Demonstration Report No. 8

On-Farm Compost Demonstration Project

Lake Champlain Basin Program

Prepared by
Clinton County Soil & Water Conservation District
Steven Wisbaum, Project Manager

for
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ON-FARM COMPOST DEMONSTRATION PROJECT
FINAL REPORT

December 1996

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This demonstration report is the eighth in a series of reports prepared under the Lake Champlain Basin Program. Those in print are listed below.

Lake Champlain Basin Program Demonstration Reports

1. *Case Study of the Town of Champlain.* Yellow Wood Associates. October 1993.

2. *(A) Demonstration of Local Economic/Other Community Impacts.* Community Case Studies for Economic Plan Elements. The City of Vergennes, Vermont. Economic and Financial Consulting Associates, Inc. October 1993.

   (B) Demonstration of Local Economic/Other Community Impacts. Community Case Studies for Economic Plan Elements. Appendix. The City of Vergennes, Vermont. Economic and Financial Consulting Associates, Inc. October 1993.

3. *The Archeology on the Farm Project.* Improving Cultural Resource Protection on Agricultural Lands: A Vermont Example. Jack Rossen. May 1994.

4. (A) *The 1992 Fort Ticonderoga-Mount Independence Submerged Cultural Resource Survey. Executive Summary.* Arthur Cohn. May 1995.

   (B) *The 1992 Fort Ticonderoga-Mount Independence Submerged Cultural Resource Survey.* Arthur Cohn. May 1995.

   (C) *The Great Bridge "From Ticonderoga to Independant Point".* Arthur Cohn. May 1995.

   (D) *Geophysical Reconnaissance in the Mount Independence Area: Larrabee's Point to Chipman Point.* Patricia Manley, Roger Flood, Todd Hannahs. May 1995.

   (E) *Ticonderoga's Floating Drawbridge; 1871-1920.* Peter Barranco, Jr. May 1995.

   (F) *Bottom Morphology and Boundary Currents of Southern Lake Champlain.* Hollistir Hodson. May 1995.

5. *Implementation, Demonstration, and Evaluation of BMPs for Water Quality: Application Methods ("Manure Injections") for Improved Management of Manure Nutrients.* Bill Jokela, Sid Bosworth and Don Meals. September 1995.

6. (A) *Malletts Bay Recreation Resource Management Plan.* T.J. Boyle and Associates, Resource Systems Group, Associates in Rural Development and Engineering Ventures. October 1995.

   (B) *Malletts Bay Recreation Resource Management Plan. Executive Summary.* T.J. Boyle and Associates. October 1995.

   (C) *Review and Relevant Studies. Malletts Bay Recreation Resource Management Plan.* T.J. Boyle and Associates. October 1995.

   (D) *Natural and Built Resources Inventory: Data Documentation. Malletts Bay Recreation Resource Management Plan.* Associates in Rural Development. October 1995. **This report will not be published but data is available at the LCBP office.**

   (E) *Survey Implementation and Analysis. Malletts Bay Recreation Resource Management Plan.* Resource Systems Group. October 1995.

(F) *Institutional Review and Analysis. Malletts Bay Recreation Resource Management Plan.* Engineering Ventures. October 1995.

7. *The Best River Ever. A conservation plan to protect and restore Vermont's beautiful Mad River Watershed.* Mad River Planning District and Friends of the Mad River. December 1995.

8. *On Farm Composting Demonstration Project.* Clinton County Soil & Water Conservation District. December 1996.

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INTRODUCTION

This report describes the results of an on-farm compost demonstration project conducted between April 1995 and September 1996 in the upper Champlain Valley of N.W. Vermont and N.E. New York State. As described in the "Project Proposal", there is increasing concern on the part of farmers and the general public regarding the potential impact of nutrient and bacteria loading from animal manure on Lake Champlain and its tributaries. Launched as a cooperative effort between agricultural and academic institutions in Vermont and New York State, the primary goal of the project was to demonstrate the potential benefits of on-farm composting both as a method to export excess nutrients from area farms and to demonstrate the potential for composting to reduce water quality impacts from manure stored and used on these farms. The project had five broad objectives:

1) Install facilities for composting animal waste on three working farms in the Lake-adjoining counties of Clinton County, NY, and Franklin and Grande Isle Counties, Vermont.

2) Demonstrate simple and economical on-farm composting technologies to farmers and other interested parties in the Lake Champlain Basin.

3) Determine the feasibility of operating commercial-scale composting facilities for animal waste produced on dairy farms in the Lake Champlain Basin.

4) Explore the marketing potential for the compost produced at these farms.

5) Educate and inform the agricultural community, students, teachers, policy-makers, natural resources managers, and the general public about the benefits and drawbacks of composting.

Composting Overview

On-farm composting is a method of manure management which utilizes natural decomposition processes under controlled conditions to recycle the nutrients, chemical energy, and organic matter stored in plant and animal wastes. The driving force behind this decomposition process are a host of beneficial soil organisms including bacteria, fungi, actinomycetes, and earthworms which transform these wastes into the nutrient-rich and biologically active component of soil known as humus.

There are many recognized benefits of applying compost to soil - these benefits include:

1. Compost increases the soil's organic matter content, biological activity, tilth, aeration, buffering capacity, and cation exchange capacity (CEC).

2. The nutrients in compost are in a more stable form and available over a longer period of time than the soluble nutrients in chemical fertilizers.

3. The heat generated in a properly managed compost process destroys weed seeds and both plant and animal pathogens.

4. Crops grown in composted soils tend to be more productive and have greater resistance to disease and pests.

There are additional benefits of when on-farm composting is used an alternative, or complementary, manure management strategy - these benefits include:

1. On-farm composting can conserve nutrients such as nitrogen and phosphorus that would otherwise contaminate ground and surface water resources from raw manure which is improperly stored and/or applied to fields. Composting can also conserve nitrogen in manure that would otherwise be lost through volatilization when the manure is left exposed on the soil surface for extended periods of time after application.

2. On-farm composting allows farmers to export excess nutrients through the sale of compost to backyard gardeners, landscapers, nurseries, and other farmers. Compost prices vary from $10 to $25 per cubic yard when sold in bulk or $30 to $60 per yard when sold in small bags.

3. In addition to destroying weed seeds and pathogens, the heat generated in the composting process also reduces fly and odor problems normally associated with stored manure.

4. Composting adds flexibility to a farm's manure management system since composted manure can be applied to fields when raw manure would interfere with cropping cycles, reduce forage palatability, or create contaminated runoff.

5. Being odorless, compost spread onto fields doesn't generate the objectional smells associated with raw manure.

6. Composting can remove much of the moisture from raw manure which makes it lighter, easier to transport, and less likely to compact soils during application.

7. Composting can also be used as a safe and inexpensive disposal method for dead animals.

8. On-farm compost operations can generate additional revenue from tipping fees charged for compostable materials (e.g. food waste, leaves, and brush) brought to the farm.

COMPOSTING BASICS

Ingredients/Raw Materials

Most plant and animal wastes can be composted effectively. Suitable compost ingredients which are typically available to farmers include: animal manure; waste silage; surplus hay; corn stover; soybean straw; animal bedding; and cut vegetation such as reed canarygrass. Generally, the greater the variety of ingredients in the compost mix, the better the composting process and the finished product. Small amounts of soil (preferably clay), finished compost, trace minerals, and microbial "bioactivators" are also thought to be beneficial to the compost process. On the other hand, contaminants such as rocks, glass, and non-biodegradable plastics should be avoided.

In this project, all three participating farms used dairy manure as the primary compost ingredient. Additional ingredients included: soybean straw; waste silage; surplus hay; horse manure/bedding from nearby horse stables; and, wood processing by-products. Soil and two different compost starters were also tried at two of the farms.

Biology of the Compost Process

Oxygen

Compost organisms are "aerobic" which means they require oxygen to survive. Conversely, if there isn't enough oxygen available in a compost windrow, the growth of anaerobic organisms is promoted resulting in the production of phytotoxic substances and unpleasant odors. The factors that effect the amount of oxygen available in a compost system are:

a. Amount of moisture in a windrow since saturated conditions will displace and impede the movement of oxygen.
b. Physical properties of the ingredients such as particle size and rigidity of the ingredients will impact the movement of oxygen, carbon dioxide, and water vapor through a windrow.
c. Frequency and effectiveness of "turning", or aeration, of a windrow.

Carbon to Nitrogen Ratio (C:N)

The relative amount of carbon compounds to nitrogen compounds both in individual compost ingredients and mixtures of ingredients, is referred to as the carbon to nitrogen ratio (C:N). Compost organisms ideally require about 25 times more carbon compounds than nitrogen compounds in their diet, or a C:N of 25:1. When the nitrogen content in a compost mixture is too high, a compost windrow is said to have a "low" C:N. Under these conditions, mineralization of nitrogen will be impeded, excess nitrogen will be lost through volatilization, and unpleasant odors will be generated. Conversely, if there is not enough nitrogen, the decomposition process will be inhibited and minimal heat will be generated.

Average C:N ratios for specific compost ingredients can be found in the "On-farm Compost Handbook" (Northeast Regional Agricultural Engineering Service, Cornell University) while C:N ratios for specific ingredients can be determined by laboratory analysis. In general, animal manures and green plants have a low C:N (i.e. a higher proportion of nitrogen compounds) while dried plant residue have a higher C:N ratio (i.e. a higher proportion of carbon compounds). A summary of C:N ratios for the compost ingredients used at the three sites is included in Table 1 - "Manure and Compost Ingredient Characteristics".

Moisture

Like all living organisms, compost microbes require a certain amount of water to survive. In a compost windrow, these microbes live mostly in the moisture envelope surrounding the organic materials they are feeding on. While a 50 to 65% moisture content (50 to 35% dry matter) is considered ideal for composting, achieving and maintaining this moisture content in an active windrow is typically the most challenging aspect of on-farm composting.

Excess water in a compost windrow will create anaerobic conditions by displacing oxygen needed by the compost microbes. Excess moisture also generates contaminated leachate and runoff and reduces the nutrient content of the finished compost. Conversely, a compost windrow that is too dry will have minimal biological activity and the compost process will be inhibited. Factors that affect the amount of moisture in a compost windrow are listed below:

a. The moisture content and water-holding capacity of the individual ingredients used.
b. Both the porosity of a windrow and the effectiveness of windrow turning will determine the rate of decomposition, amount of heat generated, and the evaporation rate.
c. Adequate compost pad drainage and proper orientation of windrows on the pad will ensure water does not collect around, and under, the windrows.
d. Windrow shape will determine if rain runs off, or into, a windrow. A windrow that has a flat top will tend to capture rainwater while a windrow with a pointed top will tend to shed it.

TABLE 1

MANURE AND INGREDIENT CHARACTERISTICS

MANURE

PARAMETER	MENARD	POQUETTE Barnyd	POQUETTE Pit	WOLCOTT/ MACCAUSLAND
Moisture	80.6	63.5	84.5	86.1
C:N Ratio	16.8	12.2	10.6	10.3
Organic Matter (%)	89.4	63.1	81.4	81.1
Density (lb/cu ft.)	53.2	39.9	68.2	60.3
pH	7.4	8.3	6.6	7.1
Nitrogen	2.68	2.64	4.01	3.98
Phosphorus (%)	0.57	0.55	0.73	1.06
Potassium (%)	1.33	1.83	2.54	2.22
Calcium (%)	1.61	1.72	1.93	2.27
Magnesium (%)	0.53	0.60	0.68	0.74
Sodium (%)	0.16	0.45	0.58	0.35

COMPOST INGREDIENTS

PARAMETER	MENARD		POQUETTE		WOLCOTT/MAC	
	Horse Manure	Silage	Horse Manure	Soybean Straw	Hay	Chips
Moisture (%)	44.2	79.3	66.8	11.4	7.8	42.1
C:N Ratio	53.3	14.3	35.4	35.1	29.8	100.4
Org. Matter (%)	66.8	84.8	82.0	91.7	95.8	96.60
pH	6.7	8.4	7.7	8.6	6.3	5.8
Nitrogen	0.64	3.05	1.15	1.26	1.53	0.47
Phosphorus (%)	0.15	0.51	0.26	0.07	0.14	0.02
Potassium (%)	0.45	2.92	1.00	1.28	0.68	0.16
Calcium (%)	0.86	2.39	1.57	1.39	0.56	0.78
Magnesium (%)	0.35	0.46	0.24	0.35	0.13	0.06
Sodium (%)	0.04	0.05	0.10	0.02	0.01	0.01
Density (lbs/ft^3)	21.1	21.3	21.3	6.30	3.40	16.4
Water Holding Cap (gal/ft^3)	3.00		3.80	1.80	1.70	2.70

To absorb excess moisture present in wet compost ingredients such as dairy manure, drier ingredients referred to as "bulking agents" have to be used. Bulking agents also typically have a high C:N ratio which helps to balance the lower C:N ratio of dairy manure. An ideal bulking agent will also have physical characteristics which improve the porosity of a compost windrow thereby ensuring optimum exchange of oxygen and carbon dioxide through the compost windrow. A summary of the moisture contents and water holding capacities for the compost ingredients used at these sites is also included in Table 1.

Excess moisture conditions in a compost windrow can also be controlled through the use of specially designed "compost covers". These covers are made of non-woven polypropylene fibers made into a light but durable fabric that is permeable to oxygen, carbon dioxide and water vapor but is able to shed 80 to 100 % of rainfall and snowmelt from the covered windrow. These covers are especially useful for compost mixtures that start out with high moisture content, during periods of extended rainfall, and/or for covering mature compost.

In the summer months compost windrows can also become too dry as large quantities of water is lost through evaporation. In this situation, compost windrows can be rehydrated with overhead sprinklers, drip irrigation systems, and flooding furrows carved down the center of the windrows. Some compost turners are also equipped with watering manifolds that allow water to be added during turning.

COMPOST FACILITIES DESIGN CRITERIA

Design and construction characteristics of a compost site will have a direct impact on the accessibility to the site during wet weather, on labor and equipment needs, and the quality of the composting process and the finished compost. Site characteristics will also determine the potential for environmental impacts such as odors and contamination of surface and ground water. The site characteristics that should be considered are:

Site Slope:

Sites slope should be between 1-3% to ensure water doesn't collect on the pad and saturate the windrows.

Pad Surfaces:

Beyond a site having adequate drainage and proper slope, compost operators must determine the type of pad surface on which windrows will be placed. If a farmer has a relatively smooth field available and can schedule composting activities during dry periods, windrows can be constructed directly on a sod base. While this is clearly the least expensive option, the site must be managed to keep weed seeds from being incorporated back into the finished compost from the surrounding and underlying soil and vegetation.

Some compost operations however will need to be operated on a daily basis because the farm either doesn't have manure storage facilities or because the site is operated as commercial compost site. Consequently, these operations must have a pad made of gravel, asphalt, or concrete to accommodate heavy equipment during periods of wet weather.

While gravel usually offers the lowest initial installation cost, it must be constructed and managed to ensure stones aren't mixed into the compost thereby reducing the marketability of the compost

and/or increasing operating costs associated with their removal Some sites have also used crushed limestone, flyash, and/or cement to stabilize the gravel but this too will increase initial construction costs. Poured concrete or asphalt eliminate the problems associated with loose gravel but these materials are also considerably more expensive to install - they are also more difficult to remove if a farmer decides to discontinue composting.

Pad Sizing:

There are numerous factors to consider when calculating the size of a compost pad - these factors include:

a Volume of manure that will be composted.
b. Volume of any other compost ingredients such as food waste accepted from off-site sources.
c. Volume of bulking agents needed to achieve the proper moisture, C:N, and porosity.
d. Total volume of all materials to be composted at any one time on the pad.
e. The windrow size and alley widths as determined by the turning method used.
g. The compost process rate as determined by the C:N, porosity of the compost mix, and the frequency and effectiveness of turning.
h. Volume of bulking agent and finished compost to be stored on the pad.
i. Potential for any of these factors to change over time.

Distance to surface water and drinking water wells:

All compost sites should be located a safe distance from surface water drinking water wells to protect against contamination by site runoff and/or leachate.

PERMITTING

Generally, there are relatively few restrictions regarding on-farm composting of agricultural by-products. On the other hand, composting of non-agricultural by-products such as food waste and even yard waste (e.g. leaves, grass, brush, etc.) is usually regulated by state and/or local environmental agencies.

Permitting requirements for both New York State and Vermont had to be considered for this project. New York regulations governing composting operations are contained in 6 NYCRR Part 360. The demonstration site in New York qualified as "conditionally exempt" from these regulations since only agriculture waste was to be composted. Under this exemption however, the compost site was still expected to operate in a safe, nuisance-free manner, using acceptable composting methods. Written notice also was also required by the NY Department of Environmental Conservation following construction and prior to commencement of compost activities.

Vermont regulations governing composting operations are contained in Subchapter 11 - Composting Facilities and Activities and Title 6, Ch 215 of the Vermont Agricultural Non-point Source Pollution Reduction Program - Accepted Agricultural Practice Regulations (AAP's). Both Vermont sites qualified for Composting Certification Exemptions Under Subchapter 11, but were similarly expected to be managed in accordance with the Accepted Agricultural Practices.

COMPOST OPERATIONS

Ingredient Mixing

The composting process begins by mixing compost ingredients together using a mixing ratio which will achieve the desired moisture content, C:N ratio, and windrow porosity. Initially, the manure at all three project farms was relatively wet requiring mixing ratios of 1 part manure to 1 to 1.5 parts bulking agent.

There are a variety of methods that can be used to mix ingredients. Ingredients can be pre-mixed in a suitable mixing area with a bucket loader and then hauled to the compost pad in a dump cart, dump truck, or bucket loader. The material is then dropped into a windrow which is then trimmed to the proper width with a bucket loader. The ingredients can also be mixed directly in a manure spreader which is also used to haul the material to the pad and to form the windrows. However, since spreaders are usually designed to discharge material over a wide swath, they also require some modification to create narrow windrows of the desired shape and dimension (see below).

Another option is to mix the ingredients in-place. This can be done by placing alternating loads of different ingredients into a dump cart or dump truck which drops the mixture into a windrow. This windrow is subsequently trimmed and mixed again using a bucket loader or a specialized compost turning machine. A variation of this last method is to place alternating layers of ingredients into a windrow with a bucket loader, side-dumping manure spreader or dump cart. This layered windrow is then mixed with a bucket loader or compost turner. Ingredients such as hay bales (round or square) can also be manually laid out to form a thick base onto which manure is added to form a windrow which is similarly mixed in-place with a bucket loader or compost turner.

Windrow Formation

The specific windrow dimensions are determined by a number of factors including: the turning method and equipment used; porosity of the windrow; and site size. Typical on-farm windrow dimensions range from 8 to 12 ft. wide at the base and 4 to 6 ft. high with wetter ingredients benefiting from smaller windrows which have larger surface to volume ratios and therefore, greater potential for evaporation and passive aeration. Windrow sizes may also be increased during the curing phase and/or during colder months to retain more heat. To accommodate the two different compost turners used at these sites, two basic windrow sizes are being used - 8.5 ft. wide by 4.5 ft. high and 10 ft. wide by 5 ft. high.

At a minimum, 3-4 feet should also be left between windrows for water movement away from the site but larger alleys may also be required if the windrows are to be turned with a bucket loader and/or are located on a sod base which needs to be cut periodically with a tractor to prevent contamination of mature compost with weed seeds.

Windrow-shaper Attachments

All three project sites mixed ingredients and formed windrows using manure spreaders which were modified with "Windrow-shaper" attachments that allowed them to be used to create windrows of the desired dimension and shape. The Windrow-shaper attachments used on the rear-exit spreaders consisted of a set of wing-like deflectors attached to the back of the spreaders. The Wolcott/MacCausland's built their's out of plywood while the Menard's was built out of steel plate by a local machine shop. It's also possible in some cases to change the position of the outside flails on some spreaders to create narrow windrows when the spreader is run at a slow enough speed.

The Windrow-shaper attachment for the Poquette's side-discharge spreader consisted of a top deflector made out of PVC sheeting and a flexible "backstop" made out of rubber roofing material - the frame was square steel tubing. This Windrow-shaper attachment also included a system of cables and a hydraulic piston which allows it to be folded out of the way when not in use. Photographs of each of these three Windrow-shaper attachments along with simplified construction plans are included in the Appendix. A list of "Design Considerations For Windrow-Shaper Manure Spreader Attachments" is also included.

Compost Turning

The primary compost method used for this project was the "turned-windrow" method. In this method windrows are turned (or aerated) periodically using a bucket loader or a compost turner. Besides releasing carbon dioxide from inside the windrow, turning also remixes the compost ingredients and restores the windrow's internal pore structure and enhances passive aeration within the windrow.

While bucket loaders can be used to turn windrows, many farms and almost all commercial sites use compost turners. The advantages of using a turner include: significantly faster turning times; reduced wear-and-tear on farm tractors; better aeration and ingredient mixing; more uniform heating of the windrow; and improved moisture control. Small to mid-size turners for on-farm composting cost between $13,000 to $20,000 for a tractor-pulled model and over $32,000 for a self-propelled model.

The most obvious disadvantage of a turner is its cost although this can be reduced by having the turning done on a "custom" basis or by purchasing a turner cooperatively. Tractor-pulled turners also require that the tractor pulling the turner have sufficient power and either a hydrostatic transmission or a "creeper gear" which keeps the tractor speed down to .5 to .75 mph.

Initially, the Menards and the Poquettes were both turning their windrows with bucket loaders. However, a few months after the project began, a tractor-pulled Sitler model 510 turner was leased by the project for use by all three farms. This turner was selected due to its affordability and recommendations from other composters. As expected, this turner clearly demonstrated its time-saving value over a bucket loader. Unfortunately, it also proved more difficult to transport between sites than anticipated and one site didn't have a tractor with a creeper gear as originally planned. In addition, the turner had some mechanical problems soon after it was received and was out of service for three critical weeks in the fall.

In light of these problems, the lease on the turner was discontinued and Champlain Valley Compost Company (CVCC) was contracted to provide custom compost turning services using a self-propelled Sandberger 80 Hp 100-inch turner. Under this agreement, CVCC assumed responsibility for providing a certain number of turning visits plus transportation between the sites for a set fee. Additionally, the Menards were able to purchase the leased turner at a reduced price after the lease was discontinued.

Passively Aerated Windrow System (PAWS)

To demonstrate an alternative on-farm dairy manure composting method, passively aerated windrows were constructed at two of the sites. In this composting method, a thick layer of a suitable bulking agent, such as straw, is used to form a 6 to 12 inch thick base. Lengths of perforated 10 foot HDPE drainage pipe are then placed across the width of straw/hay base every 18 to 24 inches. The ingredients are then mixed and windrows formed on top of the base leaving the ends of the pipes exposed. The final step is to cover the windrow with a 2-3 inch layer of a suitable insulating material such as straw, sawdust, compost, or a compost cover.

As the temperatures inside a PAWS windrow begins to rise and available oxygen is consumed during microbial decomposition, convection creates a "chimney effect" drawing in more oxygen through the open ends of the pipes. Since the windrow is not turned during the composting process, the ingredients must be well mixed prior to forming the windrows. Furthermore, when composting wet materials such as dairy manure, special attention must be given to the type and quantities of bulking agents used to provide adequate porosity within the windrow. Project participants commented that handling the drain pipes proved cumbersome and the finished product was less uniform than the material from the turned windrows.

Moisture, Runoff, and Leachate Control

As described above, dairy manure can contain excessive amounts of moisture depending on the type and volume of bedding used and the type of manure collection and storage facilities used. Since all three project sites initially had manure with high moisture contents, various methods were considered and tried to reduce this moisture prior to, and during, composting. While these moisture reduction methods are described in the "Description of Participating Farms" section, the methods that worked best included: increasing the amount of bedding used in the barns; increasing the amount of bulking agents used, and reducing the amount of additional moisture absorbed by the windrows by using compost covers - the covers used were Compostex® covers manufactured by Texel, Inc. of Quebec, Canada.

Animal manure also contains significant quantities of bacteria and nutrients such as nitrogen and phosphorus which could become surface and/or ground water pollutants via site runoff and leaching from windrows. The production of runoff and leachate is directly related to: the initial moisture content of the windrows; the amount of moisture infiltrating the windrows during composting; the site slope; the presence of vegetation under and around the compost windrows; and the potential for surface water draining onto the site. Taking all these factors into account, a variety of design and operational strategies were used to reduce contaminated runoff and leachate generated at the three sites. In addition to the moisture control methods described above, windrows were oriented parallel to the site slopes to keep water from collecting against and around windrows, a vegetated filter strip was installed to capture nutrients in any runoff from the Menard site; the concrete compost pad at the Poquette's was designed to drain runoff into their secondary manure/water storage pit; and, drainage improvements were made at all three sites to redirect any incoming surface water away the compost areas.

COMPOST PROCESS MONITORING

In order to evaluate and track the relative health and progress of the compost process, at a minimum, windrows should be monitored in the field for temperature, moisture, odor, and color. These compost monitoring criteria are described in more detail below:

Temperature

Temperature changes relate directly to the amount of microbial activity within a compost windrow with optimum decomposition occurring between 120 and 145°F. Compost thermometers and monitoring logs were provided to project participants to monitor and record temperatures in the windrows. This proved to be a very effective useful tool for assessing the effect of different mixing ratios and moisture control methods on the compost process.

Aroma and Color

Aroma is also used as a monitoring tool since there are distinct smells associated with both a healthy (aerobic) and unhealthy (anaerobic) compost windrow. While raw manure typically has a strong ammonia odor, even in the earliest stages of the compost process, this odor is replaced with a more pleasant, earthy aroma and the ingredients start turning dark brown as they decompose.

Moisture

As described above, moisture is essential to the compost process with too little or too much inhibiting the compost process and/or causing contaminated runoff and leachate. The moisture contents of both the raw ingredients and the finished compost were tested and are also included in Table 1. Moisture can also be tested by collecting and weighing a sample, drying it completely in a microwave oven, reweighing the sample, and then calculating the difference to find the percentage of dry matter and moisture.

Oxygen and Carbon Dioxide

Since compost organisms utilize oxygen and respire carbon dioxide as they metabolize and decompose raw organic matter, an extreme deficit of oxygen and/or the extreme buildup of carbon dioxide in an active windrow will create undesirable anaerobic conditions unless sufficient aeration can occur by diffusion through the windrow (passive aeration) and/or by turning. Therefore, monitoring levels of oxygen and carbon dioxide in a windrow is another tool for assessing the health of a windrow and managing the compost process. While some limited field testing for oxygen and carbon dioxide was done to collect supporting data, the relative high cost of oxygen and carbon dioxide meters makes them impractical for the average farmer-composter to purchase.

LABORATORY TESTING OF INGREDIENTS AND COMPOST

To determine proper mixing ratios and collect baseline data on the raw ingredients, samples were collected of manure and bulking agents at each site. These samples were analyzed by the UVM Plant and Soil Science laboratory for specific characteristics including: major plant nutrients (e.g. nitrogen, phosphorus, etc.), micro-nutrients (e.g. copper, zinc, etc.); moisture content; C:N; pH; organic matter; density; water holding capacity; and conductivity. Samples of partially finished and finished compost were also analyzed for some of the same parameters as the ingredient and manure samples. A summary of the laboratory results is included as Table 2 - "Compost Analyses Summary".

TABLE 2

COMPOST ANALYSES SUMMARY

ON-FARM COMPOST DEMONSTRATION PROJECT

PARAMETER	MENARD 1) 4 week 2) 12 week 3) 20 week	POQUETTE 1) 8 week 2) 20 week	WOLCOTT/MAC 1) 1 day 2) 8 Week
Moisture (%)	71.9 50.4 44.5	77.2 62.6	68.3 75.5
C:N Ratio	18.7 12.8 15.6	14.5 11.1	17.5 18.9
Organic Matter (%)	55.4 23.9 25.6	74.1 42.9	43.7 76.9
pH	8.3 7.8 8.2	8.6 7.8	8.1 8.1
Ammonium-N (ppm)	50 62		0.21(%)
Nitrate-N (ppm)	49 99		48
Total Nitrogen (%)	1.52 1.57 0.81	2.79 2.30	1.26 2.25
Conductivity (mS/cm)	1.2		3.7
Phosphorus (%)	0.44 0.41 0.27	0.91 0.63	0.48 0.59
Potassium (%)	0.87 0.53 0.89	2.51 1.85	0.94 1.22
Calcium (%)	1.32 1.10 1.40	2.59 2.46	1.41 2.46
Magnesium (%)	0.58 0.63	0.81 0.64	0.60 0.54
Sodium (%)	0.08 0.05	0.39 0.10	0.10 0.15

DESCRIPTION OF PARTICIPATING FARMS AND COMPOST FACILITY DESIGNS

The site design and operations planning process for the project began in mid-April 1995. This planning process included interviews with project participants and a thorough assessment of each farm to evaluate available ingredients, potential compost sites, existing manure handling practices and facilities, farm layout, and the suitability of existing farm equipment for composting. Facility and system designs were then developed by project staff using data and information obtained on each farm and standard compost facility construction guidelines. Additionally, a fair distribution of the limited project funds also had to be considered. Copies of each of the three site designs are included as Figures 1, 2, and 3.

Menard Farm

General Description

70 acres in field corn for silage, 18 acres in hay, and 50 acres pasture. Herd includes 75 milking cows and 70 youngstock. Housing is tiestall barn.

Manure Handling System and Facilities

Gutter cleaner to elevator to spreader. The Menards do not have any manure storage facilities so they have to spread or field-stack the manure 365 days a year.

Manure Characteristics (approx)

Moisture : 80 %
C:N: 16.8
Volume: 6 cu yd/day = 1,392 to 2,190 yd^3/yr (Smaller volume assumes manure is spread directly on fields during May, June, September, and October).

Bulking Agents Available

On-farm spoiled silage and haylage (100 yd^3/yr)
Spoiled silage from neighboring farms (variable)
Free manure/bedding from a nearby horse stable (600 yd^3/yr)

Mixing Ratios

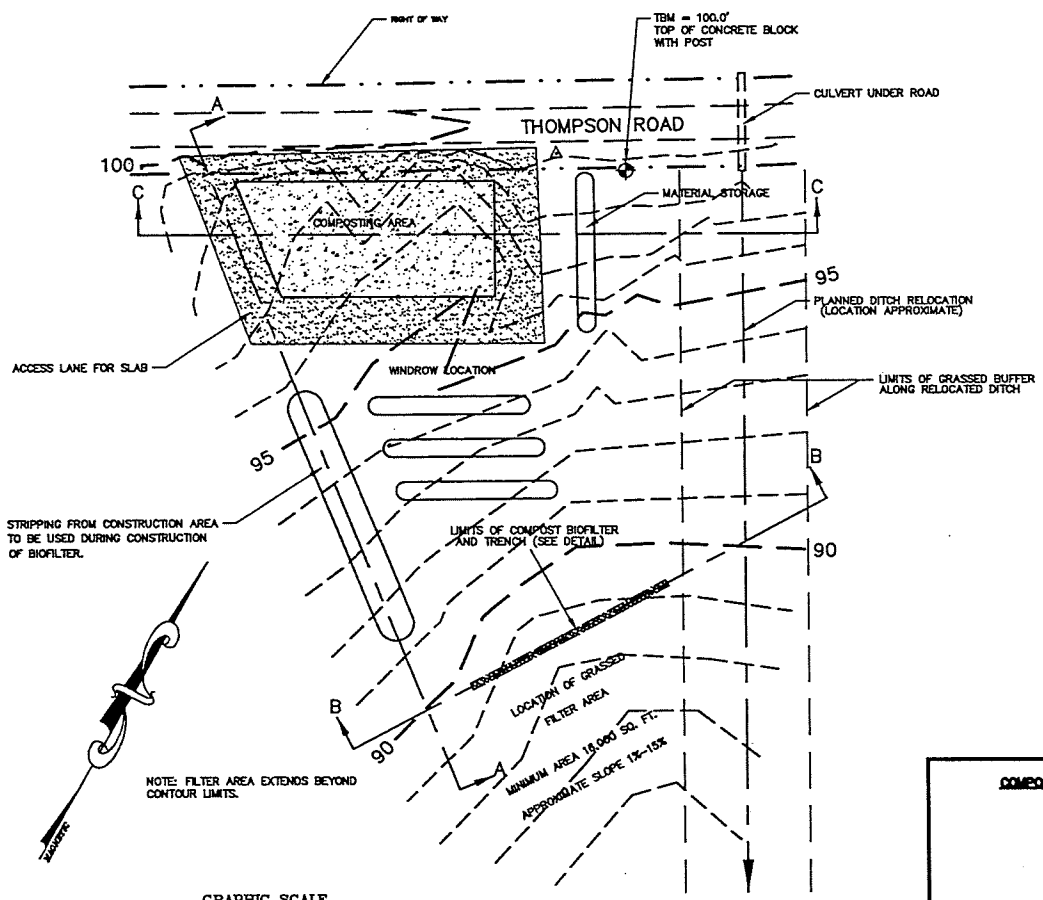
Manure has generally required a mixing ratio of 1 part manure to 1.5 parts bulking agent.

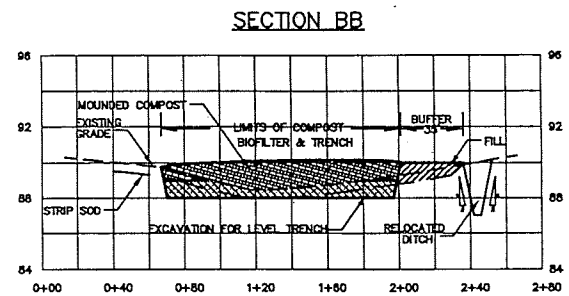
Equipment Used or Acquired for the Compost Operation

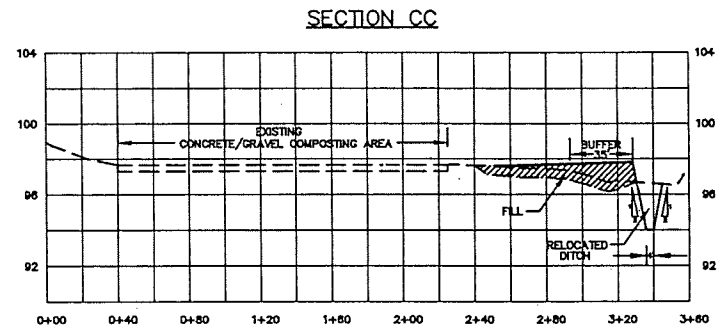
Spreader: H&S 370 rear-exit outfitted with windrow-shaper spreader attachment.
Tractor 1: International 80 HP; 1 yd^3 bucket for material handing
Tractor 2: SAME 160 Hp; for turning compost windrows.
Turner: "Sitler" tractor-pulled compost turner with 10′ wide windrow capacity. Requires 80 hp tractor with creeper gear or hydrostatic transmission. This turner was initially leased by the project for use at all three sites and when the leased expired, the Menards purchased the turner with their own money.
Truck: International 28 yd^3 dump truck is used to haul bulking agents to site.

Compost Site

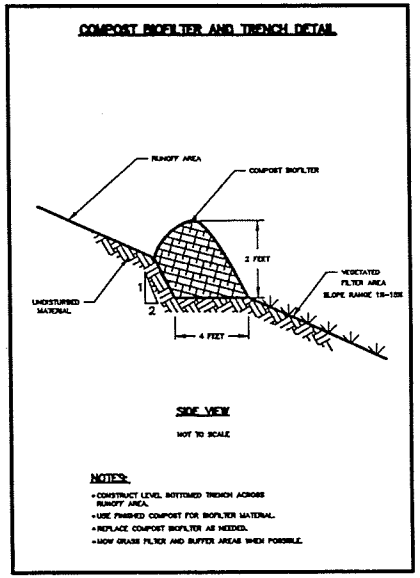
The compost site is located on a 3 acre field within 1/8 mile from the main barn. The site required significant grading and drainage improvements which cost approximately $ 5,745.







CONSTRUCTION ITEM INSTALLED	QUANTITY	SPECIFICATIONS
STRIPPING	500 C.Y.	1, 5
EARTH FILL, Class "C" compaction	500 C.Y.	5, 13
BORROW, Hauled in fill, Class "C" compaction	500 C.Y.	5, 13
FINISHED COMPOST, Loosely placed in trench	50 C.Y.	
SEEDBED PREPARATION, lime, fertilizer, seeding and mulching CRITICAL AREAS; work accomplished primarily by hand and light equipment	0.4 AC.	5, 52



CONSTRUCTION INSPECTION ITEMS FOR THIS DESIGN ARE CONTAINED IN "GUIDE FOR DESIGN AND CONSTRUCTION OF CONSERVATION PRACTICES". IN ADDITION THE FOLLOWING SPECIAL ITEMS ARE NOTED:

1. STRIP SOD FROM AREA TO BE GRADED AND FILLED.
2. GRADE COMPOSTING AREA & FILTER AREA AS SHOWN ON THE DRAWING.
3. COMPACT ALL EARTH FILL AND BORROW TO CLASS "C" COMPACTION AS DESCRIBED IN NRCS SPECIFICATION #13.
4. INSTALL A COMPOST BIOFILTER AND TRENCH TO TREAT RUNOFF AT LOCATION SHOWN ON THE DRAWING.
5. MAINTAIN GRASS BELOW BIOFILTER/TRENCH AREA AT LOCATION SHOWN ON THE DRAWING TO FURTHER TREAT ANY RUNOFF THAT MAY OCCUR.
6. NOTIFY NRCD PROJECT MANAGER 2 DAYS PRIOR TO CONSTRUCTION.
7. DIVERT SURFACE WATER AWAY FROM COMPOSTING AREA.

NOTIFY THE DIGSAFE CENTER AT 1-800-225-4977 AT LEAST 48 HOURS BEFORE STARTING TO DIG.

Figure 1

JOB CLASS II

GARY & CONNIE MENARD
GRASSED & BIOFILTER AREA
FOR COMPOST RUNOFF

MOORES NEW YORK

U.S. DEPARTMENT OF AGRICULTURE
NATURAL RESOURCES CONSERVATION SERVICE

Designed J.KERNS / J.WERY 2-24
Drawn K.Hurry 2-24
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Title
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Sheet No. 1 of 1
Drawing No.

Compost Pad

With no manure storage system in place at this site, the compost operation was designed for year-round access. A concrete compost pad (60′ x 140′) was installed along with a gravel access and perimeter road. The cost for this pad and access road was approximately $ 9,094. An additional compost area adjacent to the concrete pad was also stripped of the topsoil and graded.

Ingredient Mixing and Windrow Formation

Ingredients are mixed in the rear--exit manure spreader modified with a "Windrow-shaper" spreader attachment consisting of a pair of deflectors (or doors) mounted on the rear of the spreader to direct compost ingredients into a narrow windrow. The cost to fabricate this attachment was $ 550. Manure and bulking agents are hauled from the barn to the site in the spreader and formed into windrows. Bulking agents are also stored at the site and added to the windrows as needed.

Leachate and Run-off Control

A grassed waterway and vegetated filter strip was installed to retain nutrients from any site runoff from both the concrete pad and the adjacent sub-soil pad. Compost covers are also being used extensively.

POQUETTE FARM

General Description

125 acres in field corn for grain and silage and 300 acres in haylage, 54 acres in soybeans, and 25 acres of oats. Herd typically includes 45 milkers and 45 youngstock. Housing is a tiestall barn, large covered barnyard for most of herd, and then smaller covered barnyard for rest of young stock. Cows also have access to small pasture in late spring, summer, and early fall.

Manure Handling System and Facilities

1) Stall manure moved with gutter cleaner and pump to a dual-pit manure storage system with a primary pit for manure storage, two corner picket dams for capturing water draining from raw manure, and a secondary pit for storing this water. Based on a moisture test and visual observation, this system still does not adequately reduce the moisture content of stored manure in the primary pit. It is thought that more water would be drained if the soil berm between the two pits was replaced with a large picket dam. During the first composting cycle, most of the stored manure was spread with the remainder composted (approx. 200 $yd^{3)}$.

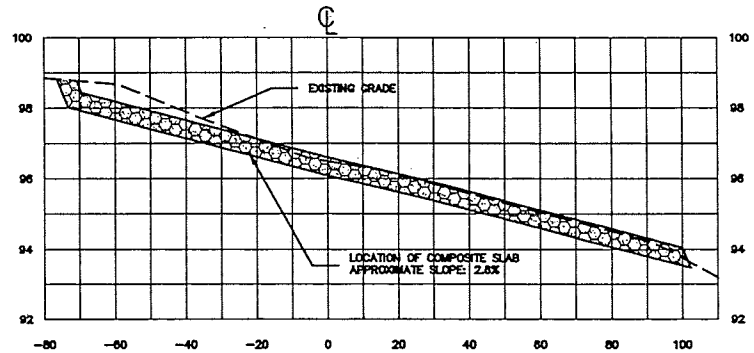
2) Manure in a large covered barnyard is scraped twice or more per week (depending on weather) and stockpiled on manure pit ramp. Once or twice per month this pile is loaded into manure spreader and placed into windrows for composting.

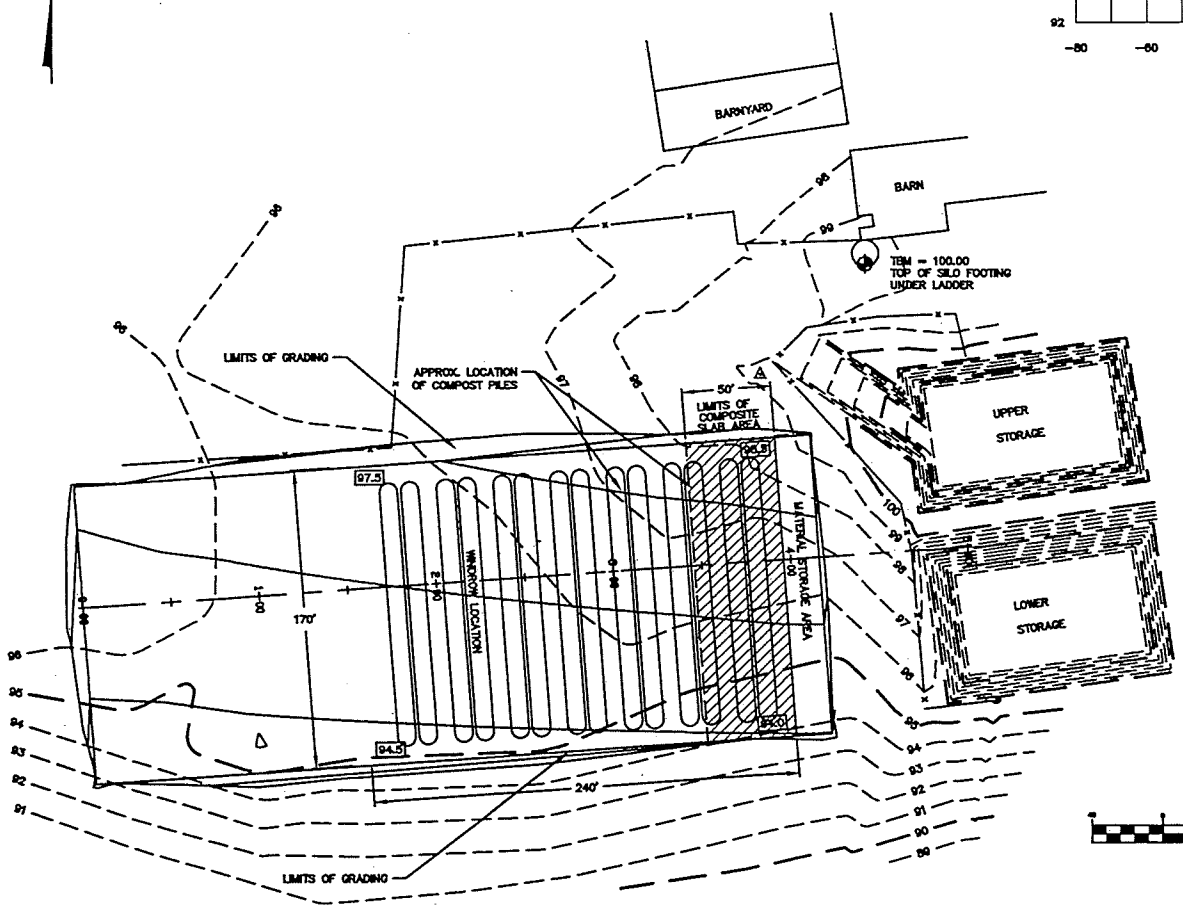
Manure Characteristics

1) Storage pit (approx.)i:
   Moisture: 80 %
   C:N: 16.8
   Volume: 4 yd/day or 1,554 - 777 yd^3/yr (Smaller volume assumes 50 % is spread directly on fields to comply with NRCS crop management program requirements).
2) Barnyard Manure (before using extra bedding):
   Moisture: 63.5 %
   C:N: 12.2
   Volume: 5 yd^3/wk or 260 yd^3/yr

CONSTRUCTION ITEM INSTALLED	QUANTITY	SPECIFICATIONS
LIME/ROCK FINES COMPOSITE, Class "C" Compaction	175 C.Y.	15, 209
EARTH FILL, Class "C" compaction	500 C.Y.	5, 13
STRIPPING	1000 C.Y.	4, 5

TYPICAL SECTION THRU COMPOSTING AREA AT STATION 3+50





CONSTRUCTION INSPECTION ITEMS FOR THIS DESIGN ARE CONTAINED IN "GUIDE FOR DESIGN AND CONSTRUCTION OF CONSERVATION PRACTICES". IN ADDITION THE FOLLOWING SPECIAL ITEMS ARE NOTED:

1. STRIP SOD FROM COMPOSTING SITE.
2. GRADE COMPOST AREA AS SHOWN ON THE DRAWINGS.
3. COMPACT ALL FILL MATERIAL TO CLASS "C" COMPACTION AS DESCRIBED IN NRCS SPECIFICATION #13.
4. INSTALL A LIME & ROCK FINE COMPOSITE SLAB AT LOCATION SHOWN ON THE DRAWING.
5. NOTIFY NRCD PROJECT MANAGER 2 DAYS PRIOR TO CONSTRUCTION.
6. MAINTIAN GRASS BELOW COMPOSTING AREA TO TREAT ANY RUNOFF THAT MAY OCCUR.

NOTIFY THE DIGSAFE CENTER AT 1-800-225-4977 AT LEAST 48 HOURS BEFORE STARTING TO DIG.

Figure 2

GRAPHIC SCALE

(IN FEET)
1 inch = 40 ft.

JOB CLASS II

TRACY & SUE POQUETTE
COMPOSTING AREA
PLAN VIEW

ALBURG VERMONT

U.S. DEPARTMENT OF AGRICULTURE
NATURAL RESOURCES CONSERVATION SERVICE

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Drawing No.

Bulking Agents Available

On-farm spoiled silage and haylage (50 yd^3/yr)
On-farm chopped hay (1,040 yd^3/yr)
On-farm chopped soybean straw (1,000 yd^3/yr)
Free manure/bedding from a nearby horse stable (2-4 yd^3/wk or 200 yd^3/yr)

Mixing Ratios

1) Manure Pit: This manure has a relatively high moisture content and low C:N requiring a mixing ratio of approximately 1 part manure to 2 parts bulking agent.

2) Barnyard: Although the barnyard did not have a roof during the first phase of the project, the manure had a moisture content of 63.5% and C:N of 12.2 which required a mixing ratio of 1 part manure/bedding to 1/2 part bulking agent. During the second phase of the project, the Poquettes installed a roof on this barn and are now adding enough chopped soybean straw and surplus hay bedding (12 to 42 yd^3/wk) that no additional bulking agents are needed.

Equipment Used or Acquired for the Compost Operation

Turner 1: Tractor-pulled Sitler - model ST-510
Turner 2: Self-propelled Sandberger SP-100 ("Custom" basis)
Spreader: Knight auger-type side-exit manure spreader modified with"windrow-shaper" spreader attachment consisting of a "back stop" hinged to a rigid top. The cost to design and fabricate this attachment was $ 1,670.
Tractor 1: John Deere 510, 80 Hp with 1.5 yd bucket. Used to move and mix manure and pull the Sitler turner.
Tractor 2: John Deere 4440, 130 Hp. Used to run the spreader and provide power to the turner.
Hay Chopper: John Deere 3950.
Dump Cart: 8 yd. used initially to haul manure from barnyard and form windrows in winter.
Dump Cart 4 yd used for hauling horse manure.
Forage Wagons: 3 - 40 yd^3 wagons

Compost Site

The compost site is located in a small hayfield located adjacent to the manure pit and the barn. The site has a slope of 2-3%, there is no potential for surface water drainage onto the site, and there are no nearby downslope streams or creeks. Lake Champlain is located approximately 500 feet to the West of the site but the site slope is in the opposite direction.

Compost Pad

Two different pad surfaces are being used at the Poquette farm. One pad is the existing sod on a nearby pasture - this pad is accessible for compost activities primarily during periods of dry weather. Additionally, a concrete pad (25′ x 150′) was constructed for composting manure removed from the barnyard during wet weather, winter, and the spring thaw. The cost of this pad and gravel perimeter access road was $ 7,062. Another concrete pad (30′ x 30′) was also constructed for storing bulking agent and/or finished compost - this pad cost $ 2,850.

Ingredient Mixing, Windrow Formation, and Composting Methods

Pit Manure: Manure is removed during late summer or fall with bucket loader and placed into the side-exit spreader with alternating loads of bulking agent. Windrows are formed as the spreader is pulled along the length of the sod pad. Windrows are covered with

compost covers, monitored for temperature, and turned as-needed. During the first phase of the project, the Poquettes used the leased Sitler turner which they operated using a two-tractor configuration - one providing the power for the turner and the other pulling the turner and the first tractor. During the second phase of the project, custom compost turning was provided by CVCC.

Barnyard: Manure is scraped once or twice per week and stockpiled on manure pit ramp. Once or twice per month, the pile is loaded into the manure spreader and placed into windrows for composting. Windrows are covered with compost covers, monitored for temperature, and turned as needed with a compost turner. As described above, the Poquettes have also reduced the amount of time needed for composting this material by covering the barnyard and using enough bedding to avoid having to add extra bulking agent prior to forming the windrows.

Leachate and Run-off Control

Sod Pad: Site is on, and surrounded, by sod. Compost covers are also used.

Concrete: In addition to compost covers, the concrete pad is designed to drain runoff directly into the secondary manure storage pit.

WOLCOTT/MACCAUSLAND FARM

General Description

50 in acres hayland and 60 acres in intensively grazed pasture. Herd includes 25 milkers and 25 young stock. Housing is a tiestall with intensively managed pasture in spring, summer, and fall.

Manure Handling System and Facilities

Manure collection and storage at this farm consists of a chain-type gutter cleaner and a single gravity-fed uncovered manure storage pit. The pit also contains a picket-dam which was previously pumped to reduce the moisture content of the stored manure. This picket dam was modified with a gravity drainage system with a manual control valve to drain water into a side-exit manure spreader for spreading on surrounding pastures. The cost of this improvement was $1,234. However, due to heavy rains during removal of the manure from the pit after this drain was installed, it is still unclear how effective this modification is for reducing the moisture content in the stored manure.

Manure Characteristics (from pit)

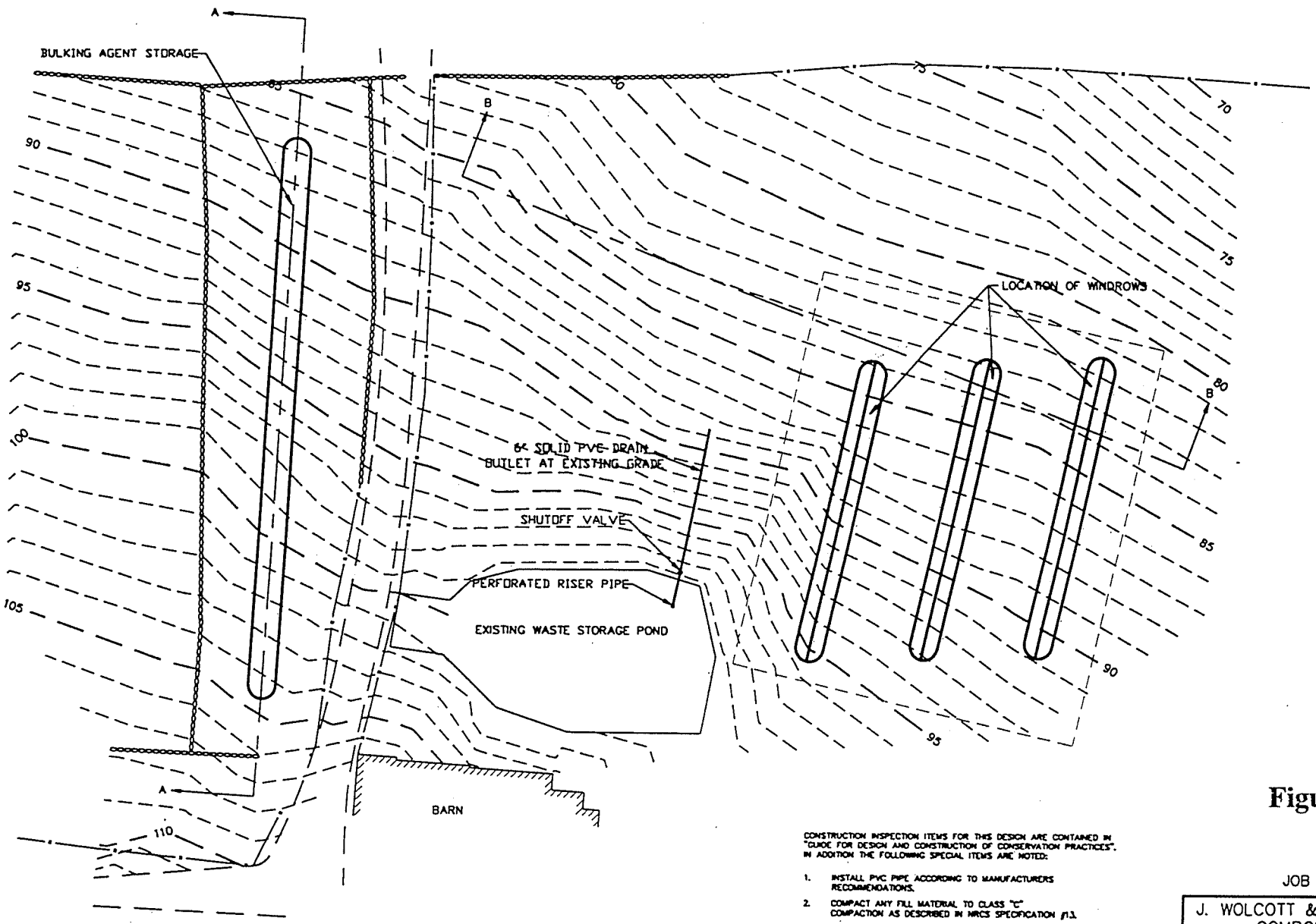
Moisture : 86.1 %

C:N Ratio: 10.3

Volume: .8 yd^3/day or 304 yd^3/yr

Bulking Agents Used/Available

During the first phase of the project, this farm had minimal on-farm crop residues to use as bulking agents and no nearby sources could be found. Therefore, sawdust/bark was purchased from lumber mills in Canada and New York state. While this material initially appeared to be an excellent bulking agent due to its high water holding capacity and its positive influence on the porosity of the windrows, it was later observed that these attributes were overshadowed by its slow decomposition rate. Having minimal nutrient value, it was also prohibitively expensive at $ 4.50/yd^3. During the second phase, the Wolcott/MacCauslands utilized surplus hay produced during an unusually wet summer.



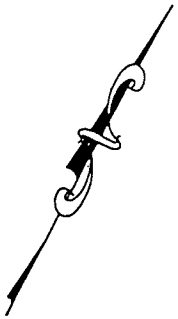


Figure 3

CONSTRUCTION INSPECTION ITEMS FOR THIS DESIGN ARE CONTAINED IN "GUIDE FOR DESIGN AND CONSTRUCTION OF CONSERVATION PRACTICES". IN ADDITION THE FOLLOWING SPECIAL ITEMS ARE NOTED:

1. INSTALL PVC PIPE ACCORDING TO MANUFACTURERS RECOMMENDATIONS.
2. COMPACT ANY FILL MATERIAL TO CLASS "C" COMPACTION AS DESCRIBED IN NRCS SPECIFICATION #13.
3. NOTIFY NRCS REPRESENTATIVE 2 DAYS PRIOR TO CONSTRUCTION.
4. MAINTAIN EXISTING GRASS BELOW COMPOSTING AREAS TO TREAT ANY RUNOFF THAT MAY OCCUR.

NOTIFY THE DIGSAFE CENTER AT 1-800-225-4977 AT LEAST 48 HOURS BEFORE STARTING TO DIG.

GRAPHIC SCALE

(IN FEET)
1 inch = 20 ft

JOB CLASS II

J. WOLCOTT & S. MACCAUSLAND
COMPOSTING AREA
PLAN VIEW

FAIRFIELD VERMONT

U.S. DEPARTMENT OF AGRICULTURE
NATURAL RESOURCES CONSERVATION SERVICE

Mixing Ratios

To date, this manure has had a relatively high moisture content and low C:N ratio requiring a mixing ratio of approximately 1 part manure to 2 parts bulking agent.

Equipment Used or Acquired for the Compost Operation

Spreader: International 540, rear-exit spreader outfitted with home-made windrow- spreader attachment for forming windrows
Tractor 1: John Deere D 5300, 50 Hp, 4-wheel drive with .5 yd^3 bucket.
Tractor 2: John Deere 2030, 60 Hp, 2-wheel drive (used to pull spreader)
Turner: Self-propelled Sandberger turner
Hay Chopper: Electric - manual feed
Hay Wagons: 2 flatbed wagons

Compost Site

Participants did not want a permanent pad and with a manure storage system, they did not need year-round access to their compost site. Therefore, the compost site was located in a small pasture adjacent to their barn and the storage pit with access provided by an existing farm road. The site also has the optimal slope of 2-3%, the subsoil is mostly clay, and there are no nearby streams or creeks. Another small area east of the manure pit was also used for ingredient storage.

Compost Pad

A sod base was used since manure is only removed from the pit once or twice per year and compost activities can therefore be timed to coincide with dry weather.

Ingredient Mixing, Windrow Formation, and Composting Methods

Manure is removed during late summer or fall with a bucket loader and placed into the rear-exit spreader along with bulking agents. An electric manual-feed chopper is now being used to chop some hay bales directly into the manure pit prior to removing manure for composting. Hay bales are also being manually spread out in a windrow prior to discharging manure from the spreader. The spreader is outfitted with a home-made Windrow-shaper attachment with windrows formed as the spreader is pulled along the length of the sod pad. Windrows are covered with compost covers, monitored for temperature, and turned as-needed by CVCC.

Leachate and Run-off Control

This site is on, and surrounded, by a sod base. Compost covers are also used to prevent excess moisture.

MARKETING STUDY AND USE OF FINISHED COMPOST

Marketing Study

One of the primary goals of this project was to explore the potential for selling compost produced on the region's farms. To this end, a marketing study was conducted by NRCS staff in the beginning of the project. While a complete summary and abstract of this survey are included in the Appendix, one of the more promising findings was a significant interest in the purchase of farm-produced compost on the part of the residents and businesses surveyed in the Franklin County region of northwest Vermont. As described below, this finding was also later confirmed by the experience of two of the project participants.

Use of Finished Compost

Menard Farm

The Menard farm was particularly well suited for marketing their compost since they have more nutrients in the form of manure than can be safely applied to their limited cropland. With some guidance from the Project Manager and a lot of their own initiative, a marketing plan was developed along with a logo and business card. The Menard's compost operation was also written up in two feature stories which appeared in the largest circulation newspaper in the area. Between these articles and word-of-mouth advertising, the Menards have had difficulty keeping up with the demand despite the low population density in the surrounding area. During the first year they sold over 500 cubic yards of compost ($12 to $15 per yd^3, plus delivery) to area landscapers, backyard gardeners, and a local nursery. Currently they have another 1,000 yards of compost ready for sale next Spring.

Poquette Farm

While the Poquettes were interested in selling some of their compost, they also wanted to save a large portion to apply on their own farmland. They were especially interested to see if the compost would help reduce weed pressure on their no-till corn. The Poquettes also developed a business card and relied on word-of-mouth advertising which resulted in sales of approximately 100 yd^3 of compost the first year at $15-20 per yd^3 in bulk and $1.00 per pail (approximately $50 per yd^3).

Wolcott/MacCausland Farm

The Wolcott/MacCauslands do not produce excess manure and therefore did not want to sell any of their finished compost. Instead they were interested in avoiding the use of raw manure on their rotationally grazed pasture both to reduce nutrient loss and to compare the impact of raw manure versus compost on forage palatability. At this point however, it's still too early to evaluate either of these potential benefits.

PUBLIC OUTREACH AND EDUCATION

As originally envisioned, public outreach and education was an integral part of this project. These activities are summarized below:

Press Releases and Published Articles

Numerous press releases, notices, and articles were submitted to local and regional newspapers during the project. These resulted in at least seven in-depth articles about the project which appeared in at least six regional newspapers including the St. Albans Messenger (circ. 5,000), the County Courier (circ. 4,300); the Press Republican (circ. 24,000), New England Country Folks (circ. 9,000), the New England Farmer (cir. 17,000), the New York Farmer (circ. 13,000). Articles and notices about the project have also appeared in various agricultural and environmental organization newsletters including "Cultivating Connections" published by the UVM Center for Sustainable Agriculture, the Lake Champlain Basin Plan annual newsletter, the Clinton County Soil and Water Conservation District Newsletter, "Beyond the Bin" published by the Association of Vermont Recyclers, the "Tuesday Letter" published by the National Association of Conservation Districts, and "Down to Earth" of the NY State Soil and Water Conservation Service. An article about the project will also appear in BioCycle which is the leading trade magazine of the U.S. and Canadian compost industry. Finally, this report will also be published as part of the Lake Champlain Basin Program's Demonstration Project Report series.

Photographic Documentation

Photographs of all aspects of the project were taken. These have been used in newspaper articles and have been incorporated into a project display (see below) and presentations about the project. Some of these photographs are included in the Appendix.

Project Display

General information about on-farm composting and the project was communicated though a poster display including written text, charts, illustrations, and photographs. Consisting of three hinged 2 x 4′ panels covered with fabric, the display was set up at numerous events including a UVM Extension Soybean Conference, the Vermont Ag Show, the St. Albans Cooperative Creamery Annual Luncheon, Franklin County Field Days, the Champlain Valley Exposition, and various UVM Extension educational events for farmers throughout the Champlain Basin.

Project Tours

At least 6 tours were conducted of the three sites. As many as 200 individuals toured one or more of the sites - attendees included farmers, backyard gardeners, students, policy makers, educators, and agricultural and resource managers from both Vermont and New York State. In addition to those people who actually attended, invitations were distributed to at least another 300 individuals.

Presentations

The Project Manager gave three presentations about the project to over 500 people in various forums in both New York and Vermont. Additional presentations about the project and on-farm composting in general are also planned by the Project Manager and NRCS staff.

Literature

A variety of published literature and resource materials about on-farm composting was distributed during project tours, presentations, and special events.

Video

An educational video about on-farm composting and the demonstration project was cooperatively produced by the Project Manager, Kathy Hakey of the NRCS, Craig Altemose and Lyn Jarvis of UVM Extension. The video will be aired in February on Channel 3 as part of a regular UVM Extension television show called "Across the Fence" hosted by Lyn. In addition to the estimated 38,000 daily viewers of this show, copies of the video will also be distributed to the public through the NRCS, Clinton County Soil and Water Conservation District, the Lake Champlain Basin Program, and UVM Extension.

BUDGET SUMMARY

A total of $72,000 in direct grant money was allotted for this project. This money was spent as follows:

Project Administration	$ 4,523
Facility Installation, Equipment, and Composting	48,461
Additives/Bulking Agents	1,874
Sampling/Analysis	1,535
Project Manager's Salary	10,000
Public education/Outreach	5,607

There was also an additional $ 31,160 in matching funds provided in the form of "in-kind" contributions such as farmer labor and equipment use, technical support, project administration, postage, and copying.

PROJECT SUMMARY

As described in this report and the attached "Participant Survey" (Appendix), the compost facilities installed and operated through this project successfully demonstrated some important benefits and drawbacks on-farm composting. Project staff and participants also gained valuable insight into the various opportunities and challenges inherent in wider acceptance of on-farm composting as a manure management strategy in the Lake Champlain region:

Observed and Anticipated Benefits On-Farm Composting

While more time will be needed to assess the long term agronomic and economic benefits of on-farm composting at the three participating farms, the following benefits have already been observed:

1. All three farms were able to transform raw manure into a high quality, weed-free, and odorless soil amendment within two to 12 months - depending on the frequency of turning and control of excess moisture in the windrows through operation and management techniques.

2. Local markets were easily found for compost produced at the farms that wanted to sell it, despite the low population densities in the communities where these farms are located.

3. By installing a concrete pad for storage and composting of raw manure, the Menards had an alternative to spreading raw manure on their wet and/or frozen fields during <u>most</u> of the fall and winter. However, a separate manure storage structure, a larger concrete compost pad, and/or using this pad more efficiently would allow all the manure to be kept off wet or frozen fields in the future.

4. By using composting as a complementary manure management strategy to the existing manure storage systems at the two other farms (Poquettes and Wolcott/MacCauslands), composting provided additional flexibility in regard to the application of nutrients onto croplands to better coincide with crop cycles and weather patterns.

5. While it is still too early to evaluate the direct agronomic benefits of compost used by the participants on their own fields, the Poquettes anticipate that compost applied this fall on their no-till corn land will decrease weed pressure compared to spreading raw manure. Similarly, the Wolcott/MacCauslands anticipate the compost will improve the short-term palatability of their intensively grazed pastures compared to spreading raw manure.

6. By integrating various agricultural waste products into their compost operations, the participating farms demonstrated that on-farm composting can also serve as a value-added recycling method for agricultural by-products that otherwise are not utilized to their full potential. These recycled by-products included horse manure, surplus hay (round and square bales, both chopped and unchopped), chopped soybean straw, and waste silage.

Observed Drawbacks of On-Farm Composting

As described in the "Participant Survey" included in the Appendix, all the participants stated that the most significant drawback of their compost operations has been the additional time and labor required. However, since all the participants also stated they plan to continue composting after the project has ended, it seems the benefits still outweigh this drawback. One reason is that the participants have found ways to make their compost operations more efficient. For example, the

Wolcott/MacCauslands and the Poquettes saved some time during the second half of the project by simply composting a smaller amount of their manure and having their windrow turning done on a custom basis. The Poquettes have also modified a large outdoor barn so minimal additional handling of the manure is required for composting. At the same time, the Menard and Poquette's compost operations have brought in some additional farm revenue as a tangible reward for these efforts .

While the project participants did not have to pay for the construction and purchase of these compost facilities and equipment, the costs of developing and operating a compost site for an average farmer could also be a major drawback to on-farm composting. As demonstrated at the Wolcott/MacCausland site however, a compost operation can also be developed with minimal costs. And as demonstrated by the Menards, construction and equipment costs can also be recouped over time through the sale of finished compost. Finally, composting also qualifies as an acceptable manure management strategy under the USDA's conservation program, which means financial assistance may be available to qualified on-farm compost projects.

LESSONS

This demonstration project taught the participants and project staff some important lessons regarding the design and management of on-farm compost operations. Some of these lessons are outlined below:

Technical Support

Composting is an acquired skill that does not lend itself to cook-book approaches. Since the project participants had little composting experience, it was especially useful to have a project team member with compost experience who could provide initial guidance and help avoid and solve technical problems as they arose. However, within a relatively short time, the participants all learned enough to operate their sites with minimal assistance from project staff.

Compost Turners

Initially, project staff and participants were skeptical of the value and need for a compost turner. However, it is now clear that the turners saved time, provided better aeration, and produced a more uniform product than turning windrows with a bucket loader. In fact, it is likely that without continued access to a turner, the participants would have been less inclined to maintain their composting operations after the demonstration project ended.

Bulking Agents

Because dairy manure tends to be wet, it requires relatively large volumes of dry bulking agents to absorb this excess water. Therefore, farms considering on-farm composting should have ready access to inexpensive off-site sources of suitable bulking agents, the ability to transport these materials to the farm, and/or the ability to grow and harvest their own hay and straw.

Complementary (or "Compost-friendly") Manure Storage Systems

To encourage and/or facilitate the wider use of on-farm composting in this region, every effort must be made to develop and/or modify manure storage facilities to reduce, rather than increase, the moisture content in stored manure. Ideally, these manure storage systems should be designed to drain water from stored manure into a separate storage area (i.e. not just a picket dam in the corner of a manure pit) which then can be used to irrigate crops and/or rehydrate compost windrows as needed. This approach is especially attractive since it provides farmers with the flexibility to use

stored manure for their own composting operations, for using it raw on their fields as weather and crop cycles permit, and/or selling the manure to other farmers for composting and/or spreading.

A Substitute for Manure Storage Structures ?

For some people, one of the more hopeful outcomes of this project might have been to demonstrate how on-farm composting could serve as a substitute for building permanent manure storage structures. However, as this project demonstrated, farmers simply do not have enough time to mix compost ingredients and form windrows 365 days a year. Furthermore, while the compost pads at both the Poquette and Menard sites were designed for year-round composting, a variety of factors such as operator discomfort; snow accumulation; frozen windrows; and space limitations severely limited composting activities during the winter.

So while this project demonstrated how on-farm composting can often complement a farm's existing manure storage system, it also showed that on-farm composting should not be considered a substitute for appropriate manure storage facilities such as manure stacking pads or manure pits with effective water drainage systems.

Compost Covers and Moisture Control

Based on observations and moisture tests, the compost covers effectively shed precipitation and thereby improved the compost process and the quality of finished product. It is presumed the use of these covers also conserved valuable nutrients which would have otherwise been leached out of the compost.

Compost Pad Surfaces

The existing sod used for compost pads at the Poquettes and Wolcott/MacCausland farms proved to be a cost effective and satisfactory pad option for a compost operation that did not require daily access. However, keeping the vegetation trimmed around the windrows was a problem at one point due to insufficient space left between the windrows for tractor access. On the other hand, while the concrete compost pads at the Menard and Poquette sites provided good access during wet weather, they were not inexpensive to install.

Windrow-shaper Spreader Attachments

The windrow-shaper spreader attachments designed and built for this project clearly improved operating efficiencies by reducing labor and equipment use for mixing ingredients and building windrows.

Management Time

These on-farm composting operations did require more time to operate and manage compared to simply storing and spreading raw manure. Time was required for gathering and handling bulking agents, mixing ingredients, building and monitoring windrows, and handling finished product. Understandably, these composting activities were also secondary to the participants' regular farming duties. However, the relative amount of time spent on these activities depends greatly on factors such as the amount of material being composted, the amount of bulking agents needed, the turning methods used, and whether custom turning services are being used. In general, it seems on-farm compost operations will be most successful when they require the least amount of the farmer's time and provide the greatest amount of flexibility in regard to scheduling composting activities.

SUGGESTIONS FOR FOLLOW-UP ON-FARM COMPOSTING DEMONSTRATIONS AND FIELD RESEARCH

This project clearly succeeded in demonstrating some of the benefits and drawbacks of on-farm composting as a complementary manure management strategy. However, during the course of this project it also became obvious that other demonstration and research projects are still needed to generate additional expertise and information regarding on-farm composting. Subject areas where these follow-up demonstrations and research projects would be especially useful are as follows:

1) Demonstration and evaluation of complementary manure storage/management systems which reduce the moisture content in stored manure though passive and/or active separation. Manure with a lower moisture content reduces the amount of bulking agents needed for composting and is easier and less expensive to apply to fields as raw manure.

2) Comparisons of the environmental fate of specific nutrients (e.g. nitrogen and phosphorus) when spread as compost versus as spread as raw manure.

3) Quantification of the effectiveness and costs of various leachate and runoff prevention and control strategies such as compost covers, vegetated filter strips, collection ponds, and constructed wetlands.

4) Comparisons of the short and long-term agronomic and economic costs and benefits of applying compost versus raw manure on typical New England crops. These comparisons should include impact of compost on soil health (e.g. organic matter content, moisture holding capacity, aeration, pH, nutrient content, etc.), on forage palatability when used on pastures, and on crop health (e.g. pest and disease resistance, yield, etc.).

APPENDIX

Photographic Documentation
Windrow Spreader Attachment Design - Side-discharge Spreader
Windrow Spreader Attachment Design - Rear-exit Spreader
Design Considerations for Windrow-shaper Manure Spreader Attachments
Marketing Study - Summary and Abstract
Business Cards - Poquette and Menard On-farm Compost Sites
Participant Survey

Menard Farm:
Windrow-Shaper manure spreader attachment made out of 10 gauge steel.

Menard Farm:
Turning compost piles with Sitler tractor-pulled turner.

Menard Farm:
Clearing brush and trees to install a vegetative filter strip
and a new drainage ditch.

Menard Farm:
Recently-turned compost piles with compost covers on the ground.
The newly-planted vegetative filter strip is in the background.

Poquette Farm:
Windrow-shaper manure spreader attachment mounted on the side-discharge spreader. Frame is 1/8" metal tubing, top is 3/16 PVC sheeting, and the backstop is rubber roofing.

Poquette Farm:
Windrow-shaper manure spreader attachment being used to form windrows.

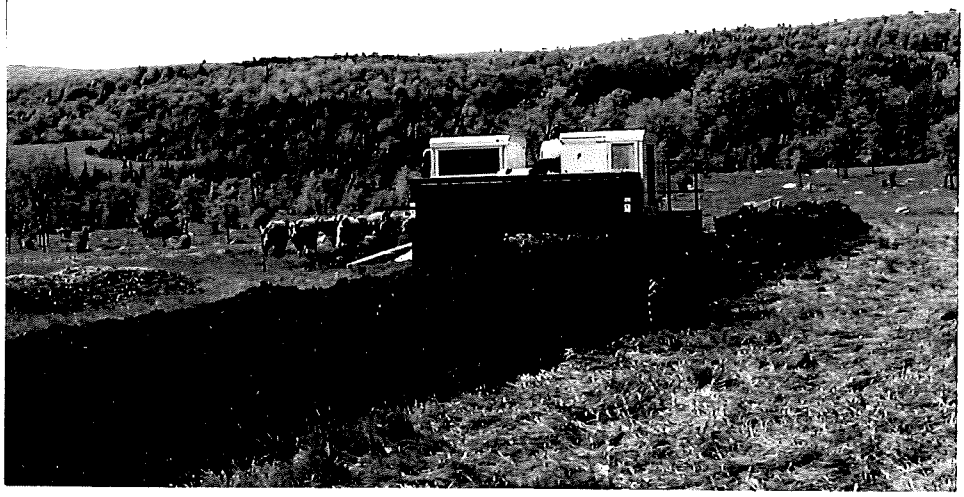
Poquette Farm:
Concrete compost pad installed to provide year-round composting of manure scraped weekly from a covered barnyard. Pad is designed to drain runoff into a secondary manure/water storage pit.

Poquette Farm:
Sitler compost turner being pulled with two-tractors - one providing power to the turner and one providing forward momentum.

Wolcott/MacCausland Farm:
Close-up of Windrow-shaper spreader attachment made with scrap wood.

Wolcott/MacCausland Farm:
Forming windrows using manure spreader and Windrow-shaper attachment.

Wolcott/MacCausland Farm:
Forming windrows with manure on a base of surplus hay. These windrows were subsequently turned with a compost turner.

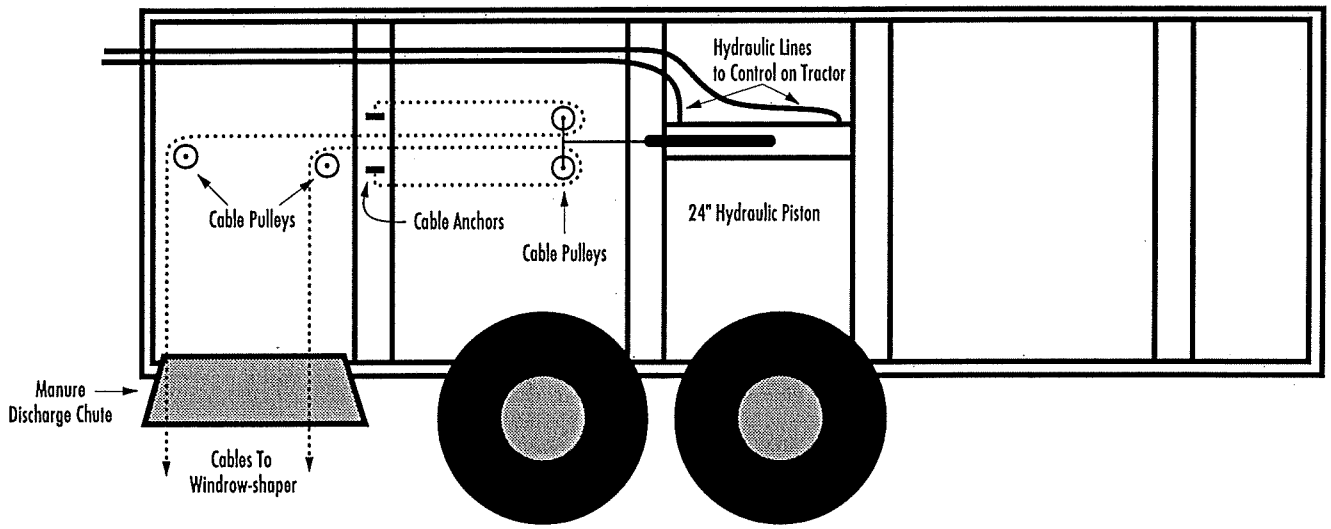


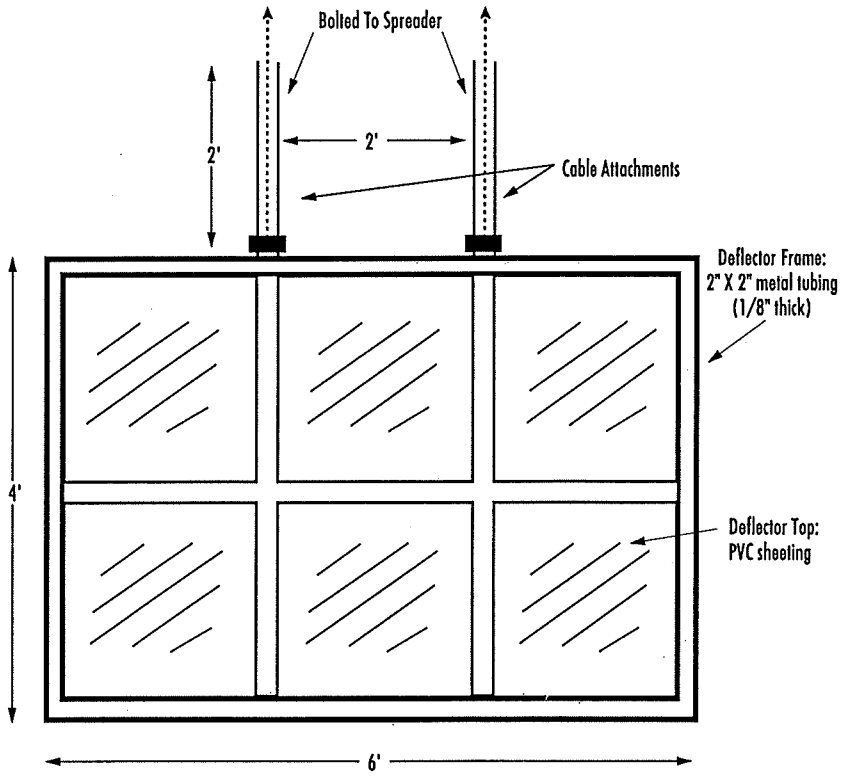
Wolcott/MacCausland Farm:
Custom turning by Champlain Valley Compost Company using a Sandberger self-propelled compost turner.

Windrow-shaper Attachment for Side-Discharge Manure Spreader

Fabricated by Giroux Equipment, Plattsburg, NY

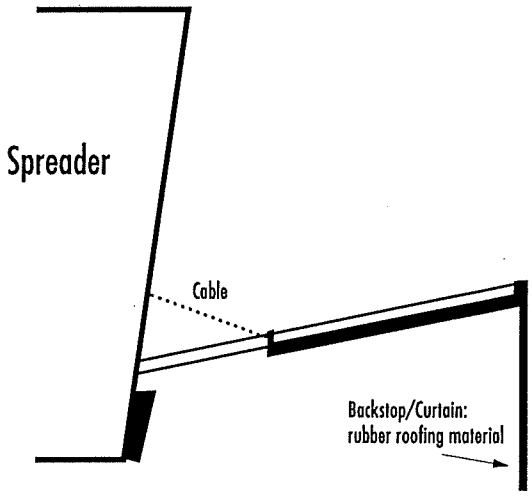
Side View of Cable and Pulley System On Spreader





Top View of Windrow-shaper

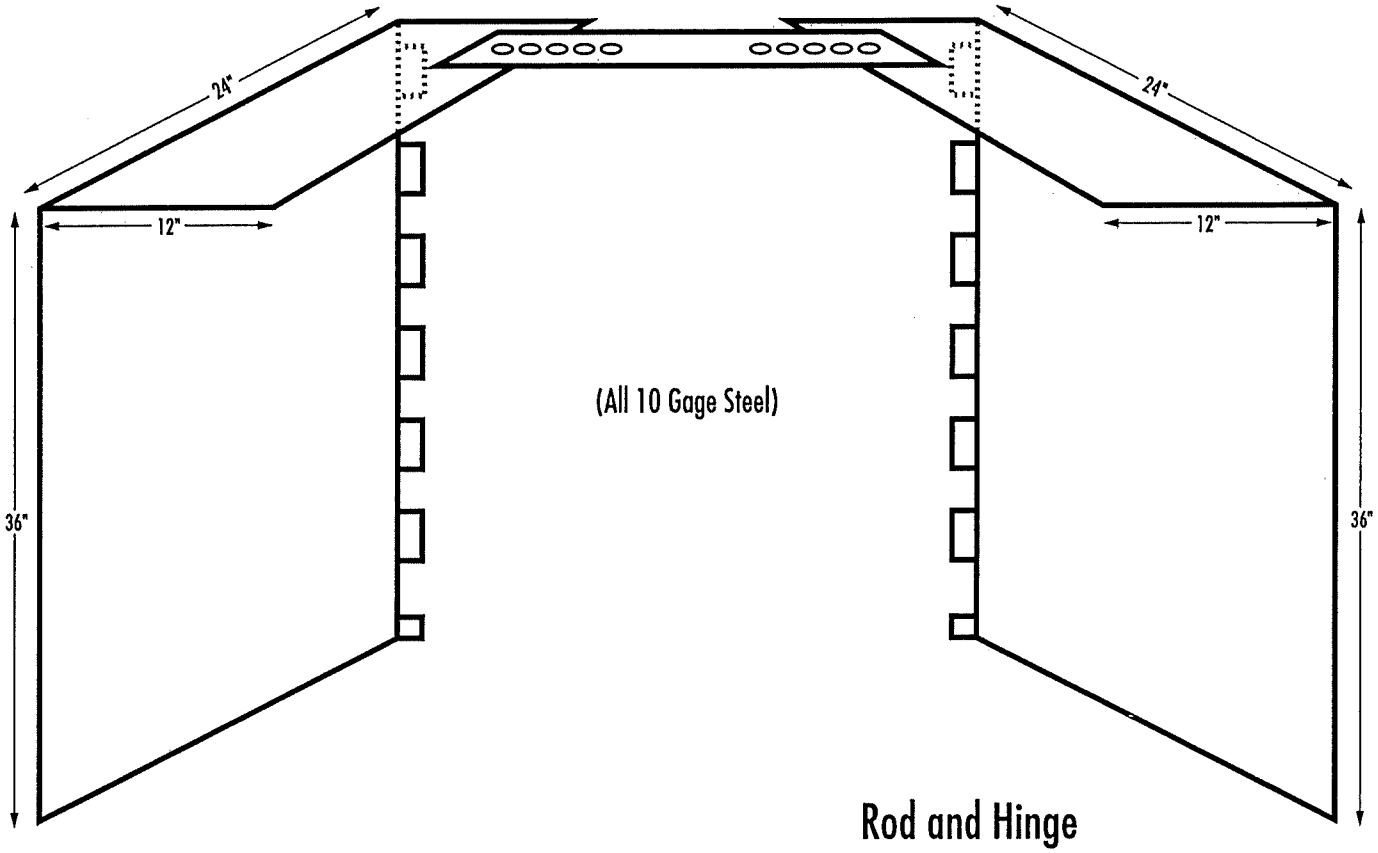
Side View of Windrow-shaper With Backstop/Curtain

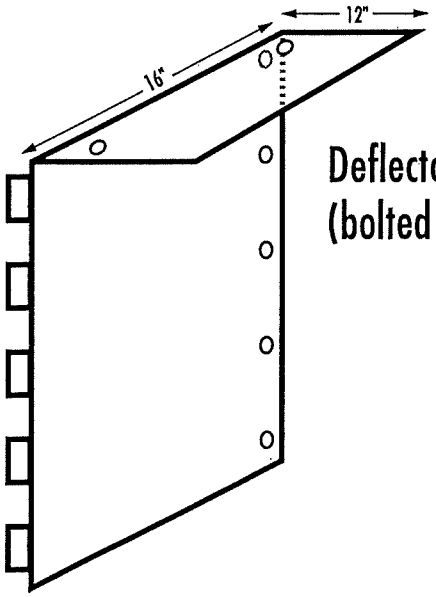


Windrow-shaper Attachment for Rear-Discharge Manure Spreader

Fabricated by Walter Kaeslin Enterprises, Mooers, NY

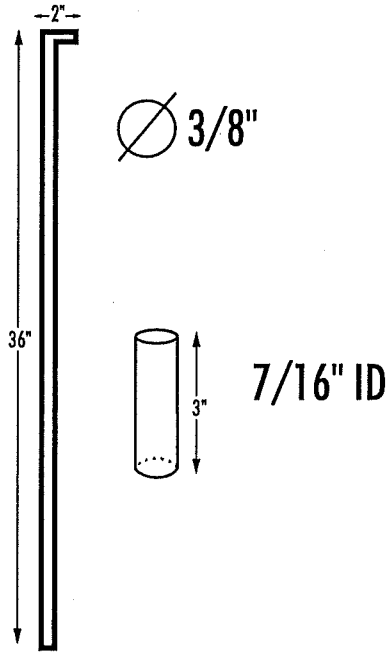
Side Deflectors





Deflector Support
(bolted to spreader)

Rod and Hinge



DESIGN CONSIDERATIONS FOR WINDROW-SHAPER MANURE SPREADER ATTACHMENTS

REAR-EXIT SPREADER ATTACHMENTS:

1) If the manure spreader is not dedicated for windrow construction, the spreader attachment should be easily removable to accommodate normal use as a manure spreader.

2) A top deflector on the spreader attachment deflects material normally discharged in both a vertical and lateral trajectory (i.e. up and to the side). However, a top deflector which spans the entire width of the spreader will also block the operator's rear view of the piles. Therefore, a "split", or partial, top deflector measuring 1 to 1.5 ft. from each side will provide adequate deflection without excessively restricting the operator's rear view.

3) Different manure spreaders discharge materials at different trajectory heights and widths so it is difficult to estimate the angle and length of the side deflectors needed to achieve the proper window dimensions. Therefore, it's best to build and test prototype deflectors prior to making final design decisions.

4) Building side deflectors with adjustable angles will add some flexibility to the design and accommodate future changes in the size and shape of the windrows. Adjustment can be achieved by using sheet metal that can be bent or by using hinged doors that can be locked in place.

5) Construction materials can be either wood or metal although metal will probably be more durable.

SIDE-EXIT SPREADER ATTACHMENTS:

1) The attachment needs to be fully retractable to ensure unrestricted mobility during transport around the farm.

2) The retraction mechanism for the spreader attachment can be a cable/pulley system or hydraulic pistons - although pistons will likely be more expensive. However, if cables are used, sufficient tension must be built into the system to ensure they won't jump/slide off their pulleys when the spreader attachment is in the upright, or non-use, position.

3) The length and height of the attachment in the extended (in-use) position must be at least equal to the desired width and height of the windrow. The top deflector could also be adjustable to accommodate different windrow widths.

4) The spreader attachment should create windrows of the desired width in one "pass".

5) The backstop/side deflector of the spreader attachment must be flexible and/or hinged to allow it to drop vertically along the side of the spreader when the attachment is in the upright (non-use) position. However, the backstop must also be rigid and/or heavy enough to provide an effective barrier to materials being thrown against it during use.

COMPOST MARKETING STUDY
ON-FARM COMPOST DEMONSTRATION PROJECT

Fred Fialco and Lynn Knight
USDA NRCS - Winooski, VT 05404

As part of this project, a Compost Marketing Study was completed in May, 1995 through the efforts of Fred Fialco, a University of Vermont student. Fred completed a market survey in order to identify and quantify the demand for composted cow manure in Franklin County, Vermont. He also identified the marketability of composted cow manure, and how and where the product can be best sold to consumers.

The results of this study offer information that can be helpful to farmers in Franklin County, Vermont who are interested in producing and marketing their own compost. This information, if taken in the proper context, reveals purchasing preferences and consumption patterns from four different subject groups who either currently use(sell) compost, or who are potential compost users (sellers). The composting business is gaining popularity and strength in the marketplace in the 1990's. It not only offers environmentally sound manure management alternatives for farmers, but also the opportunity to earn extra income. A strong marketing strategy for a high quality compost product can turn both of these prospects into reality.

Farmers in Franklin County are at an advantage for marketing local compost for a few reasons. First, the predominant economic activity in this region is agriculture. Agriculture offers many opportunities for the use of compost, from bedding material for dairy operations to soil improvement for cropland and grazing lands. In addition, compost sold by local farmers will translate into money added to the local economy, both agricultural and non-agricultural. Consumers will be more likely to keep their dollars circulating int he local economy as opposed to supporting areas outside of Franklin County.

Second, the public has demonstrated concern with the quality of their lands and waterways. This is the predominant reason why the On-Farm Composting Project was started. Farmers who make efforts to reduce amounts of nutrients leaving their lands may find that the public is very willing to support them in their endeavors. Compost producers need to emphasize that their activities are benefiting the Franklin County's lands and waters.

Third, as the study indicates, there are many potential compost consumers that are presently unaware of how they can use compost. This means that if the producer can effectively educate the public on the benefits and uses of compost, they will be able to tap into a large, currently inactive, consumer group. The marketing strategy that compost producers use to advertise and sell their product should take all three of these points into account.

Once a product has been successfully created, the compost producer should focus their marketing activities on the household gardener group. This group shows the potential for the greatest amount of purchases, at the outset of the operation. The product should be priced closely to other products on the market, and sold by the cubic yard. However, due to the large demand for bagged compost, the producer may want to sell compost by the pound, provided that customers supply their own bags. This way, purchases of small amounts will not be excluded by the producer, yet the cost of a bagging facility will be avoided. The product should be of high quality, so that it can be used in gardens and for trees and shrubs, but not so specialized that it can

only be used for one or two applications.

The compost producer may want to provide incentives for consumers to purchase their compost product. Incentives may range from coupons for free samples, to a discounted price for first time purchases. Many of the consumers surveyed marked that they would be willing to use compost on a trial basis, so if the producer has a good, reasonably priced product, consumers may not need to be enticed to use the product after the first few purchases. The product should definitely be first available to consumers int he spring, so that the composters business year captures the seasons that consumers purchase the majority of their organic materials in (spring, summer, fall).

Educating the consumer, or potential consumer, is a must for compost producers. This can be accomplished by printing up a small brochure on compost, to be handed out where the product is sold, or by getting media attention on the local news or in the paper. The producer definitely wants to reach out to potential users in the local area to let them know that compost is useful to them, and available for purchase from a nearby source. The producer may even consider giving tours of their compost site to show interested parties how the product is made and where it comes from.

Once the compost operation has been running for a while, the producer may want to branch out and focus marketing efforts towards local businesses and towns. These groups will require more marketing attention than the household group, because smaller percentages of them currently use compost products. The compost producer, in the beginning, wants to make sure that the demands of those consumer groups that are ready and willing to purchase compost from the start, with less marketing effort, are met first. In order to address the specific needs of the business and local government groups, more information and higher quality information must be obtained by the producer. This study does not contain the necessary data to offer reliable information on these groups.

The prospects for compost production and sales in Franklin County, VT are, to say the least, promising. The conditions for starting successful composting businesses seem to exist. The creation of a high quality compost product, a reasonable selling price for the product, and an education based marketing strategy stand out as the three major criteria for starting a profitable on-farm compost operation in the area.

Other Economic Activities

In addition to the Compost Marketing Study, case studies will be developed this summer, which will record the results of the farmers' experiences in both qualitative and quantitative terms. Economics is an important criteria for any decision-maker when making radical changes to their farming enterprise. Conducting detailed economic case studies should help other potential compost producers understand the options for starting up a compost operation, and hopefully avoid any pitfalls that others have experienced.

Abstract of Compost Market Study Results

presented to

The On-Farm Composting Project

by

Fred M. Fialco
May 1, 1995

I. Survey Response Rates

Household Survey:	559 mailed, 249 received, 38 voided	
	True Response Rate	= **45%**
	Adjusted Response Rate	= **48%**
Business User Survey:	43 mailed, 12 received, 11 voided	
	True Response Rate	= **28%**
	Adjusted Response Rate	= **39%**
Business Supplier Survey:	21 mailed, 5 received, 2 voided	
	True Response Rate	= **24%**
	Adjusted Response Rate	= **26%**
Local Gov't. Survey:	14 mailed, 10 received	
	True Response Rate	= **71%**

II. Statistics of Interest
(percentages based on data from respondents only)

1. Compost users - 89% households, 66.7% business users, 1 town (Swanton)

2. Most frequent reason why compost not used by all groups - "Don't know enough about compost"

3. Most frequent use for compost for all groups - "Soil Improvement"

4. Mean price a)per pound for compost - Households = $0.096
   Businesses = $0.065
   b)per cubic yard of compost - Households = $17.50
   Businesses = $2.33

5. Mean price of composted cow manure sold by suppliers - 40lb.@ $3.37

6. Presently working on ranking of compost characteristics

7. If local compost is a) 20% more expensive

	YES	NO
households	9%	72%
businesses	0.0%	42%

b) 15% more expensive		
households	14%	66%
businesses	0.0%	42%
c) 10% more expensive		
households	39%	41%
businesses	0.0%	42%
d) 5% more expensive		
households	54%	27%
businesses	17%	17%
e) same price		
households	80%	1%
businesses	42%	0.0%

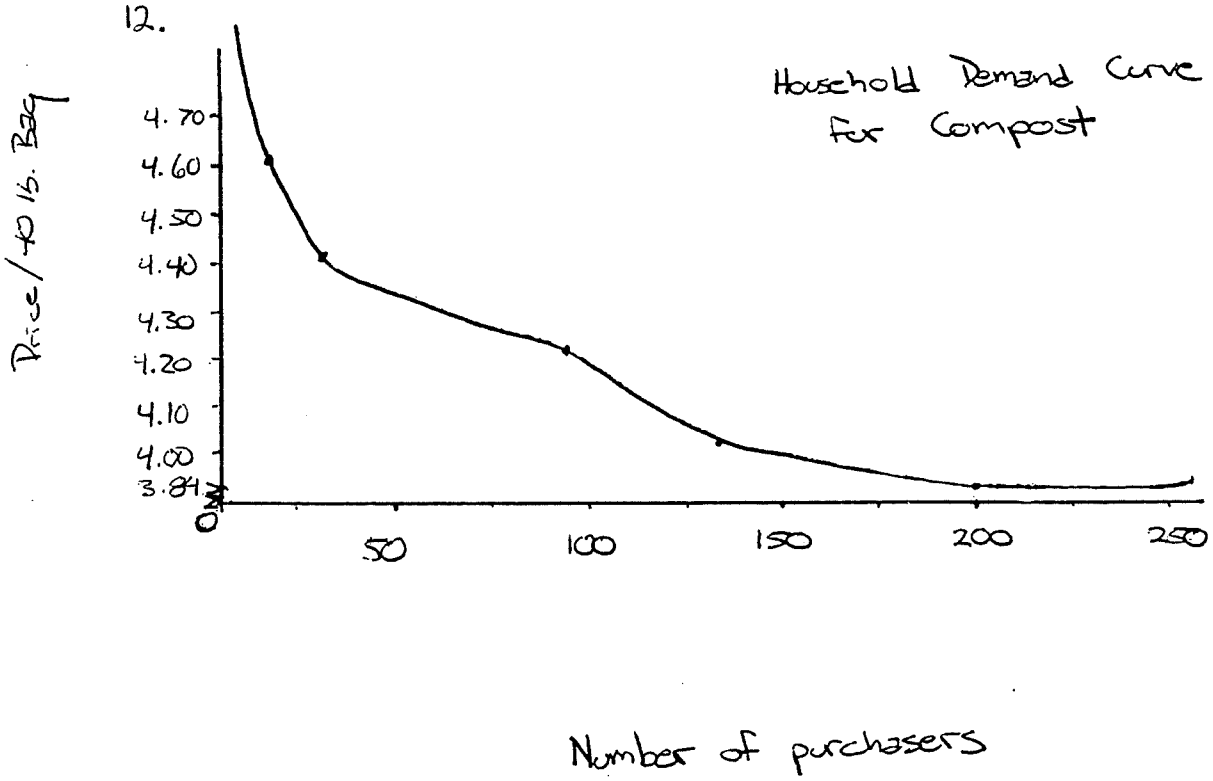
8. Percentage of respondents who make their own compost
   Households - 17%
   Business Users - 14%

9. Percentage of suppliers who will carry local compost on a trial basis - 80% (four of five respondents)

10. Percentage of respondents who's projected needs for organic materials this year are greater than their needs in 1994
   Households - 29%
   Business users - 50%

11. Percentage of respondents who want the results of the study
   Households - 50%
   Business users - 33%
   Business suppliers - 60%
   Local governments - 70%

12.



PARTICIPANT SURVEY
ON-FARM COMPOST DEMONSTRATION PROJECT

1) What would you have done differently in respect to site design, equipment, or composting methods ?

Menard: Other than making our concrete pad a little larger, we can't think of anything that we would have changed or done differently. We are very pleased with our compost operation.

Poquette: Our concrete pad could have been a little wider to allow water to flow down between the two windrows easier. Although it didn't take much of an investment in time or money, the PAWS method didn't seem to work out very well for us.

Wolcott/MacCausland:
In retrospect we think a manure separator may have been a better way to remove excess moisture from the manure than the stand-pipe drain we installed inside the picket dam.

2) Was the compost turner beneficial to your operation ?

Menard: When the project first started we didn't feel we would need a turner but once we had it we realized how valuable it was. Compared to using a spreader and bucket loader to turn windrows, it really saved a lot of time, reduced the wear and tear on our equipment, and seems to do a better job of mixing the materials and getting the windrows to heat up.

Poquette: Both turners have saved a lot of time for turning the windrows as opposed to using a loader.

Wolcott/MacCausland:
Definitely, due to the savings in labor, equipment use and space.

3) Were compost covers beneficial to your operation ?

Menard: The covers definitely helped to keep the windrows from getting too wet - especially during this wet summer. We figure they also helped improve the nutrient content of the finished product by reducing the amount of nutrients that could have been leached out.

Poquette: The covers were very beneficial for keeping excess water out of the windrows and helping maintain high temperatures. And when we didn't use the covers, the windrows got soaked.

Wolcott/MacCausland:
We didn't really have enough experience with them but we expect that when we use them consistently they will help by shedding moisture and creating a more workable windrow.

4) What have been the most significant drawbacks of composting?

Menard: The main drawback has been the time required to collect and handle bulking agents, turn the windrows, and manage the compost covers.

Poquette: Initially, the time required for mixing bulking agents and turning was a problem but now we've modified our compost operation so that it doesn't require as much extra time on our part and fits in well with the rest of our farming operation.

Wolcott/MacCausland:
Extra time in handling manure and bulking agents. Also, for the first year there was a year lapse in getting the nutrients from the manure to our fields since we composted when we would have normally spread it and then had to wait for the compost to mature.

5) What have been the most significant advantages of composting for you ?

Menard: One of the big advantages of composting has been selling the finished compost to bring in some extra income. The other advantage since we don't have any manure storage facilities, is being able to compost manure instead of spreading on wet or frozen ground.

Poquette: We like the fact that composting kills weed seeds that would have been put back into our no-till corn with raw manure. So far it also seems that the compost is a valuable soil amendment and we like the extra income from compost sales. And since we're now using more bedding in the barn to get a better compost mix, the barn is staying cleaner and the cows seem to like being there more. Composting is also giving us a way to use surplus, weedy, or poor quality feed.

Wolcott/MacCausland:

Wider window of time for applying nutrients. Nutrients are more stable and will result in less run-off. Hopefully, we will see better palatability of forages compared to spreading raw manure, improved soil structure, and improved forage health.

6) What advice would you give to other farmers who are considering composting as a manure management strategy ?

Menard: A truck is helpful to haul bulking agents if you don't have enough available on your own farm. And if time is going to be a problem, you should consider ways of reducing the time required such as producing your own bulking agents or having windrows turned on a custom basis.

Poquette: Make sure you have enough time to do it properly and consider ways to reduce the time needed. Also visit other on-farm compost operations to learn about the process before getting too far into it.

Wolcott/MacCausland:

Get your manure as dry as possible. Look into a separator - maybe one that could be contracted or owned communally.

7) Do you plan to continue composting now that the project is over ?

Menard: We most definitely will continue composting and have purchased our own turner. The demonstration project was very worthwhile for us.

Poquette: Definitely. Composting is working very well with our barnyard manure and if it proves valuable as a soil amendment on our own farm and/or if there is enough demand for outside sales, we will probably expand the operation to include more manure from our pit as well.

Wolcott/MacCausland:

To some degree yes because it is another manure management option and provides us with additional flexibility.