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Engineering Outreach Service

THE COMPOST WHITE PAPER
Large-Scale Composting in Georgia

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Executive Summary

The Compost White Paper: Large-Scale Composting in Georgia was funded by the Solid Waste Trust Fund through the Pollution Prevention Assistance Division. The goals of this report were to provide an overview of the composting industry, analyze the composting infrastructure in Georgia, review potential markets, identify barriers, and make recommendations to promote composting in Georgia.

As much as 70% of the municipal solid waste in Georgia is organic material that could potentially be composted. Based on the waste characterization studies funded by the Solid Waste Trust Fund that were conducted in the late 1990s, Georgia produces over 2 million tons per year of food processing waste, 2.5 million tons per year of wood waste, and almost 400,000 tons per year of municipal biosolids. Most of these byproducts can be composted. Diverting this material from landfills could help meet the State's 25% waste reduction goal. In addition, the reuse of these organic materials can improve soil fertility, tilth, water holding capacity, and reduce erosion, which can improve our water quality by reducing the amount of sediments and associated pollutants that reach surface waters.

Although there are many environmental benefits to composting, there are also environmental and public health concerns about concentrating raw organic wastes in the composting process. These include groundwater contamination with nitrates, surface water contamination with ammonia and phosphorus, and air quality issues with odor and potential transmission of diseases by bioaerosols. The environmental concerns listed above support the need for regulation of large-scale composting facilities. A review of state composting regulations indicated that states with well-developed composting infrastructures have a tiered-permitting system to tailor regulatory requirements to environmental risks. In general, these states' regulations also tend to be well-organized and have good support guidance.

Overview of Current Composting Infrastructure in Georgia

To analyze the composting infrastructure in Georgia, UGA staff conducted telephone interviews of 130 potential composting facilities and identified 38 large-scale composting operations in the state. Site visits were conducted at these facilities in 2002 and operators were asked to complete a survey form. The results of the survey and site visits indicated that these facilities processed about 553,600 tons per year of organic material, which is a relatively small portion of the organic waste stream in Georgia. Private facilities process 73% of the materials composted in the state. In general, the private facilities produced the highest quality compost and had the lowest stockpiles of materials. Local government facilities produced 24% of the compost in Georgia. Stockpiling percentages were higher for these facilities. Institutional composting was a small percentage of the compost produced and most of the product was used onsite.

Based on the analysis of the composting operations in Georgia, it was determined that the successful composting operations controlled the critical parameters of the composting process (i.e., carbon:nitrogen ratios, temperature, moisture, and air) to produce a consistent product. These operations charged tipping fees for materials and sold the finished product. Another important feature of the successful composting operations surveyed was an effective marketing strategy, which resulted in the operations stockpiling small quantities of product.

Barriers and Potential Markets

The survey also identified several common problems for large-scale composting operations. These included: a confusion between what defines compost versus mulch, low carbon:nitrogen ratios that caused odors or leachate problems, and generally low compost quality. Because the survey indicated that current compost production is relatively low quality, the largest potential markets for compost appear to be for erosion control, kaolin mine land reclamation, and home or commercial landscaping.

The operators surveyed indicated that low tipping fees, logistical problems (e.g., locating facilities near areas generating the largest volumes of feedstock), and the difficulty in obtaining a Solid Waste Handling Facility permit were impediments to expansion or new operations. Tipping fees for municipal solid waste at landfills in Georgia range from $20 to $40 per ton. At these rates, it can be cheaper to landfill materials than compost them, especially if the material is transported a great distance. The compost infrastructure survey indicated the maximum haul distance to acquire high nitrogen feedstocks was within a 50-mile radius of the facility. Obtaining land for a composting facility near areas generating large volumes of feedstock is difficult and often not economically feasible. Public opposition and lack of knowledge on the part of local decision makers was also mentioned as a deterrent to siting a composting facility.

The survey indicated there was considerable capacity within the existing composting infrastructure, except in the largest facilities (producing more than 25,000 tons per year).

Present operational throughput capacity at many facilities could be doubled, allowing for an additional 500,000 tons of material to be composted. However, some operators have chosen not to expand throughput capacity or feedstocks because of the difficulty and expense of obtaining a Solid Waste Handling Facility permit.

Recommendations

Based on the literature research and analysis of Georgia's composting infrastructure, the following are recommendations that the composting industry, government, or both working in partnership can implement to remove the barriers identified. The recommendations are divided into three categories: education, regulatory, and market development.

I. Education

Several types of educational materials would help promote the production of consistent, high quality composts as well as increase user satisfaction. For example, the University of Georgia and the industry should develop Georgia-specific brochures on the compost quality needed for particular uses. The composting industry in Georgia should promote the training of its members and the production of high-quality, consistent compost products. The University of Georgia's Compost Facility Operators Training Workshop should be continued and, if necessary, modified or expanded to meet any specific educational needs. To help reduce concerns over zoning and permitting a composting facility, the composting industry should take a more proactive role in educating the public and elected officials about composting. The Georgia Municipal Association and Association County Commissioners of Georgia could also assist in educating their member-base (i.e. local governments) about composting issues. An educational document, endorsed by the Georgia Environmental Protection Division (EPD), for local officials and the public that describes regulatory requirements and expectations for composting facilities could also help reduce local opposition to facilities.

II. Regulatory

There are several ways the current regulations could be improved to encourage composting while protecting the environment. Ideally, all composting regulations should be placed under a separate chapter with a tiered-permit system based on risk. A task force should be appointed to develop recommendations for the tiered-permit system. If it is unfeasible to change the composting regulations, some modification of the existing permit system could help remove regulatory barriers. For example, the current Permit-by-Rule requires 75% of the waste composted to be produced onsite, which can restrict proper compost recipe development. The Permit-by-Rule requirements could be modified to allow for a greater amount of off-site materials to be used in order for the facility to obtain the proper compost carbon:nitrogen ratio. Another potential mechanism for permitting certain composting facilities is to allow facilities to obtain a Recovered Materials Processing Facilities classification instead of a Solid Waste Handling Facility permit. However, the permit requirements would need to be amended to allow materials to remain onsite for greater than 90 days. Such an amendment would encourage the production of higher quality composts by allowing adequate time for the composting and curing processes. To clarify regulations, a guidance document should be produced by EPD that covers the permitting process, permit requirements, and recommended practices for operation and management.

The cost of new composting facility construction is greatly affected by the type of composting surface required. Currently, EPD requires either concrete or asphalt pads for most operations. One modification that could help reduce the cost of construction would be to set a permeability standard for composting pads, such as 1×10^{-7} centimeters per second, and allow several options for composting facilities to meet the standards.

Research on the amount and chemical characteristics of leachate from windrow operations, the potential for presence of pathogens in surface runoff, and optimal feedstock combinations to minimize environmental risks could be used to determine which types of facilities need fewer regulatory requirements.

III. Market Development

Market development can be facilitated by the production of consistent high quality products. To ensure that the industry produces consistent high-quality products, facilities should develop and use protocols. They should also implement testing programs to ensure that they meet their quality goals and share the test results with their users along with guidelines for use.

Additional research on compost use in agricultural production systems would support the development of an agricultural market. Compost use would also increase, if farmers shift production practices towards reduced use of tillage, irrigation, pesticides or man-made fertilizers.

The state could actively promote composting by encouraging state agencies to use the material in landscaping and for erosion control, especially once the specifications from the

Georgia DOT and Georgia Soil and Water Conservation Commission are published. The state and local economic development agencies could work with the kaolin mine industry to encourage facilities to locate near the areas where compost could be used in reclamation activities.

State/local government could provide economic incentives such as tax breaks to composting facilities or tax the landfilling of organic materials to help address issues associated with low tipping fees.

Conclusion

Although Georgia has an active composting infrastructure, it currently processes only a small portion of the organic waste generated in the state. This study indicates that Georgia has the potential to increase composting to help meet the 25% waste reduction goal with little adverse environmental impact.

THE COMPOST WHITE PAPER

Large-Scale Composting in Georgia

1. Introduction

A recent review of solid waste management in the United States indicated that landfill space is decreasing, the percentage of waste recycled is holding steady, and solid waste generation is increasing (Goldstein and Madtes, 2001). Data from the Department of Community Affairs (DCA) “Solid Waste Management Annual Report” (2000) indicate the amount of waste generated per person in Georgia is increasing and recycling efforts are holding steady. The DCA report also indicates the amount of waste imported from other states is increasing. In contrast to other states, Georgia’s landfill capacity continues to increase as older facilities operated by local governments close and are replaced by larger, privately owned facilities. Although municipal solid waste landfill capacity is estimated at 364 million cubic yards, DCA reports more than a third of this capacity is due to just three facilities.

In 1990, the Georgia General Assembly set a goal of 25% solid waste reduction. While this has never been achieved, it is still a statewide goal. According to the United States Environmental Protection Agency (USEPA, 1999), 67 to 70% of the national municipal solid waste stream is organic. That is, waste that comes from something that was once living, e.g., paper, food waste, etc. The percentage of organic materials in the wastestream in Georgia is likely to be similar. For Georgia to meet the 25% waste reduction goal, more organic materials will have to be diverted from landfills and put to other uses. One way to beneficially reuse these organic wastes is through composting.

Composting is the process of decomposing organic materials to form stabilized organic matter. It is defined as the controlled, heat dependent, microbiological process of decomposing organic materials into a biologically stable, humus-rich material (Alexander, 1996). Compost is used in agriculture, horticulture, home gardening, land reclamation, wetland mitigation, and erosion prevention to help rebuild soil organic matter and to provide a good medium for plant growth.

The organic matter in most of Georgia’s soils has been depleted over time by erosion due to agriculture, development, and by natural weathering processes. Soils with depleted organic matter have a reduced ability to hold water and are prone to increased runoff and erosion that can create surface water quality problems (Langdale et al., 1992). Increasing soil organic matter improves infiltration as well as the nutrient and water holding capacity of the soil (Tisdale et al., 1993). Consequently, more rainfall can infiltrate into the soil and less water is lost as surface runoff carrying sediment and other pollutants to streams, rivers, ponds, and lakes. Improving water use efficiency and water quality through rebuilding soil organic matter is a tool that can help manage scarce water resources as Georgia's population grows. The application of compost is one way to help rebuild soil organic matter (Magdoff and van Es, 2000).

Because composting can provide a means to meet Georgia's 25% waste reduction goal and help solve water quality and quantity problems, there is considerable interest in developing a better understanding of the current state of large-scale composting in Georgia. Stakeholders in the composting industry include the Pollution Prevention Assistance Division (P^2AD), the Environmental Protection Division Commercial & Industrial Solid Waste Program (EPD), the DCA, the USEPA, the Georgia Composting Association, and producers and users of composts. These groups have identified several areas where good information is needed to make sound policy and business decisions. These areas include the current composting infrastructure, potential capacity of current infrastructure, impediments to large-scale composting, potential environmental impacts of composting facilities, and potential for market development.

The Engineering Outreach Service at the University of Georgia was contracted by P^2AD to prepare a white paper to address the information needs listed above. Funds for this project were provided by the Department of Natural Resources Solid Waste Trust Fund throught P^2AD. The result is this document -- ***The Compost White Paper: Large-Scale Composting in Georgia***.

2. Overview of Large-Scale Composting as an Industry

2.1 Methods

The overview of the composting industry provides a framework for understanding the industry in Georgia. Information for the overview of composting practices with particular focus on the Southeast was generated by conducting a literature review. Several scientific databases including AGRICOLA, CRIS (Current Research Information Search - USDA), and the American Society of Agricultural Engineers were searched for pertinent references. The searches focused on potential environmental benefits and impacts of composting, rather than details about particular composting methodologies. Most of the regional composting research was found in the Proceedings of the Composting in the Southeast Conference - years 1996, 1998, 2000, and 2002. Information from the trade journal, Biocycle: Journal of Composting and Organics Recycling, from solid waste handling reports from various local governments, and from several University of Georgia waste characterization reports funded by P^{2}AD through the Department of Natural Resources Solid Waste Trust Fund were used.

2.2 Composting Principles

Compost is produced through the activity of aerobic microorganisms that require oxygen, moisture, and food in order to multiply. These microorganisms generate heat, water vapor, and carbon dioxide as they transform raw material into a stable soil conditioner (Alexander, 1996). Effective composting begins with a basic knowledge of the material or feedstock properties, the general principals of decomposition, and a method for controlling the process. Several feedstock characteristics are critical in the composting process. These include carbon to nitrogen (C:N) ratio, moisture content, and the size and distribution of the feedstock particles. Raw materials are blended to provide a C:N ratio between 25:1 and 30:1. These ratios are considered ideal for active composting, although initial C:N ratios from 20:1 to 40:1 consistently give good composting results (Rynk, 1992; Dougherty, 1999). Odor problems and longer composting times can result from ratios outside this range. Too little moisture, as well as too much moisture, can lead to poor composting conditions and decreased microbial activity. Moisture contents ranging between 40-60% usually provide the water needed by microbes without saturating the required air space within the compost matrix (Rynk, 1992). A particle size distribution of 90 percent cumulative passing a 2 to 3 inch screen usually is sufficient to provide a composting substrate with adequate surface area for microbial degradation and with adequate porosity for storage of oxygen (Ndegwa, 1999), although a range of particle sizes is needed to maintain porosity.

The correct mix of feedstock characteristics creates good conditions for microorganism growth and subsequent heat generation. An increase in temperature and the associated decomposition of organic matter distinguishes compost from other organic materials such as manures, foodwastes, or mulches. Organic materials that do not go through a microbiological heating process are not considered compost or a composted product.

Heating will not occur if pH, moisture content, or C:N ratios are not adequate. Temperatures will also not increase if the compost pile is not large enough to retain heat. Decomposing microorganisms, mainly bacteria, fungi, and actinomycetes have specific environmental requirements. The types of microorganisms present change as the compost temperatures move from a mesophilic stage (less than 40 C^{o} or 104 F^{o}) to a thermophilic stage (40 to 70 C^{o} or 104 to158 F^{o}) and then to a curing stage (ambient to 30 C^{o} or 86 F^{o}) (Zibilske, 1999). Most microbial pathogens are killed during the first hour of the themophilic stage (Zibilske, 1999). This is also where the fastest rate of decomposition occurs (Zibilske, 1999). For every 10 C^{o} (50 F^{o}) increase in temperature, decomposition rates double (Hartel, 1999). The final composting stage is curing where temperatures return to ambient levels. Decomposition continues but at a much slower rate, similar to decomposition rates of organic matter in soil ecosystems (Zibilske, 1999). Nutrients are stabilized during the curing stage.

Managing the composting process through these temperature stages is critical to creating a high quality compost. There are regulatory temperature requirements for certain feedstocks aimed at a high level of pathogen reduction. The USEPA requires municipal biosolids composted in in-vessel composting systems to maintain temperature levels of 55 C^{o} (131 F^{o}) for 72 hours. Windrow composting systems must maintain 55 C^{o} for 15 days with at least five turns (USEPA, 1993a). The USDA National Organic Standards for composting have the same requirements for all non-plant based organic materials. Although, not a regulatory body, the US Composting Council supports these requirements in their compost quality documentation (US Composting Council, 1996).

2.3 Composting Technologies

Four methods are commonly used by the composting industry to turn feedstocks into finished compost (Rynk, 1992; Haug, 1993). These methods include passive composting, aerated static piles, windrows, and in-vessel composting.

Passive composting is probably the most common method used today because it involves simply stacking feedstocks and leaving them to decompose over a long period of time. Very little, if any, management is performed once the pile has been constructed. Initial composting parameters, such as moisture, are controlled, but control over these parameters is not usually maintained. Passive composting is relatively easy, but can have problems such as odor generation from anaerobic conditions and leachate from too much moisture. The process also requires an extended period of time for complete composting.

Aerated static pile modifies the passive composting technique by using blowers or vacuums to supply air to the composting feedstocks. This process does not involve turning or agitation of the piles after the initial mixing of feedstocks. Bulking agents are often used to help maintain the porosity of the compost piles, which aids in aeration. In this type of composting, the capacity of the blowers and the characteristics of the feedstocks dictate the size of the piles. Electronic feedback controls are often used to monitor the pile temperature and control the operation of blowers or vacuums.

Windrow composting is another common method used in Georgia. Materials are placed in long rows and turned or aerated by mechanical equipment to maintain optimum conditions. Dimensions of the windrow normally range from three to 12 feet high and from eight to 20 feet wide. The size and shape of the windrows is based on the characteristics of feedstocks and the type of equipment used for turning. Windrow aeration is accomplished through the natural chimney ventilation effect of warm air rising through the pile and by mechanical turning. Mechanical turning is usually done with a front-end loader or a machine specifically designed for turning windrows. The flow rate of air into the pile is determined by the porosity of the feedstocks. Frequent turning helps maintain a porous media and allows for the replenishment of oxygen used by the microorganisms. The area where the composting takes place is commonly referred to as a compost pad. The size of the pad depends on the volume of material handled, the windrow shape and length, and the type of equipment used for turning.

In-vessel composting refers to any type of composting that takes place inside a structure, container, or vessel. Each type of system relies upon mechanical aeration and turning to enhance and decrease the duration of the composting process. The goal of in-vessel composting systems is to combine various composting techniques into one controlled environment, which utilizes the strengths and minimizes the weaknesses inherent to other forms of composting. These systems control the moisture and temperature of the feedstock during composting, and require frequent turning to maintain a good feedstock mixture (Rynk, 1992). High capital and operational costs are normal characteristics of in-vessel systems, which are often highly automated. In-vessel systems are often used where available land is a limiting factor.

Most composting facilities have separate areas where different stages of the composting process take place. The first area is referred to as the “hot zone”. Once organic materials have been mixed together, temperatures can increase in less than 24 hours. As the compost advances through the mesophilic and thermophilic stages, odor and leachate concerns may arise. After temperatures stabilize, the composting process moves into the "curing" phase. One of the functions of curing is to guarantee a consistent, high quality product. Some operations will have a "finished" compost area, but it is usually designed more for the consumer than the actual composting process. It may include storage of finished products, displays of various compost blends, and product pick-up.

2.4 Potential Environmental Benefits

Environmental benefits associated with composting can be substantial. Diversion of organic wastes from landfills can have significant benefits, and the environmental benefits from the utilization of compost can be equally important.

2.4.1 Organic Material Diversion

Diverting organic materials from landfills through composting benefits the environment by: 1) reducing the potential for groundwater pollution from landfill leachate; 2) reducing methane release to the atmosphere; 3) reducing the need to expand existing landfills and construct new ones; and 4) improving soil quality where compost is used. According to the USEPA (1999), organic waste in our landfills is the number one source of man-made methane in the United States. Methane is a greenhouse gas 25 times more potent than carbon dioxide. If the percentage in Georgia is similar to the national percentage (USEPA, 1999), nearly 70% of Georgia's municipal solid waste is organic material that could be composted if source separated. Before the statewide ban in 1996, yardwaste going to landfills accounted for 18% of the municipal solid waste stream and was the second leading source of waste headed to landfills after paper and paperboard (USEPA, 1999). Today, Georgia's yardwaste is mulched, composted or simply stockpiled at inert landfills. Based on waste characterization studies conducted in the late 1990s, Georgia currently landfills over 700,000 tons per year of foodwaste (Magbunua, 2000), 2.5 million tons per year of woodwaste (Adams et al., 2000), and almost 400,000 tons per year of municipal biosolids (Governo, 2000). All these wastestreams can be composted.

2.4.2 Off-Farm Use of Manure

Georgia leads the nation in poultry production, processing nearly 1.5 billion birds per year. Poultry production generates approximately 1.5 million tons annually of poultry litter (Georgia Agricultural Statistics Service, 2000). Because most poultry farms import more nutrients in feed than they export in meat and crops, increasing the off-farm use of poultry litter is one solution to concerns about nutrient management and water quality. Composting poultry litter can reduce both volume and odor, making the product more marketable for off-farm uses. Dairies and other animal feeding operations are also looking to composting to help address these concerns.

2.4.3 Pathogen and Organic Chemical Reduction

The composting process is very effective in reducing pathogens and breaking down other organic chemicals due to the microbial decomposition process. Heat generated as a byproduct of the microbial decomposition of organic materials kills both human and plant pathogens, and invasive weed seeds (Zibilkse, 1999). Composting has been shown to reduce and in some cases eliminate insecticide and herbicide residues in the original feedstocks through microbial decomposition, adsorption, humification, and volatilization (Bueyueksoenmez et al., 1999, 2000). There are some pesticide residues that are not affected by the composting process, primarily the organochlorine insecticides, such as DDT, chlordane, and pentachlorophenol, and the pyridine carboxylic group of herbicides including picloram and clopyralid (Bueyueksoenmez et al., 1999, 2000; Washington State University Online, verified 2002).

An extensive review by Bueyueksoenmez et al. (2000) of published studies on pesticides in composting concluded that although several pesticides can be detected in composts, concentrations are low and pesticide residues do not appear to be a concern even for food chain crops. The review notes that typical composting operations create a wide variety of temperatures, pHs, moisture conditions, and oxygen conditions during the composting process. This variety of conditions allows different microbial and chemical processes to degrade various pesticides and their residues over time. The authors note that, in general, longer composting times promote more complete degradation and degradation continues through the curing process. This may be due to microbes using the more resistant pesticides after other more easily degraded organic material has been broken down.

Composting is also thought to facilitate the breakdown of hormones and antibiotics in the environment (Zibilske, 1999) . The addition of organic matter and the beneficial microbial community have made compost useful in bioremediation, ecological, and land reclamation projects (Skipper, 1999).

2.4.4 Plant Growth Benefits

Compost is widely documented to increase plant growth and crop yields (Table 1). Increased plant growth and yield can be attributed to disease suppression, increased water use efficiency, and the ability of compost to act as a slow release nutrient source.

There are many studies documenting yield improvements in agricultural crops. Maynard (2000) showed tomatoes grown with compost needed 50% less fertilizer than control plots. Compost blended in transplant growing media increased pepper transplant quality and subsequent yields in Georgia (Granberry et al., 2001). Another three year study found that pepper yields from compost-amended plots equaled yields from inorganic fertilizer and animal manure-amended plots all three years (Reider et al., 2000). Growth, yield, and profit potential increased for melons and broccoli with compost applications in a Florida study (Roe and Cornforth, 2000). Municipal solid waste compost increased corn yields (Mamo et al., 2000). A South Carolina study found compost increased seed cotton yield by up to 30% compared to no compost applications (Khalilian et al., 1998).

Studies using compost in ornamental, orchard and tree production show similar results. A Florida study utilizing composted municipal solid waste as a top dressing under the tree canopy in citrus groves found significant growth responses by roots, stems, fruit size, and yield (Graham, 1998). The study concluded that compost use increased stem caliper and root mass 20 to 30%, increased the density of leaves, increased fruit size and yield, and increased nutrient uptake efficiency (Graham, 1998). Dudka et al. (1998) found ornamentals grown in composted biosolids had increased biomass, plant health, and visual aesthetics in greenhouse nursery production. This study also concluded that the use of compost can reduce fertilizer

Table 1. Summary of benefits to selected crops and plants with compost use.

Crops & Plants	Benefits	Reference	State
Tomato	Reduced fertilizer use. Reduced blossom end rot.	Maynard, 2000	CT
Pepper	Yields equal to fertilizer, manure use. Improved transplant quality and yield in mature plants.	Reider et al., 2000 Granberry et al., 2001	PA GA
Melon	Increased growth, yield, profit potential.	Roe and Cornforth, 2000	FL
Broccoli	Increased growth, yield, profit potential.	Roe and Cornforth, 2000	FL
Corn	Increased yield.	Mamo et al., 2000	MN
Cotton (seed)	Increased yield.	Khalilian et al., 1998	SC
Turfgrass	Improved color throughout year. Delayed onset of dormancy. Lowered weed populations. Consistently higher quality ratings.	Block, 2000	CA
Ryegrass	Increased yield.	Stratton and Rechcigl, 1998	FL
Citrus tree	Decreased root disease. Increased water uptake efficiency. Increased root mass. Increased yield and fruit size. Increased nutrient uptake efficiency.	Graham, 1998	FL
Christmas tree	Increased growth	Peregrim and Hinesley, 2000	NC
Ornamentals	Increased biomass. Increased visual aesthetics.	Dudka et al., 1998	GA
Native vegetation	Increased establishment	Cuevas et al., 2000	Spain

requirements and expenditures by the nursery (Dudka et al., 1998). Compost has also been shown to increase growth in mature Christmas trees (Peregrim and Hinesley, 2000), and in both hard and softwood tree seedlings (Bonnette et al., 2000).

Turfgrass as well as native vegetation establishment can benefit from compost. Field studies by the University of California Cooperative Extension staff found that compost out performed conventional and slow release fertilizers in turfgrass applications by improving turf color throughout the year, delaying onset of dormancy, and lowering weed populations (Block, 2000). Annual ryegrass grown in sandy soils doubled its yield during the second growing season using compost applications compared to fertilizer plots (Stratton and Rechcigl, 1998). Other studies have shown compost application in native vegetation improves growth. Compost applications in a semiarid shrubland increased soil chemical properties and native vegetation establishment in one season (Cuevas et al., 2000).

Recent studies indicate that compost may have a significant affect on plant disease suppression, which could reduce pesticide use. Compost applications have been gaining acceptance as a disease suppressant alternative to methyl bromide, a soil fumigant for control of soil borne plant pathogens that will be phased out by 2005 (De Ceuster and Hoitink, 1999). Compost has been shown to be effective in reducing blossom end rot in tomatoes (Maynard, 2000), plant disease in bell pepper transplants (Granberry et al., 2001), and *Phytophthera* root rot and fibrous root diseases root disease waste in citrus production (Graham, 1998). Although, in general, compost has a beneficial affect on plant growth, the use of low quality composts such as those with high soluble salts, those not well decomposed, or with certain pesticide residues, can cause plant growth problems

2.4.5 Water Use Efficiency

Increased levels of soil organic matter can increase water holding capacity (Tisdale et al., 1993) and water infiltration rates (Jordan, 1998). As a result, increased soil organic matter from compost applications can have a significant effect on reducing storm runoff, as well as reducing plant water stress and irrigation requirements. This can have a significant impact on water use reduction and conservation, which has become a critical concern for Georgia in recent years.

A layer of organic litter, such as compost, on the soil surface insulates the soil and reduces evaporation creating a better environment for the germination and root growth of plants (Jordan, 1998). A Florida study utilizing composted municipal solid waste in citrus production found it increased water uptake efficiency in mature trees (Graham, 1998). Because the compost increased water holding capacity in the soil, trees were able to use less energy to take up water, allowing them to put increased energy into fruit production instead of root production (Graham, 1998). In a similar study comparing compost with fertilizer in irrigated corn, a one time application of compost significantly increased water holding capacity (Mamo et al., 2000). Researchers concluded that yield increases in the compost-amended plots were due to reduced plant water stress (Mamo et al., 2000).

Because compost can increase the soil's ability to hold water, it serves to reduce runoff that may occur during storm events. A study conducted in Connecticut to promote the use of compost in roadside applications by the state Department of Transportation found composted wood waste increased water holding capacity of soils by improving soil structure which reduced runoff potential (Demars et al., 2000).

Composts also increase water infiltration rates. Agassi et al. (1998) found that surface applied municipal solid waste compost reduced runoff flow velocity and absorbed significantly more rainfall than bare soil control plots under simulated rainfall conditions. Approximately 85% of applied rainfall infiltrated compost-amended plots compared to 42% and 52% from control plots (Agassi et al., 1998). A similar study by the University of Connecticut evaluating compost for erosion control potential found that compost-amended plots allowed significantly more rain to infiltrate than bare soil control plots. Compost increased infiltration rates by as much as 125% compared to control plots because of improved soil structure (Demars and Long, 1998; Demars et al., 2000). Compost's ability to dissipate the energy of raindrop impact (Agassi et al., 1998), allowing water to penetrate the soil surface more easily (Jordan, 1998) may be a factor in increasing infiltration. Compost also protects the soil surface by preventing crusting.

2.4.6 Erosion Control

During the last ten years, compost has been used for slope stabilization, erosion and sediment control, and stormwater filtration applications (Tyler, 2001). Many studies show surface applied organic mulches reduce soil erosion and runoff (Adams, 1966; Meyer et al., 1972; Laflen et al., 1978; Vleeschauwer and Boodt, 1978; Foster et al., 1985). Compost blankets applied to the soil surface have been shown to prevent soil particle dislodgment and subsequent erosion in state Department of Transportation projects (Demars et al., 2000; California Environmental Protection Agency, 2000; Portland Metro, 1994). The Texas Department of Transportation and the Texas Natural Resources Conservation Commission found composted dairy and cattle manure substantially reduced soil erosion on roadway slopes (Block, 2000; USEPA, 2000). Soil erosion was reduced ten-fold with composts and mulches compared to bare soil surfaces on a 2:1 slope, in a study conducted by the Connecticut Department of Transportation (Demars and Long, 1998). Compost was 99% more effective than silt fences in keeping sediment out of nearby surface waters, and 38% more effective than hydroseeding (Demars and Long, 1998). A similar study in Portland, Oregon, found yardwaste compost used for erosion control in residential construction projects reduced erosion and improved runoff water quality compared to silt fences or hydroseeding (Portland Metro, 1994). In the Southeast, field demonstrations showed that compost blankets and filter berms can effectively control erosion and sedimentation, and some applications may outperform conventional means such as silt fences, hydroseeding, and synthetic mats (Tyler et al., 2000).

The best means to controlling erosion is to establish permanent vegetation as quickly as possible. Several erosion studies have shown increased vegetative growth on highway construction embankments due to compost application (Block, 2000; USEPA, 2000; USEPA, 1997). These studies indicate compost improves vegetation establishment as well as the soil properties controlling erosion. This type of information has prompted the Georgia Department of Transportation and the Georgia Soil and Water Conservation Commission to evaluate the use of compost as a best management practice for erosion and sediment control.

2.5 Compost Use and Markets

Compost use is dependent upon availability and quality. It is normally cost prohibitive to transport more than 50 miles, so its availability is often localized. Current uses for compost include agricultural field applications, nursery fields and beds, silviculture, turf and lawn care, sod production, potting mixes, soil blends, horticultural substrate, landscape mulch, planting backfill, biofilter media, bioremediation of contaminated soils, land reclamation and habitat restoration, erosion and sediment control, and compost teas (US Composting Council, 1996). Section 5 will provide a detailed discussion of compost use and potential markets in Georgia.

2.6 Potential Environmental Impacts of Compost Facilities

Organic wastes and composts contain nutrients such as nitrogen and phosphorus (Eghball et al., 1997; Sharpley and Moyer, 2000), and can contain metals (Cole, 1994; Frink and Sawhney, 1994), organic chemicals such as pesticide residues (Korvacic et al., 1992;

Richard and Chadsey, 1990), and pathogens (USEPA, 1993b). Although the nutrients and contaminants are typically found as a low percentage of the feedstocks or compost, the presence of large amounts of feedstocks or compost can present concerns about contamination of ground or surface waters (Cole, 1994; Frink and Sawhney, 1994; Korvacic et al., 1992; Richard and Chadsey, 1990). Two primary sources of concern are nitrate leaching to groundwater (Cabrera et al, 1998; Ballestro and Douglas, 1996; Frink and Sawhney, 1994) and excess nutrients and high oxygen demand entering surface waters through stormwater runoff (Cabrera et al., 1998; Cole, 1994).

The composting process causes a reduction in volume of the initial feedstocks (Eghball et al., 1997; Ott et al., 1983; Willson and Hummel, 1975). The associated change in nutrient concentration depends on the particular nutrient and the composting process itself. Total nitrogen content of compost is typically reduced compared to that of the initial feedstocks (Eghball et al., 1997; Ott et al., 1983; Robertson and Morgan, 1995; Witter and Lopez-Real, 1988). The percentage of nitrogen lost ranges from 19-42% in beef feedlot compost (Eghball et al., 1997) to 16-29% in municipal biosolids compost (Witter and Lopez-Real, 1988). Most studies indicate the highest percentage of nitrogen loss is due to the release of ammonia to the atmosphere (ammonia volatilization) (Ballestero and Douglas, 1996; Eghball et al., 1997; Martin and Dewes, 1992; Morisaki et al., 1989; Witter and Lopez-Real, 1988), particularly under high pH and moisture conditions. The amount of ammonia volatilization is also dependent on C:N ratios (Morisaki et al., 1989) and how often the compost is turned (DeBertoldi et al., 1982). Several studies report a significant loss of nitrogen through leaching (Ballestero and Douglas, 1996; Eghball et al., 1997; Robertson and Morgan, 1995).

Because phosphorus does not have a gaseous phase, decreases in initial feedstock concentrations are through leaching and runoff (Eghball et al., 1997; Sharpley and Moyer, 2000). Reported phosphorus losses are 0% in farmyard manure compost (Ott et al., 1983) and 2% in beef feedlot manure compost (Eghball et al., 1997).

Nutrient concentrations in leachate from composting operations are highly variable and are affected by feedstock, C:N ratio, as well as climate (Table 2). Nutrients may be higher in leachates from compost with nutrient-rich feedstocks such as manures. Leachate concentrations from yardwaste composting studies generally report relatively low concentrations. Further work is needed to characterize leachate chemistry from different types of composting operations.

Table 2. Reported concentrations from compost facilities with various dominant feedstocks. Values in parenthesis are standard deviations. NR denotes no data reported.

	Sample Tested	Total N (mg/L)	NH_4 - N (mg/L)	NO_3-N (mg/L)	Total P (mg/L)	Ortho-P (mg/L)	No. Samples	Site Conditions	Reference
Yardwaste	Runoff	NR	9.6	6.6	NR	NR	appears to be 1	sloped clay pad; IL	Cole, 1994
	Soilwater	NR	0.44 (0.35)	0.96 (1.0)	0.07 (0.08)	NR	2	no pad, sandy soil, lysimeters at 12-18 in. depth; NY	Richard and Chadsey, 1990
	Soilwater	11-21	NR	NR	NR	NR	5	no pad, gravelly loam soil, lysimeters 59 in. depth; NH	Ballestero and Douglas, 1996
	Leachate	NR	5.1-10.5	3.6-5.8	NR	NR	3	clay pad, leachate below windrow; IL	Cole, 1994
	Leachate/ Runoff	36-49	NR	0.23-0.32	12-14	NR	45 day average	polyethylene liner; VA	Christian et al., 1993
Foodwaste	Runoff	NR	0.43-9.45	0-0.28	NR	0.05-0.33	11	sloped soil pad; GA	Cabrera et al, 1998
	Groundwater	NR	NR	0.5-1.5	NR	NR	6	soil pad, well downgradient form pad 10 ft depth; GA	Cabrera et al, 1998
Biosolids	Leachate	NR	<0.5	5.1-8.3	0	NR	1 at end composting cycle	geomembrane and soil	Warmen and Termeer, 1996
	Groundwater	NR	NR	1.1 - 20	NR	NR	19	stored finished compost, no pad, sandy soil with shallow water table	Frink and Sawhey, 1994

Table 2 (Continued). Reported concentrations from compost facilities with various dominant feedstocks. Values in parenthesis are standard deviations. NR denotes no data reported.

	Sample Tested	Total N (mg/L)	NH_4 - N (mg/L)	NO_3-N (mg/L)	Total P (mg/L)	Ortho-P (mg/L)	No. Samples	Site Conditions	Reference
Manure	Runoff	NR	2.11-36.6	0.11-6.74	NR	7.37-27.8	6	geomembrane over soil; ME	Seymour and Bourden, 2003
	Runoff	100	NR	NR	50	NR	every 2 wks for 3 yrs	gravel and plastic to drainage pipe; Sweden	Ulen, 1993
	Soilwater	11-903	0 - 100*	100 - 900*	NR	NR	22	no pad, gravelly loam soil, lysimeters 60 in. depth; NH	Ballestero and Douglas, 1996 * estimated from Fig.1
	Leachate/ Runoff	9-230	0.9-55	0.09-25.1	9-82	4.4-24	36 over 3 years	concrete; NE	Eghball et al., 1997
	Leachate	NR	0.58-34.3	1.84-120	NR	17.0-26.0	6	geomembrane over soil; ME	Seymour and Bourden, 2003
	Leachate	57	NR	8	9	NR	appears to be 1	concrete paving stone, depth not reported may be leachate/runoff combination; Switzerland	Ott et al., 1983
	Soil	NR	NR	increase about 20 mg/kg over irrigated cornfield at 2 m	NR	NR	1 event	after 7 yrs compost; no pad; well-drained soil; no soil description given; NE	Nienaber and Ferguson, 1992; Nienaber and Ferguson, 1994

2.6.1 Groundwater Contamination

The potential impact of leaching losses from composting facilities on groundwater has been examined in only a few studies. Groundwater impacts are site specific. Cabrera et al. (1998) reported no nutrient contamination of shallow groundwater downgradient of the composting pad of a foodwaste composting operation in Georgia. The groundwater nitrite+nitrate-nitrogen concentrations were well below the USEPA drinking water standards of 10 mg/L after composting had been conducted for four years (Table 2). However, Frink and Sawhney (1994) did find elevated nitrate-nitrogen in shallow groundwater under finished biosolids compost stored directly on sandy soils in Connecticut. The elevated nitrates were reported after a hurricane (5.6 inches of rainfall, Table 2).

Other studies have evaluated nutrient concentrations in soilwater and one study used soil nitrate concentrations to evaluate leaching losses. Soilwater concentrations, which are measured in the plant root zone above the water table, are typically higher than groundwater concentrations. Ballestero and Douglas (1996) found very high nitrogen concentrations in soilwater under a farm waste windrow composting operation (maximum concentration = 903 mg/L). The farm waste windrow was constructed directly on a well-drained, gravelly loam soil with no composting pad. Maximum nitrogen concentrations in soilwater (21 mg/L) under a yardwaste windrow in similar conditions were considerably lower and near background conditions for the site (Ballestero and Douglas, 1996). Richard and Chadsey (1990) also found low nutrient concentrations in soilwater beneath a yardwaste windrow placed directly on sandy soils (Table 2).

The one study of nutrient concentrations in the soil below a cattle feedlot manure composting pad showed that nitrate-nitrogen concentrations had increased by about 20 mg/kg at a two meter depth above an adjacent cornfield after five and seven years of composting (Nienabar and Ferguson, 1992, Nienabar and Ferguson, 1994).

Although the data is limited, these studies indicate that composting high nutrient feedstocks on coarse-textured soils e.g. sands, loamy sands, sandy loams, where there are no barriers to soilwater movement can create elevated nitrates in shallow groundwater. Yardwaste composting appears to pose a much lower threat.

2.6.2 Surface Water Contamination

Information on nutrient losses in runoff from composting operations is also sparse. Cabrera et al. (1998) reported moderate to low nutrient concentrations in runoff from a foodwaste composting pad (Table 2). Ammonia-nitrogen was the highest constituent in the foodwaste compost runoff. Cole (1994) reported no adverse effects on adjacent surface water from a yardwaste composting facility. Upstream ammonia-nitrogen (2.8 mg/L) and nitrate-nitrogen concentrations (not detected) were similar to the downstream ammonia-nitrogen (2.0 mg/L) and nitrate-nitrogen concentrations (not detected). Ammonia-nitrogen concentrations in the runoff were higher than nitrate-nitrogen. Unfortunately, this data appeared to be from only one runoff sample, which is not enough to represent yardwaste composting conditions (Table 2). There was also no data reported in this study for soil conditions, distance of windrow from stream, or any management practices to reduce runoff impacts.

The highest reported nutrient concentrations are for a combination of runoff and leachate from beef feedlot manure composted on a concrete pad (Eghball et al., 1997). Ammonia was the dominant form of nitrogen reported in the runoff/leachate (Table 2). Phosphorus concentrations in the runoff/leachate were well above those reported for either runoff or leachate from yardwaste or runoff from foodwaste (Table 2). Data from rainfall simulation studies of composted animal manures also indicate high initial nutrient losses (Risse et al., 2002; Sharpley and Moyer, 2000). Because these studies typically simulate large rainfall events, the runoff concentrations may represent the upper end of the range for natural rainfall.

There is very little data on the oxygen demand in runoff from compost facilities. Richard and Chadsey (1990) reported average biochemical oxygen demand (BOD) of a yardwaste runoff was greater than 41 mg/L. Out of a total of 16 samples, three had BOD greater than 150 mg/L. Another report on runoff from three storm events at four composting facilities indicated that BOD can range from 20 to 3,200 mg/L (ReTap, 1998). However, the technology brief did not give feedstocks or other information to interpret the wide range in BOD concentrations reported. High BOD concentrations can cause low oxygen conditions in surface waters, which can negatively affect aquatic life.

There was no data reported on pathogens in leachate or runoff. Pathogens are largely associated with feedstocks such as municipal biosolids (Elliot and Ellis, 1977), animal manures (Reddy et al., 1981), and foodwastes. The composting process is effective in reducing pathogens if temperatures of 55 C^o (131 F^o) are reached and maintained for an adequate length of time i.e., 72 hours for in-vessel and 15 days for woodrow systems (Millner et al., 1998). Consequently, the highest potential risk for large numbers of pathogens in leachate or runoff is likely to be from the raw feedstocks. There are conflicting reports on regrowth of pathogens in compost. Sidhu et al. (2001) reported regrowth of *Salmonella spp.* in biosolids compost, but noted that the presence of other microorganisms in the compost tended to inhibit *Salmonella* regrowth. Millner et al. (1998) reported several other studies showing little regrowth in municipal biosolids composts from well-managed facilities.

2.6.3 Factors Contributing to Water Quality Risks

Both ground and surface water contamination are related to the concentration and amount of leachate or runoff reaching the water source. For example, although nutrient concentrations are high, if leachate and runoff production is low, then the threat of contamination can be low. There is not much data available on the amount of runoff or leachate produced by composting facilities. Cabrera et al. (1998) reported runoff from a foodwaste composting system on a soil pad ranged from 6.7 to 44.9% of rainfall. Seymour and Bourden (2003) reported leachate production was typically higher than runoff production in a cow manure and wood shavings compost. This compost system used a geomembrane with gravel as a compost pad. Leachate production ranged from 16 to 92% of the precipitation and runoff ranged from 12 to 90% of precipitation. Leachate and runoff production varied with amount of rainfall, maximum precipitation intensity, and average precipitation intensity. There was not enough data collected to generate relationships between precipitation and leachate or runoff production.

Eghball et al. (1997) reported from 16 to 95% of rainfall as runoff/leachate from a concrete composting pad. The amount of runoff was related to the number of days since the last rainfall and the size of the storm. The very high percentage of runoff (95%) reported by Eghball et al. (1997) was due to two large storms (3.5 and 1.4 inches) within a day of each other. In contrast, Cole (1994) reported very low levels of leachate production (about 10 gallons) from 40-foot by 12-foot windrow of yardwaste. Runoff was only collected once and the volume was not reported. This estimate may be at the low end of the production range since the study was conducted during a dry period. Christian et al. (1993) also reported very small leachate production from yardwaste composts.

From the review of the literature, factors that are associated with high risk of water quality degradation are: high nutrient feedstocks (Ballestero and Douglas, 1996; Eghball et al., 1997; Sharpley and Moyer, 2000), low C:N ratios (Krogmann and Woyczechowski, 2000; Morisaki et al., 1989), high moisture contents (Ballestero and Douglas, 1996; Willson and Hummel, 1975), and “active” or biologically unstable composts (Garcia et al., 1991). High nutrient feedstocks appear to produce more concentrated runoff and leachate (Table 2). The impact of low C:N ratios is more difficult to interpret. At composting facilities in Germany, leachate is treated if there is insufficient carbon in the feedstock mixture (Krogmann and Woyczechowski, 2000). There is evidence that carbon additions reduce ammonia volatilization (Morasaki et al., 1989), but these may not affect leaching of nitrogen (Bugbee, 1999; Eghball et al., 1997) or other nutrients (Eghball et al., 1997). However, because the C:N ratio is related to the overall nutrient concentration in the initial feedstocks, it may be useful as an indicator of higher risk.

There is little available data to correlate moisture content with water quality risks, but as discussed above, runoff as a percentage of rainfall tends to be higher with higher moisture contents (Cabrera et al., 1998; Eghball et al., 1997). Willson and Hummel (1975) also reported highest nitrogen losses from the highest moisture content treatment in a bench scale study.

A more pertinent question may be whether the risks are similar during “active” composting and the curing process. Most leachate production is thought to occur in the initial stages of the composting process. Faucette et al. (2000) reported the highest leachate production occurred during the first two weeks of active composting in an in-vessel system. Several studies on water extracts and compost maturity indicate nutrient concentrations tend to decrease after the thermophillic stage or active composting stage (Iannotti et al., 1994; Garcia et al., 1991; Martin and Dewes, 1992; Robertson and Morgan, 1995). These studies indicate the risk of nutrient contamination to water bodies would decrease over time. However, because nitrate-nitrogen concentrations can increase over time in curing compost (Garcia et al., 1991; Witter and Lopez-Real, 1988), nitrate concentrations in the runoff or leachate from finished compost may be a concern. Several studies indicate pulses of nitrate-nitrogen can move out of finished compost from high nutrient feedstocks, particularly under high rainfall conditions (Eghball et al., 1997; Frink and Sawhney, 1994).

The potential risks associated with metals and other contaminants are largely associated with particular feedstocks such as municipal biosolids (USEPA, 1993a; Frink and Sawhney, 1994), municipal solid waste (USEPA, 1993b), and in some cases yard trimmings (Korvacic et al., 1992; Richard and Chadsey, 1990). Most of these studies indicate that there is little potential for leaching of metals to groundwater (Cole, 1994; Frink and Sawhney, 1994; Richard and Chadsey, 1990) or in the runoff (Cole, 1994). The review did not identify any data on manmade organic chemicals in leachate or runoff from composting facilities.

2.6.4 Air Quality Concerns

In addition to potential risks to ground and surface water, air quality can also be a concern at composting facilities. A variety of nitrogen and sulfur compounds are released during composting. These compounds are associated with odors that many people find offensive. For example, ammonia (170 g/m^3), hydrogen sulfide (1.1 g/m^3), dimethyl disulfide (1.3 g/m^3), dimethyl sulfide (2.7 g/m^3), limonene (2.7 g/m^3) and alpha-pinene (0.3 g/m^3) were detected in off gases from a biosolids composting facility (Van Durme et al., 1992). Recent work by Das et al. (2003) showed that similar sulfur compounds are also released during composting of foodwastes. They reported measurements of 35 to 50 µl/L concentrations of dimethyl disulfide and 0.1 to 1.0 µl/L of hydrogen sulfide within the matrix of the windrow during composting. In animal manure composting, a significant portion (47 to 77% of initial nitrogen) of the nitrogen was lost through gaseous emissions (Martins and Dewes, 1992). Ninety-five percent of these emissions were ammonia with the remainder representing nitrogen oxide compounds. Increases in carbon materials, bulking agents, and/or aeration have been shown to significantly decrease the production of odors, especially for ammonia (Morisaki et al., 1989) and hydrogen sulfide (Rosenfeld et al., 2002).

Composting materials may also emit bioaerosols such as molds, bacteria, fungi, and endotoxins (Epstein et al., 2001; Fischer et al., 1999; Haas et al., 1999; Hryhorczuk et al., 2001; Marchand et al., 1995; Reinthaler et al., 1999). One of the most frequently reported bioaerosols is the fungus *Aspergillus fumigatus* (Epstein et al., 2001; Fischer et al., 1999; Hryhorczuk et al., 2001; Marchand et al., 1995; Reinthaler et al., 1999). This fungus can cause respiratory problems in some people. Concentrations of bioaerosols and dust in enclosed composting systems are reported to exceed health standards (Epstein et al., 2001; Marchand et al., 1995). Ventilation and other protective measures can be taken to reduce health risks (Epstein et al., 2001; Marchand et al., 1995). Most bioaerosols decreased with distance from the compost windrows and were higher downwind than upwind of the windrows (Hryhorczuk et al., 2001). Nearby residential areas had lower concentrations of bioaerosols than those reported onsite (Hryhorczuk et al., 2001), and in some cases median concentrations in nearby residential areas were similar to background conditions (Reinthaler et al., 1999). Although bioaerosols in general are higher during composting activity (Hryhorczuk et al., 2001), Fischer et al. (1998) reports *Aspergillus fumigatus* concentrations are lower with more frequent turning.

The frequent turning kept temperatures high, which reduced *Aspergillus fumigatus* concentrations in the compost.

Workers in composting facilities are often exposed to higher levels of bioaerosols than control populations (Millner, 1995). Bunger et al. (2000) also found a higher frequency of respiratory and skin complaints in compost workers than in a control group.

A review of studies of potential public health effects due to composting facilities by a group of international experts concluded that these facilities did not pose any unique threats (Millner, 1995). The report from this working group was summarized by Millner (1995). The summary indicated that:

1. There was not a higher risk of systemic or tissue infections in the general population due to bioaerosols from composting facilities,
2. There could be an increased threat to immunocompromised people,
3. There could be an increased risk for people with asthma or allergies, and
4. The available epidemiological evidence does not indicate increased allergies, asthma, or respiratory diseases in the general public near composting facilities.

2.6.5 Discussion and Summary

Data on potential environmental impacts from composting facilities is sparse. The few studies available generally report data from a limited time frame or a limited number of samples. Many times variables such as soil types, hydrologic factors or management practices that would affect data interpretation are not reported. With these data constraints in mind, there are several trends in the available data.

It does appear that high nutrient materials that are actively composting can pose a risk to groundwater, if flows are high and there are no barriers to leachate movement in to groundwater. Barriers to leachate movement could include impermeable or low conductivity composting pads as well as low permeability soil or geologic layers.

Actively composting materials that are high in nutrients may also lead to surface water contamination from runoff, if flows are high. Curing and finished composts may pose similar risks if materials have high nutrient concentrations or are not well composted. This suggests high nutrient materials should be composted and possibly cured on surfaces that reduce the movement of leachate to groundwater, and runoff should be controlled to prevent surface water contamination. Many facilities capture runoff/leachate and use it to maintain the proper moisture content of the windrows. Other facilities pipe leachate to wastewater treatment facilities or use natural wastewater treatment systems such as spray irrigation or constructed wetlands to treat the runoff/leachate.

The literature indicates that yardwaste composting facilities pose a reduced environmental threat because both reported concentrations and flows are lower. The data on both runoff/leachate concentrations and flows are very limited. Better documentation of potential risks and low cost runoff/leachate management techniques are needed. In particular, research is needed on the amount and chemical characteristics of leachate from windrow composting operations, the potential for presence of pathogens in surface runoff, and optimal feedstock combinations to minimize environmental risks.

Air quality concerns are largely due to odor and bioaerosols. Many odor problems can be addressed by proper management, including using proper C:N ratios and managing moisture and temperature. Reviews of the effects of composting facilities on nearby communities indicate that these do not pose unique threats to the general population. There can be increased health problems with people who have compromised immune systems, allergies, asthma, or respiratory illnesses.

3. Compost Facility Regulations Review

3.1 Methods

Composting regulations are primarily designed to protect public health and the environment, but can also encourage waste management practices that decrease landfilling rates and increase the production of valuable commodities. Ideally, composting regulations protect public health and the environment while minimizing unnecessary burdens that may adversely affect business planning as well as capital and operating costs.

To provide a context for the comparison of Georgia's regulatory approach, regulations were reviewed for the southeastern states of Florida, Georgia, Kentucky, Louisiana, Mississippi, North Carolina, South Carolina, Tennessee, and Virginia. Alabama was not included in the study because composting regulations for this state were not published at the time of the review. Regulations for states with nationally recognized composting programs were also reviewed. These included California, Maine, Oregon, and Washington.

State regulations were compiled and organized based on: permitting authority, regulatory organization, and regulatory requirements. Of particular interest was common elements in regulatory approaches and whether the regulations were well organized, complete, and clear.

The information obtained for this review is based on regulations as written and on information given on each state's environmental protection agency website (Appendix A). How regulations are interpreted or implemented, particularly when requirements are not specific, can differ from the written document. This review does not reflect those interpretations. It is also important to note that generalizations were made by the authors to identify broad trends. Composting regulations in Georgia are discussed in detail in Section 6.2.

3.2 Regulatory Organization

In general, states process permits for composting facilities through a waste management or solid waste division in the state's environmental protection department. Facilities may be permitted from a central, district, or local office depending on the state. Georgia, Kentucky, South Carolina, Tennessee, and Virginia issue permits for composting facilities from a central waste management/solid waste office. Florida, North Carolina, Maine, and Oregon issue permits from a district office. California issues permits from local offices. In contrast, some states do not have a solid waste or waste management division. Louisiana and Mississippi are two states without such a division. For these states, composting facilities are permitted through a main permitting division. Washington's approach is slightly different from the rest. Although, district solid waste divisions are involved in the permitting process, permits are obtained through local health departments.

All states reviewed place composting regulations within the solid waste management regulations. In all cases, one or more chapters within the solid waste regulations are dedicated to composting regulations. In some states, all regulations pertinent to composting are contained within the composting chapter(s). Other states place some of the regulations for composting facilities in the composting chapter with applicable regulations found in other chapters of the solid waste regulations. In most cases, the composting regulations in the composting chapter guide the reader to the additional regulations applicable to composting facilities.

Regulations are generally based on a potential risk to public health and the environment. Different facility types may pose different risks; consequently, many states have tiered systems based on factors such as: types of feedstock composted, size of the facility (usually described as volume composted), C:N ratio, or the composting method used, e.g. windrow, static aerated pile, in-vessel (Table 3). Based on what tier the facility fits into, more or less stringent regulations will be placed on a facility. California, Maine, North Carolina, Oregon, Virginia, and Washington have clearly defined tiering systems identified in the regulations. Florida, Georgia, Kentucky, Louisiana, Mississippi, and Tennessee tier their regulations to some degree, although a defined tiering system is not described in the regulations. Commonly, these states will have less stringent regulations (or exemptions) for yardwaste and manure, and more stringent regulations for biosolids (municipal sewage sludge).

Regardless of the state, some form of a permit is required before composting activities can begin. Most states have several permitting structures, these may include: notification (no permit required), permit-by-rule (registration), composting permit, and full solid waste handling permit. Georgia has three permit types: exempt, Permit-by-Rule, and Solid Waste Handling Facility permit. California, Maine, and Oregon have three or four permit types defined by each state's tiering system (Table 3). Each permit type has different regulations. Florida, Tennessee, and Virginia have two permit types. Each of these states has Permit-by-Rule (for yardwaste and manure). The second permit type is either a composting permit or a full solid waste handling permit. Kentucky, Louisiana, North Carolina, South Carolina, and Mississippi

Table 3. Tiering systems and permitting structures for nine southeastern states and four other states.

Number of Tiering Categories (if more than one)[1]	**FL**	**GA**	**KY**	**LA**	**MS**	**NC**	**SC**	**TN**	**VA**	**CA**	**ME**	**OR**	**WA**
Feedstock Type	2		2	2	2	4		3	4	4	5	3	3
Size of Facility	*				*	2		*	*	0	*	*	*
Composting Method									2				
Number of Facility Types[2]	2	1	2	2	3	8	1	3	8	9	6	5	3
Number of Permit Types[3]	2	3	1	1	1	1	1	2	2	4	4	3	1

[1] Tiering systems are used to divide composting facilities into different types. This allows for more stringent regulation of facilities that pose higher environmental risks and less stringent regulations for facilities that pose lower environmental risks. Facilities are permitted based on feedstock type (e.g. yardwaste, manure, biosolids), size of the facility (volume of compost processed), C:N ratio of the compost, and/or composting method (e.g. windrow, static aerated pile).

[2] Dividing composting facilities into different types allows states to regulate and/or permit facilities based on the environmental risks they pose.

[3] Some states not only divide regulations based on tiering categories but they also require different types of permits depending on the facility type. Less stringent permits are given to facilities that pose low environmental risks while high risk facilities are given more stringent permits.

*Facility size (usually described as volume composted) and/or C:N ratio criteria are used to define what permit types and/or regulatory requirements are needed for a given facility but defined categories for size and C:N ratio are not given.

have one permit type even though the requirements to obtain the permit may differ based on the state's tiering system.

In addition to regulations imposed by the solid waste division, regulations from other divisions of the state's environmental protection department may also be applicable to composting facilities. In nearly all cases, composting facilities must comply with regulations from the state's water protection division when discharging compost pile leachate to surface and groundwater. Facilities composting municipal biosolids are required to meet additional federal and state regulations pertaining to municipal biosolids management. In all of the states reviewed, municipal biosolids regulations are found under a water protection division and are based on the federal regulation: The Standards for the Use and Disposal of Sewage Sludge (Title 40 of the Code of Federal Regulations [CFR], Part 503). In addition, some states require facilities to meet applicable air quality standards, usually related to odor, and requirements for sedimentation and erosion control. Compliance with local regulations related to zoning and land use may also be required.

3.3 Regulatory Requirements

In one form or another, most states have regulations for the following: exemptions, prohibitions, application, siting, design/construction, operation, and closure. Although each state has regulations pertaining to all these areas, their explicitness, completeness, organization, and clarity vary significantly from state to state.

3.3.1 Exemptions

Facilities are exempt if they do not pose a significant threat to public health and the environment. Exemptions are commonly given to small facilities composting low risk feedstocks (Table 4). All states have exemptions for agricultural composting, and all except Kentucky have exemptions for home/garden composting. Seven of the thirteen states have exemptions for municipal biosolids composting at a Public Owned Treatment Works. Composting at these facilities is permitted under the facility's National Pollution Discharge Elimination System (NPDES) permit given by the state's water protection division. Georgia has explicit exemptions for agricultural and home/garden composting.

Table 4. Activities exempt from composting regulations for nine southeastern states and four other states.

Exemptions	FL	GA	KY	LA	MS	NC	SC	TN	VA	CA	ME	OR	WA
Agricultural	X	X	X	. X	X	X	X	X	X	X	X	X	X
Home/Garden	X	X		X	X	X	X	X	X	X	X	X	X
Institutional						X[2]			X[2]	X[2]		X[2]	
Industrial				X[3]			X[4]						
Vermi-Composting										X			
Chip & Grind							X[5]			X[2]			
Storage										X			
Generate and Process Compost Onsite		X			X						X		
Sewage Sludge Composting at a POTW[1]		X	X	X	X				X		X	X	
Exemptions Based on Tiering Category	X				X	X			X		X		

[1] Publicly Owned Treatment Works.
[2] Must process less than a specified volume over a given amount of time.
3Must generate and process onsite.
[4] Must compost within ¼ mile of originating site.
[5] Some chipping and grinding activities exempt.

3.3.2 Prohibitions

Many states have prohibitions on composting certain types of waste. Sometimes, prohibitions are given in a chapter of the solid waste regulations that is applicable to all facilities (e.g. landfill, composting facilities), while other times, prohibitions are found in the composting regulations. The most common prohibitions are for hazardous waste, biomedical waste, radioactive waste, used oil, and asbestos. In addition, there are common prohibitions against open burning and scavenging. Although these prohibitions are common, they are not consistent from state to state. Kentucky, North Carolina, Maine, and Washington do not mention any prohibitions. Georgia's prohibitions include those listed above.

3.3.3 Permitting Process

In order to obtain a composting permit, an application must be submitted giving detailed information about the proposed design and operation of the facility and how the facility will meet the applicable regulations. Commonly, the regulations will describe information that should be submitted with the application. Application requirements typically include: maps (e.g. topographical, floodplain, tax), an aerial photograph or map showing the composting site and surrounding properties, a site plan, drawings of individual structures, a feasibility study (e.g. zoning, soil, and groundwater investigation), description of the process design, description of how the facility will operate, a closure plan, and submittal of all other necessary permits including approval from the local zoning office. Often, the requirements for each state are not organized into categories as described above or these requirements are found throughout the regulations. Although all states address most or all of the above requirements, some states have well organized, descriptive requirements, while other states have less specific requirements in multiple chapters or documents with no cross-references. Georgia has most of the requirements listed above, but these requirements are listed in various places in the regulations.

3.3.4 Siting Requirements

Most states have siting regulations to ensure that composting sites are placed in geographical areas that minimize risk to public health and the environment. In general, a composting facility may not restrict the flow in the 100-year floodplain or be constructed in a jurisdictional wetland. Other siting requirements place restrictions on the proximity of composting facilities to surface waters, drinking water sources, residences, schools, property boundaries, and environmentally sensitive areas. Most of the southeastern states and Maine have extensive requirements for siting. California and Oregon have few siting requirements. Washington does not have state siting requirements, but local land use and health department ordinances restrict composting locations. Georgia has very explicit siting requirements that are required for all solid waste facilities.

3.3.5 Design/Construction Requirements

Design/construction and operational requirements are the most extensive section in the composting regulations. Table 5 summarizes some of the most important design/construction and operational requirements. It does not divide the regulations for each state based on tiering systems and permit types, but describes whether the state mentions a given requirement in the regulations.

As with many of the other sections, design/construction requirements vary greatly from state to state. Requirements for impervious pads differ greatly from state to state. All states except Georgia, Kentucky, South Carolina, and California specifically mention the need for an impervious pad for composting activities. Although Georgia regulations do not specifically require an impervious pad, these pads are typically required by regulators. Pad requirements vary from an asphalt or concrete pad for all activities (e.g. receiving, active composting, curing, and storage) to only needing these types of pads for certain activities or types of feedstocks (e.g., active composting or municipal biosolids). Some states use their tiering systems to determine where and if a concrete/asphalt pad is necessary. Often for small, low risk facilities, an alternative pad (e.g., clay, compacted gravel, or liner) is sufficient. Nearly all states address design requirements for diversion of stormwater and collection/treatment of leachate. California does not address either of these while Georgia, Kentucky, and Oregon only address requirements for leachate collection/treatment. Monitoring wells are required by some states for large facilities processing high risk feedstocks, including Georgia.

3.3.6 Operational Requirements

In general, states require almost all of the operational regulations given in Table 5. The exception being routine monitoring. Routine monitoring is not usually required and when it is, requirements are not specific. Pathogen reduction requirements, record keeping, reporting, and closure requirements are fairly similar from state to state. Pathogen reduction requirements are usually dependent on the type of composting method used (e.g. windrow, in-vessel). Sampling and analysis of compost is required for most states, but the extent of the regulations varies greatly. Several southeastern states classify compost based on: type of

Table 5. Summary of selected design/construction and operational composting regulations for nine southeastern states and four other states.

Design and Construction Requirements	**FL**	**GA**	**KY**	**LA**	**MS**	**NC**	**SC**	**TN**	**VA**	**CA**	**ME**	**OR**	**WA**
Pad	X			X	X	X		X	X		X	X	X
Diversion of Storm Water	X			X	X	X	X	X	X		X	X	X
Run-off Collection and Leachate Treatment	X	X	X	X	X	X	X	X	X		X	X	X
Monitoring Wells					X				X		X	X	X
Operational Requirements													
Routine Monitoring of Compost Piles	X			X		X				X	X	X	X
Pathogen Reduction			X	X	X	X			X	X	X	X	X[1]
Compost Sampling & Analysis	X		X	X	X	X	X	X	X	X	X		X
End Use Standards	X	X	X	X	X	X		X	X	X	X		X
Odor Control	X	X		X		X		X	X	X	X	X	X[1]
Record Keeping	X	X	X	X	X	X		X	X	X	X	X	X
Reporting	X		X	X	X	X	X	X	X		X	X	X
Closure	X	X	X	X			X	X	X	X	X	X	X
Financial Assurance		X		X				X	X			X	

[1] Odor control is not required in Washington but best management practices to reduce odor are given.

feedstock, compost maturity, particle size, organic matter content, and metal concentrations. Georgia regulations do not mention pathogen reduction or sampling, but do require recordkeeping, annual reports, and closure.

The extent to which states give odor requirements varies greatly from state to state. Most states only mention the need for odor control. Washington and Maine describe in detail how facilities can minimize their odor problems. Financial assurance, a requirement for nearly all landfills, is only required by some states for composting facilities. Georgia does not require odor control, but does require financial assurance.

3.4 Regulatory Summary

States may encourage or discourage composting through the “user friendliness” of regulations in terms of organization, completeness, and clarity. Several components seemed critical for regulations that are “user friendly”: a flexible permit structure, a logical organizational structure, and regulations either collected in one chapter or with clear cross-references to other applicable regulations. A defined tiering system also seems to help clarify the regulations that pertain to a given facility type. Guidance on the state’s websites for regulations, permit requirements, and even departmental organization is very helpful in understanding the regulations and steps necessary to obtain a permit.

Based on this review, regulatory approaches for composting varied widely from state to state. Several trends were noted when comparing composting regulations in the Southeast with states with a well-developed composting infrastructure. States with active composting programs have well-defined tiering systems and regulations tend to be well organized and clear with a fair amount of support guidance. These states tend to have less specific end use standards and fewer siting requirements, although siting may be controlled by local zoning. States in the Southeast generally do not have defined tiering systems, but tend to have specific end use requirements and extensive siting requirements. This may be due to a lack of local zoning ordinances in many areas of the Southeast. Several southern states have less specific regulations and the steps necessary to obtain a permit are not clearly identified.

4. Georgia Infrastructure Survey

4.1 Methods

The goal of the infrastructure survey was to determine the type and number of facilities composting in Georgia. The starting point for the survey was information provided by DCA (DCA, 2000). Each year DCA sends out a solid waste survey to all local governments to update the status of the state's solid waste management report. The 1999-2000 report indicated that 17% of all counties and 29% of all cities in the state of Georgia composted yard trimmings. In this same survey, 70% of all counties and 66% of all cities reported mulching residential yard trimmings. Because of the similarities between the composting and mulching processes, local government employees often have difficulty in distinguishing between the two. It was believed that the number of local government composting facilities reported was inaccurate and needed further verification. The only way to accurately verify operational procedures was to first conduct a telephone survey and then a follow up site visit.

The Engineering Outreach Service conducted an initial telephone survey from a contact list of local governments with composting and mulching operations provided by DCA. The telephone survey determined many local governments that reported they were composting were actually mulching. Only 45 facilities of the original 130 facilities on the DCA list were similar enough to a composting operation to warrant a site assessment. The criteria used to separate composting from mulching was: a composting operation receives organic waste and purposefully mixes and/or processes it in order to achieve and maintain specific temperatures for a length of time with the final material free of weed seeds, vectors and/or pathogens. Active turning or processing to reach an elevated temperature (above 131°F) was considered the most significant difference between mulching and composting.

In addition to the local government composting operations, there are a number of private composting operations throughout the state. Eighteen facilities that met the definition of composting and welcomed an onsite visit to discuss their operation were added to the site assessment list. Three animal manure composting operations refused to participate in the survey or allow visits. These facilities are relatively small and their nonparticipation did not significantly affect the results of this survey. On-farm composting operations that did not import materials for composting were not included in the survey as these would have little impact on the waste landfilled in Georgia.

A survey was developed for the onsite visits. The goal of the survey was to determine facility specific data including: feedstocks, processing equipment, compost quality, and the design parameters of the facility. There were six sections - four quantitative and two qualitative (Appendix B). The first section asked for general contact information, whether the facility was institutional, local government, or private, and the permit type. The second section requested information about the type and amount of feedstocks processed (tons per year), the origin of each feedstock, the finished compost bulk density, and the amount of compost stockpiled. The third section evaluated the quality of the finished compost.

During the site visit, five compost characteristics were used to qualitatively evaluate the finished product, including contaminants, odor, heat process, moisture, and screening. A scale of one to five (one is the lowest and five is the highest) was used to give each characteristic a quality score. Each operation was given a compost quality score by totaling individual characteristic quality scores. The highest score attainable was 25. Contaminants included plastics, glass, metal, and large inert materials that decrease the aesthetic quality of the compost. Odor was based on the absence of original feedstock scent and how much it smelled like “good soil”. The heat process was judged by the operator’s record of attained temperatures. The squeeze test was used to approximate the moisture content of the compost and points were deducted for being either too moist or too dry, since compost should be damp but not wet to the touch. The screening test focused on the number of large (greater than one-two inches) objects left behind after screening or if the operation screened at all. In addition to the qualitative evaluation, most sites allowed a compost sample to be taken. These samples were analyzed for percent moisture, volatile solids, pH, soluble salts, carbon:nitrogen ratio, total Kjeldahl nitrogen (organic-nitrogen plus ammonium-nitrogen), total phosphorus, total potassium, and metals.

Section four addressed finished compost sales. Operators were asked how the final product was used and if it was sold. Section five asked questions about the equipment the operation used and if any work or equipment was contracted. Section six addressed the projected maximum throughput capacity, the general appearance, and odor at the site. This section also provided for any additional comments or concerns not addressed elsewhere.

As with all surveys, gathering accurate data is difficult. This is especially true for private operations where many of the answers may be considered confidential; consequently, information considered proprietary was not recorded.

4.2 Overview of Composting Operations in Georgia

In 2002, Georgia had 38 facilities that are composting based on the above criteria. The 38 facilities are widely scattered with the majority located in the northern half of the state (Figure 1). Each facility identified in the survey was grouped into either private, local government, or institutional categories. Institutional operations included state prisons, grade schools, colleges, and universities. Local government operations were those run by cities and counties. Feedstocks processed at the operations included animal waste, yard trimmings, agricultural byproducts, foodwaste, industrial sludges, biosolids, and a range of wood byproducts generated from various industries.

Passive composting, windrows, aerated static piles, and in-vessel systems are all used for composting in Georgia to control and maintain optimum conditions. Each method is designed to achieve a similar output; however, the amount of time, energy, and cost associated with each method varies significantly. Many operations charge tipping fees for feedstocks received onsite and sell compost to financially support the operation. Tipping fees for all feedstock types ranged from $2 to $38 per ton.

The survey indicated 553,600 tons per year of organic material was processed into compost rather than being landfilled or disposed through other methods (Table 6, Figure 2). Facilities also reported their maximum potential capacity or throughput that they could handle without upgrading equipment. Based on this information, Georgia's present operational throughput capacity could be doubled, allowing for over 500,000 tons more waste to be recycled through composting. This value does not include either new and/or developing facilities.

There are 18 private operations which handled 73.1% (404,854 tons per year) of the total composted material (553,600 tons per year). Private composting operations were run as a business and thus relied upon tipping fees and compost sales for profitability. Stockpiling of finished compost was not prevalent among the majority of private operations. Although one large industrial company accounted for 77.9% of all compost stockpiled in the state, the remaining 17 operations only stockpiled a combined 3.3% of the total stockpiled material.

Eight local governments handled 24.3% (134,540 tons per year) of the state's compost. The average amount of compost stockpiled at local government facilities was higher than the average from institutional or private (with the exception of the one industrial operation mentioned previously) facilities. Stockpiled compost was relatively evenly dispersed among

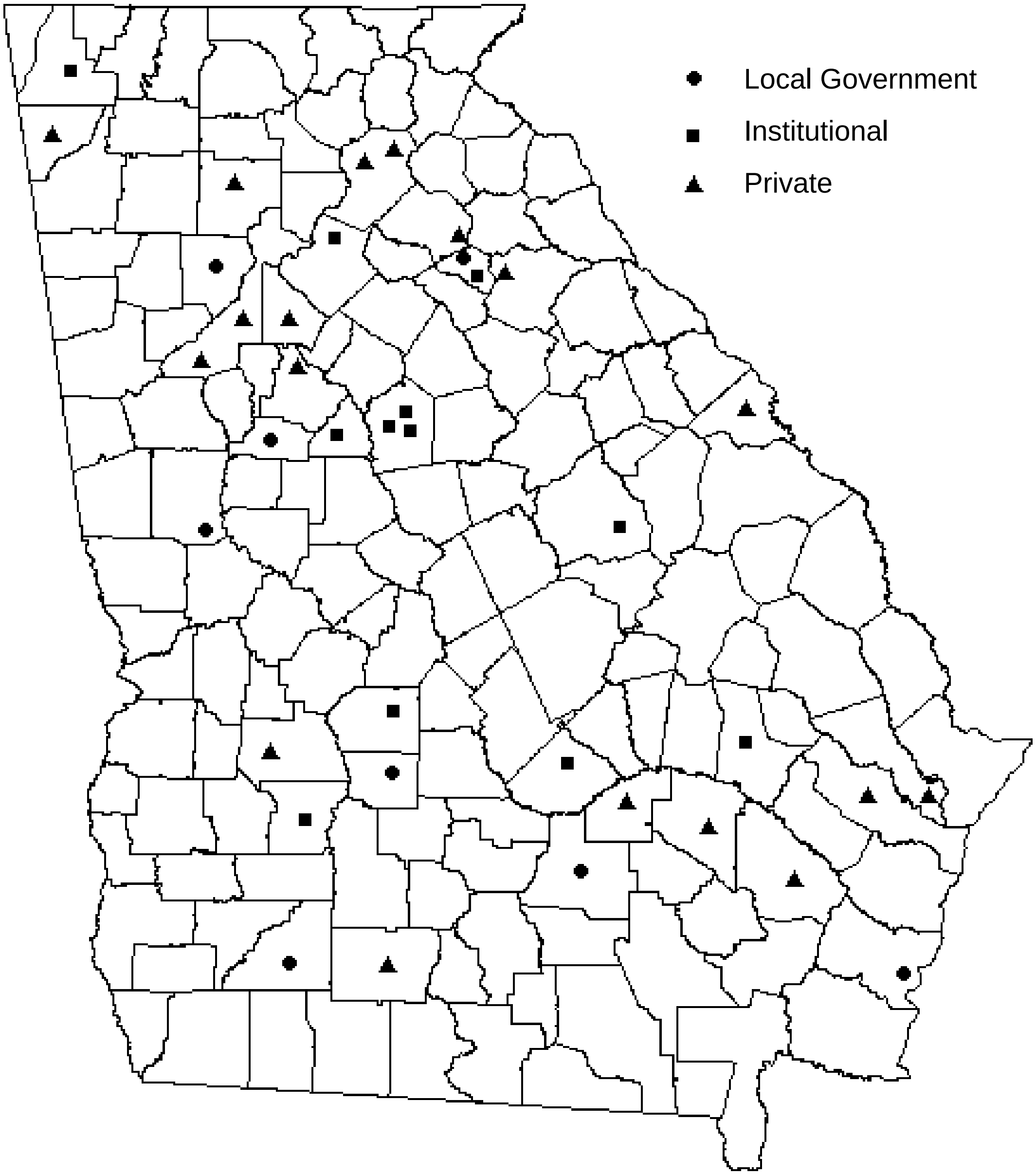

Figure 1. Location of the 38 Georgia composting facilities, which participated in the 2002 survey, represented as local government, institutional and private operations.

Table 6. Amount of compost processed and stockpiled at the 38 Georgia composting facilities based on the 2002 survey.

Facility Type	No. of Facilities	Percent by Type	Processed (tons/yr)	Percent Processed	Stockpiled (yds^3)	Percent Stockpiled by Type
Institutional	12	31.6	14,206	2.6	10,140	2.3
Local Government	8	21.0	134,540	24.3	87,000	19.8
Private	18	47.4	404,854	73.1	343,021	77.9 (3.3)[1]
Total	**38**		**553,600**		**440,161**	

[1] One private facility accounts for 74.6% of the total stockpiled in Georgia. The percent of total stockpiled without the one private facility is 3.3%.

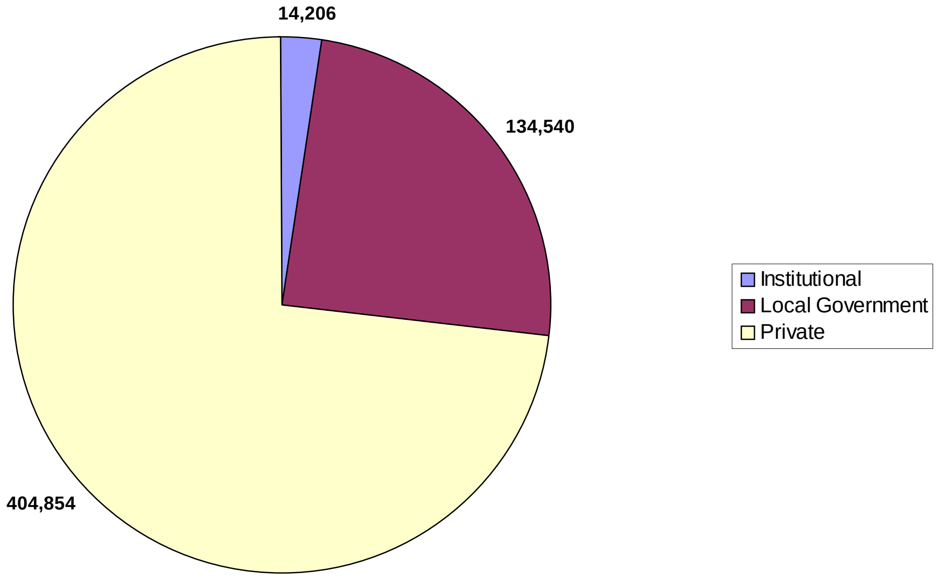

Figure 2. Amount of compost processed in tons per year by facility type based on the 2002 survey of 38 composting facilities in Georgia.

sites except for one biosolids operation that accounted for 98% of the stockpiled biosolids compost and 57.5% of all local government compost stockpiled (Table 6). Stockpiling problems seemed to be related to a general lack of proactive marketing and sales on the part of the local governments. Although some local governments used compost internally as landscape bedding or landfill cover, very few had an active marketing campaign to promote the sale or distribution of compost. Those that did market the compost often used a cumbersome system to manage financial transactions and/or had remote “pick up” locations that discouraged use.

The institutional group consisted of eight prisons, three middle schools, and one university. This group processed only 2.6% (14,206 tons per year) of the state’s compost (Table 6). Most of this compost was used in landscaping or, in the case of the prisons, on the farmland of the facility. Prison composting operations are cost effective for the quantity and type of feedstocks composted due to free labor.

4.3 Facilities by Feedstock

There are a wide variety of feedstocks composted at each type of operation. The main types of feedstocks were agricultural waste, animal manure, biosolids, foodwaste, municipal solid waste, industrial waste, and yardwaste (Table 7, Figure 3). Agricultural waste included cotton waste, vegetable culls, peanut hulls, and other crop residue. Animal manure included broiler litter, horse, cow, and hen waste. Biosolids (sewage sludge) are byproducts of municipal wastewater treatment facilities. Foodwaste included kitchen preparation waste and industrial food processing residuals. Municipal solid waste largely consisted of household and commercial garbage. Industrial waste included a wide range of materials such as tobacco processing waste, paper mill sludge, and wood processing residuals. Yardwaste included any leaf, grass, or tree trimmings that are primarily from a residential or institutional collection program.

Generally speaking, wastes other than those from agriculture and animal manures ultimately go to either Subtitle D or inert landfills. Twenty-one percent of all facilities composted materials that are not typically disposed of in landfills. Two of the agriculturally related composting operations, located in the southern portion of the state, accounted for 44.3% of the materials composted at these type operations. On-farm composting is becoming more popular as environmental regulations and nutrient management requirements for land application of

Table 7. Types of feedstocks used by the 38 Georgia composting facilities based on the 2002 infrastructure survey.

Feedstock Type	No. of Facilities	Percent by Feedstock	Processed (tons/yr)	Percent Processed	Stockpiled (yds^3)	Percent of Total Stockpiled
Ag waste	2	5.3	35,780	6.5	0	0.0
Animal	6	15.8	84,820	15.3	4,110	0.9
Biosolids	5	13.2	158,684	28.7	51,000	11.6 (0.2)[1]
Foodwaste	13	34.2	28,206	5.1	10,290	2.3
MSW[2]	2	5.3	111,000	20	26,000	5.9
Industrial	2	5.3	85,350	15.4	328,671	74.6
Yardwaste	8	21.1	49,760	9.0	20,090	4.6
Total	**38**		**553,600**		**440,161**	

[1] One municipal biosolids facility accounts for 11.4% of the total compost stockpiled in Georgia. The percent of total stockpiled without the one municipal biosolids facility is 0.2%.

[2] MSW - Municipal solid waste. One facility accepts a small percentage of industrial waste.

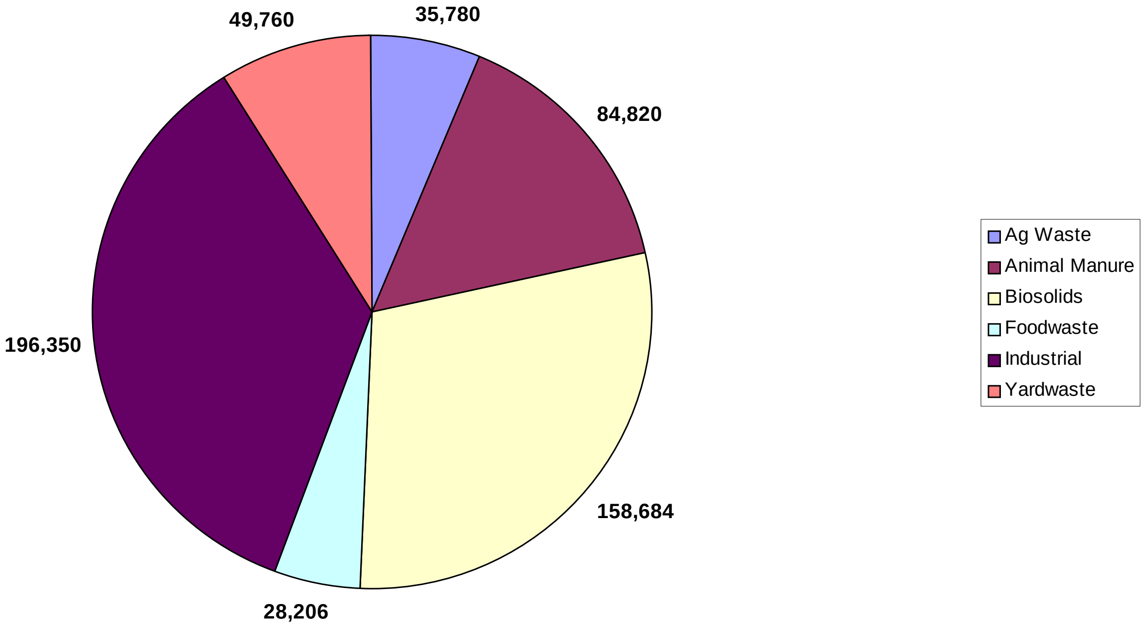

Figure 3. Amount of feedstock processed in tons per year based on the 2002 survey of 38 composting facilities in Georgia.

manures become more stringent. Farmers see composting as a beneficial alternative to land application. For example, the majority of dairy farmers in Putnam County, the dairy capital of Georgia, no longer grow their own feed, but purchase feed from suppliers. As a result of this shift, many farms no longer maintain large acreage for lagoon slurry application as they have done in the past. With less land readily available, alternative methods of manure management such as composting are being explored to move nutrients off-farm.

The origin of the primary feedstocks is shown in Table 8. All institutions derived their primary feedstocks internally from food preparation and/or grounds maintenance. Eleven institutional operations composted foodwaste. Eight prisons in the institutional category composted foodwaste generated from the kitchen and serving lines of the cafeteria. One institutional facility composted yardwaste.

Local governments received almost all of their feedstocks from services offered to their residents. In this category, there were four municipal biosolids, two yardwaste, and two municipal solid waste (including one municipal solid waste and tobacco sludge) composting facilities that processed 134,540 tons per year of waste. Municipal biosolids and municipal solid waste accounted for 16.2% and 81.7%, respectively, of all feedstocks composted by local governments.

Private operations composted all types of feedstocks, although the predominant feedstocks used were animal manure and yardwaste. There were six operations that used animal manure as the primary feedstock and five operations that used yardwaste. This was 33.3% and 27.8%, respectively, of the total private composting operations in the state (Table 9). Although only one private operation composted municipal biosolids, it accounted for 33.8% of all private materials composted and 25% of all materials composted in the state (Table 9).

The methods of composting practiced throughout the state included 22 windrow, 10 static-pile, five in-vessel, and one aerated static pile. Windrow systems, the most common method practiced in Georgia, were used for a range of feedstocks and volumes. Four foodwaste, four yardwaste, and two industrial feedstock composting operations utilized static pile systems. In-vessel systems were used in two municipal biosolids, two animal manure, and one municipal solid waste operation. In-vessel systems are more capital intensive than alternative methods; consequently, these were predominantly used at sites where tipping fees for incoming materials were charged. Tipping fees for municipal biosolids and municipal solid waste feedstocks at these sites ranged between $25 to $38/ton.

Table 8. Feedstocks origins by the type of compost facility in Georgia based on the 2002 survey of 38 composting facilities.

Facility Type	City/County	Onsite[1]	Industrial/ Commercial	Other[2]
Institutional	0	12	0	0
Local Government	7	0	1	0
Private	4	7	5	2
Total	**11**	**19**	**6**	**2**

[1] Onsite means materials were received from within their own operation.

[2] Other means materials were received from sources other than local government, industrial or onsite.

Table 9. Composting facilities in Georgia by type and feedstock based on the 2002 survey of 38 composting facilities.

Facility/Waste Type	No. of Facilities	Percent by Facility Type	Processed (tons/yr)	Percent Processed by Facility Type	Stockpiled (yds^3)	Percent Stockpiled by Facility Type
Institutional						
Yardwaste	1	8.3	1,300	9.2	0	0.0
Foodwaste	11	91.7	12,906	90.8	10,140	100
Total	**12**		**14,206**		**10,140**	
Local Government						
Biosolids	4	50.0	21,810	16.2	51,000	58.6
Yardwaste	2	25.0	1,730	1.3	10,000	11.5
MSW[1]	2	25.0	111,000	82.5	26,000	29.9
Total	**8**		**134,540**		**87,000**	
Private						
Ag waste	2	11.1	35,780	8.8	0	0.0
Animal	6	33.3	84,820	21.0	4,110	1.2
Biosolids	1	5.6	136,874	33.8	0	0.0
Foodwaste	2	11.1	15,300	3.8	150	0.0
Industrial	2	11.1	85,350	21.1	328,671	95.8
Yardwaste	5	27.8	46,730	11.5	10,090	2.9
Total	**18**		**404,854**		**343,021**	

[1] MSW - Municipal solid waste. One facility accepts a small percentage of industrial waste.

4.4 Facilities by Size and Feedstock

Composting operations in Georgia ranged from one-man operations to large businesses. For the purpose of this study, facility size was arbitrarily broken down into four groups; small operations were defined as producing less than 1,000 tons per year of compost, medium operations produced between 1,001 and 10,000 tons per year, large operations produced between 10,001 and 25,000 tons per year, and very large operations produced greater than 25,000 tons of material per year (Table 10).

Small and medium operations accounted for 28 of the 38 operations, but produced less than 11% of the total 553,600 tons per year composted. Foodwaste composting was the leader in the number of operations in the small category. Three animal manure operations composted 21,800 tons per year compared to the seven foodwaste sites at 12,271 tons per year. Small windrows and static piles were the predominant systems used because of the relatively low initial capital cost and ease of management. Many operators already owned the majority of equipment; tractors, front-end loaders, and trucks needed to handle and manage the feedstocks.

Four large operations accounted for 11% of the organic materials processed. Operations included one animal manure, one municipal biosolids, one foodwaste, and one yardwaste. Each of these operations, with the exception of the municipal biosolids, was located in a rural area. Each operation used a tipping fee or cost avoidance measure for all feedstocks composted. The animal manure operation composted the most material at 20,000 tons per year and did a very good job marketing the products to high-end markets such as the turf and golf course industries. The composting operation ranked in the highest quality rating category and also received the highest price for finished compost of all the operations in the survey. The municipal biosolids operation had problems with odor generated from the site, but solutions were implemented to minimize odor. This operation promoted the use of its compost, provided it free to the public, and encountered problems with trying to meet the consumer demand. Interestingly, these large facilities had very little stockpiled material, a combined 0.44% of the state total. This could be due to the marketing programs used by all four operations for the finished product.

The very large operations, those composting more than 25,000 tons per year, accounted for 78.2% of the total material composted. Feedstocks composted at the very large operations included yardwaste, animal manure, agricultural waste, industrial wastes, municipal

Table 10. Compost facilities in Georgia by size and feedstock based on the 2002 survey of 38 composting facilities.

Facility/Size (x 1000 tons/yr)	No. of Facilities	Percent by Facility Size	Processed (tons/yr)	Percent Processed by Facility Size	Stockpiled (yds^3)	Percent Stockpiled by Facility Size
Small (<1)						
Ag waste	0	0.0	0	0.0	0	0.0
Animal	1	9.1	680	15.2	350	2.9
Biosolids	1	9.1	310	6.9	0	0.0
Foodwaste	5	45.5	2,135	47.6	40	0.3
MSW[1]	1	9.1	1,000	22.3	11,000	90.3
Industrial	0	0.0	0	0.0	0	0.0
Yardwaste	3	27.3	360	8.0	790	6.5
Total	**11**		**4,485**		**12,180**	
Medium (1-10)						
Ag waste	1	5.9	2,300	4.2	0	0.0
Animal	3	17.6	21,800	39.4	960	1.3
Biosolids	2	11.8	10,200	18.5	51,000	70.7
Foodwaste	7	41.2	12,271	22.2	10,100	14.0
MSW	0	0.0	0	0.0	0	0.0
Industrial	1	5.9	1,300	2.4	100	0.1
Yardwaste	3	17.6	7,400	13.4	10,000	13.9
Total	**17**		**55,271**		**72,160**	
Large (10-25)						
Ag waste	0	0.0	0	0.0	0	0.0
Animal	1	25.0	20,000	32.7	800	41.0
Biosolids	1	25.0	11,300	18.5	0	0.0
Foodwaste	1	25.0	13,800	22.6	150	7.7
MSW	0	0.0	0	0.0	0	0.0
Industrial	0	0.0	0	0.0	0	0.0
Yardwaste	1	25.0	16,000	26.2	1,000	51.3
Total	**4**		**61,100**		**1,950**	
Very large (>25)						
Ag waste	1	16.7	33,480	7.7	0	0.0
Animal	1	16.7	42,340	9.8	2,000	0.6
Biosolids	1	16.7	136,874	31.6	0	0.0
Foodwaste	0	0.0	0	0.0	0	0.0
MSW	1	16.7	110,000	25.0	15,000	4.2
Industrial	1	16.7	84,050	19.4	328,571	92.9
Yard waste	1	16.7	26,000	6.0	8,300	2.3
Total	**6**		**432,744**		**353,871**	

[1] MSW - Municipal solid waste.

solid waste, and municipal biosolids. Municipal solid waste and municipal biosolids were the dominant feedstocks in the group with 25% and 31.6%, respectively. Like the large facilities, these sites were located in rural areas with the exception of one large industrial operation. This facility was located in a relatively rural setting with adequate buffer. Tipping fees up to $38 per ton were used at four sites and disposal cost avoidance accounting was used at the remaining two operations. With the exception of the agricultural waste composting site, which had land for growth, the operations were running at maximum capacity, so future growth in this size category is limited. Five of the six operations were private and though they are responsible for stockpiling 80.4% of the state's total, one site had 92.8% of this amount. This site does not market their finished compost.

4.5 Facility by Size and Permit

Permission to operate a composting facility is obtained from various departments within the Georgia Department of Natural Resources. The department, the type of feedstock, and in some situations, the amount of material processed determines the type of permit required by a facility or whether the facility is exempt. The same size and type of facility may require different types of permits depending upon where the facility is sited. For example, a municipal wastewater plant that composts municipal biosolids onsite requires an amendment to its NPDES permit. The same amount of municipal biosolids, if these were composted off-site, would require a Solid Waste Handling Facility permit.

Nine categories of permission were reported by operators in the survey: agricultural exemption; yardwaste exemption; verbal agreement; written permission; NPDES amendment; Permit-by-Rule; Recovered Materials Processing Facility classification; Solid Waste Handling Facility permit; and other. Composting regulations for Georgia explicitly discuss agricultural and yardwaste exemptions and describe when a Permit-by-Rule or Solid Waste Handling Facility permit must be obtained.

Agricultural exemption status is given to operations that compost primarily agricultural waste generated on or nearby the site. Facilities that compost yardwaste are also exempt from state regulations under a yardwaste exemption. NPDES permits allow wastewater treatment plants to discharge clean water into surface waters and an amendment to this permit is needed for onsite composting of municipal biosolids. Permit-by-Rule is granted on a case-by-case basis for all types of operations, except those composting municipal biosolids. The Recovered

Materials Processing Facility classification is not common and is generally not used to permit composting operations. Sites operating under this classificaiton must show a 40% reduction in volume in a period of 90 days for all material received onsite. The Solid Waste Handling Facility permit is the same permit used for landfills. It is required for municipal biosolids and some large-scale composters who handle materials such as municipal solid waste and large quantities of foodwaste. Verbal agreement and written permission between the composter and the state are used on a case-by-case basis usually for very small operations or demonstration projects.

Table 11 shows the number of facilities categorized by permit type along with the amount of compost processed (Figure 4). Fifteen of the sites were permitted under either agricultural or yardwaste exemption status. Verbal/written permission and Other type permits were used at five operations. Permit-by-Rule was used at nine facilities, most commonly at institutions. Recovered Materials Processing Facility classification was only used at one site. Four local government and one private operation had an amendment to their NPDES permit. Only three operations; two local government, and one private had the Solid Waste Handling Facility permit. There was no clear trend with facility size and permit type (Table 12).

4.6 Compost Quality and Markets

Compost quality affects its end use. For example, composts with high soluble salts (> 4 mmhos/cm) are not suitable for use in plant nurseries or potting soils. During the survey compost quality was evaluated qualitatively onsite and quantitatively by chemical analysis.

Several parameters were used to qualitatively evaluate the finished product, including contaminants, odor, heat process, moisture, and screening. A scale of one to five (one is the lowest quality and five is the highest quality) was used to give each characteristic a quality score (Table 13). Each operation was given a compost quality score by adding individual characteristic quality scores. The highest score attainable was 25.

No facility’s compost scored below 12 and none scored a perfect 25 (Table 14). The scores were divided into four ranges: 10-13, 14-17, 18-21 and 22-25. Only one operation, a local government operation, scored in the lowest category. Each type of operation was equally represented in the range between 14-17. Fifty percent of the facilities in the highest two ranges (18-21 and 22-25) were private composting operations. Institutions ranked second in both upper ranges.

Table 11. Number of facilities and amount of compost processed at Georgia composting facilities by permit type based on the 2002 survey of 38 composting facilities.

Type of Permit	No. of Facilities	Percent	Processed (tons/yr)	Percent Processed	Stockpiled (yds^3)	Percent Stockpiled
Agricultural Exempt	9	23.7	135,800	24.5	5,110	0.01
Yardwaste Exempt	6	15.8	32,460	5.9	19,090	4.3
EPD[1] Verbal	3	7.9	585	0.1	0	0.0
EPD Written	1	2.6	13,800	2.5	150	0.01
NPDES[2]	5	13.2	105,860	19.1	379,571	86.2
Permit-by-Rule	9	23.7	13,621	2.5	10,140	2.3
RMPF[3]	1	2.6	2,300	0.4	0	0.0
SWHF[4]	3	7.9	247,874	44.8	26,000	5.9
Other	1	2.6	1,300	0.2	100	< 0.01
Total	**38**		**553,600**		**440,161**	

[1] EPD - Environmental Protection Division (Georgia's regulatory agency).

[2] NPDES - National Pollutant Discharge Elimination System.

[3] RMPF - Recovered Materials Processing Facility.

[4] SWHF - Solid Waste Handling Facility.

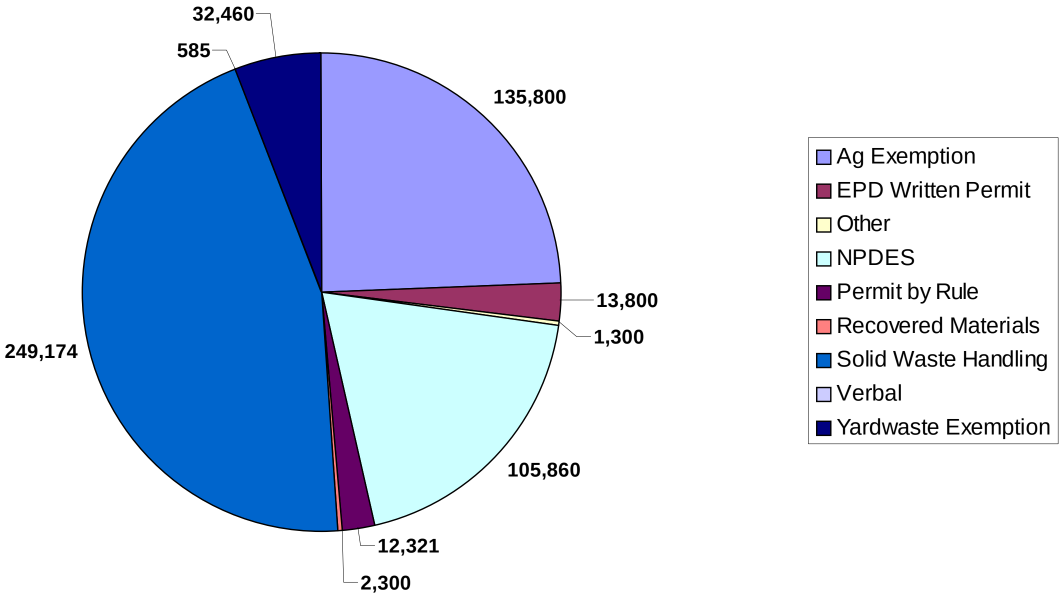

Figure 4. Amount of compost processed in tons per year by permit type based on the 2002 survey of 38 composting facilities in Georgia.

Table 12. Permit data for compost facilities in Georgia by size class based on the 2002 survey of 38 composting facilities.

Size/Permit (x 1000 tons/yr)	No. of Facilities	Percent Facility by Size	Processed by Size (tons/yr)	Percent Processed by Size	Stockpiled by Size (yds^3)	Percent Stockpiled by Size
Small (<1)						
Ag Exempt	1	9.1	680	15.2	350	2.9
Yard Exempt	3	27.3	360	8.0	790	6.5
EPD[1] Verbal	3	27.3	585	13.0	0	0.0
NPDES[2]	1	9.1	310	6.9	0	0.0
Permit-by-Rule	2	18.2	1,550	34.6	40	0.3
SWHF[3]	1	9.1	1,000	22.3	11,000	90.3
Total	**11**		**4,485**		**12,180**	
Medium (1-10)						
Ag Exempt	4	23.5	23,300	42.2	960	1.3
Yard Exempt	2	11.8	6,100	11.0	10,000	13.9
NPDES	2	11.8	10,200	18.5	51,000	70.7
Permit-by-Rule	7	41.2	12,071	21.8	10,100	14.0
RMPF[4]	1	5.9	2,300	4.2	0	0.0
Other	1	5.9	1,300	2.4	100	0.1
Total	**17**		**55,271**		**72,160**	
Large (10-25)						
Ag Exempt	2	50.0	36,000	58.9	1,800	92.3
EPD Written	1	25.0	13,800	22.6	150	7.7
NPDES	1	25.0	11,300	18.5	0	0.0
Total	**4**		**61,100**		**1,950**	
Very Large (>25)						
Ag waste	2	33.3	75,820	17.5	2,000	0.6
Yard Exempt	1	16.7	26,000	6.0	8,300	2.3
NPDES	1	16.7	84,050	19.4	328,571	92.9
SWHF	2	33.3	246,874	57.0	15,000	4.2
Total	**6**		**432,744**		**353,871**	

[1] EPD - Environmental Protection Division (Georgia's regulatory agency).

[2] NPDES - National Pollutant Discharge Elimination System.

[3] SWHF - Solid Waste Handling Facility.

[4] RMPF - Recovered Materials Processing Facility.

Table 13. Compost quality scoring criteria used for qualitative evaluation in the 2002 survey of 38 composting facilities.

	Quality Score		
Characteristics	**1**	**3**	**5**
Contaminants[1]	Large foreign objects/ visually obvious/aesthetically offensive	Minimum amount of foreign objects	No apparent foreign objects.
Odor	Strong odor of original feedstocks	Mild odor of original feedstocks	No apparent original feedstock odor/smells like soil or dirt
Heat Process[2]	"Finished" compost is warm/hot to the touch	Low heat in compost process/short time maintained	Finished compost at ambient temperatures. Extended heat process / 503 regulations followed
Moisture[3]	Won't clump/bleeds excess water/too wet or too dry	Midrange moisture content	Retains good clump during test
Screening	Not screened at all/large particle size/unfinished composted feedstocks/large foreign objects.	Minimum amount of foreign objects and large particule sizes	Consistent particle size for specific market

[1] Performed by visual inspection.

[2] Inspected operators records and felt/touched the finished compost.

[3] A squeeze test was used to help determine onsite moisture content.

Table 14. Number of facilities in each quality range for composting facilities in Georgia based on the 2002 survey of 38 composting facilities.

	Compost quality range[1]			
Facility Type	**10-13**	**14-17**	**18-21**	**22-25**
Institutional	0	1	5	6
Local Government	1	1	4	2
Private	0	1	9	8

[1] Quality judged on scale (1-lowest, 5-highest) for contaminants, odor, heat process, moisture, and screening. Highest score is 25.

Compost samples from the majority of facilities (33 of 38) were taken and analyzed for moisture, volatile solids, pH, soluble salts, nutrients, and some heavy metals (Tables 15 and 16). The average pH of composts by facility type was consistently between 6.4 to 6.9, but pH was highly variable with values at 5.0 and above 8.0 (Table 15). Soluble salts were lowest at institutional facilities that composted foodwaste and highest among private composters, especially those that composted poultry manure/litter (Table 15). The finished compost C:N ratio was generally lower at the institutional facilities composting foodwaste, because of the relatively short composting cycles and the limited amount of carbon feedstocks in their initial recipes (Table 15). Metal contents were generally low and below the Part 503 Pollutant Limits (Table 16). However, there was one private composting operation that exceeded the Part 503 Pollutant Limits for zinc (Table 16).

The finished compost was sold, given away, or used internally (Table 17). Institutions used all of their compost on their own property. Local government operations used the compost internally, provided it free to the public, or sold it by the cubic yard or by the ton. Private sites sold their compost by the cubic yard, although it was used internally and even given away at two sites. The two private operations that gave their compost away were under contract by cities to provide this service for residents. Of the 11 operations that sold compost by the cubic yard, four bagged the majority of their compost, but none of the facilities sold compost solely by the bag (Table 17).

4.7 Comparison of Georgia and California Infrastructure

The results of this survey were compared to the assessment of California’s composting infrastructure (Cotton, 2001) since this was the only other infrastructure survey existing in the U.S. at the time. According to the US Census Bureau’s (2001) population estimates as of July 1, 2001, Georgia’s 38 facilities compost approximately 132 lbs per person per year as compared to California’s 104 facilities composting 197 lbs per person per year (Table 18). Georgia primarily used smaller sized facilities averaging 14,568 tons per facility each year as opposed to California’s facility average of 32,759 tons per facility each year. One attribute of both state’s composting facilities is the fact that on average, the overall throughput can be doubled before reaching maximum capacity under present conditions. The excess capacity can be attributed to a variety of factors including management practices, design considerations, feedstock logistics, or permit limiting capacities.

Table 15. Summary of the analyses of compost samples from the 2002 Georgia survey of 38 composting facilities.

Facility Type		Moisture (%)	Volatile Solids (%)	pH (S.U.)	Soluble Salts (mmhos)	Carbon:Nitrogen Ratio	Total Kjeldahl Nitrogen (%)	Phosphorus (%)	Potassium (%)
Total	Avg	34	26	6.6	4.4	23	0.9	0.31	0.42
	St.D	12	12	1.1	5.4	7.5	0.7	0.41	0.64
	Min	7	0	5.0	0.1	8	0.2	0.01	0.01
	Max	68	51	8.6	25.2	147	3.6	1.89	3.45
	n	34	24	34	33	34	34	34	34
Institution	Avg	31	29	6.4	2.9	19	1.0	0.12	0.23
	St.D	15	30	1.0	0.4	20	0.5	0.02	0.05
	Min	7	0	5.0	0.1	8	0.4	0.03	0.08
	Max	46	51	7.8	7.5	36	3.6	0.25	0.52
	n	10	10	10	10	10	10	10	10
Private	Avg	34	23	6.9	5.8	27	0.9	0.40	0.55
	St.D	13	9	1.1	7.2	33	0.8	0.54	0.82
	Min	15	16	4.9	0.7	9	0.2	0.01	0.02
	Max	68	40	8.6	25.2	147	3.4	1.89	3.45
	n	17	8	17	16	17	17	17	17
Local Government	Avg	36	25	6.4	3.5	22	0.8	0.31	0.36
	St.D	8	10	1.4	3.3	11	0.3	0.31	0.56
	Min	25	18	5.0	0.1	9	0.6	0.07	0.06
	Max	45	45	8.4	9.9	42	1.2	0.66	1.63
	n	7	6	7	7	7	7	7	7

Avg - average; St.D - standard deviation; Min - minimum; Max - maximum; n - number of samples. All analyses on an as is basis.

Table 16. Summary of the metal analyses of compost samples from the 2002 Georgia survey of 38 composting facilities.

Facility		Aluminum (ppm)	Cadmium (ppm)	Chromium (ppm)	Copper (ppm)	Magnesium (ppm)	Molybdenum (ppm)	Nickel (ppm)	Lead (ppm)	Zinc (ppm)
Part 503 Limits[1]			39	1,200	1,500		18[2]	420	300	2,800
Total	Avg	9,688	2.2	14.9	68.1	1,670	1.1	11.7	11.2	292
	St.D	7,041	2.0	22.9	153	1,553	1.0	22	21.6	1,079
	Min	1,219	0.2	0.5	0.5	120	0.5	1.0	2.5	4.3
	Max	25,490	7.9	137	677	6,869	3.9	123	118	6,365
	n	34	34	34	34	34	34	34	34	34
Institution	Avg	10,708	2.6	8.9	9.8	845	0.6	7.1	2.5	36
	St.D	1,110	3.3	10.7	13	144	0	16.3	0	4.7
	Min	2,130	0.5	1.8	0.5	280	0.5	1.0	2.5	11.3
	Max	25,390	7.9	25.3	29.2	1,880	1.1	31.6	2.5	53.8
	n	10	10	10	10	10	10	10	10	10
Private	Avg	8,539	1.6	10.8	109	2,239	1.4	8.3	13	485
	St.D	6,406	1.4	7	209	1,956	1.2	11	12.8	1,520
	Min	1,219	0.2	0.5	0.5	120	0.5	1.0	2.5	4.3
	Max	25,490	5.2	23.8	677	6,869	3.9	42.6	40.2	6,365
	n	17	17	17	17	17	17	17	17	17
Local Government	Avg	11,020	2.9	33.6	51.7	1,467	1.2	26.8	19.1	187
	St.D	8,012	1.8	46.6	41.1	774.5	1.0	43.2	43.8	133
	Min	4,577	0.8	4.2	6.9	495	0.5	2.9	2.5	50.2
	Max	24,770	4.9	136	106	2,945	2.7	123	118	372
	n	7	7	7	7	7	7	7	7	7

Avg - average; St.D - standard deviation; Min - minimum; Max - maximum; n - number of samples. All analyses on an as is basis.

[1] USEPA 40 CFR Part 503, Table 3 Pollutant Limits.

[2] No longer part of the 503 regulations.

Table 17. Sales method for compost in Georgia participating in the 2002 survey of 38 composting facilities.

Facility Type	Internal Use Only	Free to the Public	Sold by the Cubic Yard[1]	Sold by the Ton
Institutional	12	0	0	0
Local Government	3	2	2	1
Private	5	2[2]	11	0
Total	**20**	**4**	**13**	**1**

[1] Four operations that sell by the yard also sell compost in bags.

[2] Both of these operations are under contract by local government to provide compost to public for free.

Table 18. Comparison of the Georgia and California compost infrastructure surveys.

Selected Characteristics	California	Georgia
State population	34,501,130	8,383,915
Number of compost facilities	104	38
Materials processed		
(tons/year)	3,407,000	553,600
(lbs/person/year)	197	132
Maximum capacity (tons/year)	6,100,000	1,147,530
Facility Size (tons/day)		
< 50	40	28
50 – 100	19	4
> 200	45	6

4.8 Environmental Issues at Georgia Facilities

Environmental issues associated with composting facilities include runoff (surface water contamination), leachate (groundwater contamination), and odor (nuisance complaints). Most facilities that had runoff and/or leachate collection systems were required to do so by permit. Only one site has a collection pond designed to capture runoff from the composting site that was not required by permit. The end use of the water collected in the ponds is determined by the infrastructure available to the operations. Out of the four operations that have collection ponds requiring disposal/utilization of captured runoff, two facilities used land application spray fields and two facilities discharged to the local wastewater treatment plant. One of these four operations used a portion of the captured water as a moisture supply for the composting windrows. Large amounts of leachate from compost were not observed and operators expressed no problems with leachate. In fact, many operators required more moisture for their recipe, so the issue of adding water to the piles was more of a concern. The persistent drought in Georgia for the last several years may have decreased potential runoff and leachate. If rainfall was normal or above normal, runoff and leachate could pose a more significant problem.

At the majority of outdoor composting sites, a gradual slope was used to divert rainfall/runoff water around or off the composting pad. At a few rural sites where land is plentiful, the areas between the windrows were grassed to help prevent runoff. Out of the four operations with mandated runoff/leachate collection systems, three operations composted materials under a roof and/or in an enclosed building on a concrete floor. The use of concrete pads and/or buildings to prevent runoff is very capital intensive. Another operation used a packed clay and liner system with a top layer of gravel as the primary operating surface. This is a less expensive method for controlling infiltration and potential groundwater contamination. Surrounding groundwater monitoring wells have not shown any problems or concerns that this type of alternative pad structure may have caused.

The three sites with a Solid Waste Handling Facility permit have wells to monitor the potential contaminants in groundwater that may be derived from the composting process. When asked about their monitoring wells, each operator replied that they have not had any contaminants in the wells and often very little water.

At the time of the survey, only one local government composting operation had severe odor problems and complaints. Due to the location of the site, which was in close proximity to a residential neighborhood and the nature of the materials composted, odor abatement ranked high on the priority list of this operation. The local government had recently installed an odor suppressant system designed to reduce the levels of odor leaving the site. The majority of all other composting operations in Georgia can be considered rural and odor complaints had not been a major concern.

4.9 Common Problems Identified

In the process of conducting this survey, there were several concerns and problems that repeatedly surfaced. Annually, the Department of Community Affairs conducts a solid waste survey of each local government in the state to determine how waste is being managed. The results of the solid waste survey, which were used to locate local government “composting” operations for the compost infrastructure survey, were very extensive and listed most Georgia local governments. The majority of the composting operations were not actually composting, but mulching. The difference between mulching and composting is easily confused because of the similarities in the processes and the materials being handled.

Many operations tried to make compost quickly by reducing the composting time. In some situations this was caused by capacity or throughput limitations, high product demand, or management decisions. As a result, the amount of carbon used in the recipes was insufficient for the amount of nitrogen in the feedstock. This may decrease the time required for composting, but it can lead to other concerns such as low compost quality or leachate and odor production.

Odor management was not a major concern at many of the rural operations. Some of the local government compost operations had odor issues because of limited available land that was located in residential areas. Two of the larger in-vessel, very expensive local government composting operations have received numerous odor complaints from local residents. A great deal of time and money has been spent trying to prevent and contain odors from these sites in an effort to reduce negative public opinion. Not only have these two operations had odor concerns, but the finished compost is also relatively odorous and lower quality compared to the finished composts of private operations (Tables 14, 15, and 16).

The main limiting factor to future growth of existing operations, as expressed by the operators, is the concern with acquiring new feedstocks, which may require a Solid Waste Handling Facility permit. Managers from various industries often ask compost operators if they are able to accept a particular type of waste. The compost operator usually denies these requests, because the waste is considered industrial. Even in cases where industrial waste is clean and primarily an agricultural grade waste such as cotton lint, compost facilities are not able to accept the material under the current permit structure. The combined throughput capacity for recycling at the 38 compost operations could easily be doubled to over 1,000,000 tons of organics each year with no major additional investment, if compost operations could accept a broader range of feedstocks under their current permit.

The demand for alternative disposal methods has provided new opportunities and attracted newcomers to the composting industry. The first step in any business venture is determining a workable business plan that will be the basis for future decisions. In the development of this business plan, managers and designers are faced with regulatory and permitting questions. A common problem for these companies is the availability of accurate information on how to meet and stay within the regulatory guidelines. With the exception of the Solid Waste Handling Facility permit, Georgia's current regulations are not specific on composting permit requirements. Although the ambiguity could provide flexibility for particular operations, the uncertainty about what exactly is required for a particular type of operation can make business planning difficult. An additional concern is that potential operators can receive conflicting opinions on how regulations will be interpreted.

4.10 Common Components of Successful Operations

4.10.1 Economical/Financial

The composting industry is somewhat unique in that it can command a price for its finished product and for receiving its raw material. The compost operations that can sell their product and charge tipping fees are most often financially sound and profitable. These types of operations are two businesses in one package: alternative waste management and soil amendment manufacturing. These businesses receive tipping or processing fees from $2 - $38 per ton with nitrogen rich materials normally commanding the higher prices. Sale price of composts and compost blends range from $5 - $50 per cubic yard. Some companies establish multi-year waste handling contracts that can save the waste generator thousands of dollars. They may also include product buy back agreements, if the waste generator has a landscape that can use compost or compost products. Product use agreements are common in local government for Department of Transportation projects, Parks and Recreation grounds, and even for development areas.

A diversity of products for different market niches is another common aspect to the more successful operations. Products may include various soil blends for different applications, bulk products, bagged products, and even compost teas. Product diversity requires someone in the operation to concentrate on marketing. Quite possibly the most important component of a financially successful operation is to have personnel devoted to product marketing as well as obtaining and maintaining waste handling contracts.

4.10.2 Materials Handling

Proper management and handling of raw organic wastes is not only essential to minimize environmental impacts on water and air quality, but is also critical for creating a high quality product, and thus a successful composting operation. Feedstocks are often source separated at the place of generation to minimize contaminants and inerts. Compost operators will often refuse to pick up wastes, if the materials have been contaminated. This is probably due to the fact that it is much more expensive to extract inert materials out of the waste stream than to source separate.

At the composting site, successful operations have defined areas for materials drop off, staging, and mixing zones. Materials high in moisture and nitrogen are mixed immediately with a carbon source upon arrival. Carbon source(s) are usually stockpiled near this area so mixing is timely and efficient. Often there is also a defined composting or “hot” zone where materials are actively composting. The hot zone has a prepared surface; e.g., graded or impermeable layer. Some facilities have a stormwater collection pond near this zone. After active composting, materials are moved to a curing zone where composted materials are stockpiled. Finally, some operations have a finished product or pick up zone which may be part of the curing area, but is designed for easy truck and consumer accessibility for finished product sales.

Another component to successful operations is location. Facilities in rural areas do not tend to receive odor and other complaints. Some operations located in populated areas have buffer zones around the perimeter of the operation to help minimize complaints, although no common size was observed. Typical buffer areas included trees, shrubs, and berms. Operations that are attractively maintained and do not look like a composting facility minimize complaints.

4.10.3 Process and Product Standards

Process standards are similar to material handling in that these can differentiate between good and poor product quality and environmental impact. Carbon to nitrogen ratios (C:N) of the initial mixed organic materials are most often 30:1 or greater. The higher the C:N ratio, typically the less potential there is for air and water quality concerns; however, it may also slow down the composting process. C:N ratios near 30:1 are accepted norms for optimal microbiological activity and subsequent decomposition of the organic materials. Having an adequate carbon source onsite was common with successful operations. Adding additional carbon can prevent leachate and odor when moisture contents or nitrogen ratios are too high. In fact, the number one cause of odor and leachate formation at composting facilities appeared to be a result of a lack of carbon source material.

Moisture content plays a similar role. Typically, the lower the moisture content of the organic materials, the less likelihood of leachate and odor production concerns; however, moisture contents between 40% and 60% are optimal for aerobic microbiological processes. Successful operations try to maintain their moisture between these levels for rapid and complete decomposition. Initial mixing and turning of the mixed organic materials is essential to reduce pockets of wet materials that will not compost adequately. Material that is too wet can create odors, leachate, reduce pathogen kill, and produce an inferior product.

Successful operations also controlled both aeration and temperature. Most operations have an aeration scheme that includes turning, forced aeration blowers or vacuums, or rotating in-vessel systems. Temperature monitoring is prevalent with successful processing. This lets the operator know when they have achieved the proper temperature to kill pathogens and weed seeds. It also indicates when the biological process is stabilizing and if additional moisture might be required.

The best operations compost their materials longer than the average composter. This ensures complete biological decomposition of the raw organic materials, stabilization of nutrients, as well as adequate curing and finishing time. Five months to one year processing times are not uncommon with the higher quality compost products.

Few compost operators follow a standard protocol, but it can make a difference in ensuring consistency and quality in the finished product. Some operations subscribe to the US Composting Council’s Seal of Testing Assurance program, which requires them to test compost according to standard methods as well as report process and product standards in return for a marketing seal logo. Some basic measurements that operations currently use to ensure product quality are pH, moisture content, C:N ratios, odor, temperature, inert materials analysis, and biological stability or maturity tests. Some operations perform maturity or germination rate tests to ensure the product is ready for optimal plant growth. Compost material that has not been completely composted can hinder and/or damage plant growth. Producing a consistent, high quality product is critical for market development.

5. Potential Markets

5.1 Compost Markets and Uses

5.1.1 Market Development

A well-managed commercial composting operation should have multiple marketing strategies for all facets of the business. Prior to establishment, the operation must positively demonstrate to the community, local politicians, and state regulatory agencies that it has a thorough site design and a fiscally sound business plan. This can be accomplished in a variety of ways. Sound planning can be demonstrated by using a qualified facility designer who has both experience in compost facility design and a working knowledge of the state and local regulatory requirements. A realistic and conservative business plan helps to alleviate local concerns about the stability, longevity, and sustainability of a new operation. Including the local community in on the "ground floor" of a new facility through informational meetings and public hearings may be difficult, but if done correctly, can help establish positive public relations and local support. The importance of "pre-operational" market development should not be underestimated because this can be a key element that determines the future success of the facility.

New operations must also develop the "front-end" feedstock generators. The compost operation must present its capabilities and services to targeted industries as a good environmental waste management option that not only can save money, but also provide positive public relations for their company (Faucette, 2002). Many companies are looking for environmentally-friendly waste management options. New options do not necessarily have to be less costly than current practices, if these can offset the cost by providing good environmental "press." The best way to market to front-end clients is to provide reliable high quality service and use the satisfied customers as references for potential new clients.

The most important market that should be developed is for the finished compost products. This market is primarily dependent upon the types of feedstocks used and the level of value added. The nature of some types of feedstocks (i.e. biosolids) eliminates certain markets (e.g. organic growers) regardless of the quality of the finished product. Accurate knowledge about the end-use market is critical during the preliminary design stage, because the type and amount of initial capital investment is often dependent on the ability of the operation to successfully recover costs through sales revenue. New compost operations have the tendency to base financial recovery solely on “back end” sales. It is assumed that a facility will immediately receive top return on compost sales. In reality, it usually takes the sales market much longer than anticipated to realize top returns. Consequently, it is important to make conservative estimates on sales revenue during the initial stages of an operation.

5.1.2 Compost Use

Due to the variety of composting processes and feedstocks, composts can have very different chemical, physical, and biological characteristics. These characteristics constitute compost quality, and make composts that are unsuitable for some uses suitable for others. Epstein (1997) distinguishes between compost quality criteria that protect human health or the environment and those that indicate a high quality product. Criteria that protect human health or the environment are things such as heavy metals, toxic organics, pathogens, and inerts such as glass. These human health criteria are based on regulations such as the USEPA Part 503 for the land application of municipal biosolids (USEPA, 1993a). Other criteria have been developed to help identify optimal uses. These criteria include stability, maturity, soluble salts, pH, and presence of inerts such as plastics. Stability is a measure of microbial activity (Epstein, 1997). A stable compost has completed the composting process and does not reheat when wetted. Maturity is an indicator of the presence or absence of phytotoxic chemicals that can accumulate during the composting process, particularly under anaerobic conditions (Epstein, 1997). A mature compost does not contain organics acids that can interfere with plant growth. High quality composts are usually considered those that are stable and mature with no odor, low soluble salts, and pHs near neutral. High quality composts have a greater variety of uses and potentially command higher prices.

For a user to be able to determine if compost is suitable for its intended use, they need information on the compost quality criteria listed above and other characteristics such as nutrient content, percent organic matter, and particle size. The US Composting Council has developed the Seal of Testing Approval program to address the need for standard testing and reporting procedures to promote high quality and consistent products. Participants in the program agree to test their compost for pH, soluble salts, nutrient content, moisture content, organic matter content, trace metals (USEPA, 1993a), pathogens, particle size, stability, and germination (bioassay) (US Composting Council, 2003). Testing frequency is based on the amount of compost produced. Test results and directions for use are supplied to the user. The Seal of Testing Approval does not guarantee a particular compost quality, but ensures the compost is tested consistently and the results are available to the user. For the testing and reporting program to be effective, it has to be linked to education on the compost quality needed for particular uses.

The US Composting Council developed minimum guidelines for compost use that addresses this education need in a broad sense. These use guidelines incorporate both environmental criteria (metals standards) and product quality standards for most current uses of compost (Table 19). These guidelines give broad ranges of compost characteristics to meet a given use. The document clearly states that these guidelines are a minimum standard and were developed for a wide range of uses (US Composting Council, 1996). Specific uses often have specific requirements for compost characteristics. For example, a compost that meets the US Composting Council guidelines for vegetable production may not be useful for a particular vegetable crop with specific pH needs.

These guidelines are useful as broad indicators of potential uses; consequently, the guidelines were used with data on metals, pH, and soluble salts from the infrastructure survey to examine potential compost uses and markets. Although compost stability, maturity, and particle size are important characteristics, these were not measured in samples taken as part of the infrastructure survey so were not used in the comparison. This comparison only provides a “snapshot” in time because it is based on a few characteristics of a single sample from the composting facilities in the survey; however, the snapshot does provide some insights into the current status and potential markets.

Based solely on the metals, pH, and soluble salts criteria, nearly 60% of the compost produced in Georgia does not meet any of the US Composing Council’s use guidelines (Table 20). Composts that did not meet any of the use guidelines had pHs out of the range of 5.0 - 8.0. Most of the compost pHs that were out of the guideline range were above 8.0, but one was slightly below 5.0. While these pHs are out of the recommended range, these were generally within a half pH unit of the recommended range, and could be potentially used for landfill cover, land reclamation, or in other non-sensitive areas.

Another 23% of the compost produced met one to four of the use guidelines. These composts met fewer use guidelines due to lower pHs (between 5.0 and 5.5), higher soluble salts (above 6 dS/cm), and in one case high zinc content. Composts in this category met the use guidelines for silviculture, marginal soils, landscape mulch, or erosion control. About 5% of the composts tested met 5 to 8 of the use guidelines and nearly 17% met 12 to 13 of the use guidelines.

Table 19. Summary of US Composting Council (1996) compost use guidelines.

Compost Use/ Market	Application	pH	Particle size	Soluble Salt Content	Stability
Turf	Soil Amendment	5.5-8.0	<1"	<4 dS/m	Stable
Vegetable Crop	Soil Amendment	5.0-8.0	<1"	<6 dS/m	Stable
Silviculture[2]	Soil Amendment	5.5-8.0	Must report	Must report	Moderate
Marginal Soils	Soil Amendment	5.5-8.0	Must report	Must report	Moderate
Planting Beds	Soil Amendment	5.5-8.0	<1"	<2.5 dS/m	Stable
Nursery Beds	Soil Amendment	5.5-8.0	<1"	<3 dS/m	Stable
Field Nursery	Soil Amendment	5.5-8.0	<1"	<3 dS/m	Stable
Horticultural Substrate	Soil Media Component	5.5-8.0	<1/2"	<3 dS/m	High
Blended Topsoil	Soil Media Component	5.5-8.0	Must report	<6 dS/m	Moderate
Planting Backfill	Soil Media Component	5.5-8.0	<1"	<3 dS/m	Stable
Sod Production	Soil Media	5.0-8.0	<3/8"	<3 dS/m	Stable
Landscape Mulch	Surface Application	5.5-8.0	Must report	Must report	Moderate
Erosion Control[3]	Surface Application	5.5-8.0	Must report	Must report	Must report

Note: All compost uses must report nutrient content, water holding capacity, bulk density, organic matter content, plant growth screening test, moisture contents between 35- 55%, and not exceed USEPA Part 503 Table Pollutant Concentrations[1] for heavy metals.

[1] USEPA Part 503 Table 3 Pollutant Concentration Limits (mg/kg). Arsenic - 41; Cadmium - 39, Copper - 1500, Lead - 300; Mercury - 17, Nickel - 420, Selenium - 100, Zinc - 2800.

[2] Does not have to meet USEPA Part 503 Exceptional Quality Concentration Limits for trace elements/heavy metals.

[3] Plant growth screening test not required; moisture content must be reported.

Table 20. Comparison of the compost currently produced in Georgia with the US Composting Council compost use guidelines.

Number of Use Guidelines Met	Facility Type	No. of Facilities	Percent of Total No. of Facilities	Finished Compost (yds^3/yr)	Percent of Total Compost Produced
0	Institutional	0	0.0%	0	0.0%
	Local Government	2	5.9%	105,480	21.5%
	Private	3	8.8%	167,143	34.1%
	Total	5	14.7%	272,623	55.7%
1-4	Institutional	2	5.9%	2,484	0.5%
	Local Government	0	0.0%	0	0.0%
	Private	4	11.8%	108,657	22.2%
	Total	6	17.7%	111,141	22.7%
5-8	Institutional	2	5.9%	2,520	0.5%
	Local Government	3	2.9%	13,770	2.8%
	Private	3	8.8%	8,505	1.7%
	Total	8	17.6%	24,795	4.5%
9-11	Institutional	0	0.0%	0	0.0%
	Local Government	0	0.0%	0	0.0%
	Private	0	0.0%	0	0.0%
	Total	0	0.0%	0	0.0%
12-13	Institutional	6	17.6%	7,431	1.5%
	Local Government	2	5.9%	396	0.1%
	Private	7	20.6%	73,494	15.0%
	Total	15	44.1%	81,321	16.6%
TOTALS		**34**		**489,880**	

Note: The comparison was limited to pH, soluble salts, and metals content in a single sample from the facilities participating in the 2002 compost infrastructure survey.

In general, this data indicates that the bulk of the compost produced in Georgia would be considered low quality, and is most suitable for bulk applications in silviculture, land reclamation, mulch, and erosion control. There is relatively little production that meets the use guidelines for nursery, horticultural, or planting bed use.

Private facilities and institutions produce the bulk of the high quality compost in the state (Table 20). The amount of compost generated at each facility is relatively low. Conversely, the lower quality compost is produced in large amounts by a few facilities.

5.2 Potential Markets

The total amount of compost produced in Georgia that would meet each use guideline is estimated in Table 21. These numbers count all a facility's compost production in each use category that it meets; consequently, the totals for each use category cannot be summed, and the total available for each is overestimated. This grouping is a broad brush attempt to analyze potential markets in the state. The compost volumes include institutional production that is currently used onsite.

5.2.1 Vegetable Production

Georgia potentially produces 183,000 yd^3 of compost that could be used in vegetable production, based on metals, pH, and soluble salts (Table 21). Most of this compost is produced in the private sector, and the largest single amount is produced by one private facility. The pH of the compost for this facility is below 5.5. Because most vegetable crops produced in Georgia prefer a pH of 6.0 to 6.5 (Plank, 1989), the low pH of this compost causes it to be less desirable for vegetable production. However, a lower pH compost could potentially be used for blueberry production because blueberries prefer acidic conditions.

The Georgia Agricultural Statistics Service estimated 149,300 acres of vegetables were planted in Georgia during 2001. Approximately 77,900 acres of this would be considered high value crops such as tomatoes, bell peppers, cucumbers, cantaloupes, carrots, and onions (Georgia Agricultural Statistics Service, 2002). High value crops are the most likely users of compost, because they can potentially afford compost application. Compost is being used in some vegetable production systems that use plastic covers over beds, but the demand is not high. Currently, the Horticulture Department at the University of Georgia is studying whether compost applications can reduce soil-borne diseases in some of these crops. If this is the case, compost applications in vegetable production would be economically feasible and

Table 21. Estimated volume of compost produced in Georgia that could potentially be used for the specific compost market based on a comparison of the US Composting Council's use guidelines.

		Facility Type			
Compost Use/Market	Application	Institutional (yds^3)	Local Government (yds^3)	Private (yds^3)	Totals (yds^3)
Vegetable Crop	Soil Amendment	11,000	14,000	158,000	183,000
Sod Production	Soil Media Component	9,000	1,000	149,000	159,000
Silviculture	Soil Amendment	11,000	14,000	115,000	140,000
Marginal Soils	Soil Amendment	11,000	14,000	101,000	126,000
Landscape Mulch	Surface Application	11,000	14,000	101,000	126,000
Erosion Control	Surface Application	11,000	14,000	101,000	126,000
Blended Topsoil	Soil Media Component	10,000	13,000	82,000	105,000
Turf	Soil Amendment	7,000	13,000	73,000	93,000
Nursery Beds	Soil Amendment	7,000	400	73,000	80,000
Field Nursery	Soil Amendment	7,000	400	73,000	80,000
Horticultural Substrate	Soil Media Component	7,000	400	73,000	80,000
Planting Backfill	Soil Media Component	7,000	400	73,000	80,000
Planting Beds	Soil Amendment	2,000	400	41,000	43,000

Note: The comparison with the US Composting Council's use guidelines were made only with the measured pH, soluble salts, and metal content of a single sample collected at facilities participating in the 2002 infrastructure survey. If a facilities sample met the use guidelines for pH, soluble salts and metal content, then all of its production was counted under that use; consequently, the total overestimates the amount of compost available for that use.

demand would increase (Dr. Darbie Granberry, Extension Horticulturist- Vegetables, University of Georgia, Tifton Campus, pers. com., 2003). Compost also has potential for use in strip till production systems or applied as a band for such crops as carrots or watermelons (Dr. Sharad Phatak, Professor of Horticulture - Vegetable Production, University of Georgia, Tifton Campus, pers. com., 2003). However, current production systems would need to be modified to reduce tillage. Heavy tillage increases the decomposition of organic matter which would require large annual additions of compost to maintain the desired organic matter levels. The US Composting Council recommends application rates of 10 to 60 dry tons per acre. Annual application rates for vegetable production used in Georgia range from 5 to 20 tons per acre (Dr. Darbie Granberry, pers. com., 2003). With high quality compost being marketed at $20 to $40 per ton, large annual application rates are not economically feasible, even in such high value crops as Vidalia onions (Dr. George Boyhan, Extension Horticulturist - Vegetables, University of Georgia, Statesboro, pers. com., 2003).

Another concern for producers of vegetables bound for the fresh market is human pathogens. Compost used in vegetable production has to meet pathogen requirements to ensure food safety. Research is currently being conducted on the presence of *Escheria coli* and other human pathogens with compost use by the University of Georgia Horticulture Department (Dr. Sharad Phatak, pers.com., 2003). This research may be able to answer some of the food safety concerns. Vegetable producers also report concerns about consistency. Users want a consistent product to obtain a consistent harvest.

Based on the survey numbers, if all the compost produced in the vegetable crop category were applied annually at a rate of 10 tons per acre, only 7,800 acres of the potential 77,900 acres would receive compost. If production systems were modified to include compost, there could be a large potential market in vegetable production; however, there are relatively few farmers using compost in their production systems at present. Further research on use of compost in production systems, increased availability of high quality composts for particular crops, demonstration projects, and economic analysis are needed to develop this market.

Compost is an important component of organic vegetable production systems; however, organic production in Georgia is very low. In addition, compost producers who wish to market to certified organic producers must have feedstocks approved by the Organic Materials Review Board. Consequently, this is currently not a large potential market.

5.2.2 Nursery Production

Compost can be used in nursery production as a component of the horticultural substrate (potting soil) and as a soil amendment for nursery beds and field production. The amount of compost produced in Georgia that meets the criteria for metals, soluble salts, and pH for these uses is fairly low at 81,300 yd^3 (Table 21).

Nursery production is an important industry in Georgia. The wholesale value of sales of flowers and vegetable plants produced by the nursery industry in Georgia has increased steadily from 1994 to 2000, and peaked at about $80 million dollars for operations with sales greater than $10,000 (Georgia Agricultural Statistics Service, 2002). There are no statistics available on total number of pots or flats of plants produced, but the number is substantial. For example, 219,000 foliage hanging baskets were produced by wholesalers with sales greater than $100,000, and the total number of containers produced by this group was 5.2 million (including flats of bedding plants, Georgia Agricultural Statistics Service, 2002). There are no statistics reported on nursery production of woody ornamental plants, but this is a thriving industry in Georgia.

Compost can be used as 15 to 30% of potting soil volume (US Composting Council, 1996). Assuming all potted plants are sold as one gallon containers and compost was used at 25% volume, then current production would be sufficient for 65.6 million pots. This rough estimate indicates that current production is likely to be sufficient to meet industry needs.

There are several barriers to compost use as part of the potting media in the nursery business. Most nurseries make their own potting media from pine bark and sand. Supplies of these materials are good and nurserymen are satisfied with the performance of these materials (Dr. Wayne McLaurin, Extension Horticulturist, University of Georgia, Athens Campus, pers. com., 2003). Compost could be substituted for part of the pine bark, but this adds cost in terms of time and materials. Nurseries emphasize the production of plants with consistent appearance, particularly for the wholesale market. Consequently, it is critical that compost used in nursery production is consistent in terms of nutrients, pH, soluble salts, and particle size. The industry has experienced problems with particular compost products being inconsistent in the past, which makes it difficult to develop this market (Dr. Wayne McLaurin, pers.com., 2003).

These barriers may be overcome if a compost producer is willing to provide initial samples of the product to a nursery and continue to work with them to adapt the product to their needs (Dr. Lew Naylor, Black and Veatch Corporation, Gaithersburg, MD, pers. com., 2003). Compost may become a more viable option as pine bark sources become scarce and more expensive due to the shrinking wood products industry.

The other potential use is as a soil amendment in nursery beds and field nursery production. Most of the field nursery production is located in North Georgia. Current practices do not add organic matter to the fine-textured soils in this region to prevent excessive wetness (Dr. Wayne McLaurin, pers. com., 2003); consequently, there is little overall market for this use.

5.2.3 Sod Production

Georgia produces about 159,000 yd^3 of compost that meet the US Composting Council's guidelines for metals, soluble salts, and pH in sod production. The sod industry currently does not use compost in its production practices (Dr. Clint Waltz, Extension Turfgrass Specialist, University of Georgia, Griffin Campus, pers. com., 2003). The industry could benefit from increased nutrient and water holding capacity that compost can supply, but these benefits are difficult to quantify. The US Composting Council guidelines for use in sod production recommends application of 50 to 270 yd^3 of compost over plastic film. This type of production systems is not used in Georgia and the high rates of application make it economically infeasible (Dr. Clint Waltz, pers. com., 2003).

5.2.4 Silviculture

Although the use of compost in silviculture has been examined in other sections of the United States, it is not used in the Southeast (Dr. Larry Morris, Professor of Forestry, University of Georgia, Athens Campus, pers. com., 2003). The nutrient demands of pines are relatively low and the economics of transportation and application on rough terrain make the use of compost infeasible.

5.2.5 Landscaping

Compost can be used in landscaping for planting beds, turf establishment, blended topsoils, planting backfill for trees and shrubs, and as a landscape mulch. Georgia currently produces a large amount of compost that can be potentially used for these purposes (Table 21).

There are no specific data available on the use of composts in the landscaping industry in Georgia. A recent survey of the industry by Slorkowski and Landry (2000) did not collect data on mulches or composts, or on installation costs. The study did report that 53% of the landscaping firms surveyed spent more than $20,000 on plant materials. This indicates considerable activity in this industry.

When used for planting beds, turf establishment, blended topsoils, or planting backfill, composts can improve the water holding capacity of disturbed soils, improve infiltration, provide nutrients and micronutrients for improved plant growth, and act as a filter for low levels of pollutants. These characteristics provide tangible benefits for the landowner; however, these are difficult to quantify economically.

Several of the experts interviewed for this paper indicated they felt landscaping, particularly in the residential sector, was a much bigger potential market than agriculture or horticulture (Dr. Wayne McLaurin, pers. com., 2003; Dr. Rose Mary Seymour, Extension Engineer - Green Industry Pollution Prevention, University of Georgia, Griffin Campus, pers. com., 2003; Dr. Clint Waltz, pers. com., 2003). If emphasis on green building, improved stormwater control, and water quality continues in both the private and public sector, composts are likely to have increased demand for landscaping purposes.

5.2.6 Marginal Soils

Marginal soils are those typically with low organic matter, low or high pHs, heavy metals, or other contaminants. Numerous studies have shown compost is effective in restoring these soils to better levels of productivity (Chaney et al., 2002). Application rates range from 134 to 402 yd^3 per acre (or a 1 to 3 inch layer) or higher. Based on the US Composting Council guidelines, Georgia could potentially produce 126,000 yd^3 of compost per year for this use. At the recommended application rates, if all the compost produced that meets these guidelines were used, about 315 to 940 acres per year could be reclaimed.

One of the potential markets for compost in land reclamation is the kaolin mining industry. This industry reclaims approximately 1,500 acres per year (Dr. Larry Morris, pers. com., 2003). Most of the mining occurs in the counties between Macon and Augusta. Research conducted at the University of Georgia Warnell School of Forest Resources has shown compost can double vegetation growth over current practices (McEvoy, 1999). The kaolin industry was very interested in using compost in reclamation, but a source of compost needs to be within 30 miles of the reclamation site for this alternative to be economically feasible (Dr. Larry Morris, pers. com., 2003). This could be a potential market for compost produced in the middle Georgia area. Currently there are no composting facilities in this area (Figure 1).

5.2.7 Erosion Control

Georgia currently produces 126,000 yd^3 of compost that could be potentially used for erosion and sediment control (erosion control) based on the US Composting Council guidelines for pH, soluble salts, and metals (Table 21). The utilization of compost for erosion control applications has gained considerable attention in recent years, and this is possibly the largest potential market for compost. Demonstration projects and limited research has shown that if high quality compost meets certain product specifications and is correctly applied, it can be an effective practice to prevent soil erosion and control moving sediment.

The US Composting Council guidelines for erosion control use are broad and other organizations are in the process of developing more specific guidelines for Georgia including The University of Georgia, the Georgia Department of Transportation (DOT), and the Georgia Soil and Water Conservation Commission. The Georgia DOT, the American Association of State Highway Transportation Officials, and the Georgia Soil and Water Conservation Commission all have specifications that are currently under review and unpublished.

The US Composting Council product specifications for compost utilization in erosion control report only that pH levels should be between 5.5 and 8.0, moisture content should be below 40%, heavy metals should meet USEPA 503 regulations, and particle sizes should have a wide range with most particles 1/2 inch or greater. Application procedures recommend compost blankets be applied 3 to 4 inches thick with the blanket extending 3 feet over the slope of the shoulder or into existing vegetation, and on a horizontally tracked surface. Compost filter berms should be 1.5 to 2 feet high by 3 to 4 feet wide. The US Composting Council specifications mention that low nutrient composts that have high stability and maturity indexes will perform better and pose less of a potential hazard in environmentally sensitive areas.

The Georgia DOT product specifications (under review) recommend that all compost should have the following:

- soluble salt levels less than 5.0 dS/m (if used in a topsoil blend it can be up to 10 dS/m),
- pH between 5.5-8.5,
- organic matter content from 30-65% (dry basis),
- heavy metals less than USEPA 503 Table 3 limits,
- stability greater than or equal to 8 milligrams carbon dioxide-carbon per gram of organic matter per day,

- maturity index greater than 80%, and
- sand/silt/clay/rock content less than 5%.

The compost product must also be free of weed seeds and contain no visible refuse or contaminants. Particle size distribution requires no particles over 3 inches with near 100% passing a 2 inch screen, 50% passing a 5/8 screen and no more than 15% passing a 3/8 in screen. The Georgia DOT also requires that the persons applying the compost should be able to supply on request: the original feedstock percentages of the compost, documentation that the product meets federal and state health safety requirements, documentation that it has been through a composting process that meets time and temperature requirements, and a lab report of the physical and chemical characteristics. Georgia DOT specifications for compost blanket thickness and filter berm dimensions are the same as the US Composting Council.

Although the Georgia DOT specifications are still under review, it is likely that a Georgia compost manufacturer will need to meet these requirements to be able to use their compost for erosion control. Based on the Georgia DOT specifications, 20 of the facilities surveyed could market their material for erosion control, totaling 136,000 tons per year. This estimate does not account for a facility's ability to meet the other parameters specified by the Georgia DOT, a facility's ability to improve its product quality to meet specifications, increased or decreased production quantities since the time of the survey, or newly established operations. It should be noted that only one municipal and one private operation met the specifications of both the US Composting Council and the Georgia DOT and produce enough compost (over 5,000 yds^3 per year) to actively market their compost for erosion control applications.

The erosion control market for compost is developing and has potential for rapid growth. The application and market potential is enormous in respect to the amount of land area and materials currently used for conventional erosion control within the state. Comprehensive specifications are being developed at the state and federal level. Fifteen demonstrations have been organized utilizing compost for erosion control in Georgia in which twenty private and public organizations have supported or participated. As regulations relating to storm water management and erosion control become more stringent, new and effective measures that are cost competitive will gain a greater share of the large and still growing erosion control market. While meeting high quality standard specifications is essential to entering this market, pricing the compost product to be competitive with industry standard erosion control measures is critical. Often these prices (based on linear foot or square foot applied) are significantly lower than horticultural and general garden use market prices. The advantage to this particular market is that the volume of material needed for a typical erosion control job, is often much greater than traditional compost markets.

5.3 Summary

The snapshot of the Georgia composting infrastructure indicates that current compost produced is relatively low in quality and is most suitable for use in land reclamation (marginal soils), landscape mulch, or erosion control. Interviews with various experts indicated that the economics of transportation, application, compost quality and consistency were the largest barriers to compost use. These findings are similar to the 1993 USEPA report on compost markets (USEPA, 1993b) and the Florida survey reported by Rahmini (2002).

The largest potential markets for compost appear to be for erosion control, land reclamation in the kaolin industry, and for both home and commercial landscaping. The use of compost in erosion and sediment control can be encouraged once the specifications from the Georgia DOT and Georgia Soil and Water Conservation Commission are published. The kaolin industry is interested in using compost, but there are no large-scale facilities in middle Georgia between Macon and Augusta. Better information for the user on compost quality and how to use the product may facilitate the landscaping market development. Although agriculture is potentially a large market for compost, current production methods often make compost use uneconomical. If farmers shift production practices towards reduced use of tillage, irrigation, pesticides or man-made fertilizers, compost use would increase. Further research on use of compost in production systems is needed to develop this market.

6. Potential Barriers

6.1 Economic Factors

As with any industry or business, there are factors that must be considered to ensure a positive economic return for investors considering a composting facility. The economic feasibility of composting is closely tied to the tipping fees charged by the landfills in the area. A "tipping fee" is the price that a landfill charges to dispose of a ton of material. Because landfills are usually in a competitive market, the tipping fees charged at individual landfills is determined by what the market will pay. In Georgia, tipping fees range from $20.00 to 35.00 per ton based on quantity, quality, and location (DCA, 2002). Tipping fees are generally lower in more rural areas, while urban areas normally have higher tipping fees. Landfills will often compete for some materials such as biosolids, driving the tipping fees much lower than $20 per ton. At these rates, it can be cheaper to landfill a waste than compost if the wastes have to be transported very far. The logistical problems associated with feedstock acquisition in relationship to their site location and the high cost of transporting materials is a major economic factor that presents a barrier to development of new facilities. Another factor related to transportation costs is the need for a processing facility located relatively near the waste generating areas. Land costs and public opinion can influence the availability of land near high waste generation areas. Both established and new commercial composting operations have to address these factors as present situations change and new opportunities present themselves.

6.1.1 Transportation

The collection of solid waste accounts for 50-70% of a municipality's solid waste management budget according to the University of Central Florida's College of Engineering and Computer Science (CECS, 2001). Although this figure primarily refers to municipal solid waste collection, it is fairly consistent regardless of the type of waste stream or subsequent disposal option. The need to haul low value waste materials greater distances increases as urban sprawl and the subsequent Not In My Backyard (NIMBY) philosophy increases. NIMBY syndrome increases the hauling distance to disposal options and can make site permitting of new waste processing facilities much more difficult.

The waste hauling industry is limited in the transportation methods available. Trucks have traditionally provided the primary means for waste hauling, but depending upon geographical circumstances, railroads may be an economical alternative for hauls greater than

100 miles (USEPA, 1993b). Railroad transportation is most often used in combination with trucks unless both the waste generator and receiver are on a rail line. As with any distribution network, but perhaps more so with composting because of required value-added processing costs, compost processors must determine the maximum haul distance that not only meets the needs of the waste generator, but also ensures economical feasibility for the compost operation. In Georgia, the present rate for hauling/trucking of bulk materials is between $1.50 to $2.00 per loaded mile for most distances. The compost infrastructure survey indicated the maximum haul distance to acquire nitrogenous feedstocks was within an approximate 50 mile radius of the facility for the majority of compost operators. This distance was significantly less for carbonaceous feedstocks (Jason Governo, unpublished data).

A compost operation is sometimes designed around utilizing generator specific feedstocks with known characteristics and volumes. If this is the case, determining an accurate estimated transportation cost is relatively easy. In reality, the exact specifics i.e., location, tonnage/volumes, schedules, handling systems, of potential feedstock generators are usually unknown. When this is the case, an approximate cost per ton must be assumed and can be based on a percentage of tipping fees. In the detailed economic analysis of a hypothetical compost facility located in Georgia (Appendix C), $15.00 per ton (50% of the tipping fee) for incoming nitrogenous feedstock was used to account for the transportation costs for all incoming feedstocks (nitrogenous and carbonaceous). Using a conservative estimate of 50% helps to ensure economic feasibility during the design phase. If a facility can meet financial demands on paper using conservative estimates, then the operation is more likely to be sustainable (Governo, 2002).

6.1.2 Land Availability and Cost

A major concern of the composting industry is the logistical problems associated with feedstock acquisition in relation to site location. Obtaining economically available land for a composting facility within a logistically feasible distance to high waste generating areas can be difficult.

Urban area in the US, as measured in 1990 by the Census Bureau, has doubled since 1960 (USDA Economic Research Service, 2001). As urban areas continue to increase, so does the price of land in the surrounding rural areas. There is a direct relationship between the price of land and the proximity to urban areas. Consumer costs for waste handling and subsequent disposal steadily increase as urban sprawl continues to push waste handling facilities further away from their service area. In order for a commercial composting operation to be economically sustainable, there is a certain economy of size that must be met to financially justify the high costs of land, permitting, construction, and equipment associated with a new operation. The difficulty in acquiring property for a new facility is trying to find an adequately sized and secluded, correctly zoned, tract of affordable acreage that is within reasonable hauling distances to urban feedstock sources and compost markets, and is also in a politically-friendly environment. Although politicians promote the need for recycling and waste reduction, their constituent's opposition to recycling facilities often takes precedence when it comes to actually establishing the means to accomplish these goals. Even if land is available, the prevailing political conditions can be a potential barrier to existing and new composting operations.

This problem has been exacerbated by poorly run facilities that generate offensive odors. These poorly managed facilities can quickly degrade public relations by giving the industry a "black eye" and are often used as examples to gain political disapproval when new facilities are trying to get established. The composting process inherently generates some odor regardless of the level of management, and therefore, ensuring that a composting facility location has adequate buffers between neighbors is critical. Many in the waste industry have commented, "If they don't see it, they don't smell it." Although this is not always the case, limiting public visibility through the use of trees and buffers can go a long way in reducing both real and perceived public relations concerns.

6.2 State Regulations

The state of Georgia recognizes that composting is a beneficial practice. In fact, the Solid Waste Management Rules of Georgia, Chapter 391-3-4-.16 state specifically that composting is "a desirable means of reducing the amount of solid waste destined for disposal." With this stated policy, there are several ways the current regulations could be improved to encourage composting while protecting the environment and human health.

6.2.1. Solid Waste Handling Permit

Section 16 of the Solid Waste Management Rules states that any person involved in the composting of solid waste other than yard trimmings and agriculturally exempt materials is regulated by a Permit-by-Rule or through compliance with certain permit requirements of a Solid Waste Handling Facility permit. The Solid Waste Handling Facility permit is the same permit type that Subtitle D landfills are required to obtain. The Solid Waste Handling Facility permit requirements include a design and operations plan prepared by a professional engineer that addresses capacity, equipment, storage time, waste types, air quality, wastewater, fire protection, and disposal of surplus compost. Depending upon the type of waste and nature of the proposed site, a hydrogeologic assessment of the site by a professional geologist may be required to determine if groundwater-monitoring wells are needed on the site. The permit also includes performance standards stating that a trained compost operator must supervise the facility such that it produces quality compost in a clean and sanitary environment.

Of the 38 composting operations in Georgia, only three facilities have a Solid Waste Handling Facility permit. Two are local governments (one is not active) that compost municipal solid waste and one is a private operation that composts municipal wastewater biosolids.

As previously discussed, the processing capacity at the 38 facilities could easily be doubled (presently at 553,600 ton per year) allowing for over 500,000 tons more waste to be diverted through composting rather going to another type of waste disposal facility, which is most often landfilling. The survey also reported that the main reason for not expanding facility throughput capacity or including new feedstocks, as stated by the compost operators, was the regulatory concern of obtaining a Solid Waste Handling Facility permit. This is because any feedstock other than yard trimmings and agriculture waste requires a Solid Waste Handling Facility permit in order to continue operation. Participants in the survey also expressed concern about the length of time it takes to acquire a new permit.

6.2.2 Permit-by-Rule

The regulation pertaining to solid wastes regulated by a Permit-by-Rule is found in Chapter 391-3-4-.06 (d) entitled ‘<u>Onsite waste processing and thermal treatment operations.</u>’ To be regulated under a Permit-by-Rule, a facility must *process no less than 75% by weight, solid waste generated at the Permit-by-Rule facility*. This means materials from other off-site sources must be limited to 25% of the waste processed. A Permit-by-Rule facility has many of the same requirements as a Solid Waste Handling Facility permit in the design and operations plan such as capacity, storage, disposal of waste, air quality, wastewater, fire protection, supervision, cleanliness, and record keeping.

When compared to the Solid Waste Handling Facility permitting process, the Permit-by-Rule permit process is shorter and less arduous for both the operator and EPD. One aspect of this permit that can potentially create problems is the requirement that a facility compost no less than 75% of solid waste generated onsite. This can restrict proper recipe development, which leads to potential odor and operational problems. An operator using this type of permit may generate a waste that cannot be properly composted without the addition of bulking and/or carbonaceous materials to adjust the carbon to nitrogen (C:N) ratio to an appropriate level. Correct recipe development may require a greater percentage of off-site material than is allowed by the 25% rule. Keeping in mind the potential challenge of outside feedstock requirements, the Permit-by-Rule permitting process and structure works well, although only nine Georgia composting facilities use this permit.

6.2.3 Guidance Document

Many states provide extensive guidance documents that cover the permitting process, permit requirements, and recommended practices for operation and management. The EPD has a one-page Guidance Document titled *Criteria for Siting a Composting Facility* to assist in the siting and permitting process for new composting operations. This Guidance Document explains the sections of the Criteria for Siting 391-3-4-.05 that are required by a composting operation, not including yard trimmings and agricultural composting operations that are excluded from regulation. This document is helpful as a checklist for siting requirements and other permit requirements, but could be more extensive.

One particular area that the Guidance Document does not address is the requirement for impermeable composting surfaces. Section 391-3-4-.16 does not specifically mention the need for a certain type of composting pad surface. In practice, though, EPD usually requires an impermeable surface like asphalt or concrete in order to compost materials other than yard trimmings, agricultural materials, or those of a Permit-By-Rule facility. The two active composting facilities that have a Solid Waste Handling Facility permit each have a concrete pad. The use of an impermeable surface does help insure protection of groundwater from runoff and leachate especially when operations compost feedstocks with high nutrient levels or measurable levels of hazardous constituents; however, concrete and asphalt pads are expensive.

Having specific requirements for pad surfaces in the Rules and/or the Guidance Document for types of composting operations would greatly assist in the preliminary permitting process and economic evaluation of a proposed composting facility. The Guidance Document could also contain information on the types of composting pads required for different operations or a performance standard the composting pad must meet.

For example, the Georgia Solid Waste Regulations (Rules of GA DNR EPD Chapter 391-3-4-.07) require soil under a 3 ml plastic liner be compacted to a hydraulic conductivity of 1 x 10^{-7} cm/s for composite landfill liner. Minnesota and Iowa require municipal solid waste composting facilities to have pads with a permeability of 1 x 10^{-7} cm/s (USEPA, 1994). Pads with this permeability standard could be used to prevent groundwater contamination in facilities using high nutrient materials. There are several ways that pads could be constructed to reach the 1 x 10^{-7} cm/s permeability: concrete, asphalt, landfill liners, geotextile liners, compacted clay soil, or soil stabilized with mixtures of fly ash, cement kiln dust, quicklime or cement. Alternative pad construction methods could be used to reach an impermeability standard at a much reduced cost than concrete or asphalt.

Concrete or asphalt pads, depending upon specific requirements, can cost approximately \$5.00 or \$1.25/ft^2 respectively (Mr. Don Bartles, Columbia County Solid Waste Authority, pers. com., 2001). Geo-membranes are relatively thin surface coverings made from a variety of materials including polyvinyl chloride (PVC), polypropylene, bentonite, and a variety of other geotextile composite materials that prevent liquid transfer through the membrane. Estimated costs range from \$0.27 to \$0.50/ft^2 (Mr. Gary Ezell, Company Representative, GETCO-Geoliner Manufacturer, pers. com., 2003).

Another low cost but effective alternative for construction of an impermeable surface is a process known as soil stabilization. Depending upon the type of soil, stabilization can be accomplished using lime, lime-fly ash, Portland cement, asphalt or combinations of all (Sikora and Francis, unpublished data). Soils stabilized with lime have hydraulic conductivity rates much like clays that prevent water penetration to the ground while also providing durable year round support for composting equipment. The Beltsville Agricultural Research Center Research Composting Facility in Maryland constructed a soil stabilized composting pad with fly ash, cement kiln dust, quicklime, and cement incorporated into a clay soil for one-fourth the cost of a cement pad (USDA Online, 2002). This pad supports composting of 10,000 yd^3 per year of materials with heavy wheeled composting equipment. Studies of leaching and surface runoff from fly ash pavement in an agricultural setting indicated trace minerals concentrations were below USEPA drinking water standards (Stout et al., 1999). The Research Composting Facility reports that the soil-stabilized pad is a suitable and affordable alternative to asphalt or concrete pads with an estimated cost from \$0.25 to \$0.50/ft^2 (Sikora and Francis, unpublished information).

A detailed economic model of a compost operation that has a concrete compost pad is discussed in Appendix C. Table 22 was developed by substituting various alternative pad construction costs (i.e., asphalt, geo-membrane, lime stabilized and packed clay) into the model. All parameters were held constant except for pad costs. This analysis indicates cost of construction is greatly affected by the type of composting surface required (Table 22). Allowing several options for composting facilities to meet standards is one way to encourage the composting industry.

Table 22. Hypothetical costs for a four acre compost operation using various impermeable surfaces generated by the Compost Wizard©.

Surface Type	Cost of Composting Surface ($/ft^2)	Compost Surface Construction Cost
Concrete	$5.09	$886,861
Asphalt	$1.25	$217,795
Lime Stabilized	$0.59	$102,799
Geoliner	$0.36	$62,725
Compacted Clay	$0.09	$15,681

6.3 Local Zoning Ordinances

A composting facility must meet local requirements in addition to state regulatory requirements. The local regulatory requirements and the interaction between local and state regulations can present significant barriers to new composting facilities. Before EPD can process a Solid Waste Handling Facility permit application for a composting operation, the facility must obtain a letter from the local government stating that the proposed property is adequately zoned for a composting operation. Obtaining this required zoning letter can be one of the most difficult obstacles to the establishment of a new composting facility.

Some of the difficulties with this process are due to the association of a Solid Waste Handling Facility permit with municipal solid waste and construction & demolition landfills. Typically, these are the primary types of facilities that require Solid Waste Handling Facility permits. This name association coupled with the negative public opinion of landfills often makes local officials reluctant to allow a composting operation to be located on a site, even when the property has the necessary zoning and meets all land use ordinances.

One way to alleviate some of the problems associated with the negative image associated with the Solid Waste Handling Facility permit is to house the state composting regulations under a separate umbrella. This change would eliminate negative connotations for composting operations. Changing the location of the regulations would not be effective without also changing the name of the permit from Solid Waste Handling Facility permit to something that more closely describes the nature of the process. Some examples of potential permit names could be “Composting Facility permit” or “Compost Processing Facility permit”.

Educating local officials on the basics of composting and potential benefits of a composting operation is one method to help resolve this problem. One established mechanism for education on composting to interested parties is the Compost Facility Operators Training Workshop held annually in May at the Bioconversion Research and Education Center at the University of Georgia in Athens. This workshop, taught by a variety of industry professionals, academic researchers, and state government regulatory officials, provides technical training and practical advice on all facets of the composting industry.

Another opportunity for education of both city and county officials is during their annual training workshops and conferences. The Georgia Municipal Association and the Association County Commissioners of Georgia are the two professional organizations that have the responsibility of educating and training elected officials in the many facets and responsibilities of local government. The University of Georgia’s Carl Vinson Institute of Government also plays a key role in the development and delivery of the professional training curriculum. These established venues provide a prime opportunity for providing local officials scientific information on the various opportunities and options for waste management that can potentially be used in their communities. By having a committed and reliable source for information on waste management as part of their annual training curriculum, local representatives will be more prepared to make informed decisions when approached with various waste management options by vendors and entrepreneurs in their jurisdictions.

6.4 Interactions between State and Local Regulations

The interaction between state regulatory requirements and local zoning or land use requirements can present another barrier for composting operations. One state requirement for a new composting operation is to obtain “a letter from the local government authority stating that the proposed site complies with local zoning and land use ordinances.” A zoning administrator often requires detailed information about the project before he will provide a "zoning letter." The type of information required for a composting operation includes site plans, feedstock descriptions, and potential impacts/benefits to the community. In some cases, after all the required information has been given to a zoning administrator, he might also require the compost operator to obtain a letter from EPD providing more information regarding the environmental impacts on the community *before* he will provide a zoning letter. This poses a potential conflict. The EPD is not allowed to evaluate or comment on a proposed composting facility in writing until after receiving a completed Solid Waste Handling Facility permit application from the compost facility *including* the zoning letter. The EPD requires a zoning letter from the local government authority with regards to a proposed operation *before* it can process the Solid Waste Handling Facility permit application, and the local government authority requires a letter from the EPD *before* it will give the necessary zoning letter.

This dilemma does not seem to have an easy answer. One potential solution is an educational document describing the basics of a well-managed compost facility and the regulatory requirements under which the facility will be regulated that the EPD could provide local officials upon request. Such a document would assist in educating local government officials that composting is "a desirable means of reducing the amount of solid waste destined for disposal." This information, though generic in nature, could make a tremendous difference in the opinions and subsequent position of local officials because it would come from EPD. Having such information readily available would assist in the streamlining and coordinating information requests. This would also help establish composting facilities that can be beneficial to a community while also providing adequate protection for the environment.

6.5 Proposed Regulatory Change to Reduce Barriers

Georgia's present permitting system is structured so that feedstocks are either exempt from regulations (i.e. yardwaste and agriculture waste) or regulated under a Solid Waste Handling Facility permit (i.e. biosolids, municipal solid waste), unless composted onsite using a Permit-by-Rule. As discussed in Section 3, many states use a tiered permitting system to protect the environment and facilitate the composting industry. Under a tiered system, low risk facilities have less stringent permitting requirements than high risk facilities. Such a tiered system could be developed under a separate chapter of regulations within the Solid Waste Regulations. The new permits could be called Compost Facility permits to differentiate them from landfills. Placing all composting regulations under a separate chapter with a tiered system based on risk and the development of a complete guidance document detailing best management practices would help eliminate investor uncertainty and public confusion about composting. A state task force should be formed to further investigate rule changes and develop a draft of these new proposed rules.

If it is unfeasible to rewrite the composting regulations, some modification of the existing permit systems could help remove regulatory barriers. As previously discussed, one method used by EPD to permit composting facilities is the Permit-by-Rule. The Permit-by-Rule has proven itself over the years to be an effective method of permitting for both the EPD and the compost facility operator. However, some flexibility in the requirement of 75% of materials generated onsite would be useful to develop optimum recipes for high quality compost. The Permit-by-Rule could be modified to allow for a greater amount of off-site materials to create an initial compost carbon:nitrogen ratio of 25 to 40. In most situations, this would mean importing more carboneous materials which would improve compost quality and reduce the potential for excess leachate and odor.

Another potential mechanism for permitting certain composting facilities within the current regulatory structure is through Recovered Materials Processing Facilities. Composting, by the basic nature of the process, is a method of recycling that recovers materials from the solid waste stream to be used as an ingredient to manufacture a new product. When composting is conducted in a controlled manner, the process is like any other manufacturing or processing operation that uses raw materials supplied by one or more companies to develop, assemble, or fabricate new products destined for sale in the free market place. Although the raw materials for composting are another company's byproducts, the elements of a processing business are the same.

The Rules of Georgia Solid Waste Management acknowledges this in Section 391-3-4-.04(7) Recovered Materials. It states that Recovered Materials Processing Facilities are excluded from regulations as solid waste handling facilities if the material processed has a known use, reuse, or recycling potential. The materials must have been diverted or removed from the solid waste stream for sale, use, reuse or recycling, whether or not requiring subsequent separation and processing. The rule goes on to state that such a facility cannot accumulate speculatively and that it must recycle, sell, or use at least 60% by weight or volume of the amount of material acquired in the previous 90 days of operation. The rule implicitly accommodates composting when it states that a material is used, reused, or recycled when “employed as an ingredient, including use as an intermediate, in a process to make a product.”

The simple definition of composting discussed above meets the criteria set forth by Section 391-4-4-.04(7) Recovered Materials. Composting facilities process materials previously recovered or diverted from the solid waste stream and use them as ingredients to make a new product. The composting process naturally reduces both the volume and/or weight by 40-70% (depending upon the moisture content and composition) of the recovered materials and the remaining percentage can possibly be used or sold as a quality value-added product within the 90-day period. The 90-day period could present problems for producing high quality compost since this process can take five months or longer. The Recovered Materials Processing Facility classification could be modified to allow for a longer holding period for composting operations.

The Permit-by-Rule permit and Recovered Materials Processing Facilities classification both deal with waste processing facilities, both process waste derived from on and off-site locations, both have quantifiable processing requirements, and both require accurate processing records be maintained. Both the Permit-by-Rule permit and the Recovered Materials Processing Facilities classification go through a relatively simple regulatory process (when compared to the Solid Waste Handling Facility permitting process) but because a Recovered Materials Processing Facilities is excluded from regulation as a solid waste handling facility, it does not require a zoning letter and has fewer design requirements than a Permit-by-Rule.

One of the major concerns of EPD with regard to composting facilities is the need to protect the groundwater from potential leaching of hazardous materials. One stipulation in the Criteria for Siting Guidance Document regarding the need for groundwater monitoring wells is directly related to the type of wastes composted at a facility. There is no need for a hydrogeologic assessment and subsequent groundwater monitoring wells if the operation processes wastes without measurable hazardous constituents, e.g. yardwaste, foodwaste, etc. Operations that compost municipal solid waste and municipal and/or industrial sludges fall into the category that requires groundwater monitoring systems.

In an effort to allow composting operations to be classified as a Recovered Materials Processing Facilities, EPD could use this same measurable hazardous constituents standard as one of the bases for allowing composting to be performed under Rule 391-3-4-.04(7) Recovered Materials. Like the Permit-by-Rule, if the waste materials are without measurable hazardous constituents that would pose a threat to groundwater and the operation can show potential for use, reuse or recycle as defined by the Rules for a Recovered Materials Processing Facilities, then a composting facility should be allowed to be permitted under the Recovered Materials Processing Facilities section of the Rules. The Rules have set the precedent in the Permit-by-Rule section for considering composting a type of processing operation; and therefore, the same standard should be recognized with regard to Recovered Materials Processing Facilities.

Utilizing this rule to permit composting operations would resolve many problems that often arise in the beginning stages of new facilities. The negative association of the Solid Waste Handling Facility, often referred to as the landfill permit, would be eliminated since a facility would not have to go through the same permitting process as do new landfills. Both rural and urban governments would be more likely to allow composting operations because of the lack of potential negative press that most often accompanies new solid waste handling or landfill facilities. The duration of the permitting process would be shorter and more conducive to business. Using the Recovered Materials Processing Facilities portion of the Rules would reduce a great deal of work required by EPD personnel compared to the time required to process a Solid Waste Handling Facility permit, but at the same time maintain the environmental protections which are the real purpose behind permitting and regulations. This increased efficiency could translate into a cost savings both for the compost facility and the State of Georgia.

7. Summary

The goal of this report was to provide an overview of composting in general with a particular focus on composting in the Southeast (literature review), a detailed analysis of Georgia's composting infrastructure, a review of potential markets, barriers to the composting industry, and recommendations to support the industry.

7.1 Potential Feedstocks

If Georgia percentages are similar to the national percentage, as much as 70% of Georgia's municipal solid waste is organic material that could potentially be composted. Based on waste characterization studies conducted in the late 1990s, Georgia produces over 2 million tons per year of food processing waste, 2.5 million tons per year of wood waste, and almost 400,000 tons per year of municipal biosolids. All these byproducts can be composted. Diverting this material from landfills could help meet the State's 25% waste reduction goal and reduce the environmental problems associated with landfills.

Georgia also leads the nation in poultry production which creates approximately 1.5 million tons per year of poultry litter. Dairies, hog and horse farms are other sources of animal manures. Many of these animal operations will need to export manures to maintain a nutrient balance on the farm. Composting manure can help reduce volumes and produce a product that can be used off-farm.

7.2 Potential Benefits

Moving organic materials out of landfills and off of farms, and returning them to the soil in the form of compost can improve soil fertility, tilth, water holding capacity, and reduce erosion. This, in turn, can improve our water quality by reducing the amount of sediments and associated pollutants that reach surface waters. Compost can also improve water use efficiency by increasing the amount of water than can move into the soil and the ability of the soil to store water so plants can use it. Numerous studies have shown that compost can improve plant growth and yields in a wide variety of crops including vegetables, ornamentals, turfgrass, and trees. Other studies indicate compost may act as a plant disease suppressant which can reduce the need for pesticides. Compost has been successfully used in erosion control, stormwater treatment, land reclamation, wetland restoration, and for odor control in biofilters.

7.3 Potential Environmental Impacts of Composting Facilities

Although there are many environmental benefits to composting, there are also concerns about concentrating raw organic wastes in the composting process. These include ground and surface water contamination, and air quality issues. Based on the literature review, actively composting materials that are high in nutrients can pose a risk to groundwater from leachate, if flows are high and there is no barrier to leachate movement to groundwater. These types of composting operations may also lead to surface water contamination from runoff if flows are high. This suggests high nutrient feedstocks should be composted and possibly cured on surfaces that reduce the movement of leachate to groundwater, and runoff should be controlled to prevent surface water contamination. The literature indicates that yardwaste composting facilities pose a reduced environmental threat because data reported on runoff and/or leachate concentrations and flows are lower. The data on both runoff and leachate concentrations as well as flows are very limited. More research is needed on the amount and chemical characteristics of leachate from windrow composting operations, the potential for presence of pathogens in surface runoff, and optimal feedstock combinations to minimize environmental risks.

Another potential concern is the odors and bioaerosols that can be associated with composting facilities. Odors can generally be prevented by using higher carbon recipes, bulking agents, or increasing aeration. Screens of vegetation, such as trees around the composting site, can be used to reduce odors. The literature on bioaerosols and the potential health effects of composting facilities indicates that the surrounding communities are not at higher risks for health problems, but that individuals with suppressed immune systems, asthma or respiratory problems can experience difficulties. Good management and the use of vegetation buffers can reduce the movement of bioaerosols off-site.

7.4 Regulatory Approaches

The environmental concerns listed above create the need for regulation of large-scale composting facilities. Ideally, composting regulations protect the environment and public health while minimizing unnecessary burdens for the composter. A review of composting regulations from Southeastern states as well as the West Coast and Maine indicated there were more differences in regulatory approaches than similarities. However, several trends were noted when comparing composting regulations in the Southeast with states with well-developed composting infrastructures. States with well-developed infrastructures have well-defined tiering systems. Regulations tend to be well organized and have good support guidance. These states tend to have less specific end use standards and fewer siting requirements, although siting may be controlled by local zoning. States in the Southeast generally do not have defined tiering systems, but tend to have specific end use requirements and extensive siting requirements. This may be due to a lack of local zoning ordinances in many areas of the Southeast. Several southern states have regulations where the steps necessary to obtain a permit are not easy to follow. Although general regulations can allow the regulators flexibility, it can also hamper business planning.

7.5 Composting Infrastructure in Georgia

The infrastructure survey conducted in 2002 indicated that Georgia has relatively few composting facilities. These facilities process about 553,600 tons per year of organic material, which is a relatively small portion of the organic waste stream in Georgia. There are a wide variety of feedstocks being composted including agricultural wastes, animal manure, municipal biosolids, foodwaste, industrial waste, and yardwaste. Private facilities process 73% of the materials composted in the state. Five private composting facilities each produce more than 25,000 tons per year of compost. In general, the private facilities produced the highest quality compost and had the lowest stockpiles of materials. These facilities rely on both tipping fees and compost sales for income; consequently, they have active marketing campaigns. Local government facilities handle 24% of the compost produced. Stockpiling percentages are higher for these facilities. This is probably due to the fact that there is not active marketing of the compost and compost sales are not made easy for the public. Institutional composting was a small percentage of the compost produced and most of the product was used onsite.

The survey identified several common problems in the composting industry: a confusion between compost and mulch, low carbon:nitrogen ratios, low compost quality, and logistical problems with locations near high feedstock producing areas. Many operators who initially said they were composting were producing mulch rather than compost because the mulched material was not managed through a heat process that stabilizes organic material. Many operations tend to have low carbon:nitrogen ratios, which can produce odors, leachate, and lower quality composts. Few compost operators follow a standard protocol, which can make a difference in ensuring consistency and quality in the finished product. Only one operation in the survey subscribes to the US Composting Council's Seal of Testing Assurance program which requires them to test the compost according to specified methods, report the results, as well as process and product standards in return for a marketing seal logo. Basic measurements that operations currently use to ensure product quality are pH, moisture content, carbon:nitrogen ratios, odor, temperature, inert materials analysis, and biological stability or maturity tests. Some operations perform maturity or germination rate tests to ensure the product is ready for optimal plant growth. Compost material that has not been completely composted can hinder and/or damage plant growth. Producing a consistent, high quality product is critical for market development.

There are several major concerns of the composting industry. Tipping fees in Georgia range from $20 to $40 per ton. At these rates it can be cheaper to landfill a waste than compost if the waste have to be transported very far. The logistical problems associated with feedstock acquisition in relationship to their site location and the high cost of transporting materials is a major economic factor that presents a barrier to development of new facilities. In Georgia, the present rate for hauling/trucking of bulk materials is $1.50 to $2.00 per loaded mile for most distances. The compost infrastructure survey indicated the maximum haul distance to acquire high nitrogen feedstocks was within about a 50 mile radius of the facility for the majority of compost operators. This distance was significantly less for high carbon feedstocks. Obtaining land for a composting facility close to high-waste producing areas is difficult and often economically infeasible. Public opposition and lack of knowledge on the part of local decision makers also can also be a deterrent to a new composting facility.

There are several common threads for successful composting operations. These operations controlled the critical points of the composting process (carbon:nitrogen ratios, temperature, moisture, and air) to produce a consistent product. Operations with high quality compost tended to have higher carbon:nitrogen ratios and take a longer period of time to produce the product. These operations also tended to sell the finished product as well as receive tipping fees. Marketing seems to be particularly important. Operations with marketing systems tended to have very little product stockpiled.

The survey indicated there is considerable capacity within the existing composting infrastructure, except in the largest facilities (producing more than 25,000 tons per year).

Present operational throughput capacity at these facilities could easily be doubled, allowing for over 500,000 tons of waste to be recycled through composting rather than going to a landfill. One reason given by operators that existing facilities do not expand throughput capacity or include new feedstocks was the regulatory concern of obtaining more permits. Most of the small and medium size facilities currently operate under an exemption or Permit-by-Rule. The expense associated with a Solid Waste-Handling Facility permit restricted many operators in the private sector from exploring new opportunities in waste management.

7.6 Potential Markets

The 2002 composting infrastructure survey indicated that current compost production is relatively low quality and is most suitable for use in land reclamation (marginal soils), landscape mulch, or erosion control. Interviews with various academic experts in Georgia indicated that the economics of transportation and application as well as compost quality and consistency were the largest barriers to use. These findings are similar to the 1993 USEPA report on compost markets (USEPA, 1993b) and a Florida survey reported by Rahmini (2002).

The largest potential markets for compost appear to be for erosion control, kaolin mine land reclamation, and for both home and commercial landscaping. The use of compost in erosion and sediment control can be encouraged once the specifications from the Georgia DOT and Georgia Soil and Water Conservation Commission are published. The kaolin mine industry is interested in using compost in its reclamation activities, but there are no compost production facilities in this area of the state. Better information for the user on compost quality and how to use the product may facilitate the landscaping market development. Although agriculture is potentially a large market for compost, current production methods often make compost use uneconomical. If farmers shift production practices towards reduced use of tillage, irrigation, pesticides or man-made fertilizers, compost use could increase. Better research on use of compost in agricultural production systems could help develop this market.

7.6 Potential Barriers

There were several barriers to large-scale composting identified. These include:

- the production of low quality or inconsistent composts that discourages use,
- the high cost of transportation of feedstocks and finished products coupled with the difficulties of locating a compost facility near high feedstock generation areas,
- the low tipping fees at landfills that discourage alternative waste management options, and
- the reluctance to obtain a Solid Waste Handling Facility permit to be able to compost a variety of feedstocks.

8. Recommendations

Several of the barriers listed above can be addressed both by state government, the composting industry, or both. The recommendations are divided into three categories: education, regulatory, and market development.

8.1 Education

The composting industry in Georgia can help educate its members and promote the production of high-quality, consistent compost products. Compost facility owners can encourage the training of their operators in the basics of composting including recipe development and control of the critical parameters such as temperature, moisture, and oxygen. The University of Georgia's Compost Facility Operators Training Workshop can be continued, and modified or expanded to meet these needs.

Experts from the University of Georgia and industry should develop brochures, specifically for Georgia, on the compost quality needed for particular uses. These brochures could be made available by compost facilities along with test results on their compost. The brochures will educate consumers and help promote consistent high-quality composts as well as user satisfaction.

The composting industry as well as state and local government can help with the local zoning and education issues that can compound the difficulties of located composting facilities near high feedstock generation areas. An educational document endorsed by EPD for local officials and the public that described regulatory requirements and expectations for composting facilities could assist in removing local opposition to facilities. Local officials should also be educated through Georgia Municipal Association and Association County Commissioners of Georgia on composting issues.

8.2 Regulatory

There are several ways the current regulations could be improved to encourage composting while protecting the environment and public health. Placing all composting regulations under a separate chapter with a tiered system based on risk and the development of a complete guidance document detailing best management practices would help eliminate investor uncertainty and public confusion about composting. A task force should be appointed to develop recommendations for a tiered permit system. This option should include a different name for composting permits to differentiate them from landfills.

If it is unfeasible to rewrite the composting regulations, some modification of the existing permit system could help remove regulatory barriers. Currently, the Permit-by-Rule requires 75% of the waste composted to be produced onsite. This can restrict proper compost recipe development. The Permit-by-Rule could be modified to allow for a greater amount of off-site materials to create an initial compost carbon:nitrogen ratio of 25 to 40. In most situations, this would mean importing more carbonaceous materials which would improve compost quality and reduce the potential for excess leachate and odor.

Another potential mechanism for permitting certain facilities is through the Recovered Materials Processing Facilities classification. Composting, by the basic nature of the process, is a method of recycling that removes and recovers materials from the solid waste stream to be used as an ingredient to manufacture a new product. Consequently, it meets the basic definition of a Recovered Materials Processing Facility. This permit may need to be amended to allow materials to remain on-site for greater than 90 days. This would encourage the production of higher quality composts by allowing adequate time for the composting and curing processes.

The cost of new composting facility construction is greatly affected by the type of composting surface required. Currently, EPD requires either concrete or asphalt pads for most operations. Alternatives such as geoliners or lime stabilized soil cost considerably less than concrete or asphalt pads. Setting a permeability standard for composting pads such as 1×10^{-7} centimeters per second, and allowing several options for composting facilities to meet standards is one way to reduce costs and facilitate the composting industry.

Many state regulatory agencies provide extensive guidance documents that cover the permitting process, permit requirements, and recommended practices for operation and management. This type of document is needed in Georgia and would facilitate both business planning and well-run operations. The document should include criteria for siting a new operation based on feedstock types and quantities, construction requirements (if needed for a particular type of facility) such as the pad (e.g. $1x\ 10^{-7}$ cm/s), pond with retention capacity, Best Management Practices, such as buffers, runoff control, odor control, and public relations concerns.

Research on the amount and chemical characteristics of leachate from windrow composting operations, the potential for presence of pathogens in surface runoff, and optimal feedstock combinations to minimize environmental risks could be used to modify regulatory requirements.

8.3 Market Development

Market development can be facilitated by the production of consistent, high-quality composts. Facilities should have protocols developed to produce consistent products and a testing program in place to ensure the are meeting their product quality goals. These test results should be shared with their users with guidelines for use. This proactive stance will help the industry overcome the perception of compost quality problems. The industry should also use demonstration projects with particular users or groups of users to help with market development. Some of this work is being done throughout the state by the Georgia Composting Association, individual compost facilities, the University of Georgia, and other groups.

Additional research on compost use would be helpful. In particular, better information on the use of compost in agricultural production and economic analysis of the cost/ benefits of use would support the development of an agricultural market.

The state could actively promote composting by encouraging state agencies to use the material in landscaping and erosion control, especially once the specifications from the Georgia DOT and Georgia Soil and Water Conservation Commission are published. The state and local economic development agencies could work with the kaolin mine industry to encourage facilities to locate near areas where compost could be used in reclamation activities.

In general, Georgia has low tipping fees for landfills and these can make composting economically infeasible. State government could help address this barrier by providing economic incentives such as tax breaks to composting facilities or by taxing the landfilling of organic materials.

In conclusion, although Georgia has an active composting infrastructure, it currently is processing a small portion of the organic waste in the state. Composting can have many environmental benefits, including reducing pressure on landfills and helping to rebuild Georgia’s soils, which has both water quality and water use benefits. This study indicates that Georgia has the potential to increase composting to help meet the 25% waste reduction goal with little adverse environmental impact. The economics of transportation, facility construction and permitting are the largest barriers to expansion of existing facilities and development of new facilities. Compost quality and consistency were the largest barriers to use. There are, however, potential markets for compost in erosion control, kaolin mine land reclamation, and for both home and commercial landscaping. There are also potential markets in agriculture if current production practices are modified. Some changes in regulatory approaches, increasing policy support for the use of compost, and more education should help remove some of the barriers to the growth of this industry.

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Appendix A
Website Addresses for State Regulatory Agencies

Environmental Protection Agency. Standards for the Use or Disposal of Sewage Sludge. 40 CFR, Chapter I, Part 503. Available: http://www.access.gpo.gov/nara/cfr/cfrhtml_00/Title_40/40cfr503_00.html [accessed June 2002]

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Tennessee Department of Environment and Conservation [online]. Available: http://www.state.tn.us/environment [accessed December 2001]

Virginia Department of Environmental Quality [online]. Available: http://www.deq.state.va.us [accessed January 2002]

California Integrated Waste Management Board [online]. Available: http://www.ciwmb.ca.gov [accessed December 2001]

Maine Department of Environmental Protection [online]. Available: http://www.state.me.us/dep/index.htm [accessed December 2001]

Oregon Department of Environmental Quality [online]. Available: http://www.deq.state.or.us/index.htm [accessed December 2001]

Washington Department of Ecology [online]. Available: http://www.ecy.wa.gov [accessed December 2001]

Appendix B

Georgia Compost Infrastructure Survey

Section 1

Facility Name:____________________ **Type:**____________
Address:____________________
City/Zip:____________________ **County:**____________

Contact:________________ **Permit:**____________
Phone:________________

GPS Coordinates:______N______W

Section 2

	(Tons/yr)	Feedstock Origin
Feedstocks: 1)		
2)		
3)		
4)		
5)		
Annual Throughput:		

Finished Compost:__________ __________
Bulk Density (lbs/yd Current Stock (cu yd)

Section 3

Compost Quality:
Contaminants:____________ (5-1) 5 = highest 1 = lowest
Odor:____________ (5-1)
Heat Process:____________ (5-1)
Moisture/Squeeze:____________ (5-1)
Screened:____________ (5-1)
Total Score:____________ 25 MAX

Section 4

Compost Sales:__________ ($/ton) ($/yd) Free Internal Use Other

Section 5

Equipment: Owned	Contracted
1)	1)
2)	2)
3)	3)
4)	4)
5)	5)
6)	6)

Section 6

Max Throughput Capacity:__________
(tons/yr) or (cu yd/yr)

General Appearance:__________

Site Odor:__________

Batch/Continuous:__________

Other Potential Feedstocks/Comments
____
____
____
____
____
____
____

Windrows/Static Pile/In Vessel:__________

Appendix C
Composting Facility Design and Economic Analysis

A properly designed commercial composting operation has seven defined steps; feedstock recovery, feedstock preparation, composting, stabilization, curing, refining and storing (USCC, 1994). Feedstock recovery involves removing the compostable fraction from a mixed waste stream to provide a contamination free feedstock. Feedstock preparation involves processes that initially establish optimum particle size; nutrient balance and moisture content to best facilitate microbial growth and subsequent degradation. Composting and stabilization are each steps where conditions of moisture and aeration are maintained to ensure thermophilic temperatures in the range of 113-149°F. Stability is achieved when biological activity is minimal and is characterized by low oxygen uptake rates, biological heat production and minimal odor. Refining of compost involves screening, metals separation and removal of inert and large organic contaminants.

Included in this section is a detailed feasibility design for a hypothetical windrow composting operation. A windrow composting system consists of long piles of materials that are turned or aerated by mechanical equipment to maintain optimal composting conditions. The operation was designed to compost 25,000 tons of nitrogenous feedstock (NF) per year. Because of the potentially high level of variability of feedstocks received from different generators, assumptions were made in order to provide an initial base design. The following is a list of general assumptions that were made:

- All NF is source separated and free of inert non organic materials.
- Collection and transportation of the NF and carbon material is performed by transportation contractors.
- NF is brought to the site on a continuous basis in the range of 75 to 125 tons/day.
- Carbon material is stockpiled at the site prior to receiving NF shipments.
- NF is able to be handled without any special equipment or extensive site modifications.
- All required land, zoning and permits can be acquired for the site.

Hypothetical Compost Site Design

The key material characteristics are particle size distribution, carbon to nitrogen ratio (C:N) and moisture content. Too little moisture inhibits microbial activity and therefore the rate of degradation during composting while similar consequences occur when the moisture is too high. Proper particle size distribution provides a composting substrate with adequate surface area for microbial degradation and with adequate porosity for the movement and storage of oxygen. A proper C:N ratio for decomposer microorganisms enables the compost process to operate at an optimum level and results in bio-stabilization of the composting material in a timely fashion. Recommended targets include particles sizes of 5 to 25 mm (1/4" to 1"), a C:N ratio of 30 to 45 and a moisture content of 60 to 65% (Haug, 1993).

In order to design a proper composting mixture, knowledge about the feedstocks must be determined. The following assumptions were made:

	Nitrogenous Feedstock	Carbon Material
Moisture Content	80%	48%
Bulk Density	1,500 lb/cu. yd	850 lb/cu. yd
C:N Ratio	15	50

Based on the these assumptions, the NF must be mixed with the carbonaceous material (i.e. yard trimmings, woodwaste or other materials) at a 1 to 3 volumetric ratio or a 1 to 1.7 ratio by weight. This mixture would provide a C:N ratio of 30 and moisture content of 60%. To compost 25,000 tons of NF per year, 18,063 tons of carbon materials would be required.

In order to ensure a high quality finished product the following operational time schedule was assumed. Composting required 60 days, curing for 60 days and followed by 30 days of finished product storage.

A composting period of 60 days was assumed in order to ensure pathogen and vector attraction reduction for the materials being composted. The US Environmental Protection Agency’s (USEPA, 1993) Title 40 of the Code of Federal Regulations (CFR) Part 503, which is a set of rules developed for biosolids management, will be followed. This rule requires that the composting windrows maintain an internal temperature of 131°F (55 C) for fifteen days after construction and the windrows must be turned a minimum of five times during this period. This time/temperature regime ensures that all pathogens and vector attracting characteristics in the compost are eliminated; helping to ensure the finished compost will be of exceptional quality.

A curing period of 60 days was assumed after composting. While curing, the compost becomes biologically stable as microbial activity in the compost slows.

During composting the materials experience shrinkage. Typical volumetric shrinkage during composting is 25 to 70%. A volumetric shrinkage reduction factor of 45% was assumed.

Sizing of the Composting Operation

Because of limited availability and high cost of land, the required land footprint for the compost operation must be optimized to minimize the required facility size. The composting operation will be designed assuming a continuous operation that receives approximately the same amount of material on a daily basis (75-125 tons/day of NF or a total of 172 tons/day organic materials). At this operation, processes involving feedstock recovery, feedstock preparation, composting, stabilization, curing, refining and storing will be performed. The capacity, efficiency and cost of such a composting operation are all affected by assumptions made regarding the land requirements and equipment needed for each step in this process. Because of the wide range of variables that impact the nature of composting, a small change in any design parameter can make a significant difference in the needs of the facility. When an operation is not properly designed to meet the process requirements, common problems such as odor, low product quality, high operational costs and capacity limitation can occur.

The primary unit operation at this operation is the compost processing area or composting pad. The size of the pad is based on the type and quantity of feedstock that is composted, the initial feedstock mixture/recipe and the type of equipment that is used for processing. All feedstock preparation (e.g. receiving and mixing) and active composting takes place on this pad.

In order to accommodate the volume of incoming material while minimizing the size of the composting pad, large industry standard, self-propelled compost turners were specified. These compost turners are capable of providing windrow aeration and porosity maintenance needed for good quality compost and can turn windrows 8 feet tall by 20 feet wide. Large front-end loaders (4 yard capacity) were specified in all areas of material handling. Given the assumed initial feedstock characteristics and the percent reduction, a compost pad of 4.0 acres is required.

After composting, the material will be moved off of the composting pad to an adjacent area where the compost is cured. A 2.0-acre area will be required for this process.

After curing, the compost will then be moved to a screening and storage area. During screening, inert and large organic particles are removed. Once screened, the final product is moved to a storage area where it further cures until it is distributed as finished compost. A 1.0-acre area will be required for this process.

Based on the curing and storage areas of the composting operation and its geographic location, a collection pond was designed based on a 25-year, 24-hour rainfall event. For this operation, a 2.0-acre collection pond with a depth of 6 feet is required to be constructed downgrade from the composting areas in order to capture and retain storm water runoff from the site. Collected wastewater was assumed to be pumped directly to the local municipal wastewater system and a surcharge paid to the local government for treatment of this wastewater.

Buffer areas around the operation are also included to provide ingress and egress for material haulers. Wooded buffers around a composting operation are recommended as both a visual barrier and for reducing the migration of odors off-site. The actual width of these buffer areas depends on the site-specific characteristics and usually depends on the relative sensitivity of neighbors and surrounding areas.

An overall layout of the proposed composting operation to compost 25,000 tons of compost per year is shown in Figure XX (Appendix F). The composting operation requires a total area of 14 acres.

Economic Evaluation

Often, determining the economic feasibility of a composting operation is based solely on the cost per ton to process the waste. Is it less expensive to compost organic wastes rather than disposing of them in a landfill. Composting must be less expensive and also provide enough revenue for the operation to be economically sustainable.

In the economic evaluation process, it is often assumed that an operation immediately receives top return on compost sales. In reality, it often takes market development much longer than planned to realize high-end sales of finished compost. This lag period makes it difficult for composting facilities to maintain proper operations while meeting financial agreements. In the design of this composting operation, efforts were made to accurately estimate all costs. To be conservative, all expenses were estimated on the high side while all revenues from this operation were estimated on the low side. If an operation can meet financial demands on paper using conservative estimates, then it is more likely to be sustainable over the long term.

Capital Costs

Capital costs are those expenses that are often amortized over a period of years. Capital costs include land purchases, construction of infrastructure and purchase of operational equipment. It was assumed that the 4.0-acre composting pad was constructed of 6 inch thick reinforced concrete in order to both provide sufficient groundwater protection while providing support for heavy equipment. Total capital costs for this operation were estimated to be $1,938,440. Table 1 contains a summary of capital costs for the 14-acre composting operation.

Using an estimate of $10,000/acre, the 14-acre operation has a land cost of $140,000. If the required land could be acquired for free or under a minimal leased price arrangement, this cost could be eliminated or substantially reduced.

Construction costs including the cost to construct the compost pad, curing area, storage area, collection pond, road construction and wastewater pumping system were estimated to be $1,046,494. Land clearing and preparation of the compost pad, curing and storage areas were calculated assuming $0.09/ft^2 for personnel and equipment. Utilizing concrete, this type of construction was estimated to cost $221,715/acre. The curing and storage areas were not required to have an impermeable surface and resulted in a total construction cost of $11,761 for the combined 3.0 acres. The collection pond, used to capture all storm water runoff, is lined with a liner comprised of two non-reinforced lightweight nonwoven geotextiles encapsulating a layer of sodium bentonite, overlaid by compacted clay. This type of construction was estimated to cost $11,761/acre. Construction costs associated with collection ponds are very site specific because of the unique geologic conditions associated with each site, along with the amount of land clearing required and excavation. Taking these factors into account, the total cost of construction for the collection pond was estimated to be $53,522. Installation of a water pumping system to transport water from the collection pond to the nearest wastewater line was estimated to be $15,000. Many large trucks will enter and exit the operation each day, therefore, proper road construction is critical around the site. Approximately two acres of land was included in the design for construction of a half-mile long, 20-foot wide road. Using asphalt, the paving costs were estimated to be $10.50/sq yd. The total cost of this road system, which includes land clearing and paving, was $79,350.

This composting operation was designed to process 172 tons of organic materials per day using multiple pieces of equipment estimated to cost a total of $740,000. The list of

Table 1. Capital cost summary table

Capital Costs	# of units	$/unit	Total Cost
Land required (acres)			
Compost areas	7.0	$ 10,000	$ 70,000
Collection pond	2.0	$ 10,000	$ 20,000
Buffer property	5.0	$ 10,000	$ 50,000
Total Land Required	14.0		$ 140,000
Construction			
Compost pad (acres)	4.0	$221,715	$ 886,861
Curing and storage (acres)	3.0	$ 3,920	$ 11,761
Collection pond (including liner)	2.0	$ 26,761	$ 53,522
Road, ½ mile including land clearing &			$ 79,350
Wastewater pumping system	1	$ 15,000	$ 15,000
Total Construction			$1,046,494
Equipment			
Self propelled windrow turner	1	$250,000	$ 250,000
Large wheel loader	2	$100,000	$ 200,000
Screener	1	$150,000	$ 150,000
Dump truck	2	$ 35,000	$ 70,000
Monitoring wells	6	$ 10,000	$ 60,000
Miscellaneous equipment	1	$ 15,000	$ 15,000
Total Equipment			$ 740,000
Total Capital Costs=			**$1,926,494**

required equipment includes: 1 self-propelled windrow turners, 2 bucket wheel loaders, 2 dump trucks and 1 screener. It was estimated that 1 self-propelled windrow turner at $250,000 was needed to aerate and mix the windrows. For material handling, 2 bucket wheel loaders, at $100,000 each, are needed. One loader is used for daily windrow construction and carbon material handling, and one for windrow harvesting, screener loading and distribution loading. Two dump trucks at approximately $35,000 each are used to transport materials within the site. One compost screener at $150,000 is used to remove inerts and large particles and to ensure market specific compost particle size. Six groundwater-monitoring wells, at $10,000 each are installed around the site to monitor groundwater contamination by leachate from the compost operation. Miscellaneous equipment such as probes, meters, lab equipment, computers and software were estimated to cost $10,000.

Operating Costs

Operating costs of the operation were estimated to be $455,369/yr and took into account those costs required to perform business and maintain the composting operation. For this facility, operational costs were grouped into equipment, personnel and contract work. A summary table showing the estimated annual operating costs are shown in Table 2.

Equipment costs were estimated to be $217,529/yr and take into account the cost of fuel, maintenance and repair, equipment replacement and insurance for all equipment used at this facility. A synopsis of the required equipment is shown in Table 1. Fuel costs were estimated assuming 2,644 hrs/yr of total equipment operating hours with fuel costs of $1.50/gal. Using these assumptions and the estimated fuel consumption rate of each piece of equipment, the total fuel cost for the operation was estimated to be $50,254/yr. Ongoing maintenance and equipment replacement is a critical part of normal operating procedures in order to ensure a sustainable operation. Equipment maintenance and equipment replacement were both estimated to cost 10% per year of the original cost of the equipment. Facility insurance was estimated at 1% of the total capital cost of the operation.

Personnel costs were estimated to be $150,700/yr. A total of 4 employees, 3 skilled and 1 unskilled, were estimated to be needed for this operation. Skilled labor was assumed to be paid $15.00/hr and was defined as those individuals that are trained and able to operate all pieces of heavy equipment. Unskilled labor was assumed to be paid $10.00/hr and was defined as those persons who do not operate heavy equipment. These persons will operate trucks and perform daily monitoring tasks at the site. Annual salaries were based on each employee working 2,000 hours per year (50 weeks @ 40 hrs/week). Employee insurance and benefits were estimated to be 37% of the individual yearly salaries.

Contract work at this facility was estimated to be $87,140/yr. Contract work takes into account monthly wastewater treatment, laboratory analysis and wood/yardwaste grinding done at this facility.

In composting, large amounts of carbon feedstocks are required in the process. Many common carbonaceous feedstocks require particle size reduction prior to use in composting. However, an outside contractor performs grinding of carbonaceous feedstocks at many composting operations because grinding occurs too infrequently to justify the purchase and maintenance costs associated with an industrial size grinder. At this operation, it was assumed

Table 2. Operating cost summary table.

Operating Costs		$/unit	Total Cost
Equipment	% per Yr		
Fuel cost (gallon)		$ 1.50	$ 50,264
Maintenance & repair	10%		$ 74,000
Equipment replacement	10%		$ 74,000
Facility insurance	1%		$ 19,265
Total Equipment			$217,529
Personnel	# Employees		
Skilled labor	3	$15.00	$ 90,000
Unskilled labor	1	$10.00	$ 20,000
	% of Salary		
Personnel benefits	37%		$ 40,700
Total Personnel			$150,700
Contract work			
Carbon/wood grinding	128 hrs	$ 250	$ 32,000
Monthly wastewater treatment	12 mth	$4,095	$ 49,140
Monthly laboratory analyses	12 mth	$ 500	$ 6,000
Total Contract			$ 87,140
Total Operating Costs ($/Yr) =			**$455,369**

that 75% of the incoming carbonaceous feedstocks required particle size reduction. Assuming 128 hours of grinding per year at $250/hr, this cost was estimated at $32,000/yr.

The annual cost for wastewater treatment was assumed to be $49,140/yr. This cost is believed to be overly conservative since a large portion of the water collected at most windrow composting operations is sprayed directly back onto the windrows to maintain moisture. Wastewater collected as storm runoff from the composting areas was assumed to be pumped directly into the local municipal wastewater system and a surcharge paid to the local government for treatment of this wastewater. The onsite collection pond has an approximate total monthly storage volume capacity of 3,900,000 gallons. It was assumed that 50% of the total monthly capacity was treated as wastewater at a cost of $21 per 10,000 gallons (Jordan, 1998).

Incoming feedstocks and finished compost at commercial operations should undergo laboratory analysis. Tests are performed to quantify both the physical and chemical characteristics of the materials. It was assumed that 12 tests of this type were performed each month with a total annual cost for laboratory analysis of $6,000.

Revenue Generation

This operation has two potential sources of revenue generation: tipping fees from incoming NF and product sales of the finished compost. From these two sources of income it was estimated that this operation could generate $792,090/yr. A summary of the potential revenue generation is shown in Table 3.

Table 3. Revenue generation summary.

Revenue Generation	**Tons/yr**	**$/unit**	**Total**
Tipping Fees			
Carbonaceous Materials	18,063	$ 0.00	$ 0
Nitrogenous Materials	25,000	$15.00	$375,000
	cu. yd/yr		
Product Sales	41,709	$10	$417,090
Total Revenue for the Facility ($/yr)=			**$792,090**

Tipping Fees

Tipping fees are surcharges collected by landfills for waste disposal while “processing fees” as some compost operators prefer to call them are those fees charged by composters to both collect and compost the waste material. Processing fees should generally be lower than tipping fees collected at most landfills and often contribute substantially to a composting operation’s revenue and economic sustainability. These reduced fees provide incentive to waste generators to participate in composting programs. A conventional waste disposal bill is based on quantity of material handled, size of container used for disposal, number of pick-ups per week and often the distance of the waste generation facility to the landfill. Tipping fees as well as processing fees are negotiable and flexible and not all waste generators pay the same rate. An average total disposal fee (combined tipping and transportation cost) of $35/ton is standard in many metro areas. In order to give a financial incentive to participate in the composting program, a total fee of $30/ton was assumed to be charged to the NF generators. This fee included both an assumed transportation cost ($15/ton) and a process fee ($15/ton) that is paid directly to the facility. It was assumed that no revenue was generated from receiving carbonaceous feedstocks and that the $15/ton associated with transportation costs of NF was used to transport both nitrogenous and carbonaceous materials. Normally, tipping fees at landfills for carbon feedstocks such as woodwaste and yard trimmings are very low. Total revenue from incoming feedstocks was estimated to be approximately $375,000/yr.

Product Sales

Approximately 41,709 cu. yd of compost will be produced annually from this compost operation. Market prices for compost depend on the quality of the material that is produced and the type of product that is being marketed. Generally, there is a strong correlation with price and product quality and whether the operation is run by a local government or by a private business. Local governments are often more concerned with a cost effective alternative for organic waste materials management, while private composting operations are motivated by profit through tipping fees and product sales. Revenue that is not generated in tipping fees is made in product sales, however, relying solely on product sales for revenue is generally not profitable or economically sustainable for a composting operation.

For this study it was assumed that the finished compost was initially sold in bulk rather than in bagged form. It was assumed that the finished compost was of high quality and could be sold at a price of $10/cu. yd. Although this is a low unit price for high quality compost, a new operation is readily assured of receiving this price for compost in the competitive soils amendment market. Based on these assumptions, total product sales revenue for the finished compost was $417,090/yr.

Feasibility Assessment

In Table 4 there is an overall financial evaluation of the composting operation accounting for operating costs, monthly expenses and monthly revenue. It was assumed in this evaluation that all capital costs were paid based on a 10-year loan at an interest rate of 7.00%. This time period was chosen based on the working life of the equipment. In this analysis the capital cost recovery has been separated using a cost per month basis for both land and construction and equipment. This was determined to be $13,776/mth. Total monthly operating expenses for this operation were estimated to be $37,947 and included monthly loan payments and operational costs which this operation needed to be sustainable. Based on the assumptions, the total monthly expenses for this facility were estimated to be $60,316. Taking into account both nitrogenous feedstock processing fees and compost sales, total monthly revenue was estimated be $66,008. It was estimated that after the operation makes its financial obligations and expenses are paid it should generate $5,692/mth or $68,302/yr.

Table 4. Evaluation of operation.

Revenue Generation	Units	Total
Capital cost recovery (10 years)		
- Land & construction	($/mth)	($13,776)
- Equipment	($/mth)	($ 8,592)
		($22,368)
Operating costs	($/mth)	($37,947)
Total monthly expenses	($/mth)	($60,316)
Total monthly revenue	($/mth)	$66,008
Facility net yearly income	($/yr)	$68,302
Cost per ton to compost all materials	($/ton)	($16.83)

Because of the seasonal nature of compost sales, actual monthly revenue will not be equal each month. Based on an annual processing capacity of 25,000 tons/yr of NF, the total cost per ton to compost was estimated to be $28.95/ton while the total revenue generated per ton of NF was $31.68/ton. This produced a profit of $2.73/ton.

Assessing the feasibility of starting a new composting operation is difficult because of the many design parameters which must be assumed. However, based on the site design, feedstock availability, financial costs and revenue generation potential, the proposal to compost 25,000 tons of NF appears to be feasible, although the profit margin is approximately 8.6%. This profit margin is low for a commercial business venture.