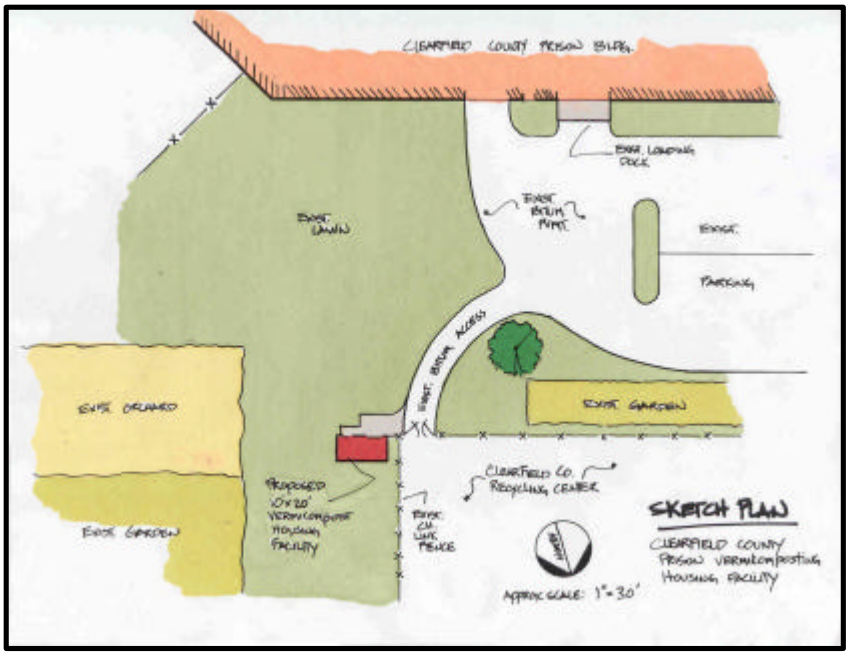
# Feasibility of a Vermicomposting Operation For Food Waste at the Clearfield County Prison

## Clearfield County




Gannett Fleming Sketch Plan
Conceptual Vermicomposting Operation, 2002

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Gannett Fleming

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## BACKGROUND

The Pennsylvania Department of Environmental Protection (PaDEP), the Governor's Center for Local Government Services, the Pennsylvania State Association of Township Supervisors (PSATS) and the Solid Waste Association of North America (SWANA) formed a training partnership for Pennsylvania local governments interested in achieving higher recycling rates. Through this partnership, the Clearfield County Solid Waste Authority was awarded $5,000 in technical assistance services from Gannett Fleming, Inc. to evaluate the feasibility of a vermicomposting operation for food waste at the Clearfield County Prison.

## INTRODUCTION

Under the direction of the Clearfield County Solid Waste Authority, the Clearfield County Prison requested technical assistance to assess the feasibility of establishing a vermicomposting operation for it's pre- and post-consumer food waste and mixed paper. The Clearfield County Prison houses 139 inmates and disposes of approximately 20 to 30 pounds per day of food waste. In 2001, the Prison paid $1,680 for waste disposal. The administration of the Clearfield County Prison expressed an interest in vermicomposting as a means to reduce disposal costs, provide inmates with productive work, and create a product that can be used for gardening projects.

Vermicomposting, which is also referred to as worm composting, is noted for its success in producing a valuable soil amendment. Relative to other composting alternatives, vermicomposting is especially good at breaking down food waste. Correctional facilities through the United States, and most notably in North Carolina, California, and New York, have successfully implemented various types of food waste composting operations.

Technical assistance was requested for suggestions on the types of waste material to include for worm composting, a conceptual design plan, and an implementation plan. We suggest a flow-through vermiculture bin in which food waste and bulking material is fed at the top, and processed material is removed through a screen at the bottom on a periodic basis. These bins are

available for purchase locally. Blue prints are available for bin construction, as well. These alternatives were considered in providing a recommendation to implement a vermicomposting operation at the prison facility.

The technical assistance also discusses the expansion of a prison vermicomposting operation to include food waste from neighboring establishments. The Wal-Mart Supercenter, Bi-Lo Grocery, the Mountain Laurel Rehabilitation Center, and the Harmony Center were contacted for their thoughts on participation. In addition, leaf waste from the Clearfield Borough and Lawrence Township curbside collection programs is also available.

## SCOPE OF SERVICES

Sam Lombardo, the Warden of the Clearfield County Prison along with Jodi McCluskey of the Clearfield County Solid Waste Authority worked together with Ray Regan and Tom Herlihy of Gannett Fleming to develop the following Scope of Services for the SWANA technical assistance project:

**Task 1**: Perform a waste audit at the Clearfield County Prison to classify and quantify appropriate organic materials. Budget permitting, the study will include other regional sources.

**Task 2**: Size and develop a conceptual vermicomposting plan to be integrated at the prison facility.

**Task 3**: Prepare a report with the findings, conceptual facility design, and recommended methods plan implementation.

## BACKGROUND ON VERMICOMPOSTING

Vermicomposting, or worm composting, is considered an easy way to recycle food wastes. When cared for properly, worms process food quickly and transform food wastes into nutrient-rich castings. Worm castings are an excellent soil amendment for gardens or potted plants. In the process of breaking down food waste, worms feed on microorganisms, which grow on the surface of the waste, and excrete particles of smaller size, which are called worm castings.

Since microbial growth is important to a successful vermicomposting operation, the carbon to nitrogen (C:N) ratio of the mix must be considered. Carbon provides energy for microbial growth; nitrogen provides the building blocks for cell structure. Just as with conventional composting, the C:N ratio *by weight* should be around 30 to 1. This target ratio provides guidance for the types and proportions of waste to use in vermiculture. Guidance on types of earthworms and food waste to use as well as other important aspects of vermicomposting is provided below.

*Types of Food Waste to Use*: Worms prefer a vegetarian diet, and will consume leafy greens, fruits, vegetables, and coffee grinds quickly. They also need a source of calcium to reproduce. Calcium can be provided through eggshells or a calcium-rich antacid tablet. The foods to include as well as those not to use in a vermicomposting operation are listed in **Table 1**.

**Table 1**: Food Types to Use and Not to Use in Vermiculture

| Food Types to Use | Food Types Not to Use |
|---|---|
| ▪ Bread<br>▪ Cereal<br>▪ Coffee Grounds<br>▪ Fruits<br>▪ Grains<br>▪ Pasta<br>▪ Tea Bags<br>▪ Vegetables | ▪ Dairy Products<br>▪ Fats<br>▪ Meat<br>▪ Oils |

Use of dairy products, fats, oils, and meats is not recommended due to the potential for rodent infestation. Additionally, grass clippings should also be avoided because the leafy greens in the food waste provide an adequate nitrogen supply.

*Proportions of Mix to Use*: Food waste vermicomposting operations often use a 3 to 1 mixing ratio *by volume* or 4 to 1 ratio *by weight* of food waste to bulking agent "as delivered." Mixing ratios can be provided on the basis of dry weight, wet weight, or a combination of the two. The term "as delivered" describes the moisture content of the material in its unaltered state. In other words, food is primarily wet, paper is primarily dry, and leaves are inherently moist when they are delivered to the site. The advantage of listing the mixing ratios for materials as delivered is that it should make it easier to use in the field. The suggested mixing ratios are not absolute, and altering of these ratios can be expected based on the observations of the operator.

*Types of Earthworms to Use*: Several species of earthworms can be used in a vermicomposting operation for animal and vegetable wastes. Most commonly, the species *Eisenia foetida* with the various common names of redworms, brandling worms, manure worms, or compost worms are used because of their appetite. Under ideal conditions, redworms can consume nearly their own body weight in raw material in a day.

*Ideal Environmental Conditions for Earthworms*: The key to a successful vermicomposting system is to provide the earthworms with an ideal environment for growth. In addition to a food source, earthworms need oxygen, moisture, and moderate digester temperatures. The pH, ammonia, and salt concentrations in the bin are important variables to control and maintain during operation, as well. Earthworms prefer moderate temperatures in the range of 40 to 90 degrees Fahrenheit, and a moisture content of between 70 and 90%.

The earthworms tend to generate heat through their activity, which can help to maintain suitable temperatures during cold periods, but can also lead to overheating in the warmer periods of the year. Overheating can be avoided by adding the waste to the bin in thin layers. Earthworms are sensitive to ammonia, and do not survive for long in wastes that contain fresh manure, poultry, and other animal-related products that release ammonia through degradation. Salty foods can

also produce a toxic environment to earthworms. Periodically wetting the system helps to flush out ammonia and salts. Finally, earthworms prefer a pH range of 5 to 9. Acidic foods, such as oranges, can be included, but to a limited extent.

*Fundamentals of Operation*: In a flow-through system, food waste is added to the top of a bin, and vermicompost and worm castings are removed through a supporting screen at the bottom. A mechanism is necessary to remove the material from the screen because it tends to stick together. If the bin is designed and operated properly, the material that is scraped off the bottom should have very few worms in it. A properly designed bin has sufficient depth to ensure that the worm population is maintained.

The basic principle of a flow-through vermicomposting operation is to add a mixture of food waste and bulking material in thin layers and allow the earthworms to process successive aerobic layers of wastes. The earthworms will generally be concentrated in the upper six inches of material, and they will move upwards as each successive waste layer is added.

A summary of important operating parameters for a vermicomposting operation is presented in **Table 2**.

**Table 2**: Important Operating Parameters for a Vermicomposting Operation

| **Observation** | **Practice** |
|---|---|
| Earthworms need oxygen | The amount of waste to be added to the top of the mix on a daily basis should not be more than 6 inches in depth. |
| Earthworms prefer moderate temperatures. | The operation should be housed in a heated building and in an insulated box. |
| Earthworms prefer a moist climate. | The vermicomposting box should be covered to prevent moisture from escaping and the mix should be dampened periodically. |
| Earthworms are sensitive to elevated ammonia levels | Manure, fresh poultry, and other animal-related products should not be added to vermicompost without preconditioning. |
| Earthworms are sensitive to elevated salt concentrations. | Dampening the mix periodically is not only important for moisture control, but also to flush out salt. |

## TASK COMPLETION

### *Task 1: Waste Audit*

The primary component of the proposed vermicomposting operation is food waste, which is generated daily in the kitchen and cafeteria area. Newspaper, office paper (no glossies), corrugated paper, and leaves are suggested as bulking agents. The waste at the Clearfield County Prison contains an adequate amount of bulking material to obtain the 3:1 *by volume* and 4:1 *by weight* suggested mixing ratios of food waste to bulking material. Prison staff estimate that the amount of food waste generated daily is between 20 and 30 pounds. Assuming that all of the food waste generated is usable in a vermicomposting operation, 7 to 10 pounds of bulking material per day is needed.

At the request of prison staff, a short list of local establishments was contacted that might be able to provide additional food waste and bulking material. An interest was expressed in eventually expanding the program to become a community service project.

#### Community Sources of Additional Food Waste

A survey of local establishments with significant sources of food waste revealed that program expansion, as a community service project, would be difficult. Grocers, such as the Bi-Lo grocery store and the Wal-Mart Supercenter in Clearfield, stated that food waste is considered a liability, and giving it away is discouraged as corporate policy. The Produce Manager at Bi-Lo intends to check with the Corporate Manager to see if an exception can be made for a supervised composting operation. Mountain Laurel Nursing & Rehabilitation Center commented that State law prohibits them and all health care facilities, such as hospitals, from giving food waste away.

The use of a vermicomposting as a community service project might be possible if set up as a drop-off center for general use. Concerns are likely to arise regarding vermin and rodent control as well as potential odors at the drop-off location. These concerns could be addressed by suggesting that only fruit and vegetable waste will be collected, the food waste must be bagged,

and that the bins will be monitored closely and emptied daily. If the drop-off bin is placed at the County Recycling Center, which is staffed and adjacent to the Prison, then a food waste drop-off program has a greater chance of success. Community participation and proper use, however, might be a problem.

### Community Sources of Additional Bulking Agent

In past years, the prison has accepted leaf waste from Clearfield Borough. As a bulking agent for vermicomposting, we anticipate that the Borough can provide as much leaf waste as needed. To avoid oversupplying the Prison with leaf waste, we estimate the amount necessary for vermicomposting on an annual basis in Task 2 (the Estimate of Loading Rate section).

Since the production of leaf waste is seasonal, the use of paper as a bulking material will be necessary for at least part of the year. Paper can also be the only bulking agent used, or incorporated with leaves as a mixture. From the estimates given for paper waste generated at the prison, an outside source for additional material is probably not necessary.

## *Task 2: Conceptual Vermicomposting Plan*

In this section, a process flow diagram is presented as a basis for the conceptual design plan. The conceptual design plan also considers a potential loading rate. Additional details on this conceptual design plan are presented in Task 3.

### Process Flow Diagram

Industrial vermicomposting operations often involve the following steps: collection, mixing and shredding, pre-composting, digester loading, harvesting, and storage. A step can be added for recycling a portion of the harvested material back into raw waste. The harvested material is rich in microorganisms. Recycling a portion of the material at a rate of 10 to 1 raw waste to

harvested material helps to inoculate the fresh food waste. A process flow diagram for vermicomposting is presented in **Figure 1**, and described in further detail below.

**Collection** Food waste, newspaper, sawdust, and other materials to be included in the mix are collected and brought to a common location. Designated bins can be placed at appropriate locations within the facility to separate and collect the materials to be composted.

**Mixing/Shredding** Proportions of food waste, leaves, newspaper, and other bulking agents are mixed together proportionally using either a scale or a bucket. As part of the mixing process, the waste needs to be broken up or shredded.

**Pre-composting** After mixing, the material experiences a period of intense microbial activity, which causes the temperature inside the pile exceed 100 degrees Fahrenheit. Pre-composting involves placing the mixed pile outside of the bin for a number of days to cool.

**Digester Loading** Preconditioned material is loaded into the digester to a depth of not greater than six inches per day. A shovel can be used for loading the material.

**Harvesting** Worm-processed material is removed from the lowest portion of the digester through the force of a scraper bar, which is drawn across the bottom inch of material and helps the material to fall through a supporting screen. This material is a mixture of vermicompost and worm castings. After being removed by the scraper, the material falls out from the bin by gravity where it can be collected for storage.

**Storage** The mixture of vermicompost and castings is moved with either a wheelbarrow or front-end loader to a long-term storage area. In storage, the material can be expected to air dry due to its fine particle size.

**Spreading** Vermicompost and worm castings are spread on gardens or used for other landscaping projects.

## Estimate of Loading Rate

Staff members of the Clearfield County Prison estimate that 20 to 30 pounds of food waste is generated per day. Some of this food waste might be meats, fats, oils, and dairy products, which should not be included in the vermicomposting operation due to the potential for rodent infestation. For this reason, we will assume that 15 to 20 pounds per day of usable food is available. Loading rates for vermicomposting digesters are expressed as pounds per day of food waste plus bulking material. The actual process of loading the digester each day, however, can be done with either a scale or a bucket.

Literature suggests that a 3:1 ratio *by volume* and 4:1 ratio *by weight* of food waste to bulking agent is common for vermicomposting operations. From an EPA document entitled "Measuring Recycling: A Guide for State and Local Governments," 55 gallons of food waste weighs 400 pounds. Therefore, 20 pounds of food waste from the County prison is equivalent to 2.75 (or approximately 3) gallons per day. So, on a daily basis, we estimate that the prison will have three one-gallon buckets of food waste, and should add to it one-gallon of shredded paper or leaves. One gallon of either shredded paper or leaves is equal to about five pounds. The conclusions to be made are listed in **Table 3**.

**Table 3**: Daily Vermiculture Mix by Volume, Weight, and Total Loading

| **Daily Vermiculture Mix By Volume** | **Daily Vermiculture Mix By Weight** | **Total Daily Loading on the Digester** |
|---|---|---|
| 3-gallons of food waste<br>1-gallon of paper or leaves<br><br>3:1 mix of food to bulking agent | 20-pounds of food waste<br>5-pounds of paper or leaves<br><br>4:1 mix of food to bulking agent | 25 pounds per day |

Since the prison would like to consider accepting leaves from local municipalities, we will take this analysis a step further and estimate the quantity of leaves needed on an annual basis for vermicomposting. At five pounds per day, the prison would need approximately 1,800 pounds (less than a ton) of leaves for a full year of operation. Using a conservative estimate of 225 pounds per cubic yard, the prison will need at most 8 cubic yards of loosely compacted leaves. This estimate can be scaled down if the prison intends to incorporate paper waste.

## Conceptual Design Plan

A Conceptual Sketch Plan is presented as **Figure 2** at the end of the report, and shows a housing facility with room for two Worm Wigwams and suggested locations for mixing, pre-composting, and storage. The proposed location for the housing facility is the clearing between the County Recycling Center and the prison orchard. This location is ideal because it is along the access road to the prison garage and easily accessible to loading equipment.

## *Task 3: Prepare a report with the findings and plans for implementation.*

The task of recommending an implementation plan consists of three sub-tasks:

- A recommendation for the bin size and type,
- A preliminary opinion of equipment and construction costs,
- Finally, an overall plan for implementation.

This section discusses three alternative systems for implementing a vermicomposting operation at the prison facility with consideration for the resources available to the prison, the estimated production rate of food waste, and the potential for expanding the operation to accept residential food waste.

## Recommended Vermicomposting Bins

We recommend a bin system over windrows to reduce the chance of vermin and rodent infestation. Enclosed systems also reduce the processing time of food waste to compost, which, in turn, reduces the spatial requirements relative to windrow composting.

We offer three alternatives for developing a vermiculture operation at the County Prison. Two of the recommended bins are available from Orner Farms in Camp Home, Pennsylvania who represents EPM, Inc. in Cotton Grove, Oregon. Although we do not intend to endorse a particular vendor or product, we suggest EPM products in this case due to the availability of a

local demonstration site at Orner Farms as well as convenience of local technical support. The third alternative is to construct a vermiculture bin from a set of modified blueprints.

### The Worm Wigwam

The Worm Wigwam, which is presented in **Figure 3**, is three feet in diameter, three feet tall, and weighs 86 pounds. This unit can handle 25 pounds of food waste plus bulking material per day. As stated by the manufacturer, the walls are constructed with 100% recycled plastic, the bottom has a scraper bar, and the system is elevated to improve aeration. The purchase price for one unit is $590, which includes an operating manual. Freight and delivery is estimated at $67.

### Industrial Model 5 by 8

The Institutional Model 5 by 8, as presented in **Figure 4**, is five feet wide, eight feet long, and four feet tall. It is designed for a daily capacity of 75 to 150 pounds per day of organic waste, which means that it can accommodate 40 to 100 pounds per day of residential food waste without the bulking material. The bin is constructed of rot-resistant wood slats in a metal frame. Insulation with an R-14 rating is provided on the interior. The purchase price for one unit is $4,465, which includes an operating manual. The estimated delivery and freight charges are estimated at $569.


**Figure 3**: The Worm Wigwam

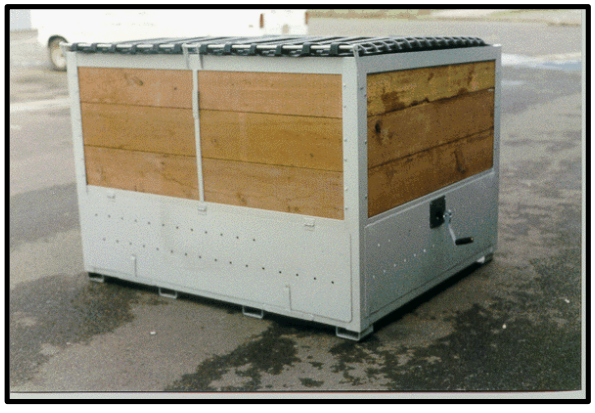

**Figure 4**: Industrial 5 by 6 Unit
(Similar in appearance to 5 by 8 unit)

### Oregon Soil Corporation Reactor (OSCR)

The Oregon Soil Corporation offers a set of construction drawings, an operator's guide, and site license for $50. The OSCR box is three feet wide, four feet long, and three feet tall. It is designed for a daily loading rate of 15 pounds per day. Therefore, two OSCR bins would be required. The bins can be constructed with supplies that are commonly found at a hardware store at a cost that OSCR estimates at $400 per bin. The total for two bins with licensing is approximately $900. From our own experience with the bins, some modification to the plans is necessary. If the prison staff would like to construct the OSCR, please contact us for the suggested modifications.

## Opinion of Probable Equipment and Construction Costs

In this section, we consider two scenarios. The first scenario is to purchase one 5 by 8 industrial unit now for handling both the prison food waste and that of other establishments. The second scenario is to purchase one Worm Wigwam now, but size the housing facility to accommodate a second unit later. As stated previously, the Worm Wigwam has sufficient capacity to handle the prison food waste, but cannot handle additional food waste from program expansion.

The equipment costs to consider for a vermicomposting operation are the bins, space heaters, fans, material shredders, mixers, and the worms. Construction costs can be expected for a facility to house the bins. An isolated housing facility is suggested to ensure that daily operations at the prison facility are not affected by potential odors, rodent or vermin infestation. Several assumptions are necessary to develop an opinion of probable costs, and they are the following:

- Pre-composting of the material may or may not be necessary. If pre-composting is necessary, the length of time required for this step will not exceed 14 days.
- A 200 square foot steel building with a roof, concrete floor, insulation, electrical outlets, water spigot, and garage door is necessary to house the bins.
- The odors generated will not be strong enough to require treatment.

- A storage area is necessary for harvested material with a 5-month (November to March) capacity. Harvested material does not need to be placed on a concrete pad, but should be covered with a tarp.

Our opinion of probable costs for the equipment and facility construction is presented in **Table 4**.

**Table 4**: Opinion of Probable Equipment and Construction Costs

| **Parameter** | **Worm Wigwam (One Unit)** | **Industrial 5 by 8 (One Unit)** | **OSCR (Two Units)** |
|---|---|---|---|
| Loading Capacity (lbs/day) | 25 | 100 | 30 total |
| Food Loading (lbs/day) | 20 | 80 | 24 total |
| 20' x 10' housing unit with insulation, electrical outlets, a water spigot, garage door, and a 6" concrete base ($60/SF) | $12,000 | $12,000 | $12,000 |
| Vermiculture Bin | $590 | $4,465 | $900 |
| Bin Delivery and Freight | $67 | $569 | 0 |
| Worms ($14 per pound) | $210 | $700 | $350 |
| Fans & Space Heaters | $75 | $75 | $75 |
| Paper & Leaf Shredders | $100 | $100 | $100 |
| Tarp | $50 | $50 | $50 |
| Incidentals | $100 | $100 | $100 |
| **Total Cost** | **$13,200** | **$18,100** | **$13,600** |

The list prices for the Worm Wigwam and Industrial 5 by 8 unit are good through April 2002. Delivery time for the 5 by 8 unit is approximately 45 days from the time of purchase.

## Plans for Implementation

In order to recommend a bin type, we feel that other factors in addition to cost should be considered. Expanding the program to become a community service project will take time and public education. Therefore, we suggest the Prison start with one to two Worm Wigwams instead of the industrial size 5 by 8 unit. Two Worm Wigwams are less expensive that one industrial size unit. The purchase of two Worm Wigwams is justifiable for any one of the following reasons:

1. The amount of usable food waste generated at the prison might be greater than anticipated.
2. A second bin makes it less time consuming to experiment with different bulking materials as well as proportions of different bulking materials.
3. In the event of a system upset, a second bin allows for continued operation.

We do not recommend the OSCR (built it yourself bin) because there does not appear to be significant cost savings relative to the Worm Wigwam.

We are aware of one potential funding source for a vermicomposting operation, which can defray some of the costs. Act 101 Section 902 grants are available from the Pennsylvania Department of Environmental Protection (PaDEP) for the implementation of municipal recycling and composting programs. The grant program provides 90% reimbursement for the costs that are associated with implementation. Reimbursement, however, is only provided for a list of approved materials of which paper and leaves are included, but food waste is not. In these cases, the PaDEP could prorate the grant award on the basis of the proportion of approved waste materials included.

For the proposed vermicomposting operation, 20% of the material to be used (the paper and leaves) qualifies under Act 101, which means that 18% of the implementation costs could be covered with a 902 grant. Our opinion of probable cost for two Worm Wigwams and a housing unit is $14,100. Therefore, at most $2,500 of the implementation costs could be covered by a Section 902 grant. The prison would need to submit the grant application through the Clearfield County Solid Waste Authority as the sponsor. Jodi McCluskey can be contacted for more information.

The cost of a vermicomposting operation can also be compared to the anticipated reduction in refuse disposal costs as well as landscaping costs. The cost savings for using vermicompost as a soil amendment is difficult to quantify, but can be expected to some extent. According to prison personnel, the annual cost for refuse disposal is $1,680. If one-half to three-quarters of the waste can be incorporated into a vermicomposting operation, then an $800 to $1,200 cost savings can

be anticipated. The return on the investment is at best 10 years assuming that a 902-grant is awarded and operating costs are minimal.

## CONCLUSIONS AND RECOMMENDATIONS

Assuming that funding sources are available, it is recommended that the prison proceed with plans to implement a vermicomposting operation. We recommend the purchase of two Worm Wigwams from Orner Farms, Inc. in Camp Home, Pennsylvania. A 200 square foot building with a roof, concrete floor, insulation, electrical outlets, water spigot, and garage door is necessary to house the bins. An isolated housing facility is necessary to ensure that daily operations at the prison facility are not affected by potential odors, rodent or vermin infestation. The proposed location between the Recycling Center and the Prison Orchard is ideal due to its accessibility for staging a vermicomposting operation.

The proposed system is sized to handle all of the usable food waste at the prison facility. We consider usable to be all of the kitchen and cafeteria food waste with the exception of dairy products, meats, fats, and oils. It is likely that prison generates an adequate amount of newspaper, office paper, and cardboard waste to use as bulking material. Leaf waste can also be incorporated, if desired. Unfortunately, program expansion to include food waste from local grocers and health care establishments will be difficult for liability reasons.

Our preliminary opinion of probable cost to implement a vermicomposting operation at the prison for the prison waste stream is $14,100. Of this amount, at $2,500 could be reimbursable under the Section 902 grant program. The cost of a vermicomposting operation can be partially justified by anticipated cost reductions in refuse disposal and landscaping costs on an annual basis. The payback period does not meet the 5-year standard that is typically used for justifying an expenditure of this type. If, however, the intent is to also provide inmates with productive work and learning opportunities, then a comparison of costs to a standard payback period becomes less relevant.