

Alternative 2 has no grants and funded by MDA to the amount of 177,500. The remainder is from equity.

Appendix G. FINLRB for Low Electricity Pricing

PLAN DESCRIPTION			Base Plan	Alt. 1	Alt. 2	Alt. 3	Alt. 4
				current	no grants no inter	no grants interest 7%	grants interest 7%
Total crop acres			975	975	975	975	975
Total labor hours			-	362	362	362	362
Change in farm assets			-	277,500	277,500	277,500	277,500
Change in farm liabilities			-	150,000	277,500	277,500	221,500
Crop Plan	Yield/Acre	Share					
Corn Silage	17.0 ton	100 %	262.6	262.6	262.6	262.6	262.6
Corn, Feed	120.0 bu.	100 %	431.1	431.1	431.1	431.1	431.1
Haylage, Alfalfa	9.0 ton	100 %	181.3	181.3	181.3	181.3	181.3
Hay, Mixed Alfalfa/Grass	4.5 ton	100 %	100.0	100.0	100.0	100.0	100.0
Livestock Plan	Unit	Sales/Unit					
Dairy, Milk production	Cow	21000 lb.	929	929	929	929	929
Dairy, Biodigester	Cow	800 lb.	-	929	929	929	929
Corn equivalents (bu.)							
Produced			51,732	51,732	51,732	51,732	51,732
Fed			111,480	111,480	111,480	111,480	111,480
Balance			-59,748	-59,748	-59,748	-59,748	-59,748
Hay equivalents (ton)							
Produced			1,266	1,266	1,266	1,266	1,266
Fed			4,552	4,552	4,552	4,552	4,552
Balance			-3,286	-3,286	-3,286	-3,286	-3,286
Silage equivalents (ton)							
Produced			4,464	4,464	4,464	4,464	4,464
Fed			4,366	4,366	4,366	4,366	4,366
Balance			98	98	98	98	98

PROFITABILITY

		Base Plan	Alt. 1	Alt. 2	Alt. 3	Alt. 4
			current	no grants no inter	no grants interest	grants interest
					7%	7%
INCOME STATEMENT (Typical Year)						
Silage equivalents	\$ 20.00/ton	1,958	1,958	1,958	1,958	1,958
Milk	\$ 15.00/cwt.	2,926,350	2,926,350	2,926,350	2,926,350	2,926,350
Milk	\$ 3.56/cwt.	-	26,458	26,458	26,458	26,458
Cull breeding livestock		203,981	203,981	203,981	203,981	203,981
Misc. livestock income		68,885	68,885	68,885	68,885	68,885
CRP payments		54,615	54,615	54,615	54,615	54,615
Other farm income		39,703	39,703	39,703	39,703	39,703
(A) Gross farm income		3,295,492	3,321,950	3,321,950	3,321,950	3,321,950
Seed		31,982	31,982	31,982	31,982	31,982
Fertilizer		25,389	25,389	25,389	25,389	25,389
Crop chemicals		10,284	10,284	10,284	10,284	10,284
Drying fuel		1,509	1,509	1,509	1,509	1,509
Purchased Corn	\$ 1.94/bu.	115,911	115,911	115,911	115,911	115,911
Purchased Hay	\$ 99.00/ton	325,339	325,339	325,339	325,339	325,339
Purchased feed		892,964	892,964	892,964	892,964	892,964
Breeding fees		31,623	31,623	31,623	31,623	31,623
Veterinary		123,315	123,315	123,315	123,315	123,315
Livestock supplies		12,672	12,672	12,672	12,672	12,672
Livestock marketing		21,618	21,618	21,618	21,618	21,618
Interest		229,127	229,127	229,127	247,571	243,849
Fuel & oil		34,032	30,032	30,032	30,032	30,032
Repairs		109,776	128,576	128,576	128,576	128,576
Hired labor		382,900	382,900	382,900	382,900	382,900
Land rent		18,833	18,833	18,833	18,833	18,833
Machinery & bldg leases		31,174	31,174	31,174	31,174	31,174
Livestock leases		5,303	5,303	5,303	5,303	5,303
Real estate taxes		8,232	8,232	8,232	8,232	8,232
Farm insurance		98,008	98,008	98,008	98,008	98,008
Utilities		65,253	30,093	30,093	30,093	30,093
Dues & professional fees		11,957	11,957	11,957	11,957	11,957
Miscellaneous		2,059	2,059	2,059	2,059	2,059
		Base Plan	Alt. 1	Alt. 2	Alt. 3	Alt. 4
			current	no grants no inter	no grants interest	grants interest
(B) Total cash farm expense		2,589,261	2,568,901	2,568,901	2,587,345	2,583,623

(C) Net cash farm income	706,231	753,049	753,049	734,605	738,327
Depreciation	220,808	256,308	256,308	256,308	256,308
(D) Net farm income	485,423	496,741	496,741	478,297	482,019

		Base Plan	Alt. 1	Alt. 2	Alt. 3	Alt. 4
			current	no grants no inter	no grants interest 7%	grants interest 7%
PROFITABILITY MEASURES (Market)						
Net farm income	(D)	485,423	496,741	496,741	478,297	482,019
Labor & management earnings	(D-E)	360,967	364,635	372,285	353,841	354,203
Rate of return on farm assets	(H/I)	13.5 %	13.0 %	13.0 %	13.0 %	13.0 %
Rate of return on farm equity	(J/K)	23.4 %	22.6 %	23.9 %	23.1 %	22.6 %
Rate of return on added investment	(L/M)		4.1 %	4.1 %	4.1 %	4.1 %
Operating profit margin	(H/N)	36.4 %	36.5 %	36.5 %	36.5 %	36.5 %
Asset turnover	(N/I)	37.1 %	35.7 %	35.7 %	35.7 %	35.7 %
(E) Interest on farm net worth	(K* 6%)	124,456	132,106	124,456	124,456	127,816
(F) Farm interest paid		229,127	229,127	229,127	247,571	243,849
(G) Value operators labor & mgt		-	-	-	-	-
(H) Return on farm assets	(D+F-G)	714,551	725,868	725,868	725,868	725,868
(I) Total farm assets		5,289,323	5,566,823	5,566,823	5,566,823	5,566,823
(J) Return on farm equity	(D-G)	485,423	496,741	496,741	478,297	482,019
(K) Total farm net worth		2,074,274	2,201,774	2,074,274	2,074,274	2,130,274
(L) Added return to added investment			11,318	11,318	11,318	11,318
(M) Added capital invested			277,500	277,500	277,500	277,500
(N) Value of farm production		1,961,278	1,987,736	1,987,736	1,987,736	1,987,736

LIQUIDITY

CASH FLOW (Typical Year)

Net cash farm income	(C)	706,231	753,049	753,049	734,605	738,327
Nonfarm income	(+)	-	-	-	-	-
Net cash available	(=)	706,231	753,049	753,049	734,605	738,327
Family living	(-)	-	-	-	-	-
Corporate income taxes	(-)	212,615	217,573	217,573	209,494	211,124
(R) Cash available for principal payments	(=)	493,616	535,477	535,477	525,111	527,203
Farm interest paid	(+)	229,127	229,127	229,127	247,571	243,849
Cash avail. for principal and interest	(=)	722,743	764,604	764,604	772,682	771,052

		66,871	66,871	66,871	66,871	66,871
		Base Plan	Alt. 1	Alt. 2	Alt. 3	Alt. 4
			current	no grants no inter	no grants interest	grants interest
8500 dairy cows		66,871	66,871	66,871	66,871	66,871
8600 capital		23,959	23,959	23,959	23,959	23,959
JD3970		5,514	5,514	5,514	5,514	5,514
JD4603		1,957	1,957	1,957	1,957	1,957
Case 884		10,518	10,518	10,518	10,518	10,518
Case 75X		5,338	5,338	5,338	5,338	5,338
FCS Lagoon		12,898	12,898	12,898	12,898	12,898
FCS Real Eastat		150,922	150,922	150,922	150,922	150,922
FCS:SBA		38,340	38,340	38,340	38,340	38,340
MDA		-	7,500	13,875	-	-
Loan 1		-	-	-	26,194	20,908
Operating loan interest		5,938	5,938	5,938	5,938	5,938
(S) Total scheduled principal and interest	(-)	322,255	329,755	336,130	348,449	343,163
Cash available after loan payments	(=)	400,489	434,849	428,474	424,234	427,890
Annual capital replacement		-	-	-	-	-
Principal paid on intermediate debts		62,367	62,367	62,367	62,367	62,367
(T) Cash required for replacement	(-)	-	-	-	-	-
(U) Cash surplus or deficit	(=)	400,489	434,849	428,474	424,234	427,890
		Base Plan	Alt. 1	Alt. 2	Alt. 3	Alt. 4
			current	no grants no inter	no grants interest	grants interest
					7%	7%
LIQUIDITY MEASURES						
Cash available for principal payments	(R)	493,616	535,477	535,477	525,111	527,203
Annual farm long term principal pymts	(-)	30,760	38,260	44,635	38,510	36,946
(V) Cash available for farm intermed. debt	(=)	462,856	497,217	490,842	486,601	490,257
(W) Farm intermediate debt to be served		1,033,536	1,033,536	1,033,536	1,033,536	1,033,536
Years to turnover farm intermed. debt	(W/V)	2.2	2.1	2.1	2.1	2.1
Surplus as a percent of payments	(U/(S+T))	124.3 %	131.9 %	127.5 %	121.7 %	124.7 %
Cash farm expense as % of income	(B/A)	78.6 %	77.3 %	77.3 %	77.9 %	77.8 %
Farm interest as % of value of prod.	(F/N)	11.7 %	11.5 %	11.5 %	12.5 %	12.3 %
Farm debt payments as % of value of prod.		16.4 %	16.6 %	16.9 %	17.5 %	17.3 %

SOLVENCY

BALANCE SHEET (Market)

Current farm assets		245,195	167,695	167,695	167,695	167,695
Intermediate farm assets	(+)	2,169,455	2,169,455	2,169,455	2,169,455	2,169,455
Long term farm assets	(+)	2,874,673	3,229,673	3,229,673	3,229,673	3,229,673
Nonfarm assets	(+)	-	-	-	-	-
(X) Total assets	(=)	5,289,323	5,566,823	5,566,823	5,566,823	5,566,823
Current farm liabilities		125,000	132,500	138,875	131,769	130,403
Intermediate farm liabilities	(+)	1,033,536	1,033,536	1,033,536	1,033,536	1,033,536
Long term farm liabilities	(+)	2,056,513	2,199,013	2,320,138	2,327,244	2,272,610
Nonfarm liabilities	(+)	-	-	-	-	-
(Y) Total liabilities	(=)	3,215,049	3,365,049	3,492,549	3,492,549	3,436,549
Net worth	(X-Y)	2,074,274	2,201,774	2,074,274	2,074,274	2,130,274

	Base Plan	Alt. 1	Alt. 2	Alt. 3	Alt. 4
		current	no grants no inter	no grants interest	grants interest

SOLVENCY MEASURES

Current percent in debt		51.0 %	79.0 %	82.8 %	78.6 %	77.8 %
Current & intermediate pct in debt		48.0 %	49.9 %	50.2 %	49.9 %	49.8 %
Long term percent in debt		71.5 %	68.1 %	71.8 %	72.1 %	70.4 %
Nonfarm percent in debt		- %	- %	- %	- %	- %
Total percent in debt	(Y/X)	60.8 %	60.4 %	62.7 %	62.7 %	61.7 %

NET WORTH CHANGE (Typical Year)

Net farm income		485,423	496,741	496,741	478,297	482,019
Nonfarm income	(+)	-	-	-	-	-
Family living	(-)	-	-	-	-	-
Corporate income taxes	(-)	212,615	217,573	217,573	209,494	211,124
Net worth change per year	(=)	272,808	279,169	279,169	268,803	270,895

	Base Plan	Alt. 1	Alt. 2	Alt. 3	Alt. 4
			no grants no grants	no grants	grants

FINANCIAL STANDARDS MEASURES		current	no inter	interest 7%	interest 7%
Liquidity					
Current ratio	1.96	1.27	1.21	1.27	1.29
Working capital	120,195	35,195	28,820	35,926	37,292
Solvency					
Farm debt to asset ratio	60.8 %	60.4 %	62.7 %	62.7 %	61.7 %
Farm equity to asset ratio	39.2 %	39.6 %	37.3 %	37.3 %	38.3 %
Farm debt to equity ratio	155.0 %	152.8 %	168.4 %	168.4 %	161.3 %
Profitability					
Rate of return on farm assets	13.5 %	13.0 %	13.0 %	13.0 %	13.0 %
Rate of return on farm equity	23.4 %	22.6 %	23.9 %	23.1 %	22.6 %
Operating profit margin	36.4 %	36.5 %	36.5 %	36.5 %	36.5 %
Net farm income	485,423	496,741	496,741	478,297	482,019
Repayment Capacity					
Term debt coverage ratio	226.6 %	234.3 %	229.8 %	223.9 %	226.9 %
Capital replacement margin	400,489	434,849	428,474	424,234	427,890
Efficiency					
Asset turnover	37.1 %	35.7 %	35.7 %	35.7 %	35.7 %
Operating expense ratio	71.6 %	70.4 %	70.4 %	70.4 %	70.4 %
Depreciation expense ratio	6.7 %	7.7 %	7.7 %	7.7 %	7.7 %
Interest expense ratio	7.0 %	6.9 %	6.9 %	7.5 %	7.3 %
Net farm income ratio	14.7 %	15.0 %	15.0 %	14.4 %	14.5 %

CROP AND LIVESTOCK PRODUCTION

Corn Silage	ton	4,464	4,464	4,464	4,464	4,464
Corn, Feed	bu.	51,732	51,732	51,732	51,732	51,732
Haylage, Alfalfa	ton	1,632	1,632	1,632	1,632	1,632
Hay, Mixed Alfalfa/Grass	ton	450	450	450	450	450
Milk	lb.	19,509,000	19,509,000	19,509,000	19,509,000	19,509,000
Milk	lb.	-	743,200	743,200	743,200	743,200

Base Plan	Alt. 1	Alt. 2	Alt. 3	Alt. 4
		no grants	no grants	grants
	current	no inter	interest	interest

SENSITIVITY ANALYSIS

Effect Of A 2 % Decrease In All Enterprises

Net farm income	415,140	425,929	425,929	407,484	411,206
Cash surplus or deficit	360,989	395,053	388,678	384,437	388,093
Net worth change per year	233,309	239,372	239,372	229,006	231,098

Effect Of A 10 % Decrease In All Enterprises

Net farm income	133,308	141,981	141,981	123,536	127,258
Cash surplus or deficit	212,685	245,125	238,750	235,432	238,901
Net worth change per year	85,004	89,444	89,444	80,001	81,906

	Base Plan	Alt. 1	Alt. 2	Alt. 3	Alt. 4
		current	no inter	no grants interest	grants interest
				7%	7%

INVESTMENT DETAIL

Capital Purchases

Biodigester	-	355,000	-	-	-
biodigester	-	-	355,000	-	355,000
diodigester	-	-	-	355,000	-
Total new investments	-	355,000	355,000	355,000	355,000

Capital Sales

Cash Withdrawal	-	77,500	-	-	-
Grants	-	127,500	-	-	-
Cash Withdrawals	-	-	77,500	-	-
cash withdrawals	-	-	-	77,500	77,500
grants	-	-	-	-	56,000
Total capital sales	-	205,000	77,500	77,500	133,500

LOAN DETAIL

Current liabilities

Original principal balance	125,000	125,000	125,000	125,000	125,000
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8500 dairy cows

Original principal balance	819,412	819,412	819,412	819,412	819,412
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8600 capital

Original principal balance	185,458	185,458	185,458	185,458	185,458
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JD3970

Original principal balance	5,514	5,514	5,514	5,514	5,514
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JD4603						
Original principal balance	1,957	1,957	1,957	1,957	1,957	1,957
	Base Plan	Alt. 1	Alt. 2	Alt. 3	Alt. 4	
		current	no inter	no grants	no grants	grants
				interest	interest	interest
Case 884						
Original principal balance	10,518	10,518	10,518	10,518	10,518	10,518
Case 75X						
Original principal balance	10,677	10,677	10,677	10,677	10,677	10,677
FCS Lagoon						
Original principal balance	36,526	36,526	36,526	36,526	36,526	36,526
FCS Real Estate						
Original principal balance	1,662,256	1,662,256	1,662,256	1,662,256	1,662,256	1,662,256
FCS:SBA						
Original principal balance	357,731	357,731	357,731	357,731	357,731	357,731
MDA						
Original principal balance	-	-	-	-	-	-
Other change	-	150,000	277,500	-	-	-
Resulting principal balance	-	150,000	277,500	-	-	-
Loan 1						
Original principal balance	-	-	-	-	-	-
Other change	-	-	-	277,500	221,500	221,500
Resulting principal balance	-	-	-	277,500	221,500	221,500

Appendix H. FINLRB for no Excess Electricity Sales

User: Margot Rudstrom, WCROC

FINPACK

PLAN DESCRIPTION			Base Plan	Alt. 1	Alt. 2	Alt. 3	Alt. 4
				current	no grants no inter	no grants interest 7%	grants interest 7%
Total crop acres			975	975	975	975	975
Total labor hours			-	-	-	-	-
Change in farm assets			-	277,500	277,500	277,500	277,500
Change in farm liabilities			-	150,000	277,500	277,500	221,500
Crop Plan	Yield/Acre	Share					
Corn, Feed	120.0 bu.	100 %	431.1	431.1	431.1	431.1	431.1
Hay, Mixed Alfalfa/Grass	4.5 ton	100 %	100.0	100.0	100.0	100.0	100.0
Haylage, Alfalfa	9.0 ton	100 %	181.3	181.3	181.3	181.3	181.3
Corn Silage	17.0 ton	100 %	262.6	262.6	262.6	262.6	262.6
Livestock Plan	Unit	Sales/Unit					
Dairy, Milk production	Cow	21000 lb.	929	929	929	929	929
Corn equivalents (bu.)							
Produced			51,732	51,732	51,732	51,732	51,732
Fed			111,480	111,480	111,480	111,480	111,480
Balance			-59,748	-59,748	-59,748	-59,748	-59,748
Hay equivalents (ton)							
Produced			1,266	1,266	1,266	1,266	1,266
Fed			4,552	4,552	4,552	4,552	4,552
Balance			-3,286	-3,286	-3,286	-3,286	-3,286
Silage equivalents (ton)							
Produced			4,464	4,464	4,464	4,464	4,464
Fed			4,366	4,366	4,366	4,366	4,366
Balance			98	98	98	98	98

PROFITABILITY

		Base Plan	Alt. 1	Alt. 2	Alt. 3	Alt. 4
			current	no grants no inter	no grants interest 7%	grants interest 7%
INCOME STATEMENT (Typical Year)						
Silage equivalents	\$ 20.00/ton	1,958	1,958	1,958	1,958	1,958
Milk	\$ 15.00/cwt.	2,926,350	2,926,350	2,926,350	2,926,350	2,926,350
Cull breeding livestock		203,981	203,981	203,981	203,981	203,981
Misc. livestock income		68,885	68,885	68,885	68,885	68,885
CRP payments		54,615	54,615	54,615	54,615	54,615
Other farm income		39,703	39,703	39,703	39,703	39,703
(A) Gross farm income		3,295,492	3,295,492	3,295,492	3,295,492	3,295,492
Seed		31,982	31,982	31,982	31,982	31,982
Fertilizer		25,389	25,389	25,389	25,389	25,389
Crop chemicals		10,284	10,284	10,284	10,284	10,284
Drying fuel		1,509	1,509	1,509	1,509	1,509
Purchased Corn	\$ 1.94/bu.	115,911	115,911	115,911	115,911	115,911
Purchased Hay	\$ 99.00/ton	325,339	325,339	325,339	325,339	325,339
Purchased feed		892,964	892,964	892,964	892,964	892,964
Breeding fees		31,623	31,623	31,623	31,623	31,623
Veterinary		123,315	123,315	123,315	123,315	123,315
Livestock supplies		12,672	12,672	12,672	12,672	12,672
Livestock marketing		21,618	21,618	21,618	21,618	21,618
Interest		229,127	229,127	229,127	247,571	243,849
Fuel & oil		34,032	30,032	30,032	30,032	30,032
Repairs		109,776	128,576	128,576	128,576	128,576
Hired labor		382,900	382,900	382,900	382,900	382,900
Land rent		18,833	18,833	18,833	18,833	18,833
Machinery & bldg leases		31,174	31,174	31,174	31,174	31,174
Livestock leases		5,303	5,303	5,303	5,303	5,303
Real estate taxes		8,232	8,232	8,232	8,232	8,232
Farm insurance		98,008	98,008	98,008	98,008	98,008
Utilities		65,253	30,093	30,093	30,093	30,093
Dues & professional fees		11,957	11,957	11,957	11,957	11,957
		Base Plan	Alt. 1	Alt. 2	Alt. 3	Alt. 4
			current	no grants no inter	no grants interest	grants interest
Miscellaneous		2,059	2,059	2,059	2,059	2,059

(B) Total cash farm expense		2,589,261	2,568,901	2,568,901	2,587,345	2,583,623
(C) Net cash farm income		706,231	726,591	726,591	708,147	711,869
Depreciation		220,808	256,308	256,308	256,308	256,308
(D) Net farm income		485,423	470,283	470,283	451,839	455,561

		Base Plan	Alt. 1	Alt. 2	Alt. 3	Alt. 4
			no grants	no grants	no grants	grants
			current	no inter	interest	interest
					7%	7%
PROFITABILITY MEASURES (Market)						
Net farm income	(D)	485,423	470,283	470,283	451,839	455,561
Labor & management earnings	(D-E)	360,967	338,177	345,827	327,383	327,745
Rate of return on farm assets	(H/I)	13.5 %	12.6 %	12.6 %	12.6 %	12.6 %
Rate of return on farm equity	(J/K)	23.4 %	21.4 %	22.7 %	21.8 %	21.4 %
Rate of return on added investment	(L/M)		-5.5 %	-5.5 %	-5.5 %	-5.5 %
Operating profit margin	(H/N)	36.4 %	35.7 %	35.7 %	35.7 %	35.7 %
Asset turnover	(N/I)	37.1 %	35.2 %	35.2 %	35.2 %	35.2 %
(E) Interest on farm net worth	(K* 6%)	124,456	132,106	124,456	124,456	127,816
(F) Farm interest paid		229,127	229,127	229,127	247,571	243,849
(G) Value operators labor & mgt		-	-	-	-	-
(H) Return on farm assets	(D+F-G)	714,551	699,411	699,411	699,411	699,411
(I) Total farm assets		5,289,323	5,566,823	5,566,823	5,566,823	5,566,823
(J) Return on farm equity	(D-G)	485,423	470,283	470,283	451,839	455,561
(K) Total farm net worth		2,074,274	2,201,774	2,074,274	2,074,274	2,130,274
(L) Added return to added investment			-15,140	-15,140	-15,140	-15,140
(M) Added capital invested			277,500	277,500	277,500	277,500
(N) Value of farm production		1,961,278	1,961,278	1,961,278	1,961,278	1,961,278

LIQUIDITY

CASH FLOW (Typical Year)

Net cash farm income	(C)	706,231	726,591	726,591	708,147	711,869
Nonfarm income	(+)	-	-	-	-	-
Net cash available	(=)	706,231	726,591	726,591	708,147	711,869
Family living	(-)	-	-	-	-	-
Corporate income taxes	(-)	212,615	205,984	205,984	197,906	199,536
(R) Cash available for principal payments	(=)	493,616	520,607	520,607	510,242	512,333

Farm interest paid	(+)	229,127	229,127	229,127	247,571	243,849
Cash avail. for principal and interest	(=)	722,743	749,734	749,734	757,813	756,183
8500 dairy cows		66,871	66,871	66,871	66,871	66,871
		Base Plan	Alt. 1	Alt. 2	Alt. 3	Alt. 4
			current	no grants no inter	no grants interest	grants interest
8600 capital		23,959	23,959	23,959	23,959	23,959
JD3970		5,514	5,514	5,514	5,514	5,514
JD4603		1,957	1,957	1,957	1,957	1,957
Case 884		10,518	10,518	10,518	10,518	10,518
Case 75X		5,338	5,338	5,338	5,338	5,338
FCS Lagoon		12,898	12,898	12,898	12,898	12,898
FCS Real Eastat		150,922	150,922	150,922	150,922	150,922
FCS:SBA		38,340	38,340	38,340	38,340	38,340
MDA		-	7,500	13,875	-	-
Loan 1		-	-	-	26,194	20,908
Operating loan interest		5,938	5,938	5,938	5,938	5,938
(S) Total scheduled principal and interest	(-)	322,255	329,755	336,130	348,449	343,163
Cash available after loan payments	(=)	400,489	419,980	413,605	409,365	413,020
Annual capital replacement		-	-	-	-	-
Principal paid on intermediate debts		62,367	62,367	62,367	62,367	62,367
(T) Cash required for replacement	(-)	-	-	-	-	-
(U) Cash surplus or deficit	(=)	400,489	419,980	413,605	409,365	413,020
		Base Plan	Alt. 1	Alt. 2	Alt. 3	Alt. 4
			current	no grants no inter	no grants interest	grants interest
					7%	7%
LIQUIDITY MEASURES						
Cash available for principal payments	(R)	493,616	520,607	520,607	510,242	512,333
Annual farm long term principal pymts	(-)	30,760	38,260	44,635	38,510	36,946
(V) Cash available for farm intermed. debt	(=)	462,856	482,347	475,972	471,732	475,388
(W) Farm intermediate debt to be served		1,033,536	1,033,536	1,033,536	1,033,536	1,033,536
Years to turnover farm intermed. debt	(W/V)	2.2	2.1	2.2	2.2	2.2
Surplus as a percent of payments	(U/(S+T))	124.3 %	127.4 %	123.0 %	117.5 %	120.4 %
Cash farm expense as % of income	(B/A)	78.6 %	78.0 %	78.0 %	78.5 %	78.4 %
Farm interest as % of value of prod.	(F/N)	11.7 %	11.7 %	11.7 %	12.6 %	12.4 %
Farm debt payments as % of value of prod.		16.4 %	16.8 %	17.1 %	17.8 %	17.5 %

SOLVENCY

BALANCE SHEET (Market)

Current farm assets		245,195	167,695	167,695	167,695	167,695
Intermediate farm assets	(+)	2,169,455	2,169,455	2,169,455	2,169,455	2,169,455
Long term farm assets	(+)	2,874,673	3,229,673	3,229,673	3,229,673	3,229,673
Nonfarm assets	(+)	-	-	-	-	-
(X) Total assets	(=)	5,289,323	5,566,823	5,566,823	5,566,823	5,566,823
Current farm liabilities		125,000	132,500	138,875	131,769	130,403
Intermediate farm liabilities	(+)	1,033,536	1,033,536	1,033,536	1,033,536	1,033,536
Long term farm liabilities	(+)	2,056,513	2,199,013	2,320,138	2,327,244	2,272,610
Nonfarm liabilities	(+)	-	-	-	-	-
(Y) Total liabilities	(=)	3,215,049	3,365,049	3,492,549	3,492,549	3,436,549
Net worth	(X-Y)	2,074,274	2,201,774	2,074,274	2,074,274	2,130,274

Base Plan	Alt. 1	Alt. 2	Alt. 3	Alt. 4
	current	no grants no inter	no grants interest	grants interest

SOLVENCY MEASURES

Current percent in debt		51.0 %	79.0 %	82.8 %	78.6 %	77.8 %
Current & intermediate pct in debt		48.0 %	49.9 %	50.2 %	49.9 %	49.8 %
Long term percent in debt		71.5 %	68.1 %	71.8 %	72.1 %	70.4 %
Nonfarm percent in debt		- %	- %	- %	- %	- %
Total percent in debt	(Y/X)	60.8 %	60.4 %	62.7 %	62.7 %	61.7 %

NET WORTH CHANGE (Typical Year)

Net farm income		485,423	470,283	470,283	451,839	455,561
Nonfarm income	(+)	-	-	-	-	-
Family living	(-)	-	-	-	-	-
Corporate income taxes	(-)	212,615	205,984	205,984	197,906	199,536
Net worth change per year	(=)	272,808	264,299	264,299	253,934	256,025

Base Plan	Alt. 1	Alt. 2	Alt. 3	Alt. 4
	current	no grants no inter	no grants interest	grants interest

FINANCIAL STANDARDS MEASURES

7%

7%

Liquidity

Current ratio	1.96	1.27	1.21	1.27	1.29
Working capital	120,195	35,195	28,820	35,926	37,292

Solvency

Farm debt to asset ratio	60.8 %	60.4 %	62.7 %	62.7 %	61.7 %
Farm equity to asset ratio	39.2 %	39.6 %	37.3 %	37.3 %	38.3 %
Farm debt to equity ratio	155.0 %	152.8 %	168.4 %	168.4 %	161.3 %

Profitability

Rate of return on farm assets	13.5 %	12.6 %	12.6 %	12.6 %	12.6 %
Rate of return on farm equity	23.4 %	21.4 %	22.7 %	21.8 %	21.4 %
Operating profit margin	36.4 %	35.7 %	35.7 %	35.7 %	35.7 %
Net farm income	485,423	470,283	470,283	451,839	455,561

Repayment Capacity

Term debt coverage ratio	226.6 %	229.7 %	225.3 %	219.5 %	222.5 %
Capital replacement margin	400,489	419,980	413,605	409,365	413,020

Efficiency

Asset turnover	37.1 %	35.2 %	35.2 %	35.2 %	35.2 %
Operating expense ratio	71.6 %	71.0 %	71.0 %	71.0 %	71.0 %
Depreciation expense ratio	6.7 %	7.8 %	7.8 %	7.8 %	7.8 %
Interest expense ratio	7.0 %	7.0 %	7.0 %	7.5 %	7.4 %
Net farm income ratio	14.7 %	14.3 %	14.3 %	13.7 %	13.8 %

CROP AND LIVESTOCK PRODUCTION

Corn, Feed	bu.	51,732	51,732	51,732	51,732	51,732
Hay, Mixed Alfalfa/Grass	ton	450	450	450	450	450
Haylage, Alfalfa	ton	1,632	1,632	1,632	1,632	1,632
Corn Silage	ton	4,464	4,464	4,464	4,464	4,464
Milk	lb.	19,509,000	19,509,000	19,509,000	19,509,000	19,509,000

Base Plan	Alt. 1	Alt. 2	Alt. 3	Alt. 4
	no grants	no grants	no grants	grants
	current	no inter	interest	interest

SENSITIVITY ANALYSIS

Effect Of A 2 % Decrease In All Enterprises

Net farm income	415,140	400,000	400,000	381,556	385,278
Cash surplus or deficit	360,989	380,481	374,106	369,865	373,521

Net worth change per year	233,309	224,800	224,800	214,434	216,526
Effect Of A 10 % Decrease In All Enterprises					
Net farm income	133,308	118,168	118,168	99,724	103,446
Cash surplus or deficit	212,685	232,933	226,558	223,226	226,709
Net worth change per year	85,004	77,252	77,252	67,795	69,714

	Base Plan	Alt. 1	Alt. 2	Alt. 3	Alt. 4
		no grants	no grants	no grants	grants
		current	no inter	interest	interest
				7%	7%
INVESTMENT DETAIL					
Capital Purchases					
Biodigester	-	355,000	-	-	-
biodigester	-	-	355,000	-	355,000
dioidigester	-	-	-	355,000	-
Total new investments	-	355,000	355,000	355,000	355,000
Capital Sales					
Cash Withdrawal	-	77,500	-	-	-
Grants	-	127,500	-	-	-
Cash Withdrawals	-	-	77,500	-	-
cash withdrawals	-	-	-	77,500	77,500
grants	-	-	-	-	56,000
Total capital sales	-	205,000	77,500	77,500	133,500

LOAN DETAIL

Current liabilities					
Original principal balance	125,000	125,000	125,000	125,000	125,000
8500 dairy cows					
Original principal balance	819,412	819,412	819,412	819,412	819,412
8600 capital					
Original principal balance	185,458	185,458	185,458	185,458	185,458
JD3970					
Original principal balance	5,514	5,514	5,514	5,514	5,514

JD4603

Original principal balance	1,957	1,957	1,957	1,957	1,957
	Base Plan	Alt. 1	Alt. 2	Alt. 3	Alt. 4
		current	no grants no inter	no grants interest	grants interest
Case 884					
Original principal balance	10,518	10,518	10,518	10,518	10,518
Case 75X					
Original principal balance	10,677	10,677	10,677	10,677	10,677
FCS Lagoon					
Original principal balance	36,526	36,526	36,526	36,526	36,526
FCS Real Eastat					
Original principal balance	1,662,256	1,662,256	1,662,256	1,662,256	1,662,256
FCS:SBA					
Original principal balance	357,731	357,731	357,731	357,731	357,731
MDA					
Original principal balance	-	-	-	-	-
Other change	-	150,000	277,500	-	-
Resulting principal balance	-	150,000	277,500	-	-
Loan 1					
Original principal balance	-	-	-	-	-
Other change	-	-	-	277,500	221,500
Resulting principal balance	-	-	-	277,500	221,500

Appendix I. FINLRB for Grazing Dairy

User: Margot Rudstrom

FINPACK

PLAN DESCRIPTION	Base Plan		
	Plan 1		
Total crop acres			460
Total pasture acres			310
Total labor hours			-
Change in farm assets			-
Change in farm liabilities			-
Crop Plan	Yield/Acre	Share	
Corn Silage, Corn Silage	10.0 ton	100 %	160.0
Oats, Feed	3.5 bu.	100 %	100.0
Hay, Mixed Alfalfa/Grass	4.0 ton	100 %	200.0
Pasture	9.0 aum	100 %	310.0
Livestock Plan	Unit	Sales/Unit	
Dairy	Cow	18500 lb.	260
Corn equivalents (bu.)			
Produced			175
Fed			-
Balance			175
Hay equivalents (ton)			
Produced			800
Fed			1,274
Balance			-474
Silage equivalents (ton)			
Produced			1,600
Fed			1,222
Balance			378
Pasture equivalents (AUM)			
Available			2,790
Used			2,340
Balance			450

PROFITABILITY

INCOME STATEMENT (Typical Year)		Base Plan Plan 1
Corn equivalents	\$ 31.00/bu.	5,425
Silage equivalents	\$ 30.00/ton	11,340
Pasture equivalents	\$ 13.00/AUM	5,850
Milk	\$ 13.50/cwt.	649,350
Cull breeding livestock		28,153
CRP payments		15,862
Custom work income		957
Other farm income		60,245
(A) Gross farm income		777,182
Seed		6,354
Fertilizer		7,345
Crop chemicals		4,728
Crop insurance		800
Purchased Hay	\$ 105/ton	49,533
Purchased feed		160,719
Breeding fees		6,607
Veterinary		15,257
Livestock supplies		18,093
Livestock marketing		11,344
Interest		28,804
Fuel & oil		13,782
Repairs		57,383
Custom hire		8,094
Hired labor		69,754
Land rent		23,610
Real estate taxes		4,381
Farm insurance		15,679
Utilities		13,839
Dues & professional fees		5,877
(B) Total cash farm expense		521,983
(C) Net cash farm income		255,199
Depreciation		20,608
(D) Net farm income		234,591

PROFITABILITY MEASURES (Market)

Plan 1

Net farm income	(D)	234,591
Labor & management earnings	(D-E)	174,928
Rate of return on farm assets	(H/I)	15.8 %
Rate of return on farm equity	(J/K)	20.7 %
Operating profit margin	(H/N)	41.5 %
Asset turnover	(N/I)	38.2 %
(E) Interest on farm net worth	(K* 6%)	59,662
(F) Farm interest paid		28,804
(G) Value operators labor & mgt		28,346
(H) Return on farm assets	(D+F-G)	235,049
(I) Total farm assets		1,484,778
(J) Return on farm equity	(D-G)	206,244
(K) Total farm net worth		994,374
(N) Value of farm production		566,930

LIQUIDITY

CASH FLOW (Typical Year)

Net cash farm income	(C)	255,199
Nonfarm income	(+)	-
Net cash available	(=)	255,199
Family living	(-)	-
Income taxes and social security	(-)	98,939
(R) Cash available for principal payments	(=)	156,259
Farm interest paid	(+)	28,804
Cash avail. for principal and interest	(=)	185,064
Farm Credit Syt		51,120
Clifford		9,692
dmolitor		20,469
Operating loan interest		-
(S) Total scheduled principal and interest	(-)	81,281
Cash available after loan payments	(=)	103,783
Annual capital replacement		-
Principal paid on intermediate debts		27,928
(T) Cash required for replacement	(-)	-
(U) Cash surplus or deficit	(=)	103,783

LIQUIDITY MEASURES		Base Plan Plan 1
Cash available for principal payments	(R)	156,259
Annual farm long term principal pymts	(-)	24,549
(V) Cash available for farm intermed. debt	(=)	131,710
(W) Farm intermediate debt to be served		254,860
Years to turnover farm intermed. debt	(W/V)	1.9
Surplus as a percent of payments	(U/(S+T))	127.7 %
Cash farm expense as % of income	(B/A)	67.2 %
Farm interest as % of value of prod.	(F/N)	5.1 %
Farm debt payments as % of value of prod.		14.3 %

SOLVENCY

BALANCE SHEET (Market)

Current farm assets		249,178
Intermediate farm assets	(+)	834,600
Long term farm assets	(+)	401,000
Nonfarm assets	(+)	-
(X) Total assets	(=)	1,484,778
Current farm liabilities		178,011
Intermediate farm liabilities	(+)	225,727
Long term farm liabilities	(+)	86,666
Nonfarm liabilities	(+)	-
(Y) Total liabilities	(=)	490,404
Net worth	(X-Y)	994,374

SOLVENCY MEASURES

Current percent in debt		71.4 %
Current & intermediate pct in debt		37.3 %
Long term percent in debt		21.6 %
Nonfarm percent in debt		- %
Total percent in debt	(Y/X)	33.0 %

NET WORTH CHANGE (Typical Year)

Net farm income		234,591
Nonfarm income	(+)	-
Family living	(-)	-
Income taxes and social security	(-)	98,939
Net worth change per year	(=)	135,651

FINANCIAL STANDARDS MEASURES	Base Plan Plan 1
Liquidity	
Current ratio	1.40
Working capital	71,167
Solvency	
Farm debt to asset ratio	33.0 %
Farm equity to asset ratio	67.0 %
Farm debt to equity ratio	49.3 %
Profitability	
Rate of return on farm assets	15.8 %
Rate of return on farm equity	20.7 %
Operating profit margin	41.5 %
Net farm income	234,591
Repayment Capacity	
Term debt coverage ratio	227.7 %
Capital replacement margin	103,783
Efficiency	
Asset turnover	38.2 %
Operating expense ratio	63.5 %
Depreciation expense ratio	2.7 %
Interest expense ratio	3.7 %
Net farm income ratio	30.2 %

CROP AND LIVESTOCK PRODUCTION

Corn Silage	ton	1,600
Oats, Feed	bu.	350
Hay, Mixed Alfalfa/Grass	ton	800
Pasture	aum	2,790
Milk	lb.	4,810,000

SENSITIVITY ANALYSIS

Effect Of A 2 % Decrease In All Enterprises		
Net farm income		217,575
Cash surplus or deficit		93,833
Net worth change per year		125,702
Effect Of A 10 % Decrease In All Enterprises		
Net farm income		149,511
Cash surplus or deficit		58,145
Net worth change per year		90,014